REN21 Renewable Energy Policy Network for the 21st Century

RENEWABLES 2014
GLOBAL STATUS REPORT

REN 21 STEERING COMMITTEE

INDUSTRY ASSOCIATIONS

Michael Brower
American Council on Renewable Energy (ACORE)

Ernesto Macías Galán
Alliance for Rural Electrification (ARE)

Li Junfeng
Chinese Renewable Energy Industries Association (CREIA)

David Green
Clean Energy Council (CEC)

Rainer Hinrichs-Rahlwes
European Renewable Energies Federation (EREF)

Steve Sawyer
Global Wind Energy Council (GWEC)

Marietta Sander
International Geothermal Association (IGA)

Richard Taylor
International Hydropower Association (IHA)

Heinz Kopetz
World Bioenergy Association (WBA)

Stefan Gsänger
World Wind Energy Association (WWEA)

INTERNATIONAL ORGANISATIONS

Bindu Lohani
Asian Development Bank (ADB)

Piotr Tulej
European Commission (EC)

Robert K. Dixon
Global Environment Facility (GEF)

Paolo Frankl
International Energy Agency (IEA)

Adnan Z. Amin
International Renewable Energy Agency (IRENA)

Marcel Alers
United Nations Development Programme (UNDP)

Mark Radka
United Nations Environment Programme (UNEP)

Pradeep Monga
United Nations Industrial Development Organization (UNIDO)

Vijay Iyer
World Bank

NGOS

Ibrahim Togola
Mali Folkecenter/ Citizens United for Renewable Energy and Sustainability (CURES)

Irene Giner-Reichl
Global Forum on Sustainable Energy (GFSE)

Sven Teske
Greenpeace International

Emani Kumar
ICLEI – Local Governments for Sustainability, South Asia

Tetsunari Iida
Institute for Sustainable Energy Policies (ISEP)

Tomas Kaberger
Japan Renewable Energy Foundation (JREF)

Harry Lehmann
World Council for Renewable Energy (WCRE)

Athena Ronquillo Ballesteros
World Resources Institute (WRI)

Rafael Senga
World Wildlife Fund (WWF)

MEMBERS AT LARGE

Michael Eckhart
Citigroup, Inc.

Mohamed El-Ashry
United Nations Foundation

David Hales
Second Nature

Kirsty Hamilton
Chatham House

Peter Rae
REN Alliance

Arthouros Zervos
Public Power Corporation

NATIONAL GOVERNMENTS

Mariangela Rebuá de Andrade Simões
Brazil

Hans Jørgen Koch
Denmark

Tania Rödiger-Vorwerk/Karsten Sach
Germany

Tarun Kapoor
India

Øivind Johansen
Norway

David Pérez
Spain

Paul Mubiru
Uganda

Thani Ahmed Al Zeyoudi
United Arab Emirates

Nick Clements
United Kingdom

SCIENCE AND ACADEMIA

Nebojsa Nakicenovic
International Institute for Applied Systems Analysis (IIASA)

David Renné
International Solar Energy Society (ISES)

Kevin Nassiep
South African National Energy Development Institute (SANEDI)

Rajendra Pachauri
The Energy and Resources Institute (TERI)

EXECUTIVE SECRETARY

Christine Lins
REN21

DISCLAIMER:

REN21 releases issue papers and reports to emphasise the importance of renewable energy and to generate discussion on issues central to the promotion of renewable energy. While REN21 papers and reports have benefitted from the considerations and input from the REN21 community, they do not necessarily represent a consensus among network participants on any given point. Although the information given in this report is the best available to the authors at the time, REN21 and its participants cannot be held liable for its accuracy and correctness.

FOREWORD

In June 2004, delegates from 154 countries gathered in Bonn, Germany, for the world's first government-hosted international conference on renewable energy. Global perceptions of renewables have shifted considerably over the past decade. Continuing technology advances and rapid deployment of many renewable energy technologies have demonstrated their immense potential.

Today, renewables are seen not only as sources of energy, but also as tools to address many other pressing needs, including: improving energy security; reducing the health and environmental impacts associated with fossil and nuclear energy; mitigating greenhouse gas emissions; improving educational opportunities; creating jobs; reducing poverty; and increasing gender equality.

Renewables have entered the mainstream. This is welcome news as we begin the Decade of Sustainable Energy for All (SE4ALL), mobilising towards universal access to modern energy services, improved rates of energy efficiency, and expanded use of renewable energy sources by 2030. While this year's *Renewables Global Status Report* (GSR) clearly documents advancements in the uptake of renewables, it also demonstrates that we need to move faster and more deliberately if we are to double the share of renewables in the global energy mix and ensure access to clean and sustainable energy for all people by 2030.

The past decade has also seen the evolution of REN21 and its community into a robust, dynamic, international network of renewable energy experts. The collective work of REN21's contributors, researchers, and authors has made the GSR the most frequently referenced report on renewable energy market, industry, and policy trends. Special thanks go to the ever-growing network of contributors, including authors, researchers, and reviewers, who participated in this year's process and helped make the GSR a truly international and collaborative effort.

On behalf of the REN21 Secretariat, I would like to thank all of those who ensured the successful production of GSR 2014. These people include lead author/research director Janet Sawin, the section authors, GSR project manager Rana Adib, and the entire team at the REN21 Secretariat, under the leadership of REN21's Executive Secretary Christine Lins.

The past decade has set the wheels in motion for a global transition to renewables, but a concerted and sustained effort is needed to achieve it. With increasingly ambitious targets and innovative policies, renewables can continue to surpass expectations and create a clean and sustainable energy future. As this year's GSR clearly demonstrates, the question is no longer whether renewables have a role to play in the provision of energy services, but rather how we can best increase the current pace to achieve a 100% renewables future with full energy access for all.

Arthouros Zervos

Chairman of REN21

GSR 2014 TABLE OF CONTENTS

REPORT CITATION

REN21. 2014. *Renewables 2014 Global Status Report* (Paris: REN21 Secretariat).

ISBN 978-3-9815934-2-6

TABLES

FIGURES

SIDEBARS

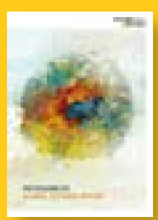
REFERENCE TABLES

RENEWABLE ENERGY POLICY NETWORK FOR THE 21st CENTURY

REN21 is the global renewable energy policy multi-stakeholder network that connects a wide range of key actors. REN21's goal is to facilitate knowledge exchange, policy development and joint action towards a rapid global transition to renewable energy.

REN21 brings together governments, nongovernmental organisations, research and academic institutions, international organisations and industry to learn from one another and build on successes that advance renewable energy. To assist policy decision making, REN21 provides high quality information, catalyses discussion and debate and supports the development of thematic networks.

Global Status Report: yearly publication since 2005



Global Futures Report

Regional Reports

www.map.ren21.net

	2004	2005	2006	2007	2008	2009
REN21 publications:		First GSR published				Chinese Renewable Energy Status Report
REN21 events:	renewables 2004, Bonn	BIREC, Bejing International Renewable Energy Conference			WIREC, Washington International Renewable Energy Conference	

REN21 Renewable Energy Policy Network for the 21st Century

PROVIDE HIGH-QUALITY INFORMATION TO DRIVE INFORMED POLICY DECISIONS

Using its multi-stakeholder network, REN21 facilitates the collection of comprehensive and timely information on renewable energy. This information reflects diverse viewpoints from both private and public sector actors, serving to dispel myths about renewable energy and catalysing policy change.

Renewables Global Status Report (GSR)

First released in 2005, REN21's *Renewables Global Status Report* (GSR) has grown to become a truly collaborative effort, drawing on an international network of over 500 authors, contributors, and reviewers. Today it is the most frequently referenced report on renewable energy market, industry, and policy trends.

Thematic Reports

REN21 produces thematic reports which aim to provide in-depth analysis about a topic and stimulate discussion:

- Renewables Global Futures Report (GFR)
- Local Renewable Energy Policies Status Report
- 10 Years of Accelerating the Global Energy Transition
- Mini-Grid Policy Toolkit

Regional Reports

These reports detail the renewable energy developments of a particular region; their production also supports regional data collection processes and informed decision making.

Renewables Interactive Map

The Renewables Interactive Map is a research tool for tracking the development of renewable energy worldwide. It complements the perspectives and findings of the GSR by providing constantly updated market and policy information and detailed exportable country profiles.

INITIATE DISCUSSION AND DEBATE TO DRIVE POLITICAL COMMITMENT

International Renewable Energy Conferences (IRECs)

The International Renewable Energy Conference (IREC) is a high-level political conference series. Dedicated exclusively to the renewable energy sector, the biennial IREC is hosted by a national government and convened by REN21. SAIREC 2015 will be held in South Africa, 4–7 October 2015.

Renewables Academy

The REN21 Renewables Academy provides an opportunity for lively exchange among the growing community of REN21 contributors. It offers a venue to brainstorm on future-orientated policy solutions and allows participants to actively contribute on issues central to the renewable energy transition.

Thematic workshops, panel discussions and webinars

REN21 convenes and participates in a series of workshops, panel discussions, and webinars to spread information on renewable energy globally.

STRENGTHEN AND LEVERAGE REN21'S MULTI-STAKEHOLDER BASE

- Broad dissemination of activities of the REN21 Secretariat as well as network members through four editions of the REN21 newsletter.
- In-depth information for members through the REN21 newswire.
- Dynamic interaction with key institutional partners such as IEA, IRENA, SE4ALL, and UNEP.

2010	Indian Renewable Energy Status Report	DIREC, Delhi International Renewable Energy Conference
2011	Global Status Report on Local Renewable Energy Policies	
2012		
2013	Global Futures Report; MENA Renewable Energy Status Report	ADIREC, Abu Dhabi International Renewable Energy Conference
2014	ECOWAS Status Report on Renewable Energy & Energy Efficiency	First REN21 Renewables Academy, Bonn
2015		SAIREC, South Africa International Renewable Energy Conference

ACKNOWLEDGEMENTS

This report was commissioned by REN21 and produced in collaboration with a global network of research partners. Financing was provided by the German Federal Ministry for Economic Cooperation and Development (BMZ), the German Federal Ministry for Economic Affairs and Energy (BMWi), and the Ministry of Foreign Affairs of the United Arab Emirates. A large share of the research for this report was conducted on a voluntary basis.

SUSTAINABLE ENERGY FOR ALL

The UN Secretary-General's initiative Sustainable Energy for All mobilises global action to achieve universal access to modern energy services, double the global rate of energy efficiency, and double the share of renewable energy in the global energy mix by 2030. REN21's *Renewables 2014 Global Status Report* contributes to this initiative by demonstrating the role of renewables in increasing energy access. A section on distributed renewable energy—based on input from local experts primarily from developing countries—illustrates how renewables are providing needed energy services and contributing to a better quality of life through the use of modern cooking, heating/cooling, and electricity technologies. As the newly launched Decade for Sustainable Energy for All (2014–2024) unfolds, REN21 will work closely with the SE4ALL Initiative towards achieving its three objectives.

RESEARCH DIRECTION AND LEAD AUTHORSHIP

Janet L. Sawin
(Sunna Research and Worldwatch Institute)

Freyr Sverrisson
(Sunna Research)

SECTION AUTHORS

Kanika Chawla (REN21 Secretariat)

Christine Lins (REN21 Secretariat)

Angus McCrone (Bloomberg New Energy Finance)

Evan Musolino (Worldwatch Institute)

Lily Riahi (UNEP)

Janet L. Sawin
(Sunna Research and Worldwatch Institute)

Ralph Sims (Massey University)

Jonathan Skeen (Emergent Energy)

Freyr Sverrisson (Sunna Research)

SPECIAL ADVISOR

Ralph Sims (Massey University)

PROJECT MANAGEMENT AND GSR COMMUNITY MANAGEMENT

Rana Adib (REN21 Secretariat)

Kanika Chawla (REN21 Secretariat)

RESEARCH AND COMMUNICATION SUPPORT (REN21 SECRETARIAT)

Martin Hullin

Sarah Leitner

Stefano Mazzaccaro

Hannah Murdock

Laura E. Williamson

Glen Wright

EDITING, DESIGN, AND LAYOUT

Lisa Mastny, editor (Worldwatch Institute)

weeks.de Werbeagentur GmbH, design

PRODUCTION

REN21 Secretariat, Paris, France

LEAD AUTHOR EMERITUS

Eric Martinot (Institute for Sustainable Energy Policy)

LEAD REGIONAL AND COUNTRY RESEARCHERS

ASEAN
Katarzyna Chojnacka, Thachatat Kuvarakul (ASEAN Centre for Energy, GIZ)

East Asia
Christopher Dent (University of Leeds)

Eastern and Southern Africa
Dennis Kibira (African Solar Designs); Natasha Kloppers, Jonathan Skeen (Emergent Energy)

ECOWAS
David Koman Achi (AD Solar + AD Education Energie); Adeola Adebiyi, Nicola Bugatti, Eder Semedo (ECREEE); Katie Auth, Tristram Thomas (Worldwatch Institute)

Central and Eastern Europe
Ulrike Radosch (Austrian Energy Agency, enerCEE)

Western Europe
Peter Bickel (ZSW); Jan Bruck, Charlotte Cuntz, Tatjana Regh, Mona Rybicki (Germanwatch)

Latin America and Caribbean
Gonzalo Bravo (Fundación Bariloche); Sandra Chavez (IRENA); Milena Gonzalez (Worldwatch Institute); Arnaldo Vieira de Carvalho (IDB)

Brazil
Suani Coelho, Maria Beatriz Monteiro (CENBIO); Renata Grisoli (MGM Innova); Camilla Ramos (CELA)

Canada
Jose Etcheverry (York University)

Chile
Jose Emiliano Detta (IDB)

China
Frank Haugwitz (Asia Europe Clean Energy (Solar) Advisory)

Colombia
Javier Eduardo Rodríguez (Mining and Energy Planning Unit, Colombia)

Ecuador
Pablo Carvajal (Ministry of Strategic Sectors, Ecuador)

Fiji
Atul Raturi (University of the South Pacific)

France
Romain Zissler (ISEP)

Ghana
Kwabena Ampadu Otu-Danquah (Ghana Energy Commission)

Honduras
Jose Emiliano Detta (IDB)

India
Shirish Garud (TERI)

Italy
Noemi Magnanini (GSE)

Japan
Tetsunari Iida, Hironao Matsubara (ISEP); Mika Ohbayashi (JREF)

Jordan
Samer Zawaydeh (AEE)

Kuwait
Adam Weber (Clean Energy Business Council)

Lithuania
Inga Valuntiene (COWI Lietuva)

Mali
Cheick Ahmed Sanogo (AMADER)

Mauritius
Fabiani Appavou (Ministry of Environment and Sustainable Development, Mauritius)

Morocco
Philippe Lempp (GIZ)

Nepal
Mukesh Ghimire (AEPC)

Nicaragua
Lâl Marandin (Pelican SA)

Norway
Benjamin Sovacool (AU Herning)

Oman
Ali Al-Resheidi (Oman Public Authority for Electricity and Water)

Philippines
Rafael Senga (WWF)

Portugal
Lara Ferreira (APREN); Luisa Branquinho Silverio (DGGE)

Senegal
Ibrahima Niane (Ministry for Energy, Senegal)

South Korea
Sanghoon Lee (Korean Society for New and Renewable Energy); Kwanghee Yeom (KFEM)

Spain
Sofia Martinez (IDAE)

Sweden
Benjamin Sovacool (AU Herning)

Tanzania
Chris Greacen (Palang Thai)

Thailand
Chris Greacen (Palang Thai); Sopitsuda Tongsopit (Energy Resource Institute)

Togo
Dodji Agbezo (JVE Togo)

Turkey
Mustafa Sezgin (TENVA); Tanay Sidki Uyar (Eurosolar)

United Arab Emirates
Dane McQueen (MoFA, UAE)

Uruguay
Pablo Caldeiro Sarli, Gabriela Horta, Alejandra Reyes (Uruguay Ministry of Industry, Energy & Mining)

ACKNOWLEDGEMENTS (CONTINUED)

LEAD TOPICAL CONTRIBUTORS

Bioenergy
Patrick Lamers (Mountain View Research);
Eija Alakangas (VTT Technical Research Centre of Finland);
Sribas Bhattacharya (IISWBA); Helena Chum (NREL);
Jaqueline Daniel-Gromke (German Biomass Research Centre);
Matthias Edel (German Energy Agency);
Anselm Eisentraut (IEA); Alessandro Flammini (FAO);
Uwe Fritsche (IINAS); Karin Haara (WBA);
Martin Junginger (Utrecht University); Heinz Kopetz (WBA);
Bharadwaj Kummamuru (WBA); Andrew Lang (WBA);
Benoit Lebot (UNDP); Julia Münch (Fachverband Biogas e.V.);
Agata Przadka (European Biogas Association);
Robert Rapier (Merica International)

Concentrating Solar Thermal Power
Elena Dufour, Luis Crespo Rodriguez (ESTELA);
Fredrick Morse (Morse Associates Inc.)

Distributed Renewable Energy
Bozhil Kondev (GIZ); Ernesto Macias Galan (ARE);
Hari Natarajan (GIZ-IGEN); Yasemin Erboy (UN Foundation);
Akanksha Chaurey (IT power); Debajit Palit (TERI);
Heike Volkmer (GIZ); Arnaldo Vieira de Carvalho (IDB);
Michael Hofman (MIF); Jiwan Acharya, Fely Arriola (ADB);
Gabriela Azuela, Koffi Ekouevi (World Bank); Frank Haugwitz (Asia Europe Clean Energy (Solar) Advisory Co. Ltd.);
Gonzalo Bravo (Fundación Bariloche); Caroline McGregor (Global Leap, U.S. Department of Energy); Wim van Ness (SNV Netherlands Development Organisation);
Emmanuel Ackom (GNESD); João Arsénio (TESE);
Morgane Benard (Sunna Design); Paul Bertheau (Reiner Lemoine Institut); Adam Camenzuli (Karibu Solar);
Helene Connor (HELIO International); Leslie Cordes (GACC);
Johan de Leeuw (Wind Energy Solutions BV); Johanna Diecker (GOGLA); Julie Ipe (GACC); Alex Lima (Electrobras);
Chandirekera Makuyana (SNV Netherlands Development Organisation); Tijana Manitašević (Strawberry Energy);
Lal Marandin (SE4ALL Nicaragua); Godfrey Ogbemudia (CREDC); Eromosele Omomhenle; Ewah Otu Eleri (ICEED Nigeria); Henrique Pancini (UNCTAD); Ruben Stegbauer (Solar Aid); Dipti Vaghela (International Rivers);
Nancy Wimmer (microSOLAR))

Geothermal Energy
Benjamin Matek (GEA); Philippe Dumas (EGEC); Luis Carlos Gutiérrez-Negrín (Geotermia, Mexican Geothermal Association)

Green Purchasing and Labeling
Joß Bracker (OEKO); Jenny Heeter (NREL);
Jennifer Martin (Center for Resource Solutions)

Heat Pumps/ Heating and Cooling
Thomas Nowak (European Heat Pump Association)

Hydropower/ Ocean Energy
Simon Smith, Richard Taylor (IHA); Christine van Oldeneel, Pilar Ocon (Hydropower Equipment Association)

Jobs
Rabia Ferroukhi, Arslan Khalid, Álvaro López-Peña (IRENA);
Michael Renner (Worldwatch Institute)

Policy
Rainer Hinrichs-Rahlwes (BEE, EREF); Maryke van Staden (ICLEI); Fabiani Appavou (Ministry of Environment and Sustainable Development, Mauritius); Karolina Daszkiewicz (IEA)

Renewable Energy and Energy Efficiency
Pedro Filipe Paralta Carqueija, Jyoti Prasad Painuly (UNEP Risø Centre); Thibaud Voïta (IPEEC); Curt Garrigan (UNEP)

Renewable Energy Costs
Michael Taylor (IRENA)

Renewable Energy Statistics
Yasmina Abdelilah, Michael Waldron (IEA); Zuzana Dobrotkova; Olivier Lavagne d'Ortigue (IRENA); Rana Adib, Laura E. Williamson (REN21 Secretariat)

Solar General
David Renné (ISES)

Solar PV
Gaëtan Masson (IEA-PVPS, iCARES Consulting);
GTM Research PV Pulse; Denis Lenardic (pvresources)

Solar Thermal Heating and Cooling
Franz Mauthner (AEE INTEC); Bärbel Epp (Solrico);
Jan-Olof Dalenbäck (Chalmers University of Technology);
IEA Solar Heating and Cooling Programme

System Transformation
Lily Riahi (UNEP); Travis Bradford (Prometheus Institute);
Bianca Barth (BSW); Cynthia Hunt Jähne (SEPA); Scott Sklar (Stella Group)

Transport
Nicolai Bader, Armin Wagner (GIZ); Heather Allen (TRL)

Wind Power
Shruti Shukla, Steve Sawyer (GWEC); Feng Zhao (Navigant Research); Stefan Gsänger, Jean-Daniel Pitteloud (WWEA);
Aris Karcanias (FTI Consulting); Shi Pengfei, Liu Minghui (CWEA)

REVIEWERS AND OTHER CONTRIBUTORS

Sheikh Adil (Institute of Environment and Sustainable Development); Asad Ali Ahmed (World Bank); Kathleen Araujo (Harvard Kennedy School of Government); Timothy Barker (Stimulate Systems); Ausilio Bauen (Imperial College London); Morgan Bazilian (NREL); Luca Benedetti (GSE); Farid Bensebaa (NRC); Edgar Blaustein; Pierre Boileau (IEA); Tom Bradley (Narec Distributed Energy); Emmanuel Branche (EDF); Christian Breyer (Lappeenranta University of Technology); Mary Brunisholz (IEA-PVPS); Ines del Campo Colmenar (CENER); Francoise D'Estais (UNEP); Pedro Dias (ESTIF); Dominique Diouf (Batan HBDO); Jens Drillisch (KFW); Michael Eckhart (Citigroup Inc.); Martha Ekkert (BMWi); Daniel Kofi Essien (IRELP); Pancaldi Estella (GSR); Emily Evans (NREL); Paolo Frankl (IEA); Lew Fulton (UC Davis); Alexander Gerlach (Q-Cells); Jacopo Giuntoli (Institute for Energy and Transport); Andreas Häberle (PSE); Niklas Hagelberg (UNEP); Jacob Ipsen Hansen (UNEP Risø Centre); Andrea Hilfrich (E-Control); Julien Jacquot (GERES); Uli Jakob (Green Chiller Verband für Sorptionskälte e.V.); El Mostafa Jamea (ERDDS); Franck Jesus (GEF); Manik Jolly (World Bank); Wim Jonker Klunne (CSIR); Anthony Jude (ADB); Sung Moon Jung (IPEEC); Jasmeet Khurana (Bridge to India); Ansgar Kiene (World Future Council); Matthias Kimmel (Duke University); Johannes Kirsch (ZVEI); Diana Kraft-Schäfer (German Electrical and Electronic Manufacturers' Association – ZVEI); Bente Kruckenberg (D.I. Energi); Arun Kumar (IIT Roorkee); Maryse Labriet (ENERIS); Fanny-Pomme Langue (AEBIOM); Krzysztof Laskowski (Euroheat & Power); Jonah Letovsky (Sciences Po); Noam Lior (University of Pennsylvania); Detlef Loy (Loy Energy Consulting); Birger Madsen; Alessandro Marangoni (Althesys); Adam Markusfalvi-Toth; H. Mitavachan (Oldenburg University); Daniel Mugnier (TECSOL SA); Nurzat Myrsalieva (RCREEE); Kevin Nassiep (SANEDI); Hans-Christoph Neidlein (PV Magazine); Jan Erik Nielsen (PlanEnergi, IEA-SHC); Bruce Nordman (LBNL); Ingrid Nyström (F3 Centre); Willington Ortiz (Wuppertal Institute); Binu Parthan (SEA); Céline Payet (EIB); Martin Pehnt (Institute für Energie und Umwelforschung Heidelberg GmbH); Tobias Persson, Mattias Svensson (Swedish Gas Centre); Liming Qiao (GWEC); Peter Rae; Heather Rosmarin (Amazon Watch); Burkhard Sanner (EGEC); Raphael Santos (Ministry of Mines and Energy Brazil); Arne Schweinfurth (GIZ); Reinoud Segers (Statistics Netherlands); Alexandra Seibt (Wuppertal Institute); Joonkyung Seong (World Bank); Anoop Singh (Indian Institute of Technology); Virginia Sonntag O'Brien; Ibrahim Soumaila (ECREEE); Djaheezah Subratty (UNEP); Sven Teske (Greenpeace International); Uwe Trenkner (Trenkner Consulting); Nico Tyabji (BNEF); Eric Usher (UNEP); Olola Vieyra (UNEP); Clare Wenner (UK Renewable Energy Association); Chris Werner (Hanergy); Marcus Wiemann (ARE); William Wills (EOS Environmental); Johan Agergaard Winberg (D.I. Energi)

The **Global Trends in Renewable Energy Investment report (GTR)**, formerly *Global Trends in Sustainable Energy Investment*, was first published by the Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance in 2011. This annual report was produced previously (starting in 2007) under UNEP's Sustainable Energy Finance Initiative (SEFI). It grew out of efforts to track and publish comprehensive information about international investments in renewable energy according to type of economy, technology, and investment.

The GTR is produced jointly with Bloomberg New Energy Finance and is the sister publication to the REN21 *Renewables Global Status Report* (GSR). The latest edition was released in April 2014 and is available for download at www.fs-unep-centre.org.

The Renewables Global Status Report provides a comprehensive and timely overview of renewable energy market, industry, investment, and policy developments worldwide. It enables policymakers, industry, investors, and civil society to make **INFORMED DECISIONS**.

The report covers recent developments, current status, and key trends; by design, it does not provide analysis or forecast.

The Renewables Global Status Report relies on **UP-TO-DATE RENEWABLE ENERGY DATA**, provided by an **INTERNATIONAL NETWORK** of more than 500 contributors, researchers, and authors.

EXECUTIVE SUMMARY

In June 2004, delegates from 154 countries converged in Bonn, Germany, for the world's first government-hosted international conference on renewable energy. REN21 emerged from that process to become the first international organisation to track renewable energy developments. At that time, there were visible upwards trends in global renewable energy capacity and output, investment, policy support, investment, and integration. Yet even ambitious projections did not anticipate the extraordinary expansion of renewables that was to unfold over the decade ahead.

Global perceptions of renewable energy have shifted considerably since 2004. Over the last 10 years, continuing technology advances and rapid deployment of many renewable energy technologies have demonstrated that their potential can be achieved. Renewables advanced further towards realising that potential during 2013.

CONTINUED RENEWABLE ENERGY GROWTH

Renewable energy provided an estimated 19% of global final energy consumption in 2012,[i] and continued to grow in 2013. Of this total share in 2012, modern renewables accounted for approximately 10%, with the remainder (estimated at just over 9%) coming from traditional biomass.[ii] Heat energy from modern renewable sources accounted for an estimated 4.2% of total final energy use; hydropower made up about 3.8%, and an estimated 2% was provided by power from wind, solar, geothermal, and biomass, as well as by biofuels.

The combined modern and traditional renewable energy share remained about level with 2011, even as the share of modern renewables increased. This is because the rapid growth in modern renewable energy is tempered by both a slow migration away from traditional biomass and a continued rise in total global energy demand.

As renewable energy markets and industries mature, they increasingly face new and different challenges, as well as a wide range of opportunities. In 2013, renewables faced declining policy support and uncertainty in many European countries and the United States. Electric grid-related constraints, opposition in some countries from electric utilities concerned about rising competition, and continuing high global subsidies for fossil fuels were also issues. Overall—with some exceptions in Europe and the United States—renewable energy developments were positive in 2013.

Markets, manufacturing, and investment expanded further across the developing world, and it became increasingly evident that renewables are no longer dependent upon a small handful of countries. Aided by continuing technological advances, falling prices, and innovations in financing—all driven largely by policy support—renewables have become increasingly affordable for a broader range of consumers worldwide. In a rising number of countries, renewable energy is considered crucial for meeting current and future energy needs.

As markets have become more global, renewable energy industries have responded by increasing their flexibility, diversifying their products, and developing global supply chains. Several industries had a difficult year, with consolidation continuing, particularly for solar energy and wind power. But the picture brightened by the end of 2013, with many solar photovoltaics (PV) and wind turbine manufacturers returning to profitability.

The most significant growth occurred in the power sector, with global capacity exceeding 1,560 gigawatts (GW), up more than 8% over 2012. Hydropower rose by 4% to approximately 1,000 GW, and other renewables collectively grew nearly 17% to more than 560 GW. For the first time, the world added more solar PV than wind power capacity; solar PV and hydropower were essentially tied, each accounting for about one-third of new capacity. Solar PV has continued to expand at a rapid rate, with growth in global capacity averaging almost 55% annually over the past five years. Wind power has added the most capacity of all renewable technologies over the same period. In 2013, renewables accounted for more than 56% of net additions to global power capacity and represented far higher shares of capacity added in several countries.

Over the past few years, the levelised costs of electricity generation from onshore wind and, particularly, solar PV have fallen sharply. As a result, an increasing number of wind and solar power projects are being built without public financial support. Around the world, major industrial and commercial customers are turning to renewables to reduce their energy costs while increasing the reliability of their energy supply. Many set ambitious renewable energy targets, installed and operated their own renewable power systems, or signed power purchase agreements to buy directly from renewable energy project operators, bypassing utilities.

By the end of 2013, China, the United States, Brazil, Canada, and Germany remained the top countries for total installed renewable power capacity; the top countries for non-hydro capacity were again China, the United States, and Germany, followed by Spain, Italy, and India. Among the world's top 20 countries for non-hydro capacity, Denmark had a clear lead for total capacity per capita. Uruguay, Mauritius, and Costa Rica were among the top countries for investment in new renewable power and fuels relative to annual GDP.

In the heating and cooling sector, trends included the increasing use of renewables in combined heat and power plants; the feeding of renewable heating and cooling into district systems; hybrid solutions in the building renovation sector; and the growing use of renewable heat for industrial purposes. Heat from modern biomass, solar, and geothermal sources accounts for a small but gradually rising share of final global heat demand, amounting to an estimated 10%. The use of modern renewable technologies for heating and cooling is still limited relative to their vast potential.

i - Note that it is not possible to provide 2013 shares due to a lack of data.

ii - Note that there is debate about the sustainability of traditional biomass, and whether it should be considered renewable, or renewable only if it comes from a sustainable source.

The growth of liquid biofuels has been uneven in recent years, but their production and use increased in 2013. There is also growing interest in other renewable options in the transport sector. The year saw a continued rise in the use of gaseous biofuels (mainly biomethane) and further development of hybrid options (e.g., biodiesel-natural gas buses, and electric-diesel transport). There are limited but increasing initiatives to link electric transport systems with renewable energy, particularly at the city and regional levels.

Some highlights of 2013 include:

- In the European Union, renewables represented the majority of new electric generating capacity for the sixth consecutive year. The 72% share in 2013 is in stark contrast to a decade earlier, when conventional fossil generation accounted for 80% of new capacity in the EU-27 plus Norway and Switzerland.
- Even as global investment in solar PV declined nearly 22% relative to 2012, new capacity installations increased by about 32%.
- China's new renewable power capacity surpassed new fossil fuel and nuclear capacity for the first time.
- Variable renewables achieved high levels of penetration in several countries. For example, throughout 2013, wind power met 33.2% of electricity demand in Denmark and 20.9% in Spain; in Italy, solar PV met 7.8% of total annual electricity demand.
- Wind power was excluded from one of Brazil's national auctions because it was pricing all other generation sources out of the market.
- Denmark banned the use of fossil fuel-fired boilers in new buildings as of 2013 and aims for renewables to provide almost 40% of total heat supply by 2020.
- Growing numbers of cities, states, and regions seek to transition to 100% renewable energy in either individual sectors or economy-wide. For example, Djibouti, Scotland, and the small-island state of Tuvalu aim to derive 100% of their electricity from renewable sources by 2020. Among those who have already achieved their goals are about 20 million Germans who live in so-called 100% renewable energy regions.

The impacts of these developments on employment numbers in the renewable energy sector have varied by country and technology, but, globally, the number of people working in renewable industries has continued to rise. An estimated 6.5 million people worldwide work directly or indirectly in the sector.

AN EVOLVING POLICY LANDSCAPE

By early 2014, at least 144 countries had renewable energy targets and 138 countries had renewable energy support policies in place, up from the 138 and 127 countries, respectively, that were reported in GSR 2013. Developing and emerging economies have led the expansion in recent years and account for 95 of the countries with support policies, up from 15 in 2005. The rate of adoption remained slow relative to much of the past decade, due largely to the fact that so many countries have already enacted policies.

In 2013, there was an increasing focus on revisions to existing policies and targets, including retroactive changes, with some adjustments made to improve policy effectiveness and efficiency, and others aimed to curtail costs associated with supporting the deployment of renewables. At the same time, some countries expanded support and adopted ambitious new targets.

Policy mechanisms continued to evolve, with some becoming more differentiated by technology. Feed-in policies in many countries evolved further towards premium payments in the power sector, and continued to be adapted for use in the heating sector. Particularly in Europe, new policies are emerging to advance or manage the integration of high shares of renewable electricity into existing power systems, including support for energy storage, demand-side management, and smart grid technologies.

As in past years, most renewable energy policies enacted or revised during 2013 focus on the power sector. A mix of regulatory policies, fiscal incentives, and public financing mechanisms continued to be adopted. Feed-in policies and renewable portfolio standards (RPS) remained the most commonly used support mechanisms, although their pace of adoption continued to slow. Public competitive bidding, or tendering, gained further prominence, with the number of countries turning to public auctions rising from 9 in 2009 to 55 as of early 2014.

Although the heating and cooling sector lags far behind the renewable power sector for attention from policymakers, the adoption of targets and support policies has increased steadily. As of early 2014, at least 24 countries had adopted renewable heating (and cooling) targets, and at least 19 countries had obligations at the national or state/provincial level. Renewable heating and cooling is also supported through fiscal incentives, as well as through building codes and other measures at the national and local levels in several countries.

As of early 2014, at least 63 countries used regulatory policies to promote the production or consumption of biofuels for transport; this was up from the 49 reported in GSR 2013. Some existing blend mandates were strengthened, and the use of fiscal incentives and public financing expanded. In some countries, however, support for first-generation biofuels was reduced due to environmental and social sustainability concerns. Although most transport-related policies focus on biofuels, many governments continued to explore other options such as increasing the number of vehicles fuelled with biomethane and electricity from renewable sources.

Thousands of cities and towns worldwide have policies, plans, and targets to advance renewable energy, often far outpacing the ambitions of national legislation. Policy momentum continued in 2013 as city and local governments acted to reduce emissions, support and create local industry, relieve grid capacity stress, and achieve security of supply. To accomplish these goals, they increasingly made use of their authority to regulate, make expenditure and procurement decisions, facilitate and ease the financing of renewable energy projects, and influence advocacy and information sharing. As cities seek to share and scale up best practices, highlight their commitments to renewable energy, and account for their achievements, local governments are increasingly prioritising systematic measurement and reporting of climate and energy data.

RENEWABLE ENERGY INDICATORS 2013

		START 2004[1]	END 2012	END 2013
INVESTMENT				
New investment (annual) in renewable power and fuels[2]	billion USD	39.5	249.5	**214.4** (249.4)
POWER				
Renewable power capacity (total, not including hydro)	GW	85	480	**560**
Renewable power capacity (total, including hydro)	GW	800	1,440	**1,560**
Hydropower capacity (total)[3]	GW	715	960	**1,000**
Bio-power capacity	GW	<36	83	**88**
Bio-power generation	TWh	227	350	**405**
Geothermal power capacity	GW	8.9	11.5	**12**
Solar PV capacity (total)	GW	2.6	100	**139**
Concentrating solar thermal power (total)	GW	0.4	2.5	**3.4**
Wind power capacity (total)	GW	48	283	**318**
HEAT				
Solar hot water capacity (total)[4]	GW_{th}	98	282	**326**
TRANSPORT				
Ethanol production (annual)	billion litres	28.5	82.6	**87.2**
Biodiesel production (annual)	billion litres	2.4	23.6	**26.3**
POLICIES				
Countries with policy targets	#	48	138	**144**
Feed-in Number of states / provinces / countries	#	34	97	**98**
RPS / quota policies Number of states / provinces / countries	#	11	79	**79**
Tendering Number of states / provinces / countries	#	8	45	**55**
Heat obligations / mandates Number of countries	#	n/a	19	**19**
Biofuel obligations / mandates[5] Number of countries	#	10	52	**63**

[1] Capacity data are as of the beginning of 2004; other data, such as investment and biofuels production, cover the full year. Numbers are estimates, based on best available information.

[2] Investment data are from Bloomberg New Energy Finance (BNEF) and include all biomass, geothermal, and wind generation projects of more than 1 MW; all hydro projects of between 1 and 50 MW; all solar power projects, with those less than 1 MW estimated separately and referred to as small-scale projects or small distributed capacity; all ocean energy projects; and all biofuel projects with an annual production capacity of 1 million litres or more. BNEF estimates that, including the unreported investments in hydropower projects >50 MW, total new investment in renewable power and fuels was at least USD 249.4 billion in 2013.

[3] The GSR 2013 reported a global total of 990 GW of hydropower capacity at the end of 2012; this figure has been revised downward due to better data availability. Data do not include pumped storage.

[4] Solar hot water capacity data include water collectors only; including air collectors, estimated totals are 283.4 GW for 2012 and 330 GW for 2013. The number for 2013 is a preliminary estimate. Note that past editions of this table have not considered unglazed water collectors.

[5] Biofuel mandates include policies at the national or state/provincial level that are listed both under the biofuels obligation/mandate column in Table 3 (Renewable Energy Support Policies) and in Reference Table R18 (National and State/Provincial Biofuel Blend Mandates). Numbers in the table do not include individual state/provincial mandates. The 10 countries identified with biofuels mandates in the "Start 2004" column were actually in place as of early 2005, the earliest year for which data are available.

Note: Renewable power capacity (including and not including hydropower) and hydropower capacity data are rounded to nearest 5 GW; other capacity numbers are rounded to nearest 1 GW except for global investment, numbers <15, and biofuels, which are rounded to one decimal point. Policy data for 2013 include all countries identified as of early 2014.

TOP FIVE COUNTRIES

ANNUAL INVESTMENT / NET CAPACITY ADDITIONS / PRODUCTION IN 2013

	1	2	3	4	5
Investment in renewable power and fuels	**China**	United States	Japan	United Kingdom	Germany
Share of GDP 2012 (USD) invested[1]	**Uruguay**	Mauritius	Costa Rica	South Africa	Nicaragua
Geothermal power capacity	**New Zealand**	Turkey	United States	Kenya	Philippines
Hydropower capacity	**China**	Turkey	Brazil	Vietnam	India
Solar PV capacity	**China**	Japan	United States	Germany	United Kingdom
CSP capacity	**United States**	Spain	United Arab Emirates	India	China
Wind power capacity	**China**	Germany	United Kingdom	India	Canada
Solar water heating capacity[2]	**China**	Turkey	India	Brazil	Germany
Biodiesel production	**United States**	Germany	Brazil	Argentina	France
Fuel ethanol production	**United States**	Brazil	China	Canada	France

TOTAL CAPACITY OR GENERATION[6] AS OF END-2013

	1	2	3	4	5
POWER					
Renewable power (incl. hydro)	**China**	United States	Brazil	Canada	Germany
Renewable power (not incl. hydro)	**China**	United States	Germany	Spain / Italy	India
Renewable power capacity *per capita* (not incl. hydro)[3]	**Denmark**	Germany	Portugal	Spain / Sweden	Austria
Biopower generation	**United States**	Germany	China	Brazil	India
Geothermal power	**United States**	Philippines	Indonesia	Mexico	Italy
Hydropower[4]	**China**	Brazil	United States	Canada	Russia
Hydropower generation[4]	**China**	Brazil	Canada	United States	Russia
Concentrating solar thermal power (CSP)	**Spain**	United States	United Arab Emirates	India	Algeria
Solar PV	**Germany**	China	Italy	Japan	United States
Solar PV capacity *per capita*	**Germany**	Italy	Belgium	Greece	Czech Republic
Wind power	**China**	United States	Germany	Spain	India
Wind power capacity *per capita*	**Denmark**	Sweden	Spain	Portugal	Ireland
HEAT					
Solar water heating[2]	**China**	United States	Germany	Turkey	Brazil
Solar water heating capacity *per capita*[2]	**Cyprus**	Austria	Israel	Barbados	Greece
Geothermal heat[5]	**China**	Turkey	Iceland	Japan	Italy

[1] Countries considered include only those covered by BNEF; GDP is for 2012 and from the World Bank. The following renewable energy projects are included: all biomass, geothermal, and wind generation projects of more than 1 MW; all hydropower projects of between 1 and 50 MW; all solar power projects, with those less than 1 MW estimated separately and referred to as small-scale projects or small distributed capacity; all ocean energy projects; and all biofuel projects with an annual production capacity of 1 million litres or more.

[2] Solar water collector (heating) rankings are for 2012, and are based on capacity of water (glazed and unglazed) collectors only; however, including air collectors would not affect order. Note that past editions of this table have not considered unglazed water collectors.

[3] Per capita renewable power capacity ranking considers only those countries that place among the top 20 worldwide for total installed renewable power capacity, not including hydropower.

[4] Country rankings for hydropower capacity and generation differ because some countries rely on hydropower for baseload supply whereas others use it more to follow the electric load and match peaks in demand.

[5] Not including heat pumps. Rankings are based on a mix of 2010 data and more recent statistics for some countries.

[6] Capacity, otherwise noted.

Note: Most rankings are based on absolute amounts of investment, power generation capacity or output, or biofuels production; if done on a per capita, national GDP, or other basis, the rankings would be quite different for many categories (as seen with per capita rankings for renewable power, solar PV, wind, and solar water collector capacity).

INVESTMENT FLOWS

Global new investment in renewable power and fuels—not including hydropower projects >50 megawatts (MW)[i]—was an estimated USD 214.4 billion in 2013, down 14% relative to 2012 and 23% lower than the record level in 2011. Including the unreported investments in hydropower projects larger than 50 MW, total new investment in renewable power and fuels was at least USD 249.4 billion in 2013.

The second consecutive year of decline in investment—after several years of growth—was due in part to uncertainty over incentive policies in Europe and the United States, and to retroactive reductions in support in some countries. Europe's renewable energy investment was down 44% from 2012. The year 2013 also saw an end to eight consecutive years of rising renewable energy investment in developing countries.

Yet the global decline also resulted from sharp reductions in technology costs. This was particularly true for solar PV, which saw record levels of new installations in 2013, despite a 22% decline in dollars invested. Lower costs and efficiency improvements made it possible to build onshore wind and solar PV installations in a number of locations around the world in 2013 without subsidy support, particularly in Latin America. Considering only net investment in new power capacity, renewables outpaced fossil fuels for the fourth year running.

Further, despite the overall downward trend in global investment, there were significant exceptions at the country level. The most notable was Japan, where investment in renewable energy (excluding research and development) increased by 80% relative to 2012 levels. Other countries that increased their investment in 2013 included Canada, Chile, Israel, New Zealand, the United Kingdom, and Uruguay. Despite the overall decline in China's investment, for the first time ever, China invested more in renewable energy than did all of Europe combined, and it invested more in renewable power capacity than in fossil fuels.

Solar power was again the leading sector by far in terms of money committed during 2013, receiving 53% (USD 113.7 billion) of total new investment in renewable power and fuels (with 90% going to solar PV). Wind power followed with USD 80.1 billion. Asset finance of utility-scale projects declined for the second consecutive year, but it again made up the vast majority of total investment in renewable energy, totalling USD 133.4 billion.

Clean energy funds (equities) had a strong year, and clean energy project bonds set a new record in 2013. North America saw the emergence of innovative yield-oriented financing vehicles, and crowd funding moved further into the mainstream in a number of countries. Institutional investors continued to play an increasing role, particularly in Europe, with a record volume of renewable energy investment during the year. Development banks were again an important source of clean energy investment, with some banks pledging to curtail funding for fossil fuels, especially coal power.

DISTRIBUTED RENEWABLE ENERGY IN DEVELOPING COUNTRIES

In many parts of the world, the lack of access to modern energy services continues to impede sustainable development. Recent assessments suggest that as many as 1.3 billion people still do not have access to electricity, and more than 2.6 billion people rely on traditional biomass for cooking and heating. However, during 2013, people in remote and rural areas of the world continued to gain access to electricity, modern cooking, heating and cooling as the installation and use of distributed renewable energy technologies increased. This expansion was a direct result of improvements in affordability, inclusion of distributed energy in national energy policies, greater access to financing, increased knowledge about local resources, and more-advanced technologies that can be tailored to meet customers' specific needs.

Furthermore, increased use of mini-grids supported the spread of renewable energy-powered electrification in un-electrified peri-urban and rural areas. Recent technical advances that enable the integration of renewables in mini-grid systems, combined with information and communication technology (ICT) applications for power management and end-user services, have allowed for a rapid growth in the use of renewables-powered mini-grids.

There is a growing awareness that stand-alone cooking and electricity systems based on renewables are often the most cost-effective options available for providing energy services to households and businesses in remote areas. As a result, an increasing number of countries is supporting the development of decentralised renewable energy-based systems to expand energy access.

With the rising awareness that off-grid, low-income customers can provide fast-growing markets for goods and services, and with the emergence of new business and financing models for serving them, rural energy markets are increasingly being recognised as offering potential business opportunities. Many companies have become active across Africa, Asia, and Latin America, selling household-level renewable energy systems and devices. Commercial lenders, social venture capitalists, local and international development entities, governments, and others are actively engaged in the financing of distributed renewable energy. In 2013, levels of participation and progress varied from country to country depending on support policies, broader legal frameworks, and political stability.

i - Except where noted explicitly, investment data in this section do not include hydropower projects >50 MW because these are not tracked by Bloomberg New Energy Finance, the source for these statistics.

MARKET AND INDUSTRY TRENDS

BIOMASS FOR HEAT, POWER, AND TRANSPORT. Biomass demand continued to grow steadily in the heat, power, and transport sectors. Total primary energy consumption of biomass reached approximately 57 exajoules (EJ) in 2013, of which almost 60% was traditional biomass, and the remainder was modern bioenergy (solid, gaseous, and liquid fuels). Heating accounted for the majority of biomass use, with modern biomass heat capacity rising about 1% to an estimated 296 gigawatts-thermal (GW_{th}). Global bio-power capacity was up by an estimated 5 GW to 88 GW. Bio-power generation exceeded 400 Terawatt-hours (TWh) during the year, including power generated in combined heat and power (CHP) plants. Demand for modern biomass is driving increased international trade in solid biofuels, including wood pellets.

Liquid biofuels met about 2.3% of global transport fuel demand. In 2013, global production rose by 7.7 billion litres to reach 116.6 billion litres. Ethanol production was up 6% after two years of decline, biodiesel rose 11%, and hydrotreated vegetable oil (HVO) rose by 16% to 3 million litres. New plants for making advanced biofuels, produced from non-food biomass feedstocks, were commissioned in Europe and North America. However, overall investment in new biofuel plant capacity continued to decline from its 2007 peak.

GEOTHERMAL POWER AND HEAT. About 530 MW of new geothermal generating capacity came on line in 2013. Accounting for replacements, the net increase was about 455 MW, bringing total global capacity to 12 GW. This net capacity growth of 4% compares to an average annual growth rate of 3% for the two previous years (2010–12). Direct use of geothermal energy—for thermal baths and swimming pools, space heating, and agricultural and industrial processes—is estimated to exceed 300 petajoules (PJ) annually, but growth is not robust. Governments and industry continued to pursue technological innovation to increase efficient use of conventional geothermal resources. In parallel, the use of low-temperature fields for both power and heat continued to expand, increasing the application of geothermal energy beyond high-temperature locations.

HYDROPOWER. Global hydropower generation during the year was an estimated 3,750 TWh. About 40 GW of new hydropower capacity was commissioned in 2013, increasing total global capacity by around 4% to approximately 1,000 GW. By far the most capacity was installed in China (29 GW), with significant capacity also added in Turkey, Brazil, Vietnam, India, and Russia. Growth in the industry has been relatively steady in recent years, fuelled primarily by China's expansion. Modernisation of ageing hydropower facilities is a growing global market. Some countries are seeing a trend towards smaller reservoirs and multi-turbine run-of-river projects. There also is increasing recognition of the potential for hydropower to complement other renewable technologies, such as variable wind and solar power.

OCEAN ENERGY. Ocean energy capacity, mostly tidal power generation, was about 530 MW by the end of 2013. In preparation for anticipated commercial projects, a handful of pilot installations were deployed during the year for ongoing tests. Particularly in the United Kingdom and France, there are indications that significant capacity growth will occur in the near future, due to concerted industry focus and government support. Major corporations continued to consolidate their positions in the ocean energy sector through strategic partnerships and acquisitions of technology developers.

SOLAR PHOTOVOLTAICS (PV). The solar PV market had a record year, adding more than 39 GW in 2013 for a total exceeding 139 GW. China saw spectacular growth, accounting for nearly one-third of global capacity added, followed by Japan and the United States. Solar PV is starting to play a substantial role in electricity generation in some countries, particularly in Europe, while lower prices are opening new markets from Africa and the Middle East to Asia and Latin America. Interest continued to grow in corporate- and community-owned systems, while the number and size of utility-scale systems continued to increase. Although it was a challenging year for many companies, predominantly in Europe, the industry began to recover during 2013. Module prices stabilised, while production costs continued to fall and solar cell efficiencies increased steadily. Many manufacturers began expanding production capacity to meet expected further growth in demand.

CONCENTRATING SOLAR THERMAL POWER (CSP). Global CSP capacity was up nearly 0.9 GW (36%) in 2013 to reach 3.4 GW. While the United States and Spain remained the market leaders, markets continued to shift to developing countries with high levels of insolation. Beyond the leading markets, capacity nearly tripled with projects coming on line in the United Arab Emirates, India, and China. An increasing range of hybrid CSP applications emerged, and thermal energy storage continued to gain in importance. Industry operations expanded further into new markets, and global growth in the sector remained strong, but revised growth projections and competition from solar PV in some countries led a number of companies to close their CSP operations. The trend towards larger plants to take advantage of economies of scale was maintained, while improved design and manufacturing techniques reduced costs.

SOLAR THERMAL HEATING AND COOLING. Solar water and air collector capacity exceeded 283 GW_{th} in 2012 and reached an estimated 330 GW_{th} by the end of 2013. As in past years, China was the main demand driver, accounting for more than 80% of the global market. Demand in key European markets continued to slow, but markets expanded in countries such as Brazil, where solar thermal water heating is cost competitive. The trend towards deploying large domestic systems continued, as did growing interest in the use of solar thermal technologies for district heating, cooling, and industrial applications. China maintained its lead in the manufacture of solar thermal collectors. International attention to quality standards and certification continued, largely in response to high failure rates associated with cheap tubes from China. Europe saw accelerated consolidation during the year, with several large suppliers announcing their exit from the industry. Industry expectations for market development are the brightest in India and Greece.

WIND POWER. More than 35 GW of wind power capacity was added in 2013, for a total above 318 GW. However, following several record years, the market was down nearly 10 GW compared to 2012, reflecting primarily a steep drop in the U.S. market. While the European Union remained the top region for cumulative wind capacity, Asia was nipping at its heels and is set to take the lead in 2014. New markets continued to emerge in all regions, and, for the first time, Latin America represented a significant share of new installations. Offshore wind had a record year, with 1.6 GW added, almost all of it in the EU. However, the record level hides delays due to policy uncertainty and project cancellations or downsizing.

The wind industry continued to be challenged by downward pressure on prices, increased competition among turbine manufacturers, competition with low-cost gas in some markets, reductions in policy support driven by economic austerity, and declines in key markets. At the same time, falling capital costs and technological advances increased capacity factors, improving the cost-competitiveness of wind-generated electricity relative to fossil fuels. The offshore industry continued to move farther from shore and into deeper waters, driving new foundation designs and requiring more-sophisticated vessels.

In recognition of their contribution, this year's publication acknowledges the **GSR community** through illustrations and text on each of the separator pages like this one.

01

01 GLOBAL OVERVIEW

Renewable energy provided an estimated 19% of global final energy consumption in 2012[i], and continued to grow strongly in 2013.[ii 1] Of this total share in 2012, traditional biomass[iii], which currently is used primarily for cooking and heating in remote and rural areas of developing countries, accounted for about 9%, and modern renewables increased their share to approximately 10%.

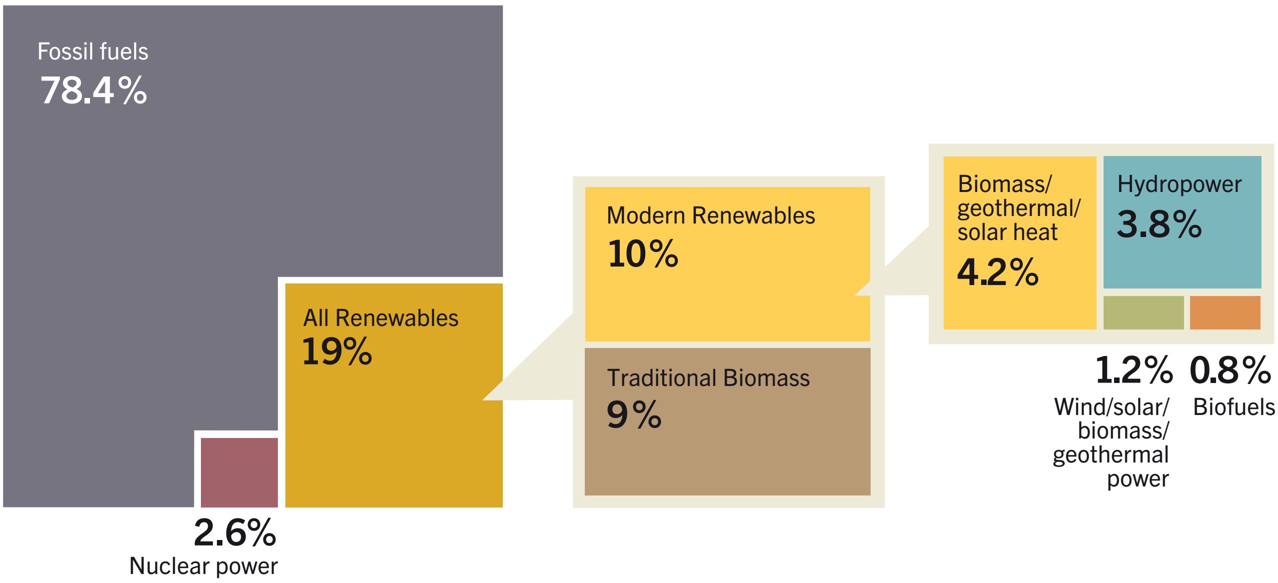
The combined modern and traditional renewable energy share remained about level with 2011, even as the share of modern renewables increased.[2] This is because the rapid growth in modern renewable energy is tempered by both a slow migration away from traditional biomass and a continued rise in total global energy demand.[3]

Modern renewable energy is being used increasingly in four distinct markets: power generation, heating and cooling, transport fuels, and rural/off-grid energy services. The breakdown of modern renewables, as a share of total final energy use in 2012, was as follows: hydropower generated an estimated 3.8%; other renewable power sources comprised 1.2%; heat energy accounted for approximately 4.2%; and transport biofuels provided about 0.8%.[4] (See Figure 1.)

During the years 2009 through 2013, installed capacity as well as output of most renewable energy technologies grew at rapid rates, particularly in the power sector.[5] (See Figure 2.) Over this period, solar photovoltaics (PV) experienced the fastest capacity growth rates of any energy technology, while wind saw the most power capacity added of any renewable technology. The use of modern renewables for heating and cooling progressed steadily, although good data for many heating technologies and fuels are lacking.[6] (See Sidebar 1, page 23.) Biofuels production for use in the transport sector slowed from 2010 to 2012, despite high oil prices, but picked up again in 2013.[7]

As renewable energy industries and markets mature, they increasingly face new and different challenges—as well as a wide range of opportunities. In Europe, a growing number of countries has reduced, sometimes retroactively, financial support for renewables at a rate that exceeds the decline in technology costs. Such actions have been driven, in part, by the ongoing economic crisis in some member states, by related electricity over-capacity, and by rising competition with fossil fuels. Policy uncertainty has increased the cost of capital—making it more difficult to finance projects—and reduced investment. (See Policy Landscape section.) During 2013, Europe continued to see a significant loss of start-up companies (especially solar PV), resulting in widespread financial losses.[8] On a bright note, the share of renewables in gross final energy consumption in the European Union (EU[iv]) reached an estimated 14.1% in 2012, up from 8.3% in 2004.[9]

Figure 1. Estimated Renewable Energy Share of Global Final Energy Consumption, 2012



Source: See Endnote 4 for this section.

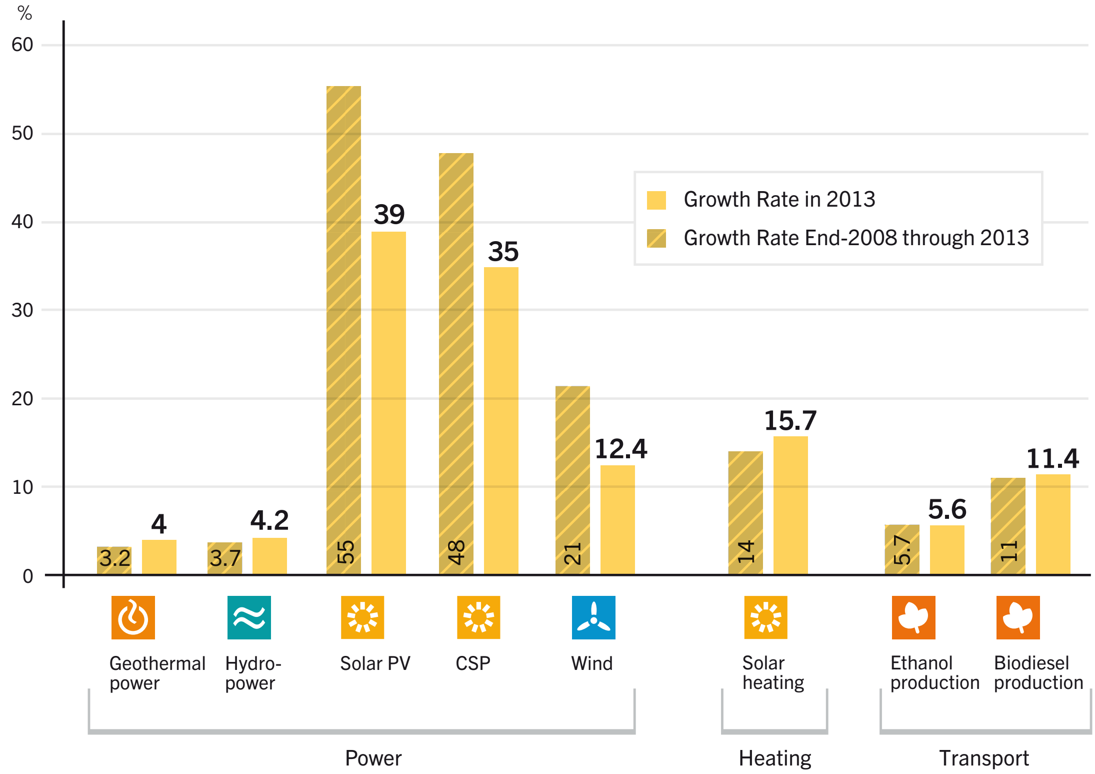
i - Note that it is not possible to provide 2013 shares due to a lack of data.

ii - Endnotes in this report are numbered by section and begin on page 152 (see full version online: http://www.ren21.net/gsr). Endnotes contain source materials and assumptions used to derive data in the GSR, as well as additional supporting notes.

iii - Traditional biomass refers to solid biomass that is combusted in inefficient, and usually polluting, open fires, stoves, or furnaces to provide heat energy for cooking, comfort, and small-scale agricultural and industrial processing, typically in rural areas of developing countries. It may or may not be harvested in a sustainable manner. Traditional biomass currently plays a critical role in meeting rural energy demand in much of the developing world. Modern biomass energy is defined in this report as energy derived efficiently from solid, liquid, and gaseous biomass fuels for modern applications. (See Glossary for definitions of terms used in this report.) There is ongoing discussion about the sustainability of traditional biomass, and whether it should be considered renewable, or renewable only if it comes from a sustainable source. For information about the environmental and health impacts of traditional biomass, see H. Chum et al., "Bioenergy," in Edenhofer et al., eds., *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* (Cambridge, U.K.: Cambridge University Press, 2011).

iv - The use of "European Union," or "EU", throughout refers specifically to the EU-28.

Figure 2. Average Annual Growth Rates of Renewable Energy Capacity and Biofuels Production, End-2008–2013



Source: See Endnote 5 for this section.

Further, renewables operate on an un-level playing field in which energy prices do not fully reflect externalities. Global subsidies for fossil fuels and nuclear power remain high despite discussions about their phase-out, encouraging inefficient energy use while also hindering investment in renewables.[10] Depending on the calculation method used, estimates for the global cost of fossil fuel subsidies range from USD 544 billion to USD 1.9 trillion—several times higher than those for renewable energy.[11] (See Sidebar 6, GSR 2013.)

Electric grid-related challenges continued in 2013. These include lack of transmission infrastructure in some locations, delays in grid connection, and sometimes the curtailment of renewable generation.[12] At high penetration levels, variable renewables can pose challenges for electricity grid system operators. A growing number of countries is aiding integration through improvements in grid management practices, improving system flexibility, and modifying existing grid infrastructure and technologies.[13] (See Feature, GSR 2013.)

Overall, with some exceptions in Europe and the United States, renewables saw a number of significant and positive developments in 2013.[14] Wind power moved more firmly into Africa and Latin America; concentrating solar thermal power (CSP) shifted its focus further to the Middle East and North Africa (MENA) region and to South Africa; renewable process heat fuelled industries from Chile to Europe to India; and solar PV continued to spread across the globe, with most capacity on-grid but also significant increases in off-grid markets in developing countries.

Such developments make it increasingly evident that renewables are no longer dependent upon a small handful of countries. Indeed, during 2013, major renewable energy companies further shifted their focus away from traditional markets in Europe and into Africa, Asia, and Latin America, where strong new markets are emerging in all sectors, both on and off the grid.[15]

Renewables have been aided by continuing advances in technologies, falling prices, and innovations in financing, driven largely by policy support. These developments are making renewable energy more economical than new fossil and nuclear installations under many circumstances, and thus more affordable for a broader range of consumers in developed and developing countries.[16] In addition, there is increasing awareness of renewable energy technologies and resources, and their potential to help meet rapidly rising energy demand, while also creating jobs, accelerating economic development, reducing local air pollution, improving public health, and reducing carbon emissions.[17]

There is also a growing recognition that renewable energy can expand access to modern energy services in developing countries, both rapidly and cost effectively.[18] As more attention turns to issues of energy access, as prices decline, and as new business models emerge, it is becoming apparent that rural energy markets in developing countries offer significant business opportunities, and products are being tailored specifically to meet the needs of these markets.[19] (See Distributed Renewable Energy section.)

Increasingly, renewable energy is considered crucial for meeting current and future energy needs. In Latin America, for example, renewables are now seen as a critical energy source.[20] (See Sidebar 2.) To achieve a variety of energy security and sustainability goals, growing numbers of cities, states, and regions around the world seek to transition to 100% renewable

SIDEBAR 1. RENEWABLE ENERGY DATA: CURRENT STATUS AND CHALLENGES OF CAPACITY AND PRODUCTION DATA

Reliable, accessible, and timely data on renewable energy are essential for establishing energy plans, defining baselines for targets, monitoring progress and effectiveness of policy measures, and attracting investment. Global data collection on renewables has improved significantly in recent years with more-comprehensive and timelier record keeping, increased accessibility, and better communication among stakeholders. Significant gains have been made over the past decade as governments, industries, and other entities have improved data collection methods. However, there are still large data gaps, particularly in the decentralised applications of renewable energy. The task also grows in complexity as the use of renewable energy increases in scale and expands geographically, making data more difficult to track. A number of challenges remain.

In many countries, renewable energy data are not collected systematically and, where data do exist, they vary widely in quality and completeness. Timing of data releases varies considerably, and reporting periods differ. The time lag between developments and availability of data (in many instances two years or longer) can be a barrier to informed decision making, given the rapidly evolving renewable energy landscape.

Some challenges are technology or sector specific, due to the decentralised nature of installations and industry structure. For example, most traditional biomass is used for heating and cooking in more than a billion dwellings worldwide, and estimates of total quantities are uncertain. Modern biomass technologies have varying rates of fuel-to-energy conversion, and the wide range of feedstocks, sources, and conversion pathways makes uniform data collection difficult. Even the energy from traded biomass is difficult to track because the traded feedstock can have both energy and non-energy uses.

Renewable heating (and cooling) data, in general, present a challenge because of the relatively large number and variety of technologies involved (e.g., feedstocks, energy conversion technologies, distribution) and the distributed nature of the sector. In some countries, there is a misconception that the use of renewable heating (such as solar thermal collectors for water heating) is an energy efficiency measure, and thus developments are not recorded with other renewable energy data. Capacity and output data on distributed heat, off-grid electricity, and other decentralised applications frequently go uncollected or are otherwise fragmented.

Energy output data are challenging to estimate accurately for a variety of reasons, including variability in local resource and system conditions. Where renewables are part of hybrid facilities (such as biomass co-firing, CSP-fossil fuel hybrids), output is often not broken down by source, resulting in over- or underestimation of the renewable component. In addition, declining efficiencies of existing stock and retirement and replacement of ageing capacity need to be accounted for, but these are seldom reported and therefore are often subject to estimation.

Many national and international entities do not report data sources and assumptions underlying their statistics. Some data are aggregated under the "other" category, which may or may not include non-renewable products. Other datasets are not publicly available. Methodologies and assumptions (including what is counted and how) can differ markedly among sources, creating inconsistencies and uncertainty about data robustness.

Formal (government) data may command some premium in the hierarchy of data, but informal data are also critical for establishing a more comprehensive view of the global renewable energy sector. The challenge is to effectively bring together data from various institutional and individual sources in a consistent, systematic, and transparent context. Several national, regional, and international initiatives have been formed to overcome gaps and improve the quality of renewable energy data, in part by systematically relying on a broader array of both formal and informal sources. These include the Global Tracking Framework under SE4ALL, projects under way at IRENA, regional initiatives in western Africa and the MENA region, and ongoing work by REN21 with global and regional status reports.

The collection and processing of renewable energy statistical information can be seen as burdensome; however, inconsistent data collection efforts hamper governments' capacity to make informed decisions. Experts agree that systematic and enhanced reporting is critical for increasing financing, establishing policy priorities, and improving energy planning over time.

Source: See Endnote 6 for this section.

SIDEBAR 2. REGIONAL SPOTLIGHT: LATIN AMERICA AND THE CARIBBEAN

Increasing interest in renewable energy in the Latin America and the Caribbean (LAC) region is reflected in ambitious targets and policy support, which have led to rapidly growing investments in renewables, beyond the traditional hydropower sector. By early 2014, at least 19 countries in the region had renewable energy policies, and at least 14 had renewable energy targets, mostly for electricity generation. (See Table 3 and Reference Tables R12 to R15.) For example, Uruguay aims to generate 90% of its electricity from renewable sources by 2015, while Grenada targets 20% primary energy from renewables by 2020.

Renewable energy already meets a substantial portion of electricity demand, with hydropower accounting for around half of the region's total installed power capacity and the vast majority of its renewable power capacity. Especially in Central America, the need for a diversified electricity mix to reduce vulnerability to a changing hydrological profile is driving interest in other abundant renewable energy resources. In Brazil, hydropower expansion is expected to become increasingly constrained by environmental sensitivity and the remoteness of much of the remaining resource. In the Caribbean, countries are aggressively pursuing the deployment of renewables to reduce their heavy reliance on fossil fuels, and thereby increase their economic and energy security.

Despite having an average electrification rate of almost 95%, one of the highest among the developing regions, energy access remains a challenge for the LAC region: an estimated 24 million people, primarily in rural and remote areas, still lack access to electricity. Some countries have achieved virtually 100% electrification, while others have far to go. Renewables can play an important role in achieving universal access to modern energy. Solar energy is abundant across the region, which is also home to nearly one-quarter of the world's geothermal potential, and wind resources are world class in Argentina, Brazil, and Mexico. By one estimate, non-hydro renewable energy has the technical potential to meet more than 50 times the region's current electricity demand.

While the region's hydropower sector is relatively mature, the vast potential of non-hydro renewables is now beginning to be realised. Wind power has experienced the fastest growth in recent years, with Brazil and Mexico leading the way. With about 1 gigawatt (GW) of geothermal capacity, Mexico is the world's fifth-largest geothermal power producer, followed in the LAC region by Central America, with a collective 500 MW of capacity. The solar PV market, while increasingly important in off-grid and rural areas, has experienced a shift in focus from small domestic applications to large-scale power plants.

In the heating sector, renewable energy applications for domestic, commercial, and industrial use are gaining ground. Solar thermal collectors for water heating are spreading beyond Brazil, one of the world's top markets. Chile's mining industry is actively installing solar thermal systems (parabolic trough and flat-plate collectors) to meet its heat energy needs in remote locations. Solar food dryers are used for processing fruits and coffee in Jamaica, Peru, and Mexico.

Over 80% of the LAC population lives in cities, and the region is urbanising at a rapid pace, with increasing demand for transportation. To meet this demand while slowing the growth of fossil fuel consumption, several countries are promoting the use of biofuels. Biofuels account for 13% of transport fuel in Brazil, and their role is growing in several other countries. Brazil, Argentina, and Colombia lead the region for biofuel production.

Several countries have adopted feed-in tariffs, public competitive bidding (tendering), tax incentives, and quotas to drive deployment. The use of public competitive bidding has gained momentum in recent years, with Brazil, El Salvador, Peru, and Uruguay issuing tenders in 2013 for more than 6.6 GW of renewable electric capacity. Eight countries had net metering laws by year's end, with pilot projects operating in Costa Rica and Barbados.

An improved environment for renewables is attracting new national and international investors. Although Brazil experienced a decline in new investment in 2013 for the second year running, others in the region saw significant increases, with Chile, Mexico, and Uruguay committing over USD 1 billion each.

Manufacturers are seeking growth opportunities in the region. While the larger economies–Brazil, Argentina, Chile, and Mexico–are the front-runners, manufacturing of renewable energy technologies, such as wind turbines, is spreading across the region.

Differences in electricity market structures and regulations have constrained efforts to integrate electricity markets regionally to date, and lack of transmission infrastructure has delayed the development of some projects. Lack of awareness about renewable heat technologies and their potential is impeding their expansion. In addition, the relatively low level of energy demand in some countries—such as the Caribbean nations—makes it difficult to support local industry and can preclude the potential to benefit from economies of scale. Despite a number of near-term challenges, the region is demonstrating unprecedented growth and presents significant opportunities for expansion.

The "Regional Spotlight" sidebar appeared for the first time in GSR 2013 and is now a regular feature of the report, focussing on developments and trends in a different world region each year.

Source: See Endnote 20 for this section.

energy in individual sectors or economy-wide, and many have already achieved their targets.[21]

As markets have become more global, industries have responded by increasing their flexibility and developing global strategies and supply chains.[22] In 2013, manufacturers continued to diversify products to increase product value, and many advanced further into project development and ownership. Many renewable industries saw a rapid increase in worldwide demand for construction and engineering, consulting, equipment maintenance, and operations services.[23] Several industries had a difficult year, with consolidation continuing, particularly in solar energy and wind power. But the picture brightened by year's end, with many solar PV and wind turbine manufacturers returning to profitability.[24]

Global investment in renewables declined again in 2013, largely due to falling system costs and policy uncertainty.[25] Still, renewables outpaced fossil fuels for the fourth year running in terms of net investment in power capacity additions.[26] Further, 2013 was a watershed year for renewable energy financing, with the development and enactment of new financing structures that provide access to low-cost money through capital markets.[27](See Investment Flows section.) Projects (particularly wind and solar PV) changed hands at record rates during the year, reflecting in part a growing interest in renewable energy asset investments among pension funds and other institutional investors that anticipate solid long-term returns.[28] Innovative financing mechanisms, such as crowd funding and risk-guarantee schemes, continued to expand and spread across China, Europe, and the United States, and are increasingly targeting off-grid projects in Africa and Asia.[29] A range of actors continued to actively engage in the financing of distributed renewable energy projects for isolated regions of the developing world.[30]

The impacts of all of these developments on employment numbers in the renewable energy sector have varied by country and technology, but, globally, the number of people working in renewable industries has continued to rise. (See Sidebar 6, page 60, and Table 1, page 63.)

POWER SECTOR

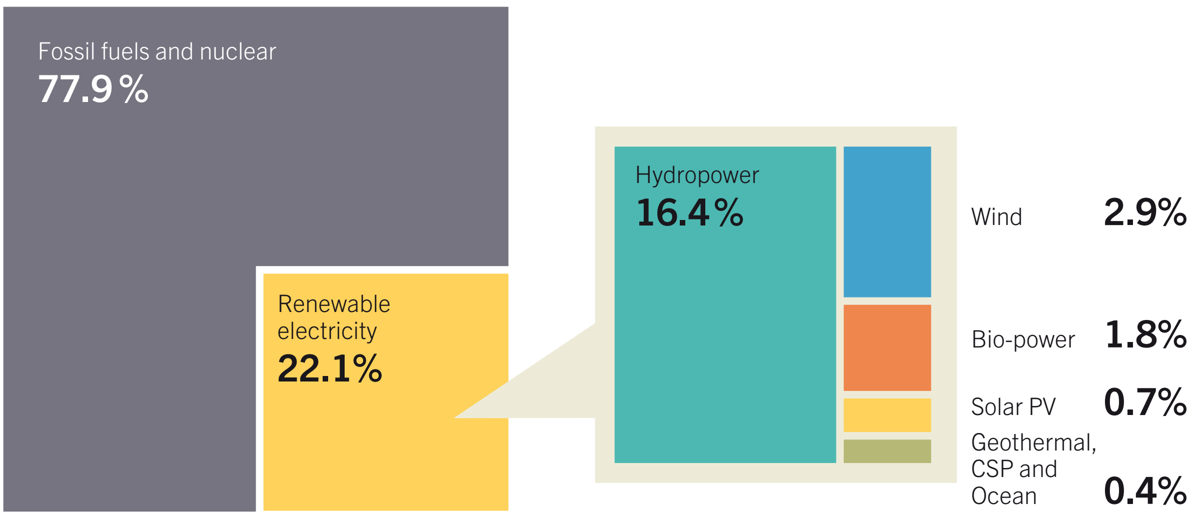
The most significant growth occurred in the power sector, with global capacity exceeding 1,560 GW in 2013, an increase of more than 8% over 2012.[31] Hydropower rose by 4% to approximately 1,000 GW[i], while other renewables collectively grew nearly 17% to an estimated 560 GW.[32] Globally, hydropower and solar PV each accounted for about one-third of renewable power capacity added in 2013, followed closely by wind power (29%).[33]For the first time, more solar PV than wind power capacity was added worldwide.[34] (See Reference Table R1.)

Around the world, policy support and investment in renewable energy have continued to focus primarily on the electricity sector. Consequently, renewables have accounted for a growing share of electric generation capacity added globally each year.[35] In 2013, renewables made up more than 56% of net additions to global power capacity and represented far higher shares of capacity added in several countries around the world.[36] In the EU, renewables accounted for the majority of new capacity for the sixth year running.[37]

By year's end, renewables comprised an estimated 26.4% of the world's power generating capacity.[38] This was enough to supply an estimated 22.1% of global electricity, with hydropower providing about 16.4%.[39] (See Figure 3.) While renewable capacity continues to rise at a rapid rate from year to year, renewable electricity's share of global generation is increasing more slowly. This is in large part because overall demand keeps rising rapidly, and also because much of the renewable capacity being added is variable.

Even so, variable renewables are achieving high levels of penetration in several countries. For example, throughout 2013, wind power met 33.2% of electricity demand in Denmark and 20.9% in Spain; in Italy, solar PV met 7.8% of total annual electricity demand.[40] Hydropower, which provides the single largest share of renewable electricity worldwide, is being used increasingly to balance systems with high shares of variable renewables, sometimes with the aid of pumped storage.

Figure 3. Estimated Renewable Energy Share of Global Electricity Production, End-2013

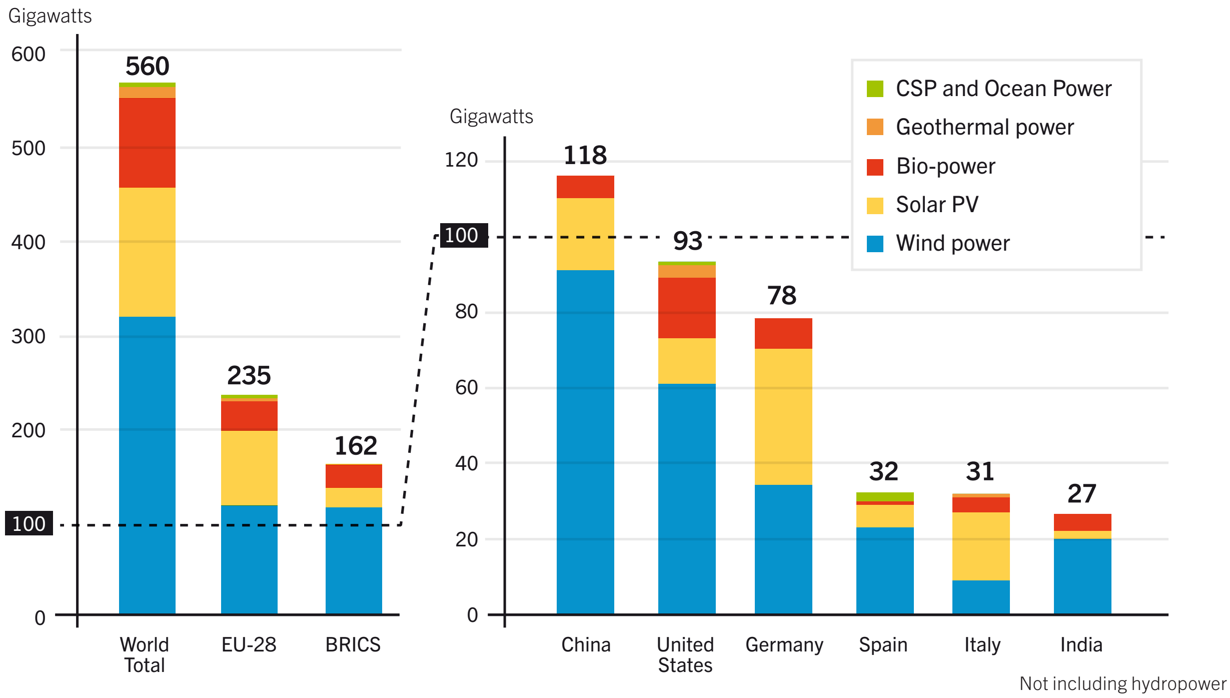


Source: See Endnote 39 for this section.

Based on renewable generating capacity in operation end-2013. Data do not add up due to rounding.

i - The GSR 2013 reported a global total of 990 GW of hydropower capacity at the end of 2012; this figure has been revised downward due to better data availability. This adjustment also affects the global figure for total renewable power capacity. In addition, global hydropower data and thus total renewable energy statistics in this report reflect an effort to remove capacity of pure pumped storage from the totals. For more information, see Methodological Notes, page 142.

Figure 4. Renewable Power Capacities in World, EU-28, BRICS, and Top Six Countries, 2013



Source: See Endnote 49 for this section.

Not including hydropower

(See Hydropower section.) Other non-variable renewables such as geothermal and bio-power can play a similar role and provide significant shares of total electricity in some countries. Geothermal power now accounts for 29% of electricity generation in Iceland, and more than one-fifth in El Salvador and Kenya.[41]

Bio-, geothermal-, and hydropower have long been cost competitive in areas where good resources are available, and this is true for a growing number of technologies in an increasing number of locations.[42] The levelised costs of generation from onshore wind and, particularly, solar PV have fallen sharply over the past five years, while average global costs from coal and natural gas generation have increased due to higher capital costs and feedstock prices.[43] As a result, an increasing number of wind and solar power projects are being built without public financial support, especially in Latin America, but also in Africa, the Middle East, and elsewhere.[44]

In response to these changing economics, distributed renewables are starting to challenge traditional electric utility business models, prompting utilities in some countries to push back and call for reduced policy support for renewable electricity.[45] At the same time, many utilities from Asia to Europe to North America are investing in wind, solar PV, and other renewables, in addition to hydropower.[46] (See Sidebar 7, page 80.)

By the end of 2013, China, the United States, Brazil, Canada, and Germany remained the top countries for total installed renewable electric capacity.[47] China was home to about 24% of the world's renewable power capacity, including an estimated 260 GW of hydropower.[48] The top countries for non-hydro capacity were again China, the United States, and Germany, followed by Spain, Italy, and India.[49] (See Figure 4 and Reference Table R2.)

Among the world's top 20 countries for non-hydro renewable power capacity, those with the highest capacity amounts per inhabitant were all in Europe. Denmark had a clear lead and was followed by Germany, Portugal, Spain, and Sweden.[i] [50] Considering investment in new renewable power (and fuels) relative to annual GDP, top countries included Uruguay, Mauritius, Costa Rica, South Africa, and Nicaragua.[51]

While the BRICS[ii] nations together led for total capacity of all renewables (thanks primarily to China), accounting for approximately 38%, the EU still had the most non-hydro installed capacity of any region at the end of 2013, with about 42% of the global total.[52] However, the EU's share of global renewable power capacity is declining as renewable electricity markets outside of Europe expand. (See Top Five Countries Table on page 16 for other rankings.)

i - While there are other countries with high per capita amounts of renewable capacity and high shares of renewable electricity, the GSR focusses here on the top 20 countries for total installed capacity of non-hydro renewables. (See Reference Table R13 for country shares of electricity from renewable sources.)

ii - The combined economies of Brazil, Russia, India, China, and South Africa.

Highlights for 2013 include:

- China's new renewable power capacity surpassed new fossil and nuclear capacity for the first time.[53] All renewables accounted for more than 20% (> 1,000 TWh) of China's electricity generation.[54]In the European Union, renewable power installations represented 72% of new electric capacity, up from 70% in 2012.[55] This is in stark contrast to a decade earlier, when conventional fossil generation accounted for 80% of new capacity in the EU-27 plus Norway and Switzerland.[56]
- In the United States, the share of renewable generation rose to nearly 12.9% (12.2% in 2012), despite a drop in hydropower output and competition from cheap natural gas from shale.[57] By contrast, the share of net electricity generation from coal declined nearly 19% over the period 2008–2013.[58]
- Spain became the first country to generate more electricity from wind power (20.9% of total) than from any other source for the entire year.[59]

- India added more than 4 GW of renewable capacity for a total of about 70.5 GW.[60] While hydropower represented most of the total (62%), solar PV and wind accounted for almost 70% of 2013 renewable additions.[61] Yet India's power capacity is expanding rapidly, and renewables made up less than 17% of total additions from all sources during 2013.[62]
- Wind power was excluded from one of Brazil's auctions because it was pricing all other generation sources out of the market.[63] By year's end, Brazil had 3.5 MW of commissioned wind power capacity, and more than 10 GW of additional capacity was under contract.[64]
- Even as global investment in solar PV declined nearly 22% relative to 2012, new capacity installations increased by more than 32%.[65]
- By early 2013, at least 18 countries generated more than 10% of their electricity with non-hydro renewable resources, up from an estimated 8 countries in 2010. These included Denmark, El Salvador, Kenya, Lithuania, and Austria.[66]
- Many communities and regions around the world have targeted, or already successfully transitioned to, 100% renewable electricity.[67] Djibouti, Scotland, and the small-island state of Tuvalu, for example, aim to derive 100% of their electricity from renewable sources by 2020.[68]

Around the world, households and businesses are opting increasingly for "green" offerings from traditional utilities and new energy providers, voluntarily buying renewable energy (most commonly electricity) that is produced outside of, or beyond, regulatory requirements. Germany remains one of the world's leaders for voluntary renewable power purchasing. Its market grew from 0.8 million residential customers in 2006 to 4.9 million in 2012, or 12.5% of all private households in the country. In 2011, they purchased 15 terawatt-hours (TWh) of green power, and commercial customers bought a further 10.3 TWh.[i 69] Other major European green power markets include Austria, Belgium (Flanders), Finland, Hungary, the Netherlands, Sweden, Switzerland, and the United Kingdom, although the market share in these countries remains below German levels.[70]

Green power markets also exist in Australia, Canada, Japan, South Africa, and the United States.[71] More than half of U.S. electricity customers have the option to purchase green power directly from their local utility, and 47 of the 50 states (plus the District of Columbia) have utilities and/or competitive electricity suppliers that offer a green power option. In 2012, total U.S. retail green power sales exceeded 48 TWh (about 1.3% of total U.S. electricity sales).[72]

Major industrial and commercial customers in Europe, India, Mexico, and the United States continued to turn to renewables to reduce their energy costs while increasing the reliability of their energy supply. Many set ambitious renewable energy targets in 2013, installed and operated their own renewable power systems, or signed purchase agreements to buy directly from renewable energy project operators, bypassing utilities.[73]

Community-owned and co-operative projects also increased in numbers in Australia, Japan, and Thailand, as well as in North America and several countries in Europe.[74] Denmark has a long history of co-operatively owned projects; in Germany, almost half of renewable power capacity was citizen owned as of 2013, and about 20 million Germans lived in so-called 100% renewable energy regions.[75]

The year saw expanded installations of small-scale, distributed renewable systems for remote locations as well as grid-connected systems where consumers prefer to generate at least a portion of their electricity on-site.[76] Technology advances are enabling the establishment of micro- and mini-grids that rely significantly, if not entirely, on renewable energy. Micro-grids are emerging in developed countries, in particular, where they are generally connected to an overlying central grid.[ii] In developing countries, mini-grids are playing an increasingly important role in providing electricity access to remote communities.[77] (See Sidebar 8 in GSR 2013.)

i - Note that part of this growth is also due to voluntary decisions of suppliers, generally for marketing purposes, to procure renewable electricity for all of their residential customers. Customers of such suppliers account for up to 20% of the voluntary green power market in Germany. (See Endnote 69 for this section.)

ii - A micro-grid is a small-scale power grid, with its own power resources, generation, loads, and definable boundaries that can operate independently of, or in conjunction with, an area's main power grid. It can be intended as back-up power or to bolster main grid power during periods of heavy demand. It is often used to reduce costs, enhance reliability, and/or as a means of incorporating renewable energy.

HEATING AND COOLING SECTOR

Energy use for the provision of useful heat represents about half of total world final energy consumption.[78] Modern renewables (excluding traditional biomass) meet a small but gradually rising share of final global heat demand (about 10%).[79] In some markets, they already contribute substantially. For example, renewables provide over 60% of final energy for heat in Iceland and Sweden.[80] In Brazil, where bio-heat covers a significant portion of industrial heat demand, the renewable share is about 43%.[81] Renewables meet 20% or more of final energy demand for heat in Austria, Denmark, Israel, New Zealand, Norway, and Thailand, and significant shares also in India (11%), Indonesia (7%), and South Africa (6%).[82]

Modern biomass, solar thermal, and geothermal energy provide hot water and space heating for tens of millions of domestic and commercial buildings around the world. These renewables also supply heat for industrial processes, agricultural applications, and cooking, at a range of temperature levels. Modern biomass accounts for the vast majority (about 90%) of renewable heating.[83] Markets for renewable heating and cooling have increased rapidly in recent years, particularly for solar thermal and some bio-energy systems.[84] In addition, passive solar building designs provide a significant amount of space heating (and light), and their numbers continue to increase, but they are not included in this report due to lack of data.

Bio-heat capacity is growing steadily, at an estimated 1–2% annually.[85] During 2013, Central Europe and the United States, in particular, saw a continuing shift towards the use of biomass for heating.[86] For old and larger buildings, bioenergy systems—such as district heat systems in Scandinavia or pellet stoves in Austria—can be more cost competitive than heat pumps. For industrial heating, bioenergy is the primary resource replacing fossil fuels, often in combined heat and power (CHP) generating systems.[87]

Most bio-heat is derived from solid biomass resources, but biogas is becoming an increasingly important heat source.[88] Although Europe remains the leading region for bio-heat consumption, mainly for space heating, demand is rising elsewhere, particularly in China.[89] The use of biogas as a cooking fuel continues to rise in a growing number of developing countries.[90]

Over the five-year period to end-2013, the capacity of solar water heaters increased by an average of 14% annually.[91] Solar thermal collectors are used worldwide for water (and increasingly for space) heating in homes, schools, hospitals, hotels, and government and commercial buildings.[92] Their use is extensive in China, where solar water heaters cost less over their lifetimes than do natural gas or electric heaters.[93] An increasing number of district heat systems rely on solar thermal technology, particularly in Central Europe, and interest in solar process heating and cooling also is growing as technologies mature.[94]

Geothermal energy is used for space heating (including district heat networks), domestic hot water supply, direct and indirect heating of public baths, greenhouses, and process heat for industry and agriculture.[95] Technological advances are making it possible to extract heat from even relatively low-temperature geothermal fields for both power and heat generation.[96]

Air-, ground-, and water-source heat pumps also provide renewable heating and cooling. One of the more significant trends related to heat pumps is a move towards the use of hybrid systems that integrate several energy resources (such as solar thermal or biomass with heat pumps) for the range of heat applications.[97] China's market for hybrid-heat pump products is double the size of Europe's, with both growing rapidly.[98] There is also growing interest in the use of larger-scale heat pumps for district heating as well as industrial processes.[99] (See Sidebar 4, page 42.)

Use of modern renewable energy technologies for heating and cooling is still limited compared with their potential. Market growth in this sector continues to lag behind the power sector, due in part to a limited awareness of the technologies, fragmentation of the market, and a relative lack of policy support.[100] Further, growth of renewable energy for heating is constrained, in many countries, by high upfront investment costs of some technologies and competition from subsidised fossil fuels. However, where a carbon charge exists, heat users tend to seek low-carbon fuels.[101] Consumers in Denmark, Japan, and the United Kingdom can choose "green heat" via voluntary purchasing programmes, but options are relatively limited compared to green power purchasing.[102]

Despite the relative lack of policies globally in support of renewable heat, several national and local governments have enacted supporting policies or set ambitious targets. Denmark banned the use of fossil fuel-fired boilers in new buildings as of 2013 and aims for renewables to provide almost 40% of total heat supply by 2020; in early 2014, the U.K. launched its Renewable Heat Incentive for residential consumers; and across the EU, all new buildings must be near zero-energy (producing as much energy as they consume) by 2019.[103] Beyond Europe, most heat-related targets focus on solar thermal energy, although Thailand has heat targets for bioenergy as well.[104] (See Reference Table R14.)

Trends in the heating and cooling sector include the increasing use of renewables for CHP; the feeding of renewable heating and cooling into district systems, particularly in Europe; hybrid solutions to address the building renovation segment; and the growing use of renewable heat for industrial purposes, from Chile to India to the United Arab Emirates.[105] At least 20 countries in Europe use renewables in their district heat systems, with at least 20% of EU-wide district heat generated by renewable sources.[106] Heat storage systems for low-temperature applications such as district heating have been demonstrated and are now available in some European markets.[107]

A limited number of countries has begun using district heat systems to absorb heat generated by renewable electricity during periods of excess supply. An example is the use of surplus wind power to heat water, either with heat pumps or directly using resistance heaters.[108] Denmark is increasing the reliability of its energy supply by combining variable renewable electricity with CHP and district heating, and has made this practice a cornerstone of its energy policy.[109] In 2013, China called on high-wind provinces to begin pilot testing of wind-to-heat technologies to ease the strain on local grids and reduce local air pollution.[110] There is also a general movement globally towards electrification in the heat sector.[111]

TRANSPORT SECTOR

Renewable energy is currently used in the transport sector in the form of liquid and gaseous biofuels—mainly for light- and heavy-duty road vehicles—and in the form of electricity for trains, light rails, trams, and both two- and four-wheeled electric vehicles (EVs).

Liquid biofuels—primarily ethanol and biodiesel (including FAME and HVO [i])—account for the largest share of transport fuels derived from renewable energy sources. They meet about 3% of total road-transport fuel demand, and around 2.3% of final liquid fuel demand (and a very small but growing portion of aviation fuels).[112] In some countries in Europe, as well as in Brazil and the United States, they represent considerably higher shares.[113]

The growth of liquid biofuels has been mixed in recent years. Global biofuel production increased again in 2013, after a temporary lull.[114] Concerns about using only environmentally and socially sustainable supplies are constraining the rate of growth in some regions. (See Bioenergy section.)

Limited but growing quantities of gaseous biofuels (mainly biomethane, which is purified biogas) are fuelling cars, buses, and other vehicles in several EU countries (most notably Germany and Sweden), and in some communities in China, North America, and elsewhere.[115] By late 2013, there were almost 700 vehicle filling stations in Europe offering compressed biogas (CBG) blended with natural gas, and nearly 300 stations selling 100% CBG.[116] Plans are under way in other regions, including the Middle East and Asia, to develop facilities for biomethane production and vehicle fuelling.[117]

Electricity is already commonly used to power trains, city transit systems, and an increasing number of electric vehicles including cars, buses, cycles, scooters, and motor bikes.[118] A growing number of initiatives aim to link these transport systems with renewable electricity. Several German cities—including Frankfurt and Nuremberg—rely on renewable electricity to operate their light-rail and subway services, while the German state of Saarland was the first to switch its local rail services to 100% renewable electricity.[119] Bogota, Colombia, rolled out South America's largest all-electric taxi fleet in 2013 and announced plans for a police fleet of 100 electric motorcycles.[120]

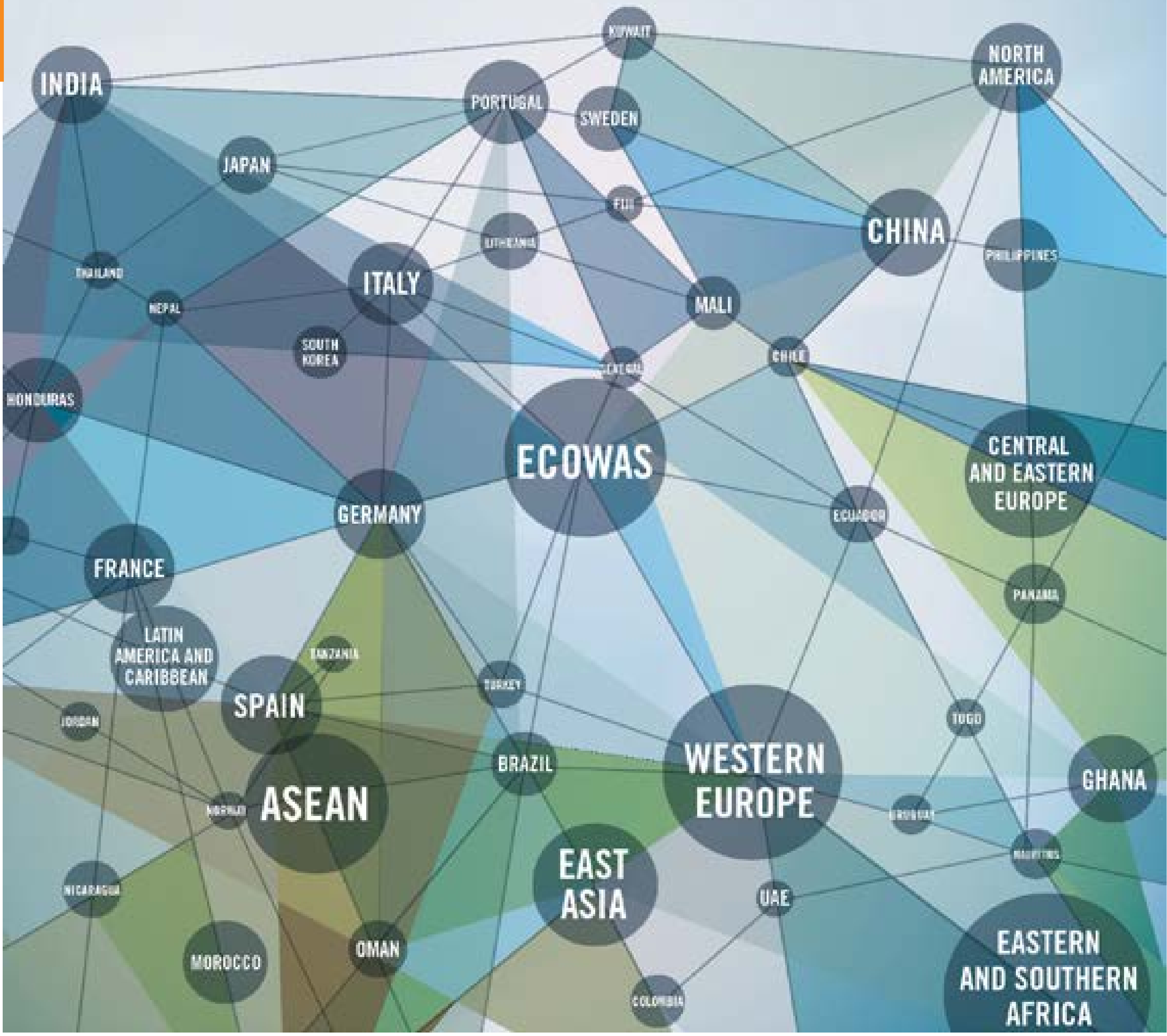
Although electric vehicles and plug-in hybrids (PHEVs) still represent a tiny share of overall automobile markets, they are making a strong entry in several countries, such as Norway, where as of early 2014, more EVs than conventional vehicles were sold each month.[121] In the United States, more than 8,000 electric charging stations were operating by the end of 2013.[122] Many towns with 100% renewable energy goals have adopted EVs as part of their energy plans.[123] Sweden aims for a fossil fuel-free vehicle fleet by 2030, with road vehicles powered primarily by biofuels or electricity, and the promotion of walking, cycling, and public transport as a further step towards Sweden's vision for an energy supply system with zero net atmospheric greenhouse gas emissions by 2050.[124] In addition, hybrid transportation options also are emerging, such as electric-diesel and biodiesel-natural gas buses.[125]

Many of these developments, along with rapid advances in related technologies, are increasing the role of electricity in the transport sector and raising the possibility to use vehicle batteries to store power in support of variable renewables in future "smart-grids."[126]

i - Fatty acid methyl ester (FAME) and hydro-treated vegetable oil (HVO). See Glossary for more information.

REN21 draws on an **international network** of over 500 renewable energy experts, who participate collaboratively in the production of the GSR.

02



02 MARKET AND INDUSTRY TRENDS

BIOMASS ENERGY

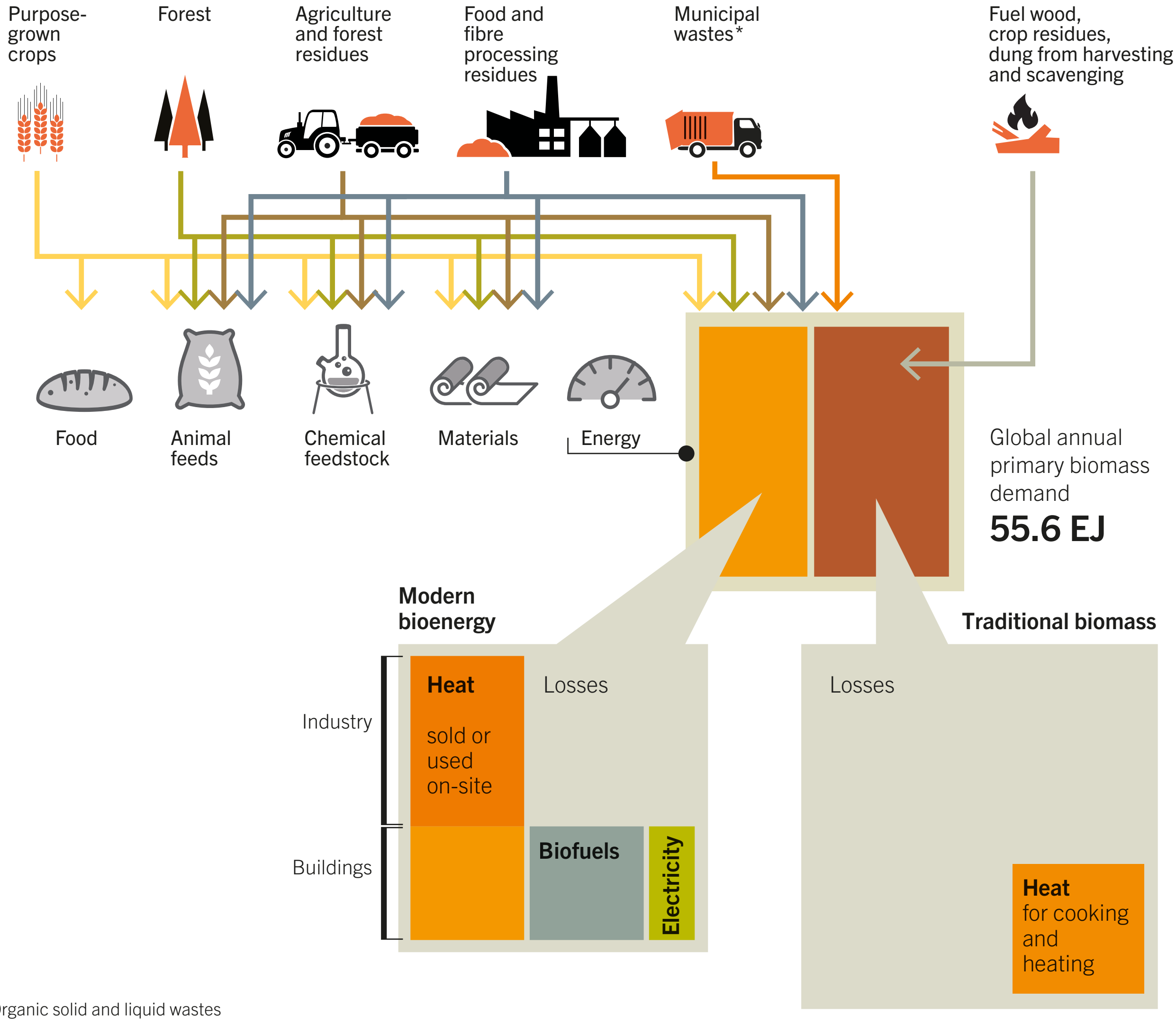
Biomass consumption continues to increase worldwide for the provision of heat and electricity. The production of liquid and gaseous biofuels for transport and stationary applications is also rising. Approximately 60% of total biomass used for energy purposes is traditional biomass: fuel wood (some converted to charcoal), crop residues, and animal dung that are gathered by hand and usually combusted in open fires or inefficient stoves for cooking, heat for dwellings, and some lighting.[1] (See Section 5 on Distributed Renewable Energy in Developing Countries.) The remaining biomass is used for modern bioenergy, which is the focus of this section.[2]

Sustainability and livelihood concerns associated with the use of biomass continue to be debated, especially where linked with deforestation, and where land and water used for energy crop production competes with food and fibre crops.[3] In addition, there is uncertainty about the use of biomass being truly "carbon neutral" within the relevant time frame due to the time lag between carbon release during combustion and carbon (re-) sequestration via re-growth of the harvested crops.[4] (See Sidebar 3.)

For modern bioenergy, the many forms of energy carriers produced from a variety of biomass resources—including organic wastes, purpose-grown energy crops, and algae—can provide a range of useful energy services such as lighting, communication, heating, cooling, and mobility.[i] The ability of the solid, liquid, or gaseous biomass resource to act as a store of chemical energy for future use can be employed to balance variable electricity generation from wind and solar systems when integrated into mini-grids or an existing main grid.[5]

The bioenergy sector is highly complex due to the variety of potential feedstocks and technical routes for converting biomass to energy. Large data gaps often exist in the

Figure 5. Biomass Resources and Energy Pathways



Source: See Endnote 6 for this section.

* Organic solid and liquid wastes

i - See Figure 5 in GSR 2013.

SIDEBAR 3. BIOENERGY CARBON ACCOUNTING

There is a continuing debate around the sustainability of biomass use for energy, particularly with respect to the carbon footprint. Many research and policy endeavours in recent years have focussed on quantifying the greenhouse gas emissions associated with direct and indirect land-use change. To date, the focus has been almost exclusively on liquid biofuel production systems. However, the increasing use of solid biomass—forest biomass in particular—in modern applications (for example, wood chips in residential heating or district heating plants, or co-firing of wood pellets in coal-fired power plants) has recently shifted the focus of the carbon footprint debate.

There appears to be general agreement among stakeholders that carbon emitted through the combustion of biomass for energy production was and will again be sequestered from the atmosphere, if the quantity of biomass used can be associated with the regrowth of a crop or forest in a sustainable (biomass) management system. However, there is concern about the time lag between carbon release via combustion and carbon (re-) sequestration via plant growth. A temporal carbon imbalance is relevant particularly for forest biomass systems that have relatively long rotation cycles, and generally for bioenergy's potential to effectively reduce greenhouse gas emissions in the medium-to-long term. Therefore, consensus is emerging to account for biogenic carbon emissions over time, although the principles to do so and the respective expectations vary considerably.

To date, much of the scientific work has focussed on determining the "carbon payback" period—the time frame by when a bioenergy system has reached its pre-harvest biogenic carbon levels and is also compensated for associated land-use and fossil fuel emissions. Results differ depending on the modelling framework and assumptions regarding affected ecosystems, conversion technologies, and behavioural economics. Generally, the use of residues from tree harvesting (tops, branches, and thinning of small trees) or wood processing (shavings, offcuts, sawdust) entails shorter carbon payback periods than the use of large-diameter stemwood, especially from slow-growing forests or low-productive regions. The use of smaller-diameter, pulpwood quality logs from fast-growing plantation forests in highly productive regions, however, can achieve relatively short carbon payback periods.

In addition, there is disagreement around what duration of carbon payback is acceptable. The two most commonly used time frames in the literature are 2050, which is relevant for policy trajectories, and 2100, which is considered relevant for stabilisation of the atmospheric carbon levels. Timeline selection influences which bioenergy systems—for example, type of feedstock, scale of magnitude, technology choices—should be considered.

Another key determining factor for a given bioenergy project is linked to alternative land-use and energy sources: that is, what would happen on the land and what energy source would be employed without the use of biomass? Answers depend on regional circumstances that vary with market conditions for wood products, forest management practices, and alternative energy systems; and perspectives on these conditions may differ among stakeholders.

Policy options to deal with biogenic carbon emissions include mechanisms that quantify associated emissions, such as the integration of forest carbon accounting in a full life-cycle assessment (LCA), although there is not a scientific consensus on how to model forest products appropriately. Preventative policy approaches include requirements for sustainable forest management that guarantee replanting and sustained carbon stocks/yields, as well as actively encouraging/discouraging the use of specific land and biomass types, such as peat soils, whose drainage releases large amounts of greenhouse gases. Conversely, promoting afforestation and reforestation of woody biomass and perennial grass production on marginal and unused land can create immediate net carbon benefits.[i]

Current policy options in Europe and North America entail all of these approaches. In 2013, for example, the U.K. government provided a draft greenhouse gas calculator (including default values) to quantify the respective emission reductions of forest biomass use for energy as part of its Renewable Obligation Scheme. Also the Dutch government announced the investigation of a specific carbon debt criterion in 2014.

i - A policy option would, for example, include the compensation or generation of carbon credits for tree planting, in proportion to the net CO_2 absorption/sequestration.

Source: See Endnote 4 for this section.

assessment of biomass volumes used for energy carriers and final energy. Further, biomass often relies on widely dispersed, non-commercial sources, which makes it difficult to formally track data and trends. National data collection is often carried out by multiple institutions that are not always well co-ordinated. As a result, production and demand for biomass and bioenergy are relatively difficult to measure, even at the local level; hence, national, regional, and global data are uncertain.[6] (See Sidebar 1, page 23, and Figure 5, page 31; see also Sidebar 2 in GSR 2012.)

BIOENERGY MARKETS

In 2013, biomass accounted for about 10% of global primary energy supply—or an estimated 56.6 EJ.[7] The "modern biomass" share included approximately 13 EJ to supply heat in the building and industry sectors; an estimated 5 EJ converted to produce around 116 billion litres of biofuels (assuming 60% conversion efficiency of the original biomass), and a similar amount used to generate an estimated 405 TWh of electricity (assuming 30% conversion efficiency).[8] Useful heat is also often generated in bioenergy combined heat and power (CHP) plants, but the total quantities are unknown because much of this is consumed on-site and not tracked.

The leading markets for biomass energy are diverse and vary depending on the fuel type. Use of modern biomass is spreading rapidly, particularly across Asia.[9] Biomass is meeting a growing share of energy demand in many countries and accounts for a significant portion of total energy in some countries. For example, end-use shares exceed 25% in Sweden, Finland, Latvia, and Estonia.[10]

Most primary biomass used for energy is in a solid form and includes charcoal, fuel wood, crop residues (predominantly for traditional heating and cooking), organic municipal solid waste (MSW)[i], wood pellets, and wood chips (predominantly in modern and/or larger-scale facilities). Wood pellets and wood chips, as well as biodiesel and ethanol, all are now commonly traded internationally in large volumes; in addition, some biomethane is traded in Europe through gas grids.[11] There is also significant informal trade in solid biomass that takes place regionally and across national borders.[12]

The total energy content of all solid biomass fuels traded (mainly pellets and wood chips) remains about twice that contained in the net trade of liquid biofuels.[13] Wood pellets account for only around 1–2% of global solid biomass demand, yet the volume of consumption continued to increase rapidly during 2013.[14]

Bio-heat Markets

Solid, liquid, and gaseous biomass fuels can be combusted to provide higher-temperature heat (200–400 °C) that is used by industry, district heating schemes, and agricultural processes, as well as lower-temperature heat (<100 °C) that is used for drying, heating water for domestic or industrial use, and heating space in individual buildings. Approximately 3 GW_{th} of new biomass heat capacity was commissioned in 2013, bringing the global total capacity to an estimated 296 GW_{th}.[15] Biomass is the most widely used renewable source for heating by far, accounting for approximately 90% of heat from modern renewables; solid biomass is the primary fuel source.[16]

Europe remained the world's largest consumer of modern bio-heat in 2013. The region's use of solid biomass for heat was up 5.4% in 2012 (the latest year for which data are available).[17] In 2013, Germany generated almost 116.6 TWh (424 PJ) of heat from biomass, up from 112.6 TWh (405 PJ) in 2012; 88% of this was from solid biomass.[18] In Sweden, bioenergy (mostly from woody biomass) accounted for more than half of all space heating in the housing and commercial sectors, either through direct use in boilers or indirectly through heat plants and district heating.[19] Wood was also the leading fuel for the district heat system during 2013 in Finland.[20] A large portion of Europe's bio-heat is produced for district heating networks, and sales into heat networks increased 12.9% in 2012.[21]

Use of biomass in small appliances has risen as well. By 2013, Europe's total stock of small-scale biomass boilers was about 8 million appliances, with annual sales of around 300,000 units. In addition to other modern appliance designs, around 1.85 million wood-burning stoves, cookers and fireplaces are sold annually, with a total of some 55 million in operation.[22]

The EU is the largest regional consumer of wood pellets, burning over 15 million tonnes in 2013 (up 1 million tonnes annually since 2010), with the largest share of demand coming from the residential heat market.[23] The use of biomass, including pellets, for heat production is increasing in North America as well.[24] In the United States, the largest domestic market for the consumption of wood pellets for heating is located in the northeast.[25]

Biogas also is being used increasingly for heat production. In developed countries, it is used primarily in CHP plants, with relatively small amounts used in heat-only plants. In 2012, most of the biogas produced in Europe was used on-site or traded locally. Most was combusted to produce 110 TJ of heat and 44.5 GWh of electricity.[26] The small remainder used by the transport sector was first upgraded to biomethane[ii], with limited volumes now being traded among EU member states by injection into the natural gas grid. Considerable effort is under way to remove trade barriers in order to expand this potential.[27]

A number of large-scale plants that run on biogas are also operating across Asia and Africa, including many for industrial process heat.[28] Biogas is also produced in small, domestic-scale digesters, mainly in developing countries—including China, India, Nepal, and Rwanda—and is combusted directly to provide heat for cooking.

Bio-power Markets

An estimated 5 GW of bio-power capacity was added for a total of 88 GW in operation at the end of 2013. Bio-power generated around 405 TWh of the world's electricity in 2013, assuming an average capacity factor of over 50%.[30] The United States is the top producer of electricity from biomass, followed by Germany, China, and Brazil. Other top countries for bio-power include India, the United Kingdom, Italy, and Sweden.[31]

The United States added nearly 0.8 GW of bio-power capacity in 2013 for a total exceeding 15.8 GW at year's end.[32] Net U.S. bio-power generation increased 3.9% compared with 2012, to 60 TWh.[33] Solid biomass provided two-thirds of the total fuel, and the remainder came from landfill gas (16%), organic MSW (12%), and other wastes (6%).[34]

To the south, Brazil increased its bio-power capacity more than 10%, from 10.8 GW to 11.4 GW. Electricity generated from sugarcane bagasse accounted for nearly 7% of national electricity production, up from 6.7% in 2012, and the black liquor share rose to over 1.1% (from just under 1%).[35]

In the EU, capacity additions during the year brought the region's total to about 34.5 GW.[36] Bio-power accounted for 5% of the region's new power capacity from all sources.[37] Electricity generated from biomass increased 7.9% relative to 2012, to 79 TWh.[38]

Germany's bio-power capacity increased by more than 0.5 GW, to just over 8 GW by year's end.[39] Bio-power generation was up about 7% to 48 TWh, and it accounted for 8% of Germany's total electricity generation in 2013.[40] Sweden continued to generate around 10% of total electricity from bio-power, with most of it coming from solid biomass.[41]

i - Municipal solid waste includes inorganic (e.g., plastics) as well as organic components, of which only the latter are renewable. Only the organic component is quoted in this report where possible, although data sources do not always separate out the share of "green" MSW from the remainder.

ii - Biomethane is produced from biogas after removal of carbon dioxide and hydrogen sulphide. It can be injected into the natural gas pipeline and is also used as a vehicle fuel.

Most wood pellets that are traded globally are used for electricity generation. In the EU, residential heating accounts for the largest share of pellet demand, but there is a large and growing demand for imported wood pellets to produce electricity.[42] To meet this growing demand, the EU imported around 6.4 million tonnes in 2013. About 75% of total imports were from North America (an increase of 55% over 2012), and much of the remainder came from Russia and Eastern Europe.[43] (See Reference Table R3.)

Use of biogas for power generation also is rising rapidly in Europe. By the end of 2012, more than 13,800 biogas power plants (up roughly 1,400 over the year), with a total installed capacity of 7.5 GW, were in operation.[44] Germany has seen rapid growth, particularly during 2009–2011, and still dominates the market.[45] However, while capacity expansion has continued since then, Germany's rate of annual increase has slowed in response to changes in the renewable energy law.[46] Sweden also has growing bio-power shares from gaseous fuels.[47]

In China, bio-power capacity rose very rapidly for several years, but growth has slowed recently due to limited availability of suitable biomass.[48] By the end of 2013, bio-power capacity reached 6.2 GW (excluding 2.3 GW of waste-to-energy combustion). Most of this was direct combustion of agricultural and forestry biomass, including 1.7 GW of bagasse, 1.2 GW from gasification of sludge and biomass, 0.3 GW of large-scale biogas, and other sources.[49]

India was also one of the top markets in 2013, adding about 0.4 GW of bio-power capacity in 2013, mostly by bagasse-based CHP plants, to reach a total of over 4.4 GW by year's end.[50] However, India's capacity additions were around 40% below those in 2012, and around 10% below the national target.[51]

Elsewhere in Asia, Japan added 0.1 GW under the new feed-in tariff, for an estimated 3.4 GW at the end of 2013.[52] In Thailand, electricity from biomass, including biogas, has increased rapidly over the past decade, and growth is set to continue with new capacity under construction.[53] In 2013, a contract was signed for construction of a 9.5 MW facility in Samut Sakhon that will run on coconut wastes (husks, shells, fronds, and leaves), and the electricity will feed into the public grid under the attractive biomass FIT.[54]

Demand for bio-power is also driven by the renovation of old and idled coal-fired power plants and their conversion to 100% biomass. Expansion is occurring in the United States and elsewhere.[55] However, concerns about the revised regulatory and policy framework in the United Kingdom led E.ON to halt its plans to convert an existing coal plant to bioenergy.[56]

Conversion of fossil fuel power plants to enable co-firing with varying shares of solid biomass or biogas/landfill gas is also increasing demand. By 2013, about 230 existing commercial coal- and natural gas-fired power and CHP plants had been converted, mainly in Europe and the United States but also in Asia, Australia, and elsewhere.[57] In Japan, Sumitomo Osaka Cement, Nippon Paper Industries, and Idemitsu Kosan took advantage of the national FIT for bio-power to reduce their dependence on coal by part-substituting wood chips and other biomass feedstocks.[58] Further developments have been constrained, however, with increasing awareness of practical handling and operating limitations, such as reduced power output with higher biomass shares.[59]

Transport Biofuel Markets

Global biofuel consumption and production increased 7% in 2013, to a total of 116.6 billion litres, following a slight decline in 2012.[60] (See Figure 6). World fuel ethanol volumes were up around 5% to 87.2 billion litres, and biodiesel production was up over 11% to 26.3 billion litres[i]. Hydrotreated vegetable oil (HVO) continued to increase, but from a low base.

North America remained the top region for the production and consumption of ethanol, followed by Latin America. Once again, Europe produced and consumed the largest share of biodiesel. In Asia, production of both ethanol and biodiesel continued to increase rapidly.[61] Thailand, for example, continued its rapid expansion of biofuels production (both ethanol and biodiesel), which rose by around 30% in 2013 (after a 28% increase in 2012).[62] Its growth is due primarily to the Renewable Energy Development Plan.[63] (See Reference Table R4.)

Global ethanol production was dominated by the United States and Brazil, which retained their top spots and accounted for 87% of the global total.[64] U.S. ethanol production in 2013, at around 50 billion litres, was similar to 2012 production, and almost all of this was made from corn feedstock.[65] Ethanol displaced about 10% of U.S. gasoline transport demand during the year.[66] In addition, nearly 2.4 billion litres (630 million gallons) was exported, primarily to Canada (54%) and the Philippines (9%); the United Arab Emirates, Brazil, Mexico, and Peru were also leading markets for U.S. ethanol.[67] There was also significant demand for the co-products of ethanol production, including corn oil and livestock feed.[68]

Brazil increased its sugarcane ethanol production by 18% (up 4.2 billion litres) in 2013, to reach around 25.5 billion litres.[69] Elsewhere in Latin America, Argentina nearly doubled its ethanol production to almost 0.5 million litres, with the opening of a large corn ethanol plant. The expansion was driven by Argentina's 5% ethanol fuel blend mandate.[70] Other significant producers of ethanol included China (2 billion litres) and Canada (1.8 billion litres).[71]

The EU has been the largest regional biodiesel producer for years and, in 2013, it accounted for 10.5 billion litres of fatty acid methyl ester (FAME) production plus 1.8 billion litres of HVO.[72] However, its share of the global total (about 42%) has remained static in recent years.[73]

By contrast, U.S. production of both biodiesel FAME and HVO has risen rapidly over the past few years and accounted for 17% of the global total in 2013 (up from 14.5% in 2012).[74] Production was up by one-third over the year to approximately 5.1 billion litres, making the United States again the largest national producer.[75] U.S. output exceeded the Environmental Protection Agency (EPA) target under the federal renewable fuels standard (RFS), which called for inclusion of 4.8 billion litres (1.28 billion gallons) in diesel fuel markets in 2013.[76]

i - Biodiesel is FAME (fatty acid methyl esters), with data for HVO (hydrotreated vegetable oil, also known as "renewable diesel") shown separately. HVO is a "drop-in" biofuel produced from waste oils, fats, and vegetable oils and has different markets than FAME biodiesel, including potential as aviation fuel. HVO blends more easily with diesel and jet fuel than does FAME, has a lower processing cost, is compatible with existing diesel infrastructure, reduces nitrous oxide emissions, and has greater feedstock flexibility.

The United States was followed by Germany and Brazil, which both increased their biodiesel production by around 16% and 5%, respectively, to 3.1 billion litres and 2.9 billion litres. Argentina was the fourth largest producer, at 2.3 billion litres.[77] However, Argentina's production declined almost 10% relative to 2012 as a result of anti-dumping duties placed by the European Commission on imports of U.S. and Argentine biodiesel.[78]

Demand for biodiesel in China is driven in part by tax and trade incentives. China supplemented its small annual domestic production of under 0.2 billion litres of biodiesel with about 1.9 billion litres of imported fuel.[79] These imports took significant market share away from the state's oil refiners; in response, they boosted exports of petroleum diesel, which led China to levy a consumption tax on imported biodiesel as of 1 January 2014.[80]

Certification and sustainability requirements have affected international biodiesel trade. To take advantage of lower import duties and feedstock flexibility, for example, EU biodiesel producers have shifted the focus of their imports from biodiesel to vegetable oils, used cooking oils, and animal fats.[81] In 2013, the Netherlands saw a strong increase in the import of palm oil and other certified vegetable oils, much of which was processed into HVO at facilities located at Dutch sea ports and then redistributed to other parts of Europe.[82] Globally, the production of HVO increased around 16% in 2013, with most production in Europe (1.8 billion litres), Singapore (0.9 billion litres), and the United States (0.3 billion litres).[83]

Despite the increase in global production of biofuels, several markets faced challenges in 2013. These challenges included sustainability concerns, a reduction in transport fuel demand due to increased vehicle efficiency, and a growing interest in vehicles that run on electricity and compressed natural gas.[84] As a result, markets were static in several countries.[85] In Australia, for example, biofuels maintained a 0.6% share of the transport fuel mix in 2013, and the fuels have been slow to gain greater acceptance, in spite of the recently extended government grant programmes to encourage production, and a biofuels mandate in New South Wales.[86]

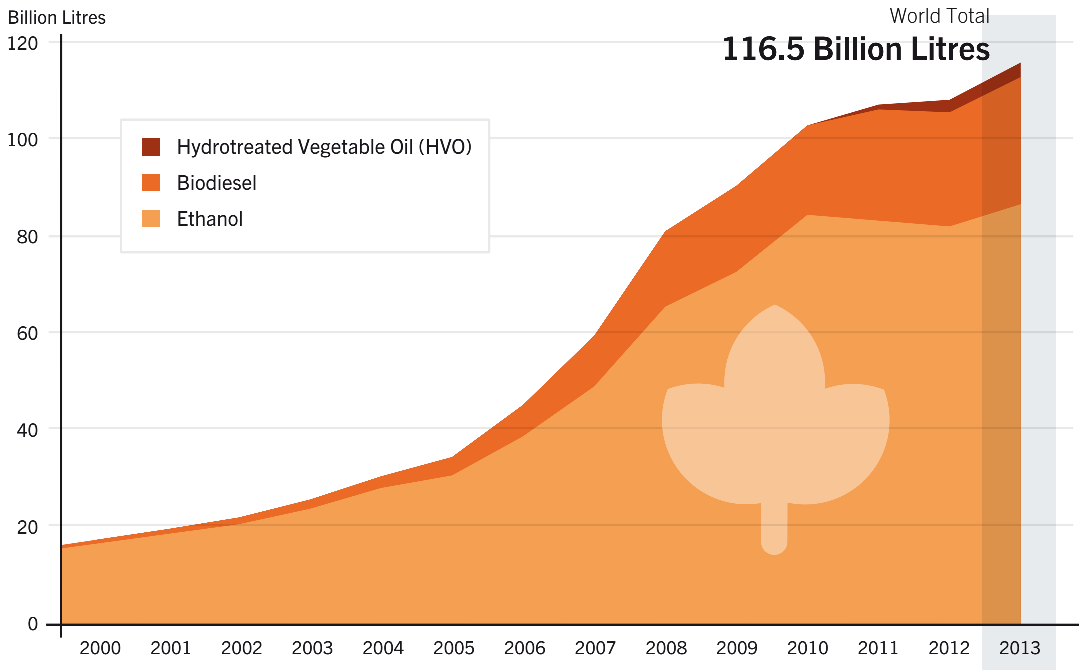
The use of biomethane as a transport fuel is increasing as well. In Sweden, for example, bus fleets in more than a dozen cities rely entirely on biomethane, local plants produce more than 60% of the total biomethane used in Swedish natural gas vehicles, and more filling stations opened in late 2012 and 2013.[87] In Norway, the company Cambi AS liquefies biomethane to provide fuel for a local bus fleet.[88]

BIOENERGY INDUSTRY

The bioenergy industry includes feedstock suppliers and processors; firms that deliver biomass to end-users; manufacturers and distributors of specialist biomass harvesting, handling, and storage equipment; and manufacturers of appliances and hardware components designed to convert biomass to useful energy carriers and energy services. Some parts of the supply chain use technologies that are not exclusive to biomass (such as forage crop and tree harvesters, trucks, and steam boilers).

Rising concerns about sustainability, particularly in Europe and the United States, have led governments to define new guidelines and regulations for bioenergy. Industries have responded by adopting a number of initiatives by sector (e.g., for solid biomass in the EU), for power and heat through the Sustainable Biomass Partnership); by feedstock (e.g., the Roundtable for Sustainable Palm Oil); and by fuel (e.g., the Renewable Fuels Association).[89] Many bioenergy companies are participating voluntarily in sustainability certification schemes, using best management practices (as endorsed by the industry) for feedstock supply and processing, and absorbing associated costs into their operations. In several developing countries, the industry is also facing regulations that focus on the protection of biodiversity

Figure 6. Ethanol, Biodiesel, and HVO Global Production, 2000–2013



Source: See Endnote 60 for this section.

and impacts on poverty, land tenure, food security, and social equity.[90] In addition, some corporate social responsibility (CSR) schemes are including social programmes.[91]

The industry has also responded by producing a number of co-products from biomass feedstocks, such as chemicals and animal feeds. This practice, known as "bio-refining," can maximise value and enhance profitability while reducing greenhouse gas emissions. The U.S. "bio-refinery" industry has expanded steadily, and, in 2013, it counted some 211 facilities that were producing a range of co-products with ethanol; another 165 were expanding or under construction.[92] Biorefineries also exist in many other countries and include the newly opened Amyris plant in Brazil, which converts sugarcane plant sugars into a variety of renewable ingredients, including farnesene (used *inter alia* in flavourings) and patchouli (used in fragrances), together with renewable diesel and jet fuel.[93]

Solid Biomass Industry

During 2013, a large number of companies were actively engaged in supplying equipment and bioenergy plants that convert solid biomass—mainly wood chips and pellets—to heat and electricity. Businesses in the United States, Europe, Asia, and elsewhere were busy constructing new biomass heat and power plants.[94]

Particularly in the forest and sugar industries, CHP plants typically are used for providing process heat on site, with surplus electricity sold off-site as a source of revenue. Global waste-to-energy plants together with landfill gas plants provided revenue of around USD 12 billion in 2012, an amount that is projected to increase by around 30% over the next 3–4 years.[95]

Global pellet production reached 23.6 million tonnes in 2013, an increase of nearly 13% over 2012 volumes.[96] (See Figure 7). The EU accounted for nearly half of global production, followed by North America (33%).[97] Companies in Canada and the United States were busy building new pellet production facilities to keep up with European demand; their 2013 shipments were up 50% over 2012 and almost double those of 2011, reaching a value of more than USD 650 million.[98] The production of torrefied pellets remained below 200,000 tonnes per year.[99]

In response to the increase in international trade of solid biomass, several shipping ports have begun to upgrade their handling facilities to remain competitive.[100] For example, the Port of Amsterdam had invested around USD 138 million (EUR 100 million) in biomass handling and storage as of early 2014. The port handled the import of 100,000 tonnes of pellets and wood chips in 2013, and expects the quantity to rise rapidly.[101] Further investment is planned for the construction of dedicated biomass storage capacity, with importers such as Cargill (United States) and CWT Europe (Netherlands) watching developments at several ports before committing their future business.[102] In 2013, Korea Southern Power and other Korean energy and trading companies, including GS, LG, and Samsung, were exploring pellet import opportunities with suppliers from Australia, Canada, Indonesia, Malaysia, the United States, Thailand, Vietnam, and elsewhere.[103]

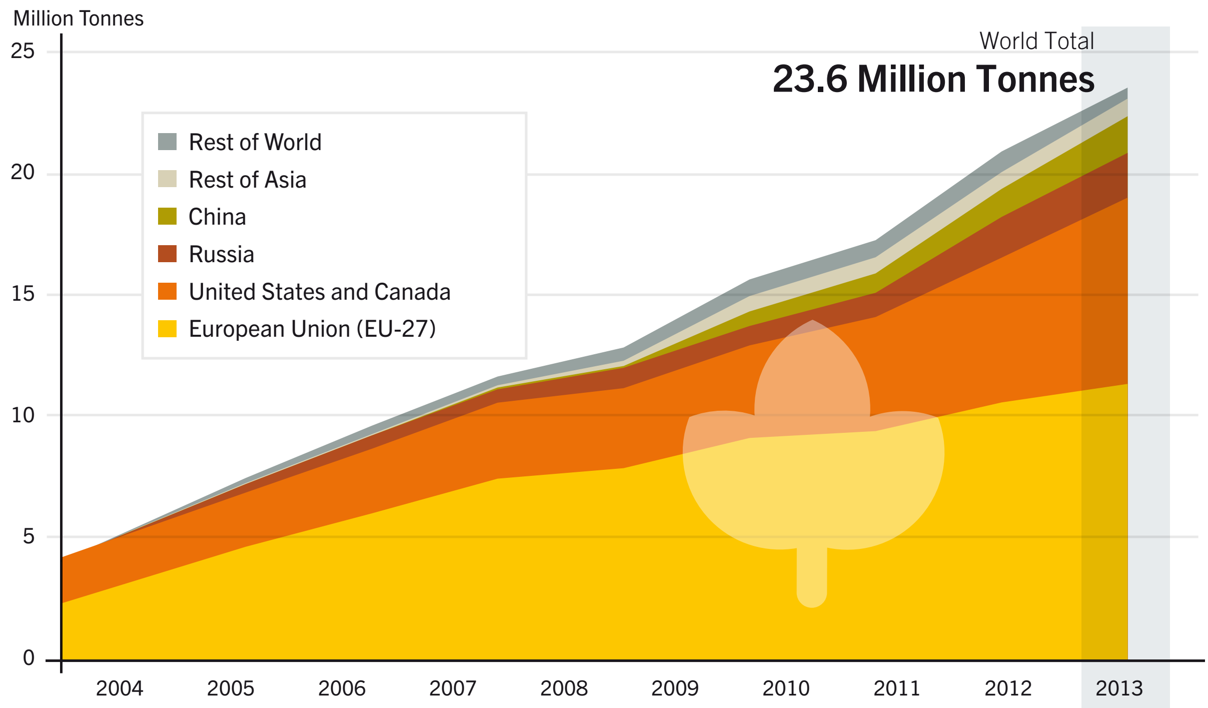
Gaseous Biomass Industry

In 2013, worldwide manufacture and installation of farm and community-scale biogas plants continued for the treatment of wet-waste biomass, including that from wastewater treatment plants. The year also saw a further expansion of efforts to upgrade biogas, sewage gas, and landfill gas to higher-quality biomethane for use as a vehicle fuel or for injection into the natural gas grid. Many food and fibre processing businesses continued to find innovative ways to produce energy from their own waste materials.

Production of biogas is expanding rapidly in a number of countries, although the actual volume of biogas produced is not known.[104] In the United Kingdom, the number of plants producing biogas rose

Figure 7. Wood Pellet Global Production, by Country or Region, 2000–2013

Source: See Endnote 60 for this section.



from 54 in 2011 to 112 in 2012, and, in 2013, the first U.K. plant to inject biomethane into the gas grid entered into operation.[105] A further 200 U.K. sites had received planning consents by early 2014, with growth driven by policies to divert organic waste from landfill sites in order to meet the EU Directive.[106] Elsewhere in Europe, rapid expansion has also been driven by policy changes.[107] For example, Italy alone saw its number of operational biogas plants increase from 521 to 1,264 within a year, driven primarily by a high feed-in tariff and support focussed on small-scale plants.[108] The Czech Republic and Slovakia also have seen significant expansion in the number of plants.[109] In the United States, there were well over 2,200 plants producing biogas.[110]

The industry was busy in other regions as well, including Latin America. Brazil had 24 biogas production plants operating in 2013 with capacity totalling 84 MW, and more were planned.[111] Companies in Chile and Colombia were producing biogas from their agricultural waste streams to generate electricity, some of which is fed into the grid.[112]

Several companies, including consultant SLR (U.K.), are building new landfill gas sites in Africa and other regions. However, the gas potential is often limited by waste composition, and poor control and management, which render the landfill sites unsuitable for gas production.[113]

Thanks to recent technology advancements, companies are able to produce gaseous fuels through the digestion of dry feedstocks, using either a hydrolyser via the Schmack pre-treatment process or a special Bioferm fermentation process.[114] Göteborg Energi (Sweden) completed construction of a 20 MW facility that gasifies forest residues and then converts the synthesis gases—hydrogen and carbon monoxide—into biomethane.[115] This novel approach aims for a 65% conversion efficiency of solid biomass to biomethane that is suitable for grid injection. The excess heat is used in a district heating scheme, resulting in 90% overall conversion efficiency.[116]

Liquid Biofuels Industry

Investment in biofuels production capacity continued to decline in 2013, down to USD 4.9 billion from the 2007 peak of USD 29.3 billion.[117] And despite the increase in production and consumption, biofuels met only about 2.3% of total transport fuel demand.[118] Yet several new plants opened in 2013, and the aviation industry demonstrated its continuing interest in the development and use of advanced biofuels.

In 2013, there were 210 fuel ethanol plants in 28 U.S. states, with installed nameplate capacity of more than 56 billion litres (14.9 billion gallons); of this total, 192 plants were in operation, representing production capacity of 53 billion litres. As of early 2014, another seven plants were under construction or expansion.[119] Although the EU continued its anti-subsidy barrier against U.S. corn ethanol for another year, U.S. producers retained strong earnings in 2013, thanks mainly to lower corn prices (in 2012, prices were high due to drought). By early 2014, however, U.S. producers were concerned about the potential reduction to federal blending mandates and the possible future elimination of advanced biofuels incentives.[120]

In Brazil, the ethanol price paid to producers in Brazil rose 15% from January to December 2013, due to the higher oil prices and seasonal variations in sugarcane yields and sugar prices.[121] During the year, Brazil had 367 registered sugarcane ethanol plants in operation, and additional biofuel production facilities were being planned.[122] For example, in late 2013/early 2014, POET (United States) finalised the details of its 50 million litre per year corn ethanol plant that was to be constructed in Mato Grosso do Sul, Brazil.[123] However, the company faced public concern about the expansion of corn ethanol production and the possible impacts on commodity prices and the local environment. The city already had two operating "flex"-ethanol plants (using sugar cane and corn as feedstocks).[124]

In Argentina, Promaíz S.A. began production at its new 130 million litre capacity facility, the country's largest ethanol plant using corn feedstock. The plant, which incorporates a continuous fermentation process, will provide biofuel to help meet Argentina's mandated E5 blend.[125]

The number of biodiesel producers in the United States reached 115 in 2013, with a total capacity of about 8.5 billion litres. Production margins were reduced after the loss of a federal tax credit for U.S. biodiesel blenders in 2011, and the industry continued to struggle in 2013, mainly because the price of soybeans (which constitute around half of the feedstock) did not decline as expected.[126]

In Brazil, in contrast to rise in ethanol prices, the competitive auction price for biodiesel declined by 12.7% compared with 2012. The decrease was due to high soybean production levels and strong global supply of vegetable oils. As a result, 60% of Brazil's biodiesel production capacity remained unused in 2013.[127]

Elsewhere around the world, several new processing plants began operation with feedstocks other than corn and sugar cane. They include Manildra (0.3 billion litres per year), the only fuel ethanol producer in New South Wales, Australia, to receive a government subsidy for producing ethanol from wheat starch. Other feedstocks being used at plants in Australia include red sorghum (United Petroleum) and molasses (at the Wilmar Bioethanol plant).[128] In sub-Saharan Africa, cassava, traditionally grown for beer and flour, is growing in popularity as a biofuel feedstock. For example, Sunbird Bioenergy Africa partnered with China New Energy to establish a USD 24 million cassava-based ethanol plant in Nigeria (110 million litre per year); it is expected to be the first of 10 such plants.[129]

Advanced biofuels using non-food feedstocks became commercially available in 2013. In North America, U.S.-based plants owned by Gevo and KiOR finally produced and sold their first batches into the market.[130] Enerkem commissioned its 38 million litre per year biomethanol plant in Edmonton, Alberta, using MSW as the feedstock.[131] By early 2014, cellulosic biofuel production facilities were under development in 20 U.S. states.[132] In Europe, Novozymes and Beta Renewables opened a new commercial plant in Italy which, as of commissioning in October, was the world's largest advanced biofuels facility. The plant will produce ethanol from wheat straw, rice straw, and *arundo donax* (a high-yielding energy crop that is grown on marginal land).[133] A commercial-scale plant also has been constructed in China.[134]

Advanced biofuel demonstration plant developments in 2013 included the Canadian enzyme and biofuels company Iogen licensing its ligno-cellulosic-to-ethanol technology (piloted for 10 years) to REP (Brazil). REP plans to make 40 million litres of ethanol per year in a new USD 100 million plant.[135] Lanzatech (New Zealand) uses hydrogen-producing microbes to convert the carbon monoxide recovered from steel mill waste gases, chemical plants, and biomass gasification, into drop-in, hydrocarbon biofuels and chemicals, entering the Chinese market.[136] In addition, Empryo BV, a subsidiary of BTG BV, began construction of a pyrolysis plant in the Netherlands that will produce 20 million litres of bio-oil annually; and Clarion's cellulosic demonstration plant in Straubing, Germany, ferments wheat straw into ethanol that is then blended with conventional fuel additives by Haltermann (Germany) to produce a novel drop-in fuel equivalent to E20.[137]

The aviation industry continued to monitor the increasing uptake of advanced biofuels, including those produced from algae. The industry's interest stems from the current high dependence on petroleum fuels, uncertainty about long-term supplies, and the lack of other suitable fuel alternatives.[138] In 2013, Boeing (United States) claimed that there was enough biofuel production capacity already in place to supply around 1% of jet fuel demand (about 6 billion litres per year) at a competitive cost.[139] The Sinopec group, which runs oil refineries in China, was licensed to market its own version of No. 1 Aviation Biofuel for use at the commercial level.[140]

GEOTHERMAL POWER AND HEAT

GEOTHERMAL MARKETS

Geothermal resources provide energy in the form of electricity and direct heating and cooling, totalling an estimated 600 PJ (167 TWh)[i] in 2013.[1] Geothermal electricity generation is estimated to be a little less than half of the total final geothermal output, at 76 TWh, with the remaining 91 TWh (328 PJ) representing direct use.[ii] Some geothermal plants produce both electricity and thermal output for various heat applications.

At least 530 MW of new *geothermal power* generating capacity came on line in 2013, bringing total global capacity to 12 GW, generating an estimated 76 TWh annually.[2] Accounting for the replacement of some existing units, the net increase in total world capacity was at least 465 MW. This growth in cumulative capacity of about 4% compares to an average annual growth rate of 3% for the two previous years (2010–12).[3]

Countries that added capacity in 2013 were New Zealand, Turkey, the United States, Kenya, Mexico, the Philippines, Germany, Italy, and Australia.[4] (See Figure 8.) At the end of 2013, the countries with the largest amounts of geothermal electric generating capacity were the United States (3.4 GW), the Philippines (1.9 GW), Indonesia (1.3 GW), Mexico (1.0 GW), Italy (0.9 GW), New Zealand (0.9 GW), Iceland (0.7 GW), and Japan (0.5 GW).[5] (See Figure 9.)

New Zealand installed 241 MW of new geothermal power capacity in 2013, for net additions of 196 MW, increasing total capacity by 30% to 0.9 GW. The Te Mihi plant (159 MW) came on line in 2013, but problems with well pumps delayed full commissioning into 2014.[6] Te Mihi will eventually replace parts of the Wairakei station, which was built in 1958, operating at a higher efficiency level and with a smaller environmental footprint.[7] Currently, the result is a net capacity increase of about 114 MW.[8] Late in the year, New Zealand also commissioned the 82 MW Ngatamariki geothermal power station.[9] Reportedly the world's largest binary[iii] installation, Ngatamariki re-injects all used geothermal fluid back into the underground reservoir without depleting it, thereby minimising emissions and other environmental impacts.[10]

Turkey added at least 112 MW of geothermal generating capacity in 2013, for a total of at least 275 MW.[11] Most notable may be the installation of a 60 MW triple-flash turbine in the Denizli field.[12] Other capacity to come on line in Turkey in 2013 was made up of smaller binary units.[13] Turkey promises to be an important market in the region in the near future, with over 300 MW of additional capacity under licence or construction at year's end.[14]

The United States added 84 MW of geothermal generating capacity in 2013, for a total of 3.4 GW, representing nearly 29% of total world operating capacity. One of the larger U.S. plants to come on line in 2013 was Enel Green Power's 25 MW binary plant in Fort Cove, Utah.[15] Although relatively small in capacity,

i - This total does not include the output of ground-source (geothermal) heat pumps.

ii - The estimated value for direct use output is subject to great uncertainty due to incomplete and conflicting data.

iii - In a binary plant, the geothermal fluid heats and vaporises a separate working fluid, which drives a turbine for power generation. Each fluid cycle is closed, and the geothermal fluid is re-injected into the heat reservoir. In a conventional thermal power plant, the working fluid is water. Organic Rankine Cycle (ORC) binary geothermal plants use an organic fluid with a lower boiling point than water, allowing effective and efficient extraction of heat for power generation from relatively low-temperature geothermal fields. The Kalina cycle is another variant for implementing a binary plant. (See for example: Ormat, "Binary Geothermal Power Plant," http://www.ormat.com/solutions/Geothermal_Binary_Plant, and U.S. Department of Energy, Geothermal Technologies Office, "Electricity Generation," http://www1.eere.energy.gov/geothermal/powerplants.html.)

perhaps the most significant U.S. project completed in 2013 was the Desert Peak 2 (1.7 MW) in Nevada, the first commercial grid-connected EGS (enhanced or engineered geothermal system) installation in the United States (see more on EGS below).[16] Desert Peak 2 is located within an existing operational geothermal field ("in-field") and serves to enhance its overall productivity.[17] Nevada is also home to the new Don A. Campbell binary plant (16 MW), notable for cost-effective power generation from a relatively low-temperature resource, and the first 30 MW phase of the Patua plant.[18] In addition, 12 MW of repowering and refurbishment took place at two U.S. facilities during 2013.[19]

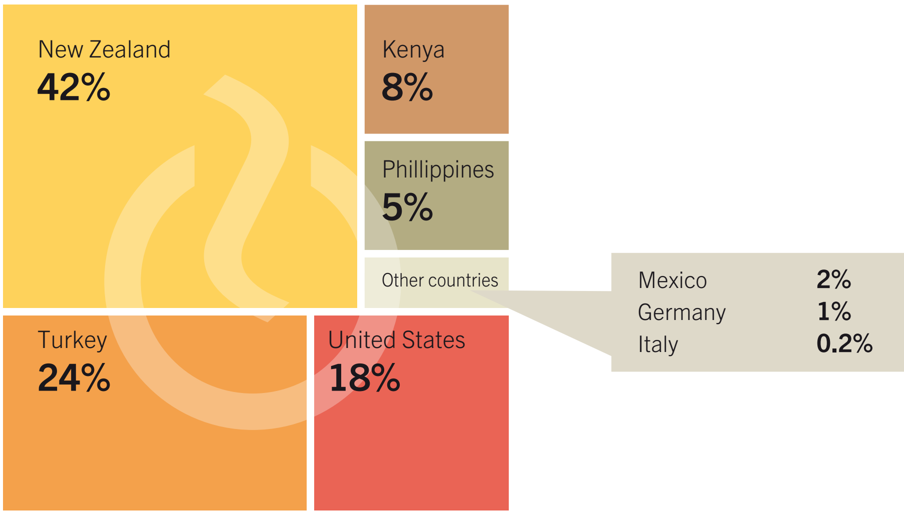
Kenya is one of the fastest-growing geothermal power markets in the world. In 2013, the country added 36 MW of capacity at the Olkaria III complex. A further 16 MW was added to Olkaria III in early 2014, bringing the complex to a total of 110 MW.[20] As of early 2014, Kenya had another 280 MW of geothermal power capacity under construction.[21]

Mexico completed the second of two 25 MW units of the Los Humeros II project, replacing 15 MW of existing capacity.[22] Ongoing reforms to Mexico's energy laws are expected to spur growth and involvement of private parties in the country's geothermal development.[23]

Also in 2013, the Philippines began operations at the 20 MW Maibarara geothermal power plant.[24] At year's end, the country's portfolio of geothermal power plants stood at 1.9 GW, second only to that of the United States, with another 40 MW expected

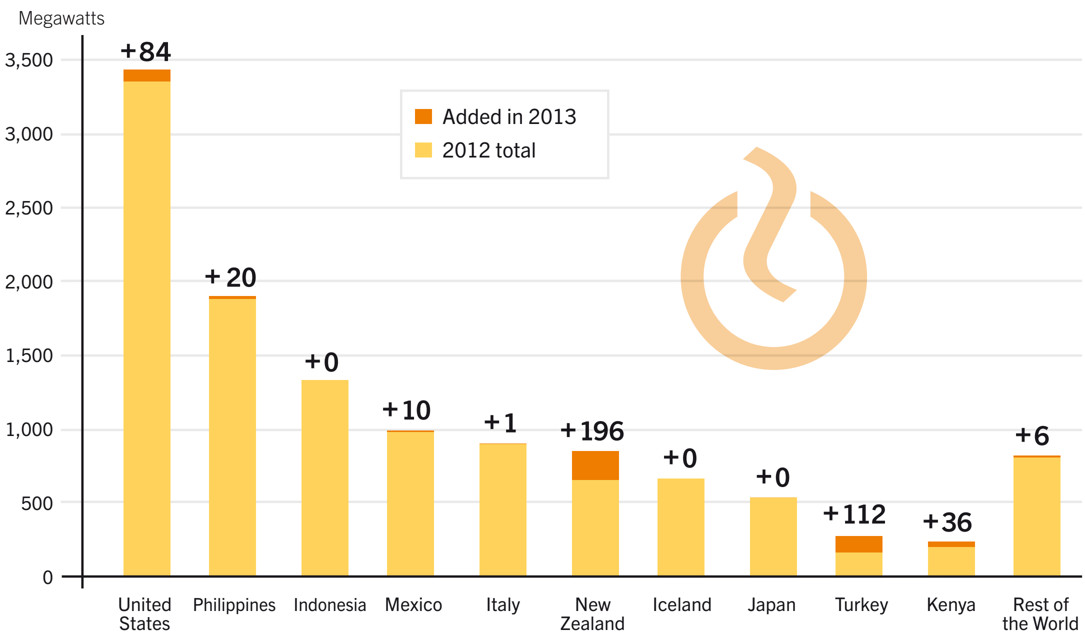
GEOTHERMAL POWER

Figure 8. Geothermal Power Capacity Additions, Share of Additions by Country, 2013



Source: See Endnote 4 for this section.

Figure 9. Geothermal Power Capacity and Additions, Top 10 Countries and Rest of World, 2013



Source: See Endnote 5 for this section.

Additions are net of repowering and retirements.

to come on line in 2014.[25] The three new plants in Kenya, Mexico, and the Philippines are all registered CDM projects under the UN Clean Development Mechanism, and thus credited for reducing greenhouse gas emissions.[26]

Several relatively small plants came on line in Europe during the year. Southern Germany has been active in development of binary plants with two 6 MW units completed near Munich in late 2012 and early 2013.[27] In addition, Germany's co-generating Sauerlach binary plant (5 MW / 4 MW_{th}) was inaugurated in January 2014, delivering heat in addition to electricity.[28] In Italy, a 1 MW binary plant was installed at the volcanic area of Monte Amiata (Tuscany).[29] While Europe still has far more conventional dry-steam and flash geothermal capacity than the low-temperature binary variety, future growth potential for binary plants is very promising.[30]

With growing reliance on variable renewable resources, such as solar PV and wind power, there is also increasing interest in the potential for geothermal power to provide renewable balancing power and storage capability. It has been noted that geothermal power can be designed with the necessary flexibility, especially in locations where the growing need for balancing resources and geothermal potential coincide, as in California.[31]

Geothermal direct use refers to direct thermal extraction for heating and cooling, exclusive of heat pumps.[i] [32] (See Sidebar 4, page 42.) The main applications for direct use of geothermal energy are space heating (including district heat networks), domestic hot water supply, direct and indirect heating of public baths and swimming pools, greenhouse heating, industrial process heat, aquaculture, and agricultural drying.[33]

Geothermal direct use continued to grow during 2013, with capacity added in at least a number of European countries. It is estimated that global direct use was in the range of 280–375 PJ during 2013, with a mean of 328 PJ (91 TWh).[34] This wide range reflects widely varying data for China, which is a significant user of geothermal for heat purposes.[35] The collection of data on direct use of geothermal energy is lacking.[36]

Direct use is concentrated among the few countries where good geothermal resources coincide with heat demand that can easily be served by the resource, such as Iceland, and where geothermal heat has served both industry and social traditions, such as thermal baths in Japan, Turkey, and Italy.[37] The countries with the largest geothermal direct use capacity are China (3.7 GW_{th} in 2010), Turkey (2.7 GW_{th} in 2013), Iceland (2.2 GW_{th} in 2013), Japan (2.1 GW_{th} in 2010), Italy (0.8 GW_{th} in 2012), and Hungary (0.7 GW_{th} in 2012).[38] Together, these countries account for about half of total global capacity, estimated to be in the range of 19–26 GW_{th}, with a mean of 22.6 GW_{th}.[39]

China remains the presumptive leader in direct geothermal energy use, but estimates range from 13 TWh in 2009 to 45 TWh in 2011, or about 20–50% of global output.[40] Other top users of direct geothermal heat are Turkey (estimated 16.4 TWh in 2012)[ii], Iceland (7.8 TWh in 2013), Japan (7.2 TWh in 2013), and Hungary (2.8 TWh in 2012).[41]

Among notable new thermal plants that opened in 2013 is a district heating plant (60–70 MW_{th}) in Miskolc, Hungary.[42] The project exceeded initial expectations and is considered to be among the better low-temperature wells in mainland Europe, producing 70–90 litres per second at 100 °C.[43] In Italy, a 6 MW_{th} district heat system was inaugurated by Enel Green Power in April to serve municipalities in Tuscany.[44] In early 2014, a cogeneration plant with thermal capacity of 4 MW_{th} (noted above) was inaugurated in Sauerlach, Germany.[45]

In Europe, there have been recent efforts to improve accounting of direct use geothermal energy across all sectors, specifically balneology (e.g., spas, swimming pools), which may not have been fully reported before.[46] Such examination reveals divergent profiles for geothermal heat applications. For example, district heating commands a relatively minor share of geothermal heat capacity in Hungary (19%), Turkey (30%), and Italy (10%), but very substantial shares in France (81%), Iceland (80%), and Germany (77%).[47]

i -Direct use refers here to deep geothermal resources, irrespective of scale, as distinct from shallow geothermal resource utilisation, specifically ground-source heat pumps. In addition, the term hydrothermal energy is reserved for energy stored in the form of heat in surface water, as per Article 2(d) of European Council Directive 2009/28/EC. Heat pumps—whether geo-, hydro, or aerothermal—are discussed in Sidebar 4.

ii - Estimate based on 2012 capacity and 2010 capacity factors. Of this total, 11 TWh is associated with bathing and swimming, of which the 2010 data on capacity utilisation is notably high at 100%. See Endnote 38 for this section.

GEOTHERMAL INDUSTRY

In 2013, the geothermal industry, often with the support of governments, continued to pursue technological innovation for expanded resource access and improved economies of extraction. Objectives include improving the efficiency of conventional geothermal resources utilisation, as well as advancing technologies that allow expanded use of low-temperature fields for both power and heat, thereby increasing the application of geothermal energy beyond high-temperature locations.

Among notable industry advances in 2013 was Australia's first EGS facility, one of only a handful of such projects in the world. Geodynamics' (Australia) Habanero Pilot Plant (1 MW) in the Cooper Basin of South Australia successfully completed its initial 160-day trial in 2013, with production and injection wells extending more than four kilometres into hot granite.[48] In Italy, Enel Green Power (Italy) started operation of its 1 MW binary plant at Monte Amiata, fitted with a first-of-its-kind radial outflow ORC turbine by Exergy (Italy), which is said to advance generating efficiency.[49] The industry also saw some repowering and refurbishment of existing facilities. Ormat Industries (United States) refurbished a 7.5 MW unit in California and repowered a 4 MW plant in Utah.[50]

The geothermal industry, whether it is in power or heat generation, is made up of a relatively few firms that work on the various segments of geothermal project development, from exploration, drilling, engineering, and design, through construction and, finally, plant operation. Some of these firms are vertically integrated, in that they work on most or even all stages of geothermal project development, while others are highly specialised.[51] For example, Enel, Ormat Industries, and Chevron (United States) are vertically integrated energy companies.[52] Highly specialised firms include drilling contractors like Thermasource (United States) and Iceland Drilling (Iceland), as well as engineering firms with specialised knowledge of the geothermal projects, such as Mannvit (Iceland), Verkis (Iceland), and Power Engineers (United States).

Some firms possess particular expertise and proprietary technology within the industry. These include, for example, Ormat, which specialises in design, engineering, and construction of binary (ORC) power plants and their components, such as the Ngatamariki plant that opened in New Zealand in 2013; Turboden (Italy), which specialises in binary turbine-generators, such as the 5.6 MW unit inaugurated in 2013 near Munich, Germany; and Exergy, which implemented a new turbine design in Italy, as noted above.[53] Other suppliers of turbine-generator components count the industrial heavyweights that also operate in the thermal (fossil and nuclear) and hydropower sectors, such as Mitsubishi Heavy Industries, Toshiba, Fuji Electric (all Japan, commanding about two-thirds of the turbine-generator market), Alstom (France), Ansaldo Energia (Italy), and Siemens (Germany).[54]

Whether for heat or power generation, the industry continues to face many technology challenges. Areas that need improvement include discovery, access, maintenance, and monitoring of the geothermal resource, whether it is conventional geothermal, low-temperature, or a candidate for Enhanced Geothermal Systems (EGS).[55] To that end, the industry is applying innovations that include directional drilling and other lessons from the oil and gas sectors.[56] In those locations where sufficient heat demand coincides with geothermal resources, such as the new Sauerlach plant in Germany, the development of combined heat and power is also helping to improve project economics.[57]

Enhanced geothermal systems are on the forefront of technological innovation in the industry and represent a very significant potential. This relatively new technology was pioneered in the United States, but the world's first grid-connected EGS plant to come on line was the 2 MW Soultz facility in France in 2008.[58] EGS enhances extraction of heat by fracturing subsurface rock for greater permeability, allowing production similar to naturally occurring conventional geothermal fields.[59] Unlike conventional geothermal resources, which are limited to relatively few places on Earth, the heat bound in deep rock that EGS is designed to tap into is far more widespread and plentiful, but also more difficult to harness.

Despite the large potential of EGS, attracting the requisite funds to advance EGS technologies is reportedly a challenge, largely because they may still be 10–15 years from commercial maturity and carry significant technological risk.[60] Key priorities for the EGS industry today are continued advances in the technology of sustainable field enhancement and reduced drilling costs.[61] The industry is learning to control and reduce risks of any adverse effects associated with EGS development so that the vast potential of EGS may materialise.[62]

Project risk is a uniquely significant aspect of geothermal development in general. A typical geothermal plant may take 5–7 years from start to finish, with up to five years devoted to exploration, test drilling, and field development before construction of the plant itself.[63] Project developers face significant financial risk of high upfront cost and long lead times, but also the risk of failing to meet required parameters at each stage of development, from initial exploration to plant operation.[64]

To manage this risk, one urgent objective is better and more-comprehensive global geothermal resource assessment.[65] Several countries have implemented risk funds, insurance funds, or loan guarantees to absorb some of the risk, with renewed enthusiasm for establishing a single fund for the European Union.[66] The U.S. Department of Energy provides targeted financial support to the geothermal sector, and Japan's Oil, Gas and Metals National Corporation provides liability guarantees but also direct funding and information on geothermal resources.[67] To uncork the bottleneck on behalf of developing countries, in 2013 the World Bank launched a Global Geothermal Development Plan to focus the attention of donors and multilateral development banks on exploratory test drilling rather than just the production phase of geothermal projects. The Plan had an initial target funding of USD 500 million.[68]

SIDEBAR 4. HEAT PUMPS AND RENEWABLE ENERGY

Heat pumps provide heating, cooling, and hot water for residential, commercial, and industrial applications by drawing on one of three main sources: the ground, ambient air, or water bodies such as lakes, rivers, or the sea.[i] Heat pumps can also be employed efficiently using waste heat from industrial processes, sewage water, and buildings. The energy output of heat pumps is at least partially renewable on a final energy basis.

As the term implies, heat pumps transfer heat from one area (source) to another (sink) using a refrigeration cycle driven by external energy, either electric or thermal energy. Depending on the inherent efficiency of the heat pump itself and its external operating conditions, it is capable of delivering significantly more energy than is used to drive the heat pump. A typical input-to-output ratio for a modern electrically driven heat pump is 4:1, meaning that the heat pump delivers four units of final energy for every one unit of energy it consumes, which is also known as a coefficient of performance (COP) of 4. That incremental energy delivered is considered the renewable portion of the heat pump output.

For a heat pump that operates at a seasonal COP of 4, the renewable component is at least 75% (3 out of 4 units) on a *final* energy basis. However, the renewable share on a *primary* energy basis can be much lower.[ii] The total share of renewable energy delivered by a heat pump on a primary energy basis depends not only on the efficiency of the heat pump and its operating conditions, but also on the composition of the energy used to drive the heat pump. In addition, for electrically driven heat pumps, the overall efficiency and renewable component depends on both the generation efficiency and the primary energy source of the electricity (renewable, fossil fuel, or nuclear). When the energy source is 100% renewable, so is the output of the heat pump.

Data on the global heat pump market, installed capacity, and output are fragmented and limited in scope. Recent versions of the GSR have provided estimates of global ground-source heat pump installations and output, based largely on comprehensive survey data prepared in 2010. Such surveys have been updated for Europe in 2013 but updates for other regions are not yet published. For air- and water-source heat pumps, less is known about current global capacity and output, again with the exception of Europe.

The European heat pump market saw steady growth until about 2008 but has since shown relative stagnation and actually contracted overall from 2011 to 2012. Europe saw at least 0.75 million units sold in 2012, with most of the market (86%) dominated by air-source heat pumps. For use in new buildings, there is an ongoing shift from ground-source to air-source units as they improve in efficiency and economy. As new buildings become more efficient, the economics of ground-source heat pumps makes the pumps attractive for large and very large buildings, while growth is limited for single-family homes. Overall, heat pumps have achieved a relatively stable 15% share of European heating system installations.

The most significant trend related to heat pumps is towards the use of hybrid systems that integrate several energy resources (such as solar thermal or biomass with heat pumps) for the range of heat applications. There is also growing interest in the use of larger-scale heat pumps for district heating as well as industrial processes. For example, Denmark has been developing the use of absorption heat pumps for district heating, the latest being a 12.5 MW plant at Sønderborg, commissioned in 2013. In neighbouring Norway, Star Refrigeration (U.K.) opened a 14 MW hydrothermal heat pump system in the municipality of Drammen in early 2014, utilising sea water for district heating.

In 2009, the European Commission set out to standardise calculation of heat pump output and to define the renewable component thereof, noting first that the final energy output of any heat pump counted in this context would have to "significantly" exceed the primary energy consumed. At the time, the Commission provided a formula for calculating the renewable component of heat pump output that took into account both the operating efficiency of the heat pump itself (seasonal performance factor[iii]) and the average ratio of primary energy input to electricity production across the EU. This serves to standardise assumptions about the renewable energy contribution of heat pumps in Europe and to ensure that the net final energy output that is counted under these new rules will always exceed the primary energy (including primary energy in electricity generation) used to drive the heat pumps.

In March 2013, the Commission issued remaining rules for applying its formula, including default values for climate-specific average equivalent full-load hours of operation and seasonal performance factors for various heat pumps. The default values resulted in a minimum COP of 2.5 for electrically driven heat pumps in 2013, well below the average value of new units.

i - Also called geothermal, aerothermal, and hydrothermal sources. Ground-source heat pump applications generally rely on shallow geothermal energy (covering depths of up to 400 metres), clearly distinguished from deep geothermal (medium-to-high temperature) resources, mostly for direct use and geothermal power generation.

ii - A heat pump providing four units of final energy for every one unit of energy input (COP of 4), driven by electricity from a thermal plant at 40% efficiency, provides about 1.6 units of final energy for every one unit of primary energy consumed (4/(1/0.4) = 1.6).

iii - Seasonal Performance Factor (SPF) refers to the net seasonal coefficient of performance (sCOPnet) for electrically driven heat pumps or the net primary energy ratio (sPERnet) for thermally driven heat pumps, per Commission Decision of 1 March 2013 (2013/114/EU).

Source: See Endnote 32 for this section.

HYDROPOWER

HYDROPOWER MARKETS

An estimated 40 GW of new hydropower capacity was commissioned in 2013, increasing total global capacity by about 4% to approximately 1,000 GW.[i 1] Global hydropower generation, which varies each year with hydrological conditions, was estimated at 3,750 TWh in 2013.[2] The top countries for hydropower capacity and generation remained China (260 GW / 905 TWh), Brazil (85.7 GW / 415 TWh), the United States (78.4 GW / 269 TWh), Canada (76.2 GW / 388 TWh)[ii], Russia (46.7 GW / 174.7 TWh), India (43.7 GW / estimated 143 TWh), and Norway (29.3 GW / 129 TWh), together accounting for 62% of global installed capacity.[3] (See Figure 10 and Reference Table R6.) An estimated 2 GW of pumped storage capacity was added in 2013, bringing the global total to 135–140 GW.[iii 4]

The lion's share of all new capacity in 2013 was installed by China, with significant additions by Turkey, Brazil, Vietnam, India, and Russia.[5] (See Figure 11.) China commissioned a record 29 GW, for a total of 260 GW of hydropower capacity at year's end. Among significant milestones for China in 2013 was the start of operations at the Xiluodu plant in July, with 9.2 GW of capacity generating electricity by year's end. Xiluodu is expected to reach full capacity (13.86 GW) by mid-2014, when it will rank as the third largest hydropower plant in the world, behind China's Three Gorges and Brazil's Itaipu.[6]

The 6.4 GW Xiangjiaba plant, also on the Jinsha River, will be China's third largest hydropower plant when completed in 2015. By mid-2013, four 800 MW turbine-generators—reported to be the world's largest hydroelectric units—had been installed at this facility.[7] By the country's own accounts, investment in China's hydropower infrastructure exceeded USD 20 billion (CNY 124.6 billion) for the year.[8] Chinese banks and industry have also pursued hydropower projects overseas, with a notable presence in Africa and Southeast Asia.[9]

Turkey continues a rapid expansion in its hydropower sector to meet significant growth in national electricity demand. After adding about 2 GW in 2012, Turkey brought another 2.9 GW on line in 2013, for a total of 22.5 GW, placing Turkey among the top 10 countries for hydropower capacity.[10] Turkey's hydropower capacity generated 59.2 TWh in 2013.[11]

Brazil added at least 1.53 GW and possibly as much as 2 GW in 2013, including 264 MW of small-scale hydro (<30 MW) capacity, for a year-end total of at least 85.7 GW.[12] The 334 MW Simplicio plant, completed mid-year, is considered notable for its high power output relative to reservoir area.[13] In addition, two run-of-river plants, both part of the Madera River complex, advanced during 2013. The first of fifty 75 MW turbines at the Jirau plant (3.75 GW) became operational and, by year's end, the Santo Antonio plant (3.6 GW) had 22 turbines in operation. Santo Antonio was expanded from 44 to 50 bulb-type turbines to improve operational flexibility in a river characterised by great flow variability.[14] These two plants exemplify a trend in Brazil away from larger reservoirs and toward run-of-river projects, driven in part by the objective of reducing land use in sensitive areas and improving project sustainability.[15] The Belo Monte has also been modified to address sustainability concerns. To reduce flooded area, its reservoir capacity will be smaller than originally planned, with a firm year-round capacity of only 4.5 GW; however, it will retain a peak seasonal capability of 11.2 GW, second in Brazil only to the 14 GW Itaipu plant.[16] Another significant project under way in 2013 was the Teles Pires project (1,820 MW by 2015), which overcame charges of having neglected obligatory social impact studies.[17]

Vietnam has developed its hydropower resources at a rapid pace in recent years. It appears that at least 1.3 GW of capacity was added in 2013, for a total of 14.2 GW installed.[18] However, following earthquake damage at the Song Tranh 2 dam, as well as concerns about adverse social impacts associated with resettlements, local and central governments are taking a more measured approach to the development of additional hydropower facilities, calling for evaluations of safety at existing dams and curtailment of new hydropower development.[19]

Significant capacity was also added in India and Russia during 2013. India installed 0.8 GW of hydropower capacity in 2013, of which nearly 0.6 GW was in installations larger than 25 MW.[20] In late 2013, the Permanent Court of Arbitration in The Hague gave a green light to India's 330 MW Kishenganga plant, having determined that it would qualify as a run-of-river plant and thus not violate terms of the 1960 Indus Waters Treaty with Pakistan.[21] Russia may have installed as much as 3.2 GW of new turbine-generators during the year, but the net increase in installed capacity amounted to only 0.7 GW, with rehabilitation of existing facilities presumably accounting for the difference.[22]

Africa saw at least two projects completed during the year. Ghana's second largest hydropower station, the 400 MW Bui plant, and Gabon's 160 MW Grand Poubara plant both became operational in late 2013.[23] These plants were built by Sinohydro (China) and financed largely by China Exim Bank.[24] Meanwhile, rehabilitation started on the 350 MW Inga 1, which entered service in the early 1970s.[25] There are many ageing facilities in Africa that operate below original rated power and now require refurbishment, such as ongoing work on the Kainji and Jebba plants in Nigeria.[26]

There is growing support for future development in Africa, and many impending new hydropower sites exist on the continent. During 2013, Alstom (France) was awarded a contract for eight 375 MW Francis turbines at the Grand Renaissance Dam in Ethiopia, a project that will total 6 GW and has raised tensions with downstream Sudan and Egypt over water rights.[27] The World Bank announced funding for the Regional Rusumo Falls plant (80 MW) under its new Great Lakes Regional Initiative, with the primary aim of increasing power supply for the people of Tanzania, Rwanda, and Burundi.[28] Also in 2013, a new purchase agreement between South Africa and Congo prompted an

i - The GSR 2013 reported a global total of 990 GW at the end of 2012, but that figure has been revised downward by 30 GW. For additional information, see Methodological Notes, page 142, and Endnote 1 of this section. Unless otherwise specified, all capacity numbers exclude pure pumped storage capacity if possible.

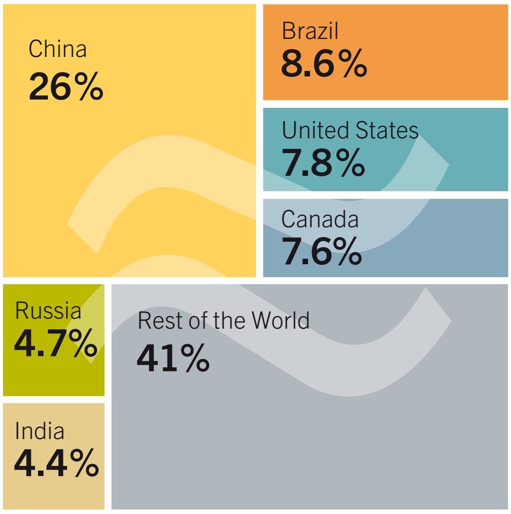
ii - Despite slightly lower total capacity, Canada's baseloaded output exceeds the more load-following output in the United States.

iii - Pumped hydro plants are not energy sources but means of energy storage. As such, they involve conversion losses and are powered by renewable or non-renewable electricity. Pumped storage can play an important role as balancing power, in particular for variable renewable resources. Some conventional hydropower plants also have pumping capability.

HYDROPOWER

Figure 10. Hydropower Global Capacity, Shares of Top Six Countries, 2013

Source: See Endnote 3 for this section.

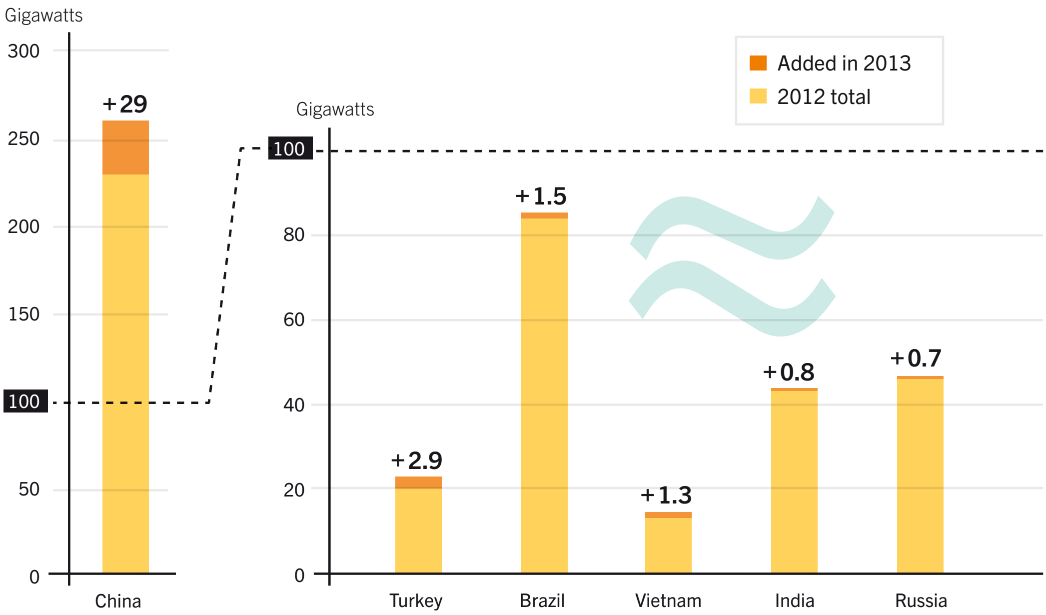


Global capacity reaches 1,000 GW

Figure 11. Hydropower Capacity and Additions, Top Six Countries for Capacity Added, 2013

Source: See Endnote 5 for this section.

Additions are net of repowering and retirements.



announcement that construction of the Inga 3 project (4.8 GW) on the Congo River would begin by late 2015.[29] This project is the long-anticipated next step towards what might become the largest hydropower complex in the world, at about 40 GW.[30]

Pumped storage capacity expanded during 2013 in China and Europe. China added 1.2 GW of pure pumped storage capacity for a total of 21.5 GW.[31] In addition, the last phase of Spain's La Muela pumped storage complex was inaugurated, counting 2 GW of capacity at year's end.[32] La Muela was conceived as part of a backbone for Spain's extensive variable renewable power capacity.[33] It has been argued that further expansion of storage capacity, which is considered increasingly important as shares of variable wind and solar power rise, will require that markets place greater monetary value on facilities that provide storage and ancillary services.[34] Variable resources have helped to moderate peak system loads and thus peak power prices, but in doing so, they may also have upset the traditional business model for pumped storage. Subsequently, power markets may need to evolve to reflect these changing circumstances.[35]

Looking ahead, plans for future hydro pumped storage projects in Europe are said to be hampered by onerous market conditions such as two-way transmission fees (for both generation and pumping).[36] On the other hand, Germany appears to have addressed such concerns to some extent and has expanded exemptions for pumped storage facilities from grid charges under certain conditions.[37] However, pumped storage has always had relevance outside the context of variable resources. For instance, Japan's 26 GW of pumped storage capacity (in addition to 22 GW of conventional hydropower capacity), was conceived primarily as load-following support to baseload nuclear power; going forward, it will be used increasingly to balance variable resources.[38]

Any shortage of transmission capacity and interconnection can constrain both access to hydropower resources and their potential for balancing variable renewable resources.[39] Trans-border interconnections conceived primarily to facilitate flow of hydropower include the Eastern Electricity Highway between Ethiopia and Kenya, which was launched in 2013 and could carry up to 2 GW upon completion, planned for 2018.[40] The 1,800 kilometre Central American SIEPAC[i] interconnection was largely completed in 2013, improving transmission capacity and reliability across the region. Despite its modest scale (300 MW capacity), it is regarded as an opportunity to increase implementation of large and small renewable energy projects, including hydropower.[41] In North America, at least two interconnection projects were under consideration in 2013 to bring Canadian hydropower to U.S. markets: the controversial Northern Pass project that would supply 1,200 MW of baseload power from HydroQuebec (Canada) to New England, and an agreement to complement a North Dakota wind farm with 250 MW of balancing supply from Manitoba Hydro (Canada).[42]

In 2013, the World Bank Group announced that it remains committed to environmentally and socially sustainable hydropower projects of all sizes and types, highlighting hydropower's role in climate change mitigation, but also its vulnerability to any climate-related water scarcity.[43] Uncertainty regarding the future impact of climate change on hydropower and other renewable energy technologies—including energy production, policies, and markets—prompted Norway's Statkraft to launch an R&D programme on the topic.[44]

HYDROPOWER INDUSTRY

Hydropower capacity additions in the five-year period end-2008 to 2013 were significantly greater than during the previous five years.[45] However, despite a significant jump in new capacity in 2013, the intake of new orders for some major companies declined relative to 2012.

For example, Andritz Hydro (Austria) reported that both sales and new orders were down from very high levels in previous years, although project activity was deemed satisfactory for small-scale hydropower.[46] New orders were down for Voith Hydro (Germany) as well. Sales increased by 6% in the 2012–13 fiscal year, but the market was below Voith's expectations. However, the company noted that the market for plant modernisation is a major driver of new orders in many regions.[47] Voith also announced advances in the area of very large generating units (such as the 784 MW turbines supplied to the Xiluodu plant in China), as well as small in-stream and low-head units, such as its prototype StreamDiver.[48]

Alstom (France) noted a slowdown in demand for new capacity but growing demand for rehabilitation of the ageing stock of existing plants.[49] Aiming to strengthen its capacity in China, Alstom inaugurated its upgraded hydropower industrial site in Tianjin, which supplied four 800 MW Francis turbines to the Xiangjiaba plant in 2012–13.[50] Alstom also inaugurated a global hydropower technology centre in Grenoble, France, for all of its hydropower R&D.[51]

Dongfang's (China) production of hydropower turbine-generators was reported to be 4.2 GW in 2013, up 28.6% from 2012. A company highlight for the year was installation of a 770 MW unit at the Xiluodu plant. Harbin (also in China) produced 3.2 GW of hydropower turbine-generators during the year, a decrease of 3.7% relative to 2012.[52]

The hydropower industry is tackling projects of ever-larger capacity, and manufacturers are setting new records for capacity of individual turbines (≥800 MW per unit). At the same time, there are indications of a trend towards reduced reservoir capacity and the development of multi-turbine run-of-river projects, as seen in Brazil. As part of this trend, the industry has been developing more-flexible turbines that can adapt to varying flow rates. The use of multiple in-stream turbines in place of few large ones requires different technology, materials, and expertise.[53] Another trend is the rise of regional approaches to system development, including interconnection, and a view of hydropower as complementing other renewable energy technologies.[54]

OCEAN ENERGY

OCEAN ENERGY MARKETS

Ocean energy refers to any energy harnessed from the ocean by means of ocean waves, tidal range (rise and fall), tidal currents, ocean (permanent) currents, temperature gradients, and salinity gradients.[1] At the end of 2013, global ocean energy capacity was about 530 MW, with most of this coming under the category of tidal power.[2]

The largest ocean energy facilities in operation are all tidal projects and are used for electricity generation. They include the 254 MW Sihwa plant in South Korea (completed in 2011), the 240 MW Rance station in France (1966), the 20 MW Annapolis plant in Nova Scotia, Canada (1984), and the 3.9 MW Jiangxia plant in China (1980).[3] Other projects are smaller, and many are pre-commercial demonstration projects, with a notable concentration of tidal and wave energy development installations (about 11 MW) in the United Kingdom.

Although no commercial capacity additions were identified for 2013, some large pilot machines were installed at the European Marine Energy Centre (EMEC) in Orkney, Scotland. Alstom (France) deployed its 1 MW tidal stream turbine there in early 2013, which subsequently reached full power operation; further testing was to continue into 2014.[4] Another tidal turbine deployed at EMEC in 2013 was the 1 MW HyTide unit by Voith Hydro Ocean Current Technologies (Germany), following testing of a smaller model in South Korea.[5]

Several large projects were also granted consent in 2013 and early 2014, with construction expected to begin within the next

i - Sistema de Interconexión Eléctrica de los Países de América Central.

few years; most of these developments are planned for U.K. coastal waters. Scotland awarded approval to MeyGen Ltd. (U.K.), now fully owned by Atlantis Resources Ltd. (Singapore), for the 86 MW first phase of what could eventually be a 398 MW tidal array in the Inner Sound of Pentland Firth. MeyGen plans to start with a demonstration of six turbines, with construction commencing in 2014.[6] Consent was also granted for a 40 MW (40–50 device) wave farm off the coast of Lewis, Scotland, which is considered one of the best wave energy locations in Europe. The deployment of Aquamarine Power's (Scotland) Oyster wave energy devices will take place in the coming years, alongside necessary grid interconnection.[7]

In March 2014, the U.K. government accepted an application for the proposed 240 MW Swansea Bay Tidal Lagoon, advancing this concept closer to realisation.[8] Construction is planned for the period 2015–2018.[9] Meanwhile, the proposed Severn Barrage in Wales (U.K.), which might provide 5% of the U.K.'s electricity demand if built, was dealt a heavy blow when a parliamentary committee said that the project should not go ahead as presented because it had not yet demonstrated evidence of economic, environmental, and technological viability.[10]

Another potential 240 MW tidal project, proposed for the Alaska coast (United States), was granted a preliminary permit extension in early 2014, for the purpose of establishing project feasibility.[11]

OCEAN ENERGY INDUSTRY

Ocean energy technologies continued to advance during 2013, with a wide variety of devices under development. Industry firms advanced their goals through acquisitions and collaborative agreements, and governments often lent a hand.

Scotland's EMEC, the world's leading test facility for wave and tidal energy converters, continued to share its expertise globally during 2013. It announced an agreement to help set up a test facility in Singapore—the latest of several agreements with parties across North America and Asia.[12] In addition, neighbouring Ireland recently launched its Offshore Renewable Energy Development Plan, committing funds for test facilities, R&D, and a feed-in tariff for ocean power.[13] (See Policy Landscape section.)

Alstom started the year by completing the acquisition of Tidal Generation Limited from Rolls-Royce Holdings plc.[14] By an agreement between Alstom and ScottishPower Renewables (Scotland), which is owned by Iberdrola (Spain), four of Alstom's 1 MW tidal turbines will be deployed at the planned Sound of Islay array, beginning in late 2015.[15] In late 2013, Voith Hydro acquired the remaining 20% share of Voith Hydro Ocean Current Technologies from Innogy Venture Capital.[16] As noted above, both companies launched turbines at EMEC in 2013. Voith's HyTide turbine has a direct drive (no gears), uses symmetrical blades for bi-directional operation, and relies on sea water lubrication, all for simplicity and robustness in the harsh marine environment.[17] Unlike the HyTide, which has a fixed nacelle and blades, Alstom's turbine has adjustable nacelle position and blade pitch for maximum energy potential.[18]

Atlantis Resources Ltd, developer of the AR1000 1 MW tidal turbine, raised capital in its initial public offering in early 2014 and received additional funding from the European Commission.[19] Atlantis plans to use the funds to advance the MeyGen project, including the AR1500 turbine developed with Lockheed Martin (United States), and to fund its AR1000 demonstration project in China. Atlantis acquired all remaining shares in MeyGen Ltd from GDF Suez (France) and Morgan Stanley (United States) in October.[20]

In early 2013, DCNS (France) acquired a majority stake in OpenHydro (Ireland), which continued to test new versions of its open-center tidal turbine at EMEC.[21] Later in the year, DCNS announced an agreement with Fortum and AW-Energy (both Finland) to develop a 1.5 MW wave power demonstration project in Brittany, France, using AW-Energy's WaveRoller device.[22] In September 2013, the French government issued tenders for pilot tidal projects off the coast of France.[23] Both DCNS and GDF Suez have expressed interest in the projects, the latter possibly joining forces with Voith and Alstom for their tidal turbines.[24]

Aquamarine Power continued testing of its second Oyster 800 wave energy device at EMEC, and Pelamis Wave Power (Scotland) continued to develop its articulating cylindrical wave energy converter.[25] Pelamis tested new scale models in 2013, with the aim of improving power, reliability, and economics of the device through changes in configuration, shape, and controls.[26] In partnership with the University of Dundee, Pelamis is investigating the advantages of utilizing concrete, in place of steel, as the main construction material for its device, for improved design options and economics.[27] Vattenfall (Sweden) intends to start testing of the latest Pelamis device at EMEC in 2014.[28]

Wello Ltd (Finland) redeployed its Penguin wave energy converter at Orkney in July 2013. The device fully encapsulates a rotating eccentric mass that is actuated by waves, driving a generator typically used in wind turbines.[29] Seatricity (U.K.), another relatively new wave technology company, is poised to develop a 10 MW array of its Oceanus 2—a buoy-type device that pumps seawater onshore for power generation—at the Wave Hub test facility in Cornwall (U.K.).[30]

Minesto (Sweden) started tests in Ireland of a 1:4 scale prototype of its Deep Green tidal device, which it describes as an underwater kite that is designed to work well in low-velocity currents. Deep Green marries a turbine with a wing and a tether, capturing tidal energy while looping tangentially to the direction of the tide. A full-scale device is to be deployed by 2015.[31]

China announced funding for ocean energy technology in 2013, including a 200 kW turbine developed by Harbin Engineering University, as part of a plan to use ocean energy to improve sustainability of remote islands.[32] Other Chinese pilot projects launched in late 2012 and 2013 included wave energy converters developed by Guangzhou Institute of Energy Conversion, and a 120 kW wave buoy developed by Shandong University.[33]

In early 2014, the European Commission launched a two-step action plan to support ocean energy in Europe.[34] The first step was the launch of the Ocean Energy Forum in April, with the aim of bringing together a wide range of stakeholders to find solutions to issues challenging the industry.[35]

SOLAR PHOTOVOLTAICS (PV)

SOLAR PV MARKETS

The global solar PV market had a record year, after a brief slowdown, installing more capacity than any other renewable technology except perhaps hydropower. More than 39 GW was added, bringing total capacity to approximately 139 GW.[1] Almost half of all PV capacity in operation was added in the past two years, and 98% has been installed since the beginning of 2004.[2] (See Figure 12 and Table R7.)

The year saw a major shift geographically as China, Japan, and the United States became the top three installers, and as Asia passed Europe—the market leader for a decade—to become the largest regional market.[3] China's spectacular growth offset Europe's significant market decline, and hid slower-than-expected development in the United States and other promising markets.[4] Nine countries added more than 1 GW of solar PV to their grids, and the distribution of new installations continued to broaden.[5] By year's end, 5 countries had at least 10 GW of total capacity, up from 2 countries in 2012, and 17 had at least 1 GW.[6] The leaders for solar PV per inhabitant were Germany, Italy, Belgium, Greece, the Czech Republic, and Australia.[7]

Asia added 22.7 GW to end 2013 with almost 42 GW of solar PV in operation.[8] China alone accounted for almost one-third of global installations, adding a record 12.9 GW to nearly triple its capacity to approximately 20 GW.[9] (See Figure 13.) Capacity has been added so quickly that grid connectivity and curtailment have become challenges.[10] Much of China's capacity is concentrated in sunny western provinces far from load centers and consists of very large-scale projects, making three state-owned utilities the world's largest solar asset owners.[11] Yet there is increasing interest in smaller-scale distributed PV, and the government aims to shift more focus towards the rooftop market.[12]

Japan saw a rush to install capacity in response to its national FIT, adding 6.9 GW in 2013 for a total of 13.6 GW.[13] The majority of Japan's capacity is in rooftop installations, and homebuilders are promoting solar homes to differentiate their products.[14] For the first time, however, the non-residential sector represented Japan's largest market.[15] Despite the rise of the large-scale market, many more projects were approved than built in the country due to shortages of land, funds, grid access, qualified engineers and construction companies, and Japanese-brand equipment.[16] Elsewhere in Asia, the most significant growth was in India (added 1.1 GW), followed by South Korea (0.4 GW) and Thailand (0.3 GW).[17]

Beyond Asia, about 16.7 GW was added worldwide, primarily in the EU (about 10.4 GW) and North America (5.4 GW), led by the United States—the third largest country-level market in 2013.[18] U.S. installations were up 41% over 2012 to almost 4.8 GW, for a total of 12.1 GW.[19] Falling prices and innovative financing options that enable installation with low-to-no upfront payment are changing the game for U.S. consumers.[20] The residential sector experienced the greatest market growth relative to 2012, while large ground-mounted projects represented more than 80% of additions.[21] U.S. businesses made large investments in solar PV to reduce energy costs, and some utility companies signed long-term contracts, choosing solar PV over other options based on price alone.[22] Utility procurement continued to slow, however, as many approached their Renewable Portfolio Standard (RPS) targets.[23] California installed more than half of the new capacity and is the first major U.S. residential market to successfully transition away from state-level incentives.[24]

Europe continued to operate more solar PV capacity than any other region, with more than 80 GW total by year's end.[25] But the EU's 10.4 GW (11 GW in broader Europe) added was less than half the 2011 amount, and the region's share of the global market also fell rapidly—from 82% in 2010 to 26% in 2013.[26] In most EU markets, demand contracted due to reductions in policy support and retroactive taxes in some countries, which have hurt investor confidence.[27] (See Policy Landscape section.) Yet solar PV's share of generation continues to rise, and PV is increasingly facing barriers such as direct competition with conventional electricity producers.[28]

Germany remained the largest EU market, but fell from first to fourth globally, adding 3.3 GW after three years averaging around 7.6 GW.[29] With a total approaching 36 GW, Germany still has the most capacity of any country by far.[30] About one-third of the electricity generated from new systems is used on-site, a trend driven by FIT rates below prices for retail electricity.[31] The United Kingdom (adding at least 1.5 GW) emerged as the region's strongest market for large-scale projects, with subsidies attracting institutional investors and developers from across the EU.[32] Other top EU markets included Italy (1.5 GW), Romania (1.1 GW), and Greece (1 GW).[33] Italy's market was down dramatically relative to the previous two years, and significant market reductions were seen in Belgium, Denmark, and France.[34]

Australia installed its one-millionth rooftop system, up from around 8,000 in 2007.[35] Over 0.8 GW was added in 2013, as Aussies turned to solar PV to reduce their electricity bills, bringing the total to nearly 3.3 GW.[36] By late 2013, rooftop systems operated on 14% of Australia's residences, and atop one-quarter of the homes in South Australia.[37]

In Latin America and the Caribbean, a number of countries had projects in planning or development by year's end.[i 38] Markets in Brazil and Chile have been slower to develop than was expected, while Mexico has emerged as a regional leader.[39] Both Chile and Mexico brought several large projects on line in 2013 and early 2014.[40]

Most countries in the Middle East now include solar PV in their energy plans, driven by rapid increases in energy demand, a desire to free up more crude oil for export, and high insolation rates.[41] During 2013 and early 2014, large plants were commissioned in several countries—including Jordan, Kuwait, Saudi Arabia, and the United Arab Emirates—and a number of governments signed purchase agreements or launched tenders.[42] There are also many promising markets across Africa.[43] One of the continent's largest markets to date is South Africa, which has procured substantial capacity under a government bidding process and connected the first plant (75 MW) to the grid in late 2013.[44]

By early 2014, at least 53 solar PV plants larger than 50 MW were operating in at least 13 countries.[i 45] The world's 50 biggest plants reached cumulative capacity exceeding 5.1 GW by the end of 2013.[46] At least 14 of these facilities came on line in 2013,

i - For information on off-grid, distributed solar PV for providing energy access in Latin America and elsewhere, see Section 5 on Distributed Renewable Energy in Developing Countries.

including plants in Japan and South Africa (Africa's largest).[47] The largest was a 320 MW PV plant in China, co-located with an existing 1.28 GW hydropower dam.[48] The United States led for total capacity of facilities bigger than 50 MW, with a cumulative 1.4 GW in operation by year's end, followed by Germany, China, India, and Ukraine.[49] Many projects are planned and under development around the world that range from 50 MW to over 1,000 MW in scale.[50]

The share of commercial and utility-owned PV continued to increase in 2013, but the residential sector also saw strong capacity growth.[51] Many utilities are pushing back against the expansion of distributed PV in several countries, due to concerns about a shrinking customer base and lost revenue. In Europe, for example, some utilities are blocking self-consumption by instituting fees, raising rates on customers with PV systems, or debating the future of net metering; in several U.S. states, debates are intensifying over net metering laws; in Australia, major utilities are acting to slow or halt the advance of solar PV.[52] (See Sidebar 7.)

Community-owned PV projects are emerging with a variety of models in an increasing number of countries, including Australia, Japan, the United Kingdom, and Thailand, which has a community solar target under its national FIT.[53] U.S. community solar gardens, which sell power to local utilities in exchange for monthly credits to investors, continued to spread in 2013, and some U.S. states have adopted community solar carve-outs in RPS laws.[54]

The concentrating PV (CPV) market remains small, but interest is increasing due greatly to higher efficiency levels in locations with high direct normal insolation and low moisture.[55] CPV continued its spread to new markets in 2013, with sizable projects completed in Australia, Italy, and the United States, and small pilots under way in Chile, Namibia, Portugal, Saudi Arabia, and elsewhere.[56] China commissioned the world largest plant (50 MW) during 2013.[57] By year's end, more than 165 MW was operating in more than 20 countries, led by China and the United States.[58]

Solar PV is starting to play a substantial role in electricity generation in some countries, meeting an estimated 7.8% of annual electricity demand in Italy, nearly 6% in Greece, 5% in Germany, and much higher daily peaks in many countries.[59] By year's end, the EU had enough solar PV capacity to meet an estimated 3% of total consumption (up from 0.3% in 2008) and 6% of peak demand; global capacity in operation was enough to produce at least 160 TWh of electricity per year.[60]

SOLAR PV INDUSTRY

Following a two-year slump, in which oversupply drove down module prices and many manufacturers reported negative gross margins, the solar PV industry began to recover during 2013.[61] It was still a challenging year, particularly in Europe, where shrinking markets left installers, distributors, and others struggling to stay afloat.[62] Consolidation continued among manufacturers, but, by late in the year, the strongest companies were selling panels above cost.[63] The rebound did not apply lower down the manufacturing chain, however, particularly for polysilicon makers.[64] Low module prices also continued to challenge many thin film companies and the concentrating solar industries, which have struggled to compete.[65] International trade disputes also continued through 2013.[66]

Module prices stabilised, with crystalline silicon module spot prices up about 5% during 2013, in response to robust demand growth in China, Japan, and the United States in the second half of the year.[67] At the same time, module production costs continued to fall. Low material costs (particularly for polysilicon) combined with improved manufacturing processes and scale economies have reduced manufacturing costs, and far faster than targeted by the industry, with top Chinese producers approaching costs of USD 0.50/W in 2013.[68] Interest has turned to lowering soft costs to further reduce installed system costs, which have also declined but not as rapidly as module prices (particularly in Japan and the United States).[69] Although investment in solar PV (in dollar terms) was down for the year, actual installed capacity was up significantly, with the difference explained by declining costs of solar PV systems in recent years.[ii][70] (See Figure 14.)

As of 2013, the cost per MWh of rooftop solar was below retail electricity prices in several countries, including Australia, Brazil, Denmark, Germany, and Italy.[71] By one estimate, solar PV is deemed to be competitive without subsidies in at least 19 markets (in 15 countries).[72] Further, several projects that were planned or under development by year's end were considered to be competitive[iii] with fossil options, without subsidies.[73]

An estimated 43 GW of crystalline silicon cells and 47 GW of modules were produced in 2013, up 20% from 2012, and module production capacity reached an estimated 67.6 GW.[74] Thin film production rose nearly 21% in 2013, to 4.9 GW, and its share of total global PV production stayed flat year-over-year.[75]

Over the past decade, module production has shifted from the United States, to Japan, to Europe, and back to Asia, with China dominating shipments since 2009.[76] By 2013, Asia accounted for 87% of global production (up from 85% in 2012), with China producing 67% of the world total (almost two-thirds in 2012).[77] Europe's share continued to fall, to 9% in 2013 (11% in 2012), and Japan's share remained at 5%.[78] The U.S. share was 2.6%; thin film accounted for 39% of U.S. production, up from 36% in 2012.[79] In India, most manufacturing capacity was idle or operating at low utilisation rates, primarily because it was uncompetitive due to lack of scale, low-cost financing, and underdeveloped supply chains.[80]

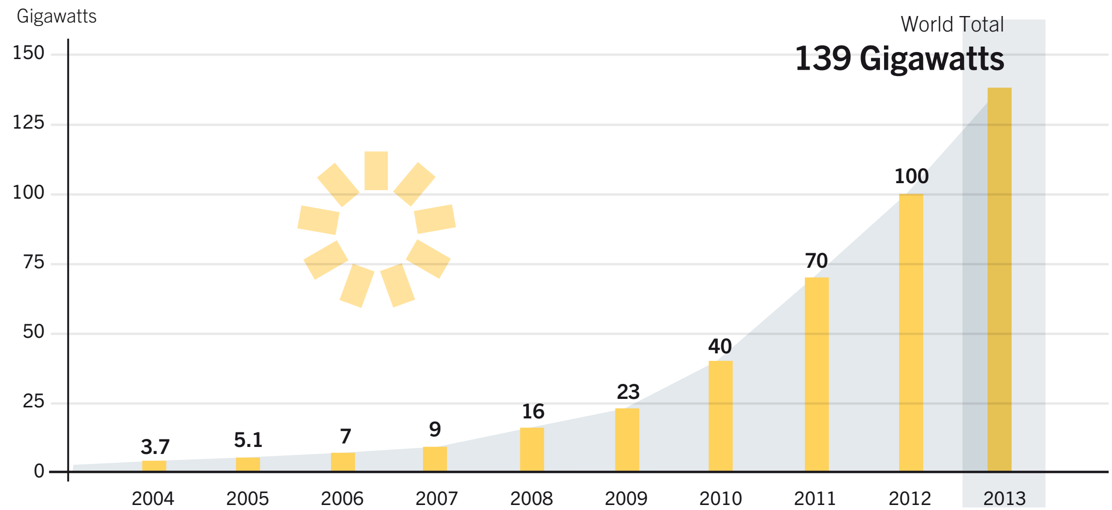
i - It is telling of the rapid changes in PV markets that the 2011 edition of the GSR reported on utility-scale projects >200 kW in size, the 2012 edition on projects >20 MW, and the 2013 edition on projects >30 MW.

ii - Note that data in Figure 14 come from different sources, so they are not perfectly aligned. The investment data reflect the timing of investment decisions, not the amount of capacity installed. So, for example, some dollars invested during calendar year 2012 may have been for systems installed during 2013.

iii - The source for this information does not define "competitive." However, the IEA-PVPS defines possible competitiveness as the situation in which PV produces electricity more cheaply than other sources could have delivered electricity at the same time, per IEA-PVPS, *Trends 2013 in Photovoltaic Applications: Survey Report of Selected IEA Countries Between 1992 and 2012* (Brussels: 2013), p. 65.

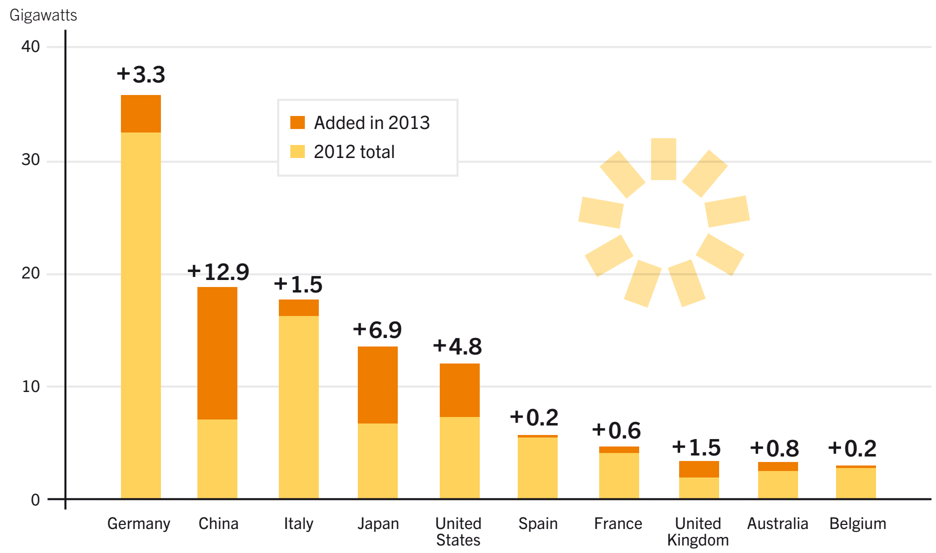
SOLAR PV

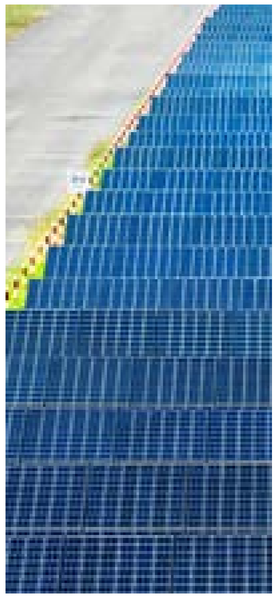
Figure 12. Solar PV Total Global Capacity, 2004–2013



Source: See Endnote 2 for this section.

Figure 13. Solar PV Capacity and Additions, Top 10 Countries, 2013



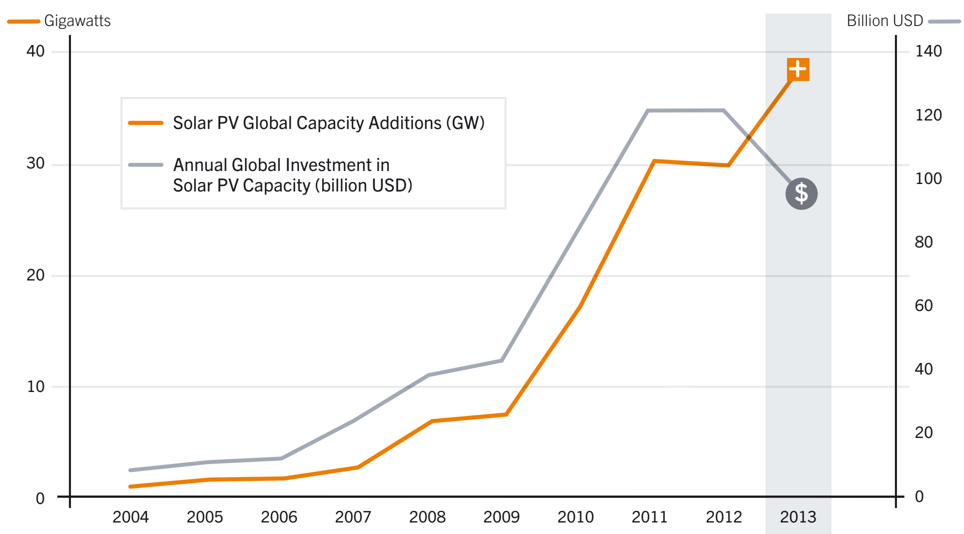


Source: See Endnote 9 for this section.

2013: SOLAR PV INVESTMENT -22%

SOLAR PV ADDITIONS +32%

Figure 14. Solar PV Global Capacity Additions and Annual Investment, 2004–2013



Source: See Endnote 70 for this section.

Yingli and Trina Solar (both China) were the leading module manufacturers in 2013. They were followed by Canadian Solar (Canada), Jinko Solar, and ReneSola (both China). Sharp Solar (Japan), First Solar (United States), Hanwha SolarOne (China), Kyocera (Japan), and JA Solar (China) rounded out the top 10.[81]

Market consolidation among manufacturers continued in 2013, with merger and acquisition activity reaching record levels mid-year, and bankruptcies and closures continuing.[82] CIGS[i] manufacturers, in particular, faced significant challenges due to standardisation and streamlining of crystalline silicon manufacturing and low silicon prices, with several companies entering insolvency or exiting the industry.[83]

China's large investment in solar PV manufacturing helped create the supply-demand imbalance that led to industry upheaval, and even China has suffered the results.[84] Much of the older, less efficient capacity was shut down in 2013, as the national government encouraged consolidation and investment in modern facilities to curb oversupply and to improve quality, which suffered when corners were cut to reduce costs.[85] China's top 10 companies had more than USD 16 billion in debt by August 2013, and Suntech became the first company ever to default on publicly traded debt in China.[86]

Even as some manufacturers idled production capacity or closed shop, others opened new facilities and began expanding capacity across the globe—from North and South America to Europe, Jordan to Turkey, and Kazakhstan to Malaysia.[87] Ethiopia's first module-manufacturing facility (20 MW) began operating in early 2013 to supply the domestic market.[88] Massive new builds were planned in China, which is also set to become a serious thin film player, with Hanergy's acquisition of several companies in 2013.[89] Japanese manufacturers increased domestic production to meet growing domestic demand.[90]

Innovation and product differentiation have become increasingly important.[91] Successful manufacturers have continued expanding into project development, operations, and maintenance.[92] They also are building strategic partnerships to advance technologies and expand markets. For example, First Solar acquired GE's cadmium telluride portfolio, while both announced a partnership to advance thin films; SolarCity (United States) teamed up with American Honda and BMW to make solar PV more affordable for hybrid and electric vehicle owners; and Hanergy partnered with retailer IKEA to offer solar PV installation services to U.K. customers.[93] Manufacturers also joined with utilities and fossil fuel companies to build solar PV plants, while traditional energy and even non-energy companies, such as toll road operator Huabei Express (China), moved further into solar development.[94]

Merger and acquisition activity continued on the development side. Existing large-scale projects were purchased on a far more global scale than in past years, due to increasing ease of financing and growing interest among pure investment firms.[95] At least two German developers filed for insolvency during 2013, while others expanded their reach—Juwi (Germany) opened a subsidiary in Dubai to serve customers in East Africa and the MENA region.[96] SunEdison bought EchoFirst (both United States), which offered what it claimed was the first combined solar electric and solar thermal lease for the U.S. residential market.[97]

New business models and innovative financing options continued to emerge, with practices such as solar leasing spreading beyond the United States to Canada, Europe, the Pacific, and elsewhere.[98] In late 2013, Toshiba (Japan) entered the solar power business in Germany, installing PV systems on apartment buildings and selling electricity to residents directly; systems will be owned and funded by a group of pension funds.[99] By early 2014, Mosaic (United States), an online platform for solar project investments, had financed more than USD 5 million by enabling people to invest small amounts towards specific projects, and SolarCity (United States) announced plans to offer a bond-like product for individual investors, backed by cash flows from existing customers.[100] New models also are emerging in Latin America, including the sale of PV electricity into the wholesale market (rather than through long-term contracts), with such merchant plants being built in Chile and Mexico.[101]

Solar cell efficiencies continued to increase with more records announced during 2013.[102] Perhaps the biggest technology advance centered on perovskite materials, which experienced a steep rate of efficiency improvement during 2012 and 2013. They offer the potential for high-performing yet inexpensive solar cells, although they have significant challenges to overcome before coming to market.[103]

CPV had a mixed year in 2013, with key companies closing plants and consolidation affecting both module and system suppliers. At the same time, the industry saw new strategic partnerships and expansions in manufacturing capacity.[104] Soitec (France) announced plans to consolidate by closing its 40 MW plant in Freiburg, Germany, but also achieved full production capacity at its factory in California, and partnered with Alstom (France) to develop CPV plants in France.[105] Solar Junction and Amonix (both United States) partnered to improve CPV efficiency.[106] The industry is showing signs of moving beyond niche markets, with Soitec building a 44 MW project in South Africa, and several companies announcing or commissioning production lines in 2013 to meet growing interest in China.[107] New cell and module conversion efficiency records were set in 2013, and improvements to mirror and tracker technologies continued.[108]

Solar inverters are becoming more sophisticated to actively support grid management, and are considered one of the fastest developing technologies in power electronics.[109] Partly because of this rapid development, in 2013 ABB (Switzerland) acquired Power-One (United States), one of the world's largest manufacturers of solar power inverters.[110] At the same time, the industry has become increasingly crowded and markets more fragmented, and the largest incumbents faced challenges maintaining growth or even surviving in 2013.[111] Inverter manufacturers were under pressure to reduce prices, as the European market slowed faster than expected and as the focus of cost-cutting efforts turned increasingly towards balance-of-system technologies.[112]

i - Copper indium gallium selenide solar cells, which are in the thin film category of solar PV.

CONCENTRATING SOLAR THERMAL POWER (CSP)

CSP MARKETS

The concentrating solar thermal power (CSP) market continued to advance in 2013 after record growth in 2012. Total global capacity increased by nearly 0.9 GW, up 36%, to more than 3.4 GW.[1] (See Figure 15 and Reference Table R8.) The United States and Spain continued their global market leadership.[2] However, a global shift to areas of high direct normal irradiation (DNI) in developing-country markets is accelerating.[3] Global installed capacity of CSP has increased nearly 10-fold since 2004; during the five-year period from the end of 2008 to the end of 2013, total global capacity grew at an average annual rate approaching 50%.[4]

Parabolic trough technologies represented all of the facilities added during the year, as well as the majority of plants under construction by mid-2013. Towers/central receivers continued to increase their market share, however, with significant capacity added in early 2014.[5] Fresnel and parabolic dish technologies remain in an earlier developmental stage.

The United States became the leading market in 2013, adding 375 MW to end the year with almost 0.9 GW in operation, and just short of 1 GW under construction.[6] The new Solana plant (250 MW) in Arizona is the world's largest parabolic trough plant and the first U.S. CSP plant with thermal energy storage (TES).[7] U.S. capacity took another significant leap in early 2014, when the 377 MW Ivanpah plant started feeding electricity into the grid.[8] Upon its completion, the Ivanpah plant, based on tower/central receiver technology, was the largest solar thermal electric facility of any type operating in the world.[9]

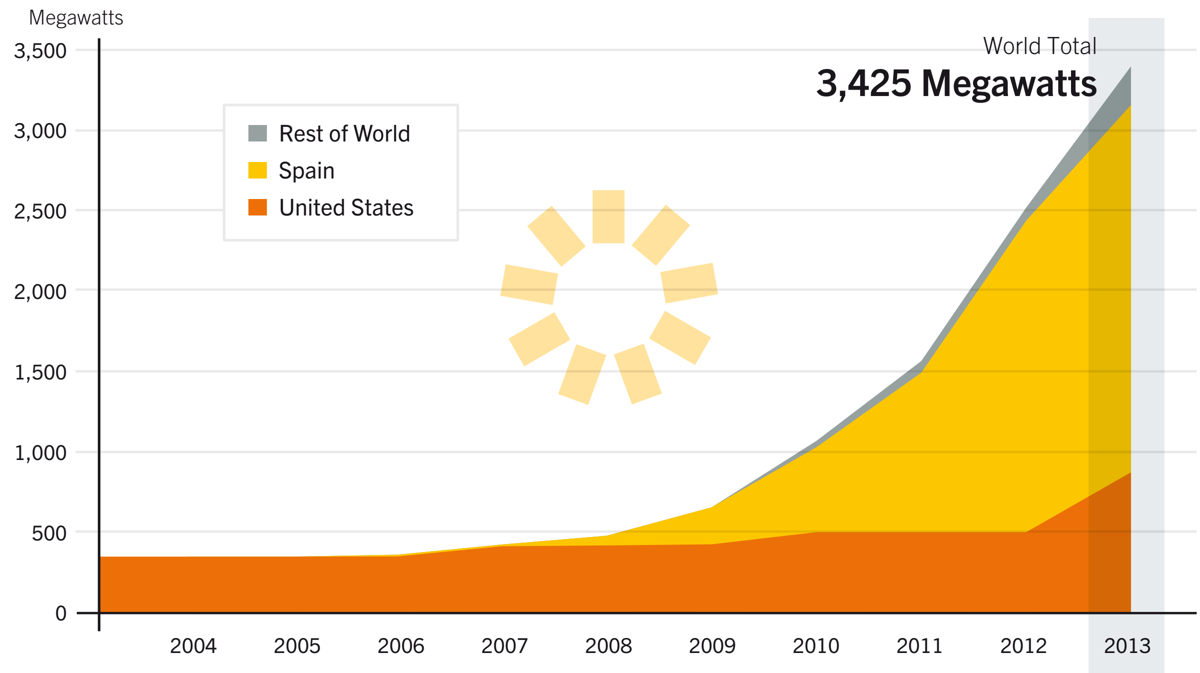
Spain sustained its global leadership in existing CSP capacity, adding 350 MW in 2013 to increase operating capacity by 18%, for a total of 2.3 GW at year's end.[10] Parabolic trough remained the dominant technology in Spain, making up all of the capacity that came on line during the year. Due to policy changes in 2012 and early 2013 that placed a moratorium on new construction in the country, no new plants were under construction by the end of 2013.[11] Thus, the United States is set to maintain its position as the leading CSP market in 2014.

In other markets, capacity nearly tripled during 2013, to just under 250 MW.[12] Additions included the 100 MW Shams 1 plant in the United Arab Emirates and a 50 MW plant in Rajasthan, India (both parabolic trough plants), and the first phase (10 MW) of a 50 MW tower/central receiver plant in Delingha, China.[13] Other countries with existing CSP that did not add capacity in 2013 include Algeria (25 MW), Egypt (20 MW), Morocco (20 MW), Australia (13 MW), and Thailand (5 MW).[14] Several additional countries had small pilot plants in operation, including France, Germany, Israel, Italy, South Africa, South Korea, and Turkey.[15]

During 2013, CSP continued to expand to new markets in Asia, Latin America, and particularly across Africa and the Middle East.[16] South Africa remained one of the most active markets, with 100 MW of parabolic trough and 100 MW of power tower capacity under construction at year's end.[17] In neighbouring Namibia, preliminary evaluation of a 50 MW plant with TES was under way.[18] Over USD 600 million was pledged in 2013 to support Algeria, Egypt, Jordan, Libya, Morocco, and Tunisia in bringing more than 1 GW of CSP to the regional market.[i] [19] As of early 2014, construction was under way in Morocco (160 MW) and Egypt (100 MW).[20]

In the Middle East, Kuwait opened bidding procedures for a 50 MW CSP plant with thermal storage, expected to be operational in 2016.[21] Saudi Arabia announced plans to spend USD 109

Figure 15. Concentrating Solar Thermal Power Global Capacity, by Country or Region, 2004–2013



Source: See Endnote 1 for this section.

i - This was pledged by the Climate Investment Funds, which are supported by the African Development Bank, the Asian Development Bank, the European Bank, the Inter-American Development Bank, and the World Bank Group.

billion on more than 50 GW of renewable energy by 2032, 25 GW of which will come from CSP.[22] In Israel, construction was scheduled to begin in 2014 on the first phase (121 MW) of a 250 MW CSP plant in the Negev Desert.[23]

Elsewhere around the world, Chile advanced towards its first commercial CSP capacity with the award of a 110 MW tower/central receiver tender in 2013.[24] In India, six of the plants being developed under the Jawaharlal Nehru National Solar Mission (JNNSM) were held back by technical, procurement and financing delays, as well as apparent errors in solar resource assessments.[25] Italy's market—hindered by regulatory challenges in the past—received a boost after the feed-in tariff introduced in December 2012 attracted licence applications for over 200 MW of new CSP capacity.[26]

CSP technologies are being used to support an increasing number and range of hybrid electricity generation activities and processes, and are being applied to augment steam production at coal, gas, and geothermal power plants.[27] The 44 MW_{th} Kogan Creek Solar Boost project under construction in Australia is expected to start supplementing existing coal-based steam generation when operations commence in 2015.[28]

In some markets, CSP continues to face challenges related to strong competition from solar PV technologies and environmental concerns, with several plants in the United States being delayed, withdrawn, or converted to solar PV.[29] While global growth of CSP is expected to fall short of past projections, interest in CSP plants using TES is growing in a number of markets, where it is seen as a valuable source of renewable dispatchable electric capacity.[30] Emerging markets such as Saudi Arabia and Chile have made TES mandatory for future CSP developments.[31]

CSP INDUSTRY

The industry continued expanding into new markets in 2013.[32] Yet while global growth of the sector remained strong, revised projections, fed by increasing competition from declining solar PV costs, led a number of companies to close their CSP operations.[33]

The top companies in 2013 included Abengoa, Acciona, ACS Cobra, and Torresol Energy (all Spain); Brightsource and Solar Reserve (both United States); Schott Solar (Germany); and AREVA (France). German firm Siemens announced the closure of its CSP business after losses of USD 1 billion or more since 2011, while Schott Solar closed its 400 MW U.S. plant to focus on winning projects in the Middle East.[34]

As of early 2013, Abengoa Solar had the world's largest portfolio of plants in operation or under construction, and Spanish companies continued to lead the industry with ownership interest in almost three-quarters of CSP capacity deployed around the world.[35] However, the dead stop in the Spanish market pushed Spanish CSP developers further afield in search of development opportunities.[36]

The limitations of synthetic oils and molten salts as heat transfer media have driven research into a range of alternatives, such as superheated steam; ternary salts; graphite storage; ceramic storage; and rocks, pebbles, and slag.[37] The growing potential of TES systems was showcased when the system at Spain's Gemasolar plant enabled uninterrupted power generation for 36 consecutive days.[38]

A trend towards larger plants continued, as evidenced by the commencement of operations at the Ivanpah and Solana plants in the United States and by the scale of many of the plants under construction in the MENA region. Growing evidence emerged of the potential cost reductions of larger plants, relating to their ability to work at higher temperatures and achieve greater efficiencies.[39]

CSP costs also continue to be reduced through enhanced design and improved manufacturing and construction techniques. SHEC Energy (Canada) claimed significant reductions in materials cost through the adoption of new production technologies; the application of lightweight, high-strength materials and a proprietary structural stiffening technique; and automated, manufacturing processes to create light and strong structures.[40]

Research on hybrid CSP applications, and the augmentation of steam production at traditional power plants, continued in 2013. In the United States, the National Renewable Energy Laboratory (NREL) and the Idaho National Laboratory launched joint research on the augmentation of geothermal plants with CSP, while the U.S. Department of Energy pledged USD 10 million for integration of CSP at the 500 MW natural gas-fired Cosumnes Power Plant in Sacramento, California.[41]

SOLAR THERMAL HEATING AND COOLING

SOLAR THERMAL HEATING AND COOLING MARKETS

Solar thermal technologies contribute significantly to hot water production in many countries, and increasingly to space heating and cooling as well as industrial processes. In 2012[i], the world added 55.4 GW_{th} (more than 79 million m^2) of solar heat capacity, increasing the cumulative installed capacity of all collector types in operation by over 14% for a year-end total of 283.4 GW_{th}.[ii 1] An estimated 53.7 GW_{th} (almost 97%) of the market was glazed water systems and the rest was unglazed water systems mainly for swimming pool heating (3%), as well as unglazed and glazed air collector systems (<1%).[2] Glazed and unglazed water systems provided an estimated 239.7 TWh (863 PJ) of heat annually.[3]

The vast majority of solar heat capacity is in China, which accounts for 86% of the world market and 64% of total capacity in 2012.[4] (See Figure 16.) The top countries for capacity added in 2012, including both glazed and unglazed systems[iii], were China, Turkey, India, Brazil, and Germany, and the top five for total capacity in operation remained China, the United States, Germany, Turkey, and Brazil.[iv 5] (See Figure 17 and Reference Table R9.)

Most countries focus on glazed water collectors, with China primarily using evacuated tube water collectors (ETC), and other key markets relying mainly on flat plate (FPC). In the United States, the majority of systems use unglazed water collectors for pool heating. The only other markets of note for unglazed water collectors are Australia and Brazil.[6]

In 2013, an estimated 57.1 GW_{th} (81.6 million m^2) of gross capacity was added worldwide, bringing operating global solar thermal capacity to about 330 GW_{th} (including 325.9 GW_{th} of water collectors and an estimated 3.6 GW_{th} of air collectors).[7] (See Figure 18.) There was enough capacity by year's end to provide approximately 276.6 TWh (996 PJ) of heat annually.[8]

China was again the main demand driver in 2013, adding 46.2 GW_{th} (up 3.3% over 2012).[9] A significant share (21%) of the new collectors in China replaced existing capacity, although the replacement rate was reportedly lower than in past years; approximately 36.6 GW_{th} of newly installed capacity was additional, bringing the country's total to 217 GW_{th}.[10] In China, solar water heaters cost far less over their lifetimes than do electric or gas water heaters—a major factor driving the market.[11] China's use of solar thermal on urban apartment buildings is expanding rapidly, and it includes roof- and façade-integrated systems. The urban sector represented nearly half of the 2013 market, with growth driven largely by green building policies and solar mandates.[12]

The European Union (EU-28) supports a greater diversity of uses for solar thermal heat technologies than any other market.[13] In 2012, Europe's total operating capacity was up 7.5% over 2011 to 30.2 GW_{th}, but the annual market declined for the fourth consecutive year, down 5.8% to 2.3 GW_{th}.[14] In 2013, the region continued to account for a significant share of the capacity additions made outside of China. However, growth contracted again in many countries, constrained by lower construction and renovation rates (due in large part to the economic crisis), pressure from solar PV and heat pumps (particularly in Austria, Germany, and France), and the reduction of support policies for solar heating.[15] Germany and Austria, the long-term EU leaders for total installations, both experienced marked declines. Germany remained Europe's largest installer in 2013, adding 0.7 MW_{th} for a total of 12.3 GW_{th}; but this was down 11% from 2012, following a 9.4% drop in 2011.[16] The Austrian market shrank about 14% in 2013, following declines of nearly 16% in 2012 and 13% in 2011.[17]

Over a six-year period, Brazil's market more than doubled, with nearly 1 GW_{th} added in 2013 for a total approaching 7 GW_{th}.[18] Demand is driven largely by the economic competitiveness of solar thermal in Brazil and by municipal building regulations and social housing programmes, such as Minha Casa, Minha Vida ("My House, My Life"), that mandate solar water heaters in new buildings for very poor families.[19] Mexico is also starting to play a role, and there are very small but growing markets in Argentina, Chile, Costa Rica, and Uruguay.[20]

India and Japan are the largest Asian markets outside of China. India added 0.9 GW_{th} during 2013 for a year-end total of 5.2 GW_{th}.[21] Japan's market was stable during 2012 and 2013, at about 0.1 GW_{th} per year, but cumulative capacity is declining due to decommissioning of old systems.[22] After Thailand's five years of steady growth, driven by the national incentive programme and rising fuel prices, the market for subsidised systems declined 28% in 2013.[23] The drop is considered to be a direct result of Thailand's new solar PV programme, which drew investment away from solar heating.[24]

Turkey, the United States, and Australia continue to be important markets; as of publication, however, data for 2013 were not available. In 2012, Turkey added 1.1 GW_{th} to end the year with 10.8 GW_{th} and retain its fourth place ranking for total operating capacity.[25] The market was down relative to a spike in 2011, but is generally quite stable even without government incentives.[26]

About 60% of all unglazed water collectors operate in the United States, where an estimated 30,000 swimming pool systems are installed annually.[27] While the country continues to rank second for total collector area, with 16.2 GW_{th} at the end of 2012 (14.3 GW_{th} of which is unglazed), it placed sixth for additions that year (0.7 GW_{th}).[28] Some U.S. states have set solar thermal carve-outs in their renewable portfolio standards (RPS), or allow electric utilities to meet RPS requirements with solar water heating systems.[29]

Australia added an estimated 0.6 GW_{th} during 2012 (71% unglazed), for a year-end total of 5.1 GW_{th} (59% unglazed).[30] A large share of Australian households heats water with solar thermal systems, with the highest number in New South Wales. By early 2013, more than 630,000 systems were in operation.[31]

In the Middle East, Israel leads for total capacity (with about 85% of households using solar water heaters), followed by Jordan and Lebanon.[32] Solar thermal systems are used to heat water in

i - The year 2012 is the most recent one for which firm global data and most country statistics are available.

ii - Data include air collectors. Gross (including replacements) water heating collector capacity additions in 2012 were 55.4 GW_{th}, for a year-end total of 281.7 GW_{th}.

iii - Starting with this edition, the GSR covers both glazed and unglazed water systems throughout. For more details, see Methodological Notes, page 142.

iv -Note that the 2012 data in Figure 18 are total installations of water collectors and include replacement capacity, which accounts for a large share of China's additions. In 2013, for example, about 21% of China's additions (9.6 GW_{th}) were to replace existing capacity.

SOLAR THERMAL HEATING AND COOLING

Figure 16. Solar Water Heating Collectors Global Capacity, Shares of Top 10 Countries, 2012

Source: See Endnote 4 for this section.

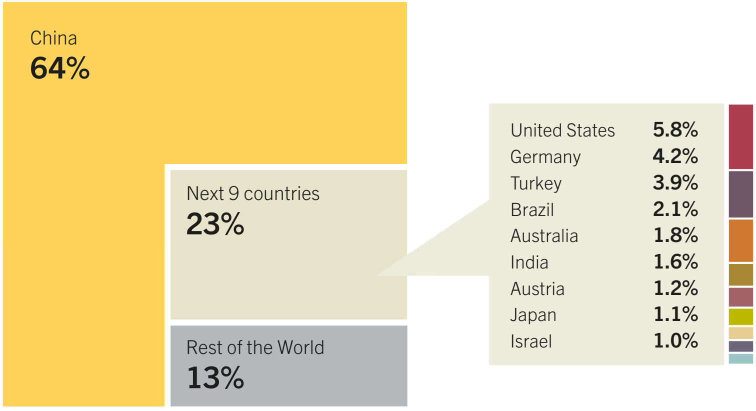


Figure 17. Solar Water Heating Collector Additions, Top 10 Countries for Capacity Added, 2012

Source: See Endnote 5 for this section.

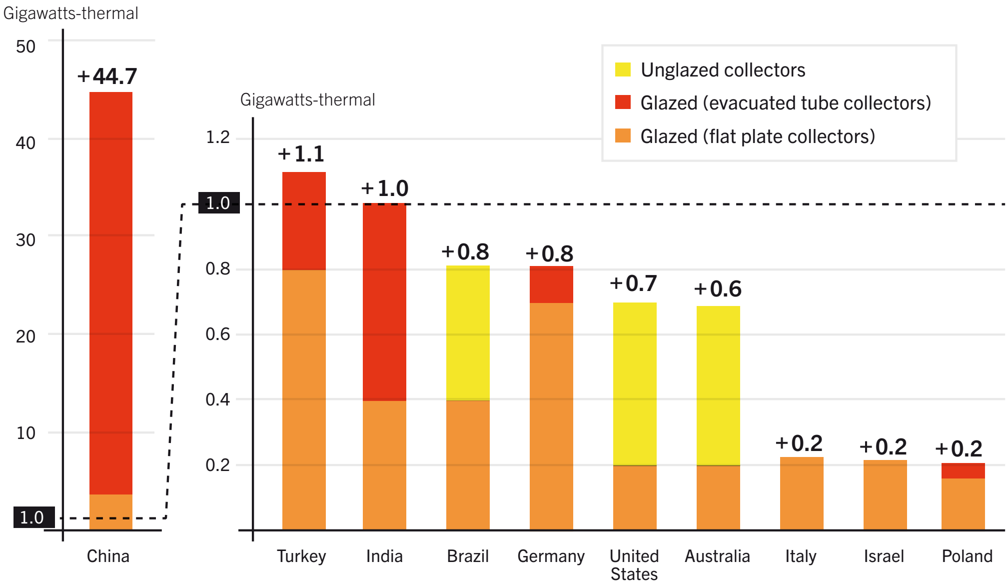
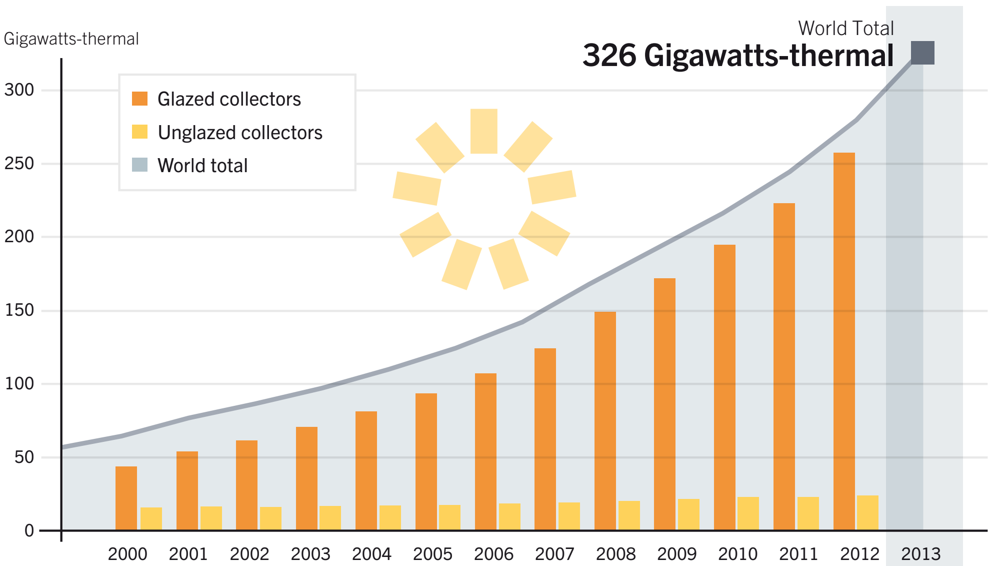


Figure 18. Solar Water Heating Collectors Global Capacity, 2000–2013

Source: See Endnote 7 for this section.



Data are for solar water collectors only (not including air collectors).

several African countries, including Egypt, Mozambique, Tunisia, Zimbabwe, and South Africa, the most mature market in sub-Saharan Africa.[33] However, markets in many developing countries are challenged by a lack of standards, leading to use of inferior products and poor installations, which have undermined solar thermal's reputation.[34]

At the end of 2012, Cyprus remained the world leader on a per capita basis considering all water collectors, with 548 kilowatts-thermal (kW_{th}) per 1,000 inhabitants, followed by Austria (420 kW_{th}), Israel (385 kW_{th}), Barbados (320 kW_{th}), and Greece (268 kW_{th}).[35]

Most solar thermal systems are used for domestic water heating, and they typically meet 40–80% of demand.[36] There is a trend towards larger domestic water heating systems for hotels, schools, multi-family homes, and other large complexes.[37] The use of solar thermal systems for space heating is also gaining ground, particularly in Central Europe, where 100% solar-heated buildings have been demonstrated (although typically solar meets 15–30% of space heating demand).[38] "Combi-systems," which provide water and space heating, account for about 4% of the global solar thermal heat market.[39] They are most common in Europe (particularly Austria, Germany, Italy, and Poland) and represent about 40% of installed systems in Austria and Germany.[40] Solar thermal heating can be combined with various back-up heat sources, and hybrid systems with heat pumps are gaining popularity in Europe.[41]

Domestic hot water and space heating are provided by conventional flat plate and evacuated tube collectors, which typically supply heat at temperatures below 60 °C.[42] Advanced collectors can be used for solar-assisted district heating as well as industrial and commercial applications with typical operating temperatures in the 60–120 °C range; they can also drive some cooling systems.[43] Concentrating systems—including parabolic trough, dish, and Fresnel collectors (smaller than their CSP relatives and adapted to specific needs)—provide heat at higher temperatures (typically 120–250 °C, and up to 400 °C) for industrial processes or to drive double- or triple-stage absorption chillers.[44]

An increasing number of district heating systems relies on solar thermal technology, often combined with other heat sources such as biomass.[45] Although the market for such systems remains relatively small, interest has increased in recent years, particularly across Europe.[46] More than 200 solar thermal district heating plants operate in about 20 EU countries, with 50 of these in Denmark (where systems are cost competitive), and over 20 each in Austria, Germany, and Sweden.[47] Interest is rising beyond Europe as well, with large heat systems also operating in Canada, China, and South Africa.[48] At least 17 plants bigger than 700 kW_{th} (1,000 m^2) were constructed in 2013, and the world's largest plant began operating in Denmark in early 2014.[49]

The still-modest global solar cooling market grew at an average annual rate exceeding 40% between 2004 and 2012, and approximately 1,050 systems of all technology types and sizes were installed by 2013.[50] While most of these systems were in Europe (81%), use of solar cooling is rising in many regions with sunny dry climates, including Australia, India, Mediterranean islands, and the Middle East.[51] The availability of small (<20 kW) cooling kits for residential use has increased interest in the residential sector in Central Europe and elsewhere, and large-scale systems are gaining appeal due to their more favourable economics.[52] One of the market drivers for solar cooling is the potential to reduce peak electricity demand, particularly in countries with significant cooling needs.[53]

Solar thermal technologies are being used increasingly for industrial applications, providing heat and steam, refrigeration, and air conditioning.[54] Major industrial applications include food processing, cooking, and textile manufacturing.[55] In 2013, the world's largest low-temperature system was inaugurated in Chile, where it is expected to cover 85% of the heat demand of the Gaby copper mine.[56] Other 2013 projects included dairies in Mexico and Switzerland, leather tanneries in Kenya and Thailand, and a chemical manufacturing facility in Germany.[57] India leads in the use of concentrating solar thermal systems with at least 145 systems producing steam, primarily for cooking.[58] Rising fuel prices have driven rapid expansion and, as of early 2014, India had an estimated 40 MW_{th} for industrial applications.[59] In 2013, several countries offered funding specifically for solar process heat.[60]

Although interest is growing around the world, district heating networks, solar air conditioning, and solar process heat for industrial purposes account for only about 1% of global solar thermal capacity.[61] There also exists a large untapped potential for new applications such as water treatment and sea water desalination.[62]

SOLAR THERMAL HEATING/COOLING INDUSTRY

China maintained its multi-year lead in the global solar heating industry, producing an estimated 50.1 GW_{th} (71.6 million m^2) of collectors in 2013.[63] Export activities remained negligible (1.8% in 2012, or USD 300 million) compared to the industry's total turnover, but they continued to increase.[64] The market shares of Chinese vacuum tubes continued to rise in price-sensitive export markets including Poland, Turkey, and India.[65]

By contrast, Europe saw accelerated consolidation during 2013, with several large suppliers announcing their exit from solar thermal manufacturing.[66] In two cases, management buyouts prevented abandonment of the collector technology or brand.[67] However, a large number of smaller European collector manufacturers no longer considers in-house production to be economically feasible due to high price pressures and low-cost imports from outside Europe, especially from China.[68] To offset decreasing domestic demand, many European companies have focussed on foreign markets through local partnerships and investments.[69]

South Africa's supply chain has been in a consolidation phase, with the number of commercial entities in the solar water heater market falling from a high of over 700 in 2011 to about 400 in 2013.[70] Brazil had about 150 solar thermal suppliers by mid-2013.[71] While most focussed on the domestic market, a small number of companies were exporting to other countries in the region.[72]

In 2013, industry expectations for current and future market development were brightest in India and Greece.[73] Manufacturers in India expanded production capacities and integrated vertically in response to rapid market growth.[74]

Production costs of solar thermal heat technologies have continued to decline. In Europe, for instance, production costs of standard collectors fell about 23% for every doubling of installed capacity from 1995 to 2012, or nearly 50% over the period.[75] And new technologies continue to emerge. For example, by early 2014 there were more than 130 hybrid solar thermal-heat pump systems from more than 80 companies (mostly in Europe) for combined production of domestic water and space heating.[76] About 30 companies in at least 12 countries were making a variety of photovoltaic thermal (PV-T) hybrid solar collectors that combine solar PV and thermal water collectors for simultaneous production of power and heat.[77]

Attention to quality standards and certification continued in response to high failure rates associated with cheap tubes from China, and harmonisation of standards and certification played an important role in the industry's export strategies.[78] In September, the International Standard Committee approved a global collector test standard, paving the way for a variety of new collector technologies to receive a Solar Keymark label in Europe.[79] In addition, several countries are working on domestic standards.[80]

A growing number of manufacturers around the world specialise in concentrating collectors for industrial applications.[81] Solar process heat is already competitive in many niche markets today, but the technology is not widely known.[82]

The cost of solar cooling kits continues to fall, declining by 45–55% (depending on system size) over the period 2007–2012.[83] The variety of thermal chillers continued to increase in 2013, as did their standardisation.[84] At least two European companies released new chillers for small systems down to 5 kW, and companies in Europe and Asia introduced cooling kits that include integrated heat rejection (which removes waste heat generated by the system).[85] Alternative heat rejection systems are under development to reduce costs and planning time.[86] In addition to new chillers, innovative technologies continue to emerge, particularly for large-scale and industrial systems.[87]

WIND POWER

WIND POWER MARKETS

More than 35 GW of wind power capacity was added in 2013, bringing the global total above 318 GW.[1] (See Figure 19 and Reference Table R10.) Following several record years, the wind power market declined nearly 10 GW compared to 2012, reflecting primarily a steep drop in the U.S. market.[2] The top 10 countries accounted for 85% of year-end global capacity, but there are dynamic and emerging markets in all regions.[3] By the end of 2013, at least 85 countries had seen commercial wind activity, while at least 71 had more than 10 MW of reported capacity by year's end, and 24 had more than 1 GW in operation.[4] Annual growth rates of cumulative wind power capacity have averaged 21.4% since the end of 2008, and global capacity has increased eightfold over the past decade.[5]

Asia remained the largest market for the sixth consecutive year, accounting for almost 52% of added capacity, followed by the EU (about 32%) and North America (less than 8%).[6] Non-OECD countries were responsible for the majority of installations, and, for the first time, Latin America had a substantial share (more than 4.5%).[7] China led the market, followed distantly by Germany, the United Kingdom, India, and Canada. Others in the top 10 were the United States, Brazil, Poland, Sweden, and Romania, and new markets continued to emerge in Africa, Asia, and Latin America.[8] The leading countries for wind power capacity per inhabitant were Denmark (863 W per person), Sweden (487.6), Spain (420.5), Portugal (412), and Ireland (381).[9]

China added an estimated 16.1 GW of new capacity in 2013, increasing total installed capacity by 21% to 91.4 GW.[10] (See Figure 20.) About 14.1 GW was integrated into the grid, with approximately 75.5 GW in commercial operation by year's end.[11] Difficulties continued in transmitting power from turbines (particularly in remote northeast areas) to population demand centres, and about 16 TWh lost due to curtailment.[12] However, new transmission lines and turbine deployment in areas with better grid access are reducing the number of idled turbines, and the rate of curtailment dropped from 17% in 2012 to 11% in 2013.[13]

Wind generated 140.1 billion kWh in China during 2013, up 40% over 2012 and exceeding nuclear generation for the second year running.[14] By year's end, almost 25% of total capacity was in the Inner Mongolia Autonomous Region, followed by Hebei (10%), Gansu (9.1%), and Liaoning (7.3%) provinces, but wind continued its spread across China—10 provinces had more than 3 GW of capacity.[15]

The European Union remained the top region for cumulative wind capacity, with 37% of the world's total, although Asia was nipping at its heels with more than 36%.[16] Wind accounted for the largest share (32%) of new EU power capacity in 2013; more than 11 GW of wind capacity was added for a total exceeding 117 GW.[17] Europe is experiencing a seaward shift, with the offshore market up 34%.[18] However, the total market in the region was down 8% relative to 2012, and financing of new projects is becoming more challenging in response to policy uncertainty and declining incentives.[19]

Germany and the United Kingdom accounted for 46% of new EU installations, a level of concentration not seen since 2007.[20]

Driven largely by anticipated reforms to the Renewable Energy Sources Act (EEG), Germany remained Europe's largest market and set a new record for installations.[21] More than 3.2 GW was added to the German grid in 2013, including more than 0.2 GW for repowering; by year's end, a total of 34.3 GW was grid-connected (and 34.7 GW total installed).[22] Germany generated 53.4 TWh with the wind in 2013.[23] The United Kingdom added 1.9 GW to the grid, 39% of which was offshore, for a year-end total of 10.5 GW.[24]

Other top EU markets were Poland (0.9 GW), Sweden (0.7 GW), Romania (0.7 GW), and Denmark (0.7 GW).[25] France (0.6 GW) and Italy (0.4 GW) both saw significant market reductions in 2013.[26] Spain remained third in the region for cumulative capacity, but recent policy changes have brought the market to a virtual standstill, with the lowest additions (less than 0.2 GW) in 16 years.[27] The highest growth rates were seen in Croatia (68%) and Finland (56.3%), from low bases, and Romania (36.5%) and Poland (35.8%).[28] Slovenia added capacity for the first time.[29]

India was the fourth largest market in 2013, although demand contracted by 26%.[30] Over 1.7 GW was installed for a total approaching 20.2 GW.[31] A steep devaluation of the rupee against the U.S. dollar (which increased financing and import costs), and removal of key support policies in 2012, delayed investment in wind power.[32] However, retroactive reinstatement of the Generation Based Incentive in late 2013 helped resurrect the market.[33] Elsewhere in the region, Japan saw a slowdown in deployment, due largely to new regulatory requirements and delays for grid access, while Thailand and Pakistan both doubled their capacity.[34]

Canada installed a record 1.6 GW, a market increase of more than 70%, for a total of 7.8 GW, led by Ontario (2.5 GW) and Quebec (2.4 GW).[35] The United States ended the year with 61.6 GW, up by just over 1 GW.[36] This represented a significant drop from the 13.1 GW installed in 2012, when developers rushed to complete projects before the federal Production Tax Credit (PTC) expired.[37] Even so, utilities and corporate purchasers signed a record number of long-term contracts in response to low power prices, and more than 12 GW of projects was under construction by year's end.[38] Texas led for total capacity (12.4 GW), followed by California (5.8 GW), Iowa (5.2 GW), Illinois (3.6 GW), and Oregon (3.2 GW).[39]

Elsewhere, the most significant growth was seen in Latin America. Brazil installed more than 0.9 GW of capacity (down from 1.1 GW in 2012) to rank seventh for newly installed wind capacity.[40] It ended the year with almost 3.5 GW of commissioned capacity—nearly three-fourths of the region's total—of which 2.2 GW was grid-connected and in commercial operation.[41] Utility interest in wind power is increasing because it complements Brazil's reliance on hydropower, and by year's end more than 10 GW of additional capacity was under contract.[42] Others in the region to add wind capacity included Argentina, Chile, and Mexico.[43]

Australia was again the only country in the Pacific to add wind capacity (0.7 GW), bringing its total to more than 3.2 GW.[44] In Turkey, where interest in wind power is driven partly by heavy reliance on Russian gas, 0.6 GW was installed for a total approaching 3 GW.[45] Africa and the Middle East saw little new operating capacity beyond Morocco (0.2 GW) and Ethiopia, which completed Africa's largest individual wind farm (120 MW), with the aim of mitigating the impact of dry seasons on national hydropower output.[46] However, other countries in the region moved ahead with new projects, and several announced long-term plans.[47]

Offshore wind is still small compared with global onshore capacity, but it is growing rapidly. A record 1.6 GW was added to the world's grids for a total exceeding 7 GW in 14 countries by year's end.[48] More than 93% of total capacity was located off Europe, which added 1,567 MW to the grid for a total of 6,562 MW in 11 countries.[49] The United Kingdom has more than 52% of the world's offshore capacity. It was the largest market (adding 733 MW) in 2013, followed in Europe by Denmark (350 MW), Germany (595 MW total, and 240 MW grid-connected), and Belgium (192 MW).[50] But the EU record hides delays due to policy uncertainty, particularly in Germany and the United Kingdom, and cancellation or downsizing of projects due to cost and wildlife concerns.[51] The remaining offshore capacity is in China, Japan, and South Korea; China added 39 MW for almost 430 MW total.[52] Two U.S. projects qualified for the PTC before it expired and are competing to be the first commercial project operating off U.S. shores.[53]

Offshore and on, independent power producers and energy utilities remained the most important clients in the market in terms of capacity installed. However, there is growing interest

02

in other sectors. The number of large corporate purchasers of wind power and turbines continued to increase during 2013.[54] In addition, interest in community-owned wind power projects is growing in Australia, Canada, Japan, the United States, parts of Europe, and elsewhere.[55] Community and co-operative power has long represented the mainstream ownership model in Denmark and Germany.[56] Today, shared ownership is expanding through a variety of means, including innovative financing mechanisms such as crowd funding.[57]

The use of individual small-scale[i] turbines is increasing, with applications including defence, rural electrification, water pumping, battery charging, telecommunications, and other remote uses.[58] Off-grid and mini-grid applications prevail in developing countries.[59] Worldwide, at least 806,000 small-scale turbines were operating at the end of 2012, exceeding 678 MW (up 18% over 2011).[60] While most countries have some small-scale turbines in use, capacity is predominantly in China and the United States, with an estimated 274 MW and 216 MW, respectively, by the end of 2012.[61] They are followed by the United Kingdom, which added a record 38 MW in 2012, driven by a micro-generator FIT, to exceed 100 MW total.[62] Other leaders include Germany, Ukraine, Canada, Italy, Poland, and Spain.[63]

Repowering of existing wind capacity has also expanded in recent years. The replacement of old turbines with fewer, larger, taller, and more efficient and reliable machines is driven by technology improvements and the desire to increase output while improving grid compliance and reducing noise and bird mortality.[64] (See Sidebar 5.) Repowering began in Denmark and Germany, due to a combination of incentives and a large number of ageing turbines, and has spread to several other countries.[65] During 2013, turbines were repowered in Denmark, Finland, and Japan, and in Germany, which replaced 373 turbines with combined capacity of 236 MW with 256 turbines totalling 726 MW.[66] There is also a thriving international market in used turbines in several developing and emerging economies.[67]

Wind power is playing a major role in power supply in an increasing number of countries. In the EU, capacity operating at year's end was enough to cover nearly 8% of electricity consumption in a normal wind year (up from 7% in 2012), and several EU countries met higher shares of their demand with wind.[68] Wind was the top power source in Spain (20.9%, up from 16.3%) during 2013, and met 33.2% of electricity demand in Denmark (up from 30%).[69] Four German states had enough wind capacity at year's end to meet over 50% of their electricity needs.[70] In the United States, wind power represented 4.1% of total electricity generation (up from 3.5% in 2012) and met more than 12% of demand in nine states (up from 10% in nine states in 2012), with Iowa at over 27% (up from 25%) and South Dakota at 26% (up from 24%).[71] Wind power accounted for 2.6% of China's electricity generation.[72] Globally, wind power capacity by the end of 2013 was enough to meet an estimated 2.9% of total electricity consumption.[73]

WIND POWER INDUSTRY

Over the past few years, capital costs of wind power have declined, primarily through competition, while technological advances—including taller towers, longer blades, and smaller generators in low wind speed areas—have increased capacity factors.[74] These developments have lowered the costs of wind-generated electricity, improving its cost competitiveness relative to fossil fuels. Onshore wind-generated power is now cost competitive, or nearly so, on a per kWh basis with new coal- or gas-fired plants, even without compensatory support schemes, in several markets (including Australia, Brazil, Chile, Mexico, New Zealand, South Africa, Turkey, much of the EU, and some locations in India and the United States).[75] By one estimate, global levelised costs per MWh of onshore wind fell about 15% between 2009 and early 2014; offshore wind costs rose, however, due to increasing depths and distance from shore.[76]

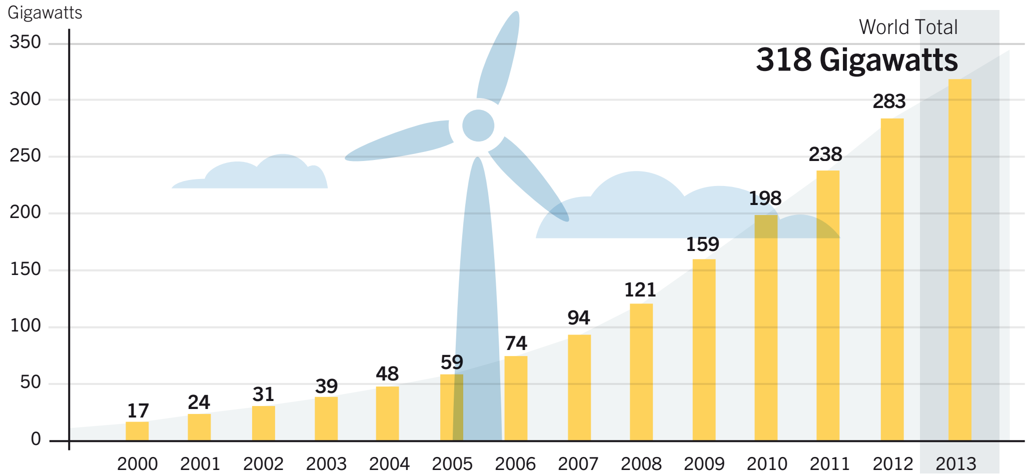
Despite these largely positive trends, during 2013 the industry continued to be challenged by downward pressure on prices, increased competition among turbine manufacturers, competition with low-cost gas in some markets, reductions in policy support driven by economic austerity, and declines in key markets.[77] In Europe, market contraction led to industry consolidation, with manufacturers Bard and Fuhrländer (both Germany) filing for insolvency in late 2013, and Vestas (Denmark) cutting its staff by 30%.[78] European turbine makers also experienced a decline in market share within China, where domestic suppliers constituted over 93% of the market in 2013, up from 28% just six years earlier.[79] The United States experienced factory closures and layoffs due to a shortage of new turbine orders; by year's end, however, U.S. production capacity had ramped up dramatically, with wind-related manufacturing in 44 of 50 states.[80] In India, Suzlon, which has struggled for years with massive debt, ceded its top position for the first time in a decade.[81]

Grid-related challenges are increasing and range from lack of transmission infrastructure, to delays in grid connection, to rerouting of electricity through neighbouring countries, to curtailment where regulations and current management systems make it difficult to integrate large amounts of wind and other

i - Small-scale wind systems are generally considered to include turbines that produce enough power for a single home, farm, or small business (keeping in mind that consumption levels vary considerably across countries). The International Electrotechnical Commission sets a limit at 50 kW, and the World Wind Energy Association (WWEA) and the American Wind Energy Association currently define "small-scale" as less than 100 kW, which is the range also used in the GSR; however, size varies according to needs and/or laws of a country or state/province, and there is no globally recognised definition or size limit. For more information see, for example, Stefan Gsänger and Jean Pitteloud, *Small Wind World Report 2014* (Bonn: WWEA and New Energy Husum, March 2014), Executive Summary, http://small-wind.org/wp-content/uploads/2014/03/2014_SWWR_summary_web.pdf.

WIND POWER

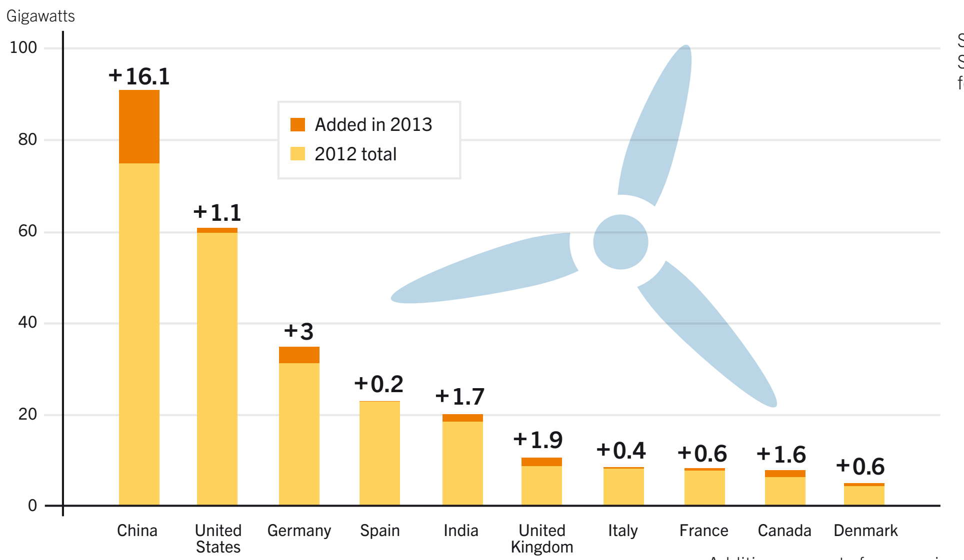
Figure 19. Wind Power Total World Capacity, 2000–2013



Source: See Endnote 1 for this section.

71 countries have more than **10 MW,** **24** countries have more than **1 GW** INSTALLED

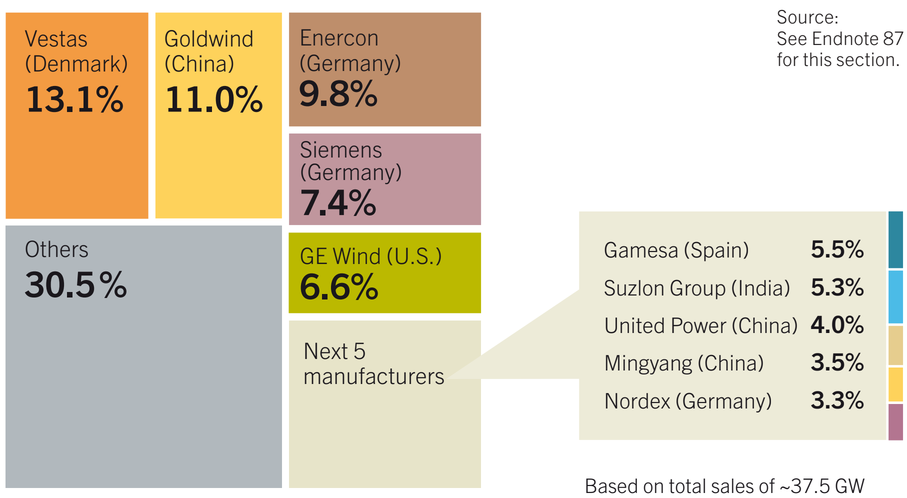
Figure 20. Wind Power Capacity and Additions, Top 10 Countries, 2013



Additions are net of repowering.

Source: See Endnote 10 for this section.

Figure 21. Market Shares of Top 10 Wind Turbine Manufacturers, 2013



Based on total sales of ~37.5 GW

Source: See Endnote 87 for this section.

Share of DENMARK'S ELECTRICITY COVERED BY **WIND** in 2013: **33.2%**

02

SIDEBAR 5. SUSTAINABILITY SPOTLIGHT: WIND ENERGY

A decade of surging growth in the wind energy sector has changed the electricity mix in many countries and brought significant environmental benefit. Wind energy displaces fossil fuel extraction and mining activities that have potentially severe ecological impacts. Lifecycle carbon dioxide emissions from wind-generated electricity are around 40 times less per kWh than those from natural gas power and around 80 times less than those from coal, reducing the risk and impact of climate-related threats to humans and ecosystems.

Yet the rise of wind power also has raised concerns about negative environmental and social impacts. Many are typical impacts of large-scale infrastructural development and can be understood and addressed as such. Some are unique to wind turbines and are driving focussed research aimed at quantifying, understanding, and mitigating the associated risks. Others remain subjective or yet unsubstantiated by existing evidence or ongoing research.

Observed or claimed impacts pertain to visual and aesthetic obstruction, noise generation, land-use impacts, wildlife mortality, discord and dispute within communities, and consumption of raw materials. Offshore wind turbines may produce specific marine impacts, including noise and vibrational impacts on marine life, disturbance of the seabed and marine ecosystems, and impacts on navigational safety and access to shipping lanes and fisheries. Some have suggested that infrasound, electromagnetic interference, noise, shadow flicker, and blade glint from wind turbines may lead to public health effects, although these claims are currently unsupported by statistical or medical evidence.

Some of the impacts of wind turbines are being mitigated through technological innovation. The development of turbine blades with thinner trailing edges and more aerodynamic blade tips has resulted in both higher efficiency and less noise generation. As such, the noise generation of modern wind turbines is often inaudible relative to other background noise. In the offshore sector, various techniques are being applied or developed to reduce noise impacts on marine life during construction, including the use of "bubble curtains" to diminish the sound of foundation pile driving.

Technical solutions are reducing collisions with birds and bats as well. These include radar or GPS systems that idle turbine blades when large flocks or individual birds are detected. Research is also under way on the use of ultrasonic noise to deter bats from the vicinity of wind turbines. Idling turbines during low wind conditions (when bats are more active) has been shown to significantly reduce bat fatalities. Other areas under investigation include the use of strike detection systems that shut down turbines to prevent further collisions with flocks, the use of more visible turbine shapes and colours, and the use of tower and turbine shapes that prevent nesting.[i]

Studies have shown that land-use impacts of turbines are small in terms of the land surface that is disturbed: typically, less than 0.4 hectares per MW are disturbed permanently, with roughly 1.4 hectares / MW disturbed during construction. Surrounding land can be used for productive purposes such as public parkland, agriculture, or highways. Concerns over the availability of "rare earths" (used in direct-drive turbines) are being actively mitigated by the research on alternative materials, stock piling, and the development of alternative mining reserves.[ii]

Impacts are also being managed through better planning and regulation. Wind farms can alter the appearance of landscapes and horizons substantially; however, these effects can be mitigated or avoided through effective use of environmental impact assessments, thorough public engagement during the development process, and appropriate turbine placement. A variety of best practice guidelines for public engagement have been developed by public and private entities, including wind energy industry associations and organisations. Furthermore, many countries, including Australia, Ireland, South Africa, and the United Kingdom, now require impact assessments, mitigation, or compensation measures.

The "Sustainability Spotlight" sidebar is a regular feature of the Global Status Report, focussing on sustainability issues regarding a specific renewable energy technology or related issue.

i - Studies on bird and bat collisions indicate that the turbine-related mortality rate of wind turbines is several orders of magnitude lower than other anthropogenic influences, including hunting by domestic and feral cats, collisions and electrocutions caused by power lines, and collisions with houses, buildings, and vehicles.

ii - Rare earth impacts are addressed in "Sidebar 3. Sustainability Spotlight: Rare Earth Minerals and PV Recycling" in GSR 2011.

Source: See Endnote 64 for this section.

variable renewables.[82] In addition, there is a shortage of skilled personnel in new markets that are experiencing rapid growth, particularly in Africa and Latin America, and in some more mature markets where significant policy uncertainty makes it difficult to keep trained staff in the sector.[83] (See Sidebar 6 for more on renewable energy jobs.)

Most of the world's turbine manufacturers are in China, Denmark, Germany, India, Spain, the United States, and Japan, and components are supplied from many countries.[84] An increasing number of manufacturers are in Brazil, with France and South Korea also emerging as producers of wind technology.[85] The world's top 10 turbine manufacturers captured nearly 70% of the market in 2013 (down from 77% in 2012).[86] Vestas (Denmark) regained the top spot from GE Wind (United States), which suffered from the poor U.S. market and fell to fifth. Goldwind (China) climbed four steps to second, followed by Enercon and Siemens (both Germany), which switched spots. Other top manufacturers were Gamesa (Spain), Suzlon Group (India), United Power and Mingyang (both China), and Nordex (Germany).[87] (See Figure 21.)

To deal with challenges and to maintain profitability, turbine manufacturers are revamping their supply chains with techniques such as component commonality and just-in-time stocking.[88] While many still make most of the critical parts, there is a trend towards outsourcing and flexible manufacturing.[89] Some companies focus increasingly on project operation and maintenance, which provides steady business even when sales are down, and can increase value in an increasingly competitive market.[90] Others are joining forces: Mitsubishi (Japan) and Vestas, and Areva (French nuclear supplier) and Gamesa, announced joint ventures for offshore turbine development.[91] Most are now vertically integrated, with very few companies left that are purely wind turbine manufacturers.[92]

Local sourcing is increasing in response to local-content rules as well as the potential for cheaper finance, shorter lead times, insulation from exchange rate changes and customs duties, and reduced costs and logistical issues associated with shipping of big, heavy turbines and parts.[93] To reduce transport costs, Vestas and shipper SNCF Geodis (France) in Europe, and Siemens in the United States, have begun moving blades by rail, although the practice is still in an early phase.[94]

Turbine designs continue to evolve to reduce costs and increase yield, with trends towards larger machines (higher hub height, longer blades, greater nameplate capacity), developments to reduce operations and maintenance costs, and shifts in technologies and strategies to improve the economics of wind power in a wider range of wind regimes and operating conditions.[95] Progress in recent years has boosted energy yields, particularly in low-wind sites.[96] In 2013, GE launched services packages to improve the power output of individual turbines and wind farms, and introduced a 2.5 MW turbine that incorporates energy storage capability.[97] The share of gearless, or direct-drive, turbines increased again (from 12% in 2008 to 28% in 2013), and the move continued towards tailor-made turbine designs for offshore use.[98]

The average size of turbines delivered to market in 2013 was 1.9 MW, up from 1.8 MW in 2012.[99] Average turbine sizes were 2.7 MW in Germany, 1.8 MW in the United States, 1.7 MW in China, and 1.3 MW in India.[100] The largest commercially available turbine (Enercon's E-126, up to 7.6 MW), is used in the onshore sector.[101] The average size installed offshore in Europe remained at about 4 MW.[102] New machines in the 5–8 MW range are being tested for offshore use in Europe and Asia, while leading Chinese manufacturers are competing to develop turbines of 10 MW and larger, spurred on by government grants.[103]

In addition to bigger turbines, the offshore industry is seeing larger projects, and moving farther out, into deeper waters.[104] To date, deep-water offshore wind has focussed on foundations adapted from the oil and gas industry, but new designs are under development around the world.[105] In 2013, Japan floated two 2 MW machines, with plans to commercialise the technology as soon as possible, and the United Kingdom launched a leasing round for floating offshore wind.[106] Japan and others aim to drive down costs and hope offshore wind will revitalise old ports and related industries.[107]

New, larger and more-sophisticated vessels are being developed to deploy turbines in deeper waters and under harsher weather conditions, with British, Chinese, German, and South Korean shipbuilders expanding into the industry.[108] Larger vessels are also required to transport longer and larger subsea cables to higher-capacity, more distant offshore projects.[109] These trends have pushed up prices in recent years.[110] As of early 2014, the levelised cost of offshore wind power was nearly USD 240/MWh (EUR 172/MWh), but the potential for lowering costs through reductions in lifecycle financial costs is considered significant.[111]

The small-scale (<100 kW) wind industry also continued to mature in 2013, with hundreds of manufacturers worldwide, expanding dealer networks, and increasing importance of turbine certification.[112] Most manufacturers and service providers are concentrated in China, North America, and Europe.[113] About three-quarters of the world's manufacturers produce horizontal-axis machines, with others focussing on vertical or both types; most vertical-axis models have been developed over the past 5–7 years.[114]

See Table 2 on pages 64–65 for a summary of the main renewable energy technologies and their characteristics and costs.[115]

02

SIDEBAR 6. JOBS IN RENEWABLE ENERGY AND RELATED FIGURES

As the slow recovery in the global economy fails to invigorate labour markets, the issue of job creation has come to the forefront of the policymaking debate and strategic choices made by countries. Globally, an estimated 6.5 million people[i] worked directly or indirectly in the renewable energy sector, based on a wide range of studies primarily from the period 2012 to 2013. (See Table 1 and Figure 22.)

Recent trends in renewable energy prices and investment have affected job creation across the value chain. Employment is also shaped by regional shifts, industry realignments, growing competition, advances in technologies and manufacturing processes, and the impacts of austerity and policy uncertainty. For instance, although declining prices of solar PV and wind equipment are introducing new challenges for suppliers and affecting manufacturing jobs, they are also driving employment growth in installation and operations and maintenance.

Employment in solar PV manufacturing has experienced some turbulence as intensified competition, overcapacities, and tumbling prices have caused layoffs. But surging demand in countries such as China and Japan has eased some of the oversupply concerns, and jobs in the other segments of the value chain continue to grow, making solar PV the largest employer.

The next largest employer is the biofuels value chain, with 1.45 million jobs. The United States is the largest producer while Brazil's sugarcane-based ethanol industry is the largest employer.

Wind employment was affected during 2013 by policy uncertainty, which led to a significant drop in new U.S. installations and to weak markets in Europe and India. This was offset by positive impulses in China and Canada. In offshore wind, Europe accounted for the bulk of global employment with 58,000 jobs, the U.K. being the leader.

Discrepancies exist among available sources for solar heating/cooling, but the most recent estimates suggest some half million jobs globally. The remaining renewable energy technologies are less dynamic and employ far fewer people.

Renewable energy employment continues to advance to more and more countries, but the bulk of employment remains concentrated in just a few: China, Brazil, the United States, India, Bangladesh, and some countries in the EU.

China remains the largest employer in the sector, with 60% of employment concentrated in solar PV and a marked shift towards jobs in the installation segment of the value chain in 2013. Solar water heating jobs showed a significant reduction that year, possibly due to a change in the estimation method.

In 2012, the latest year for which data are available, the EU saw significant employment gains in the wind and bio-power sectors and large losses in solar PV. Biofuels, biogas, and geothermal showed small gains, and the heat pump and solar thermal sectors had small losses. Germany remains the dominant force in European renewable energy employment.

In the United States, employment in the solar energy sector has been rising rapidly, mostly in solar PV project development and installation. In the wind industry, manufacturing capacity has grown strongly, but the stop-and-go nature of the national support mechanism triggers periodic fluctuations in employment.

No updated numbers are available for India. A recent study suggests that employment in wind and grid-connected solar PV remains at the level of 2009. Solar PV manufacturers have struggled in the face of cheap panel imports from China.

In 2013, global employment continued to grow, with noteworthy shifts in the breakdown along the segments of the value chain. More analysis of renewable energy employment patterns is required for a thorough understanding of the underlying dynamics.

i - This global number, estimated by IRENA, should not be understood as a direct, year-on-year comparison with the IRENA estimate of 5.7 million jobs in the GSR 2013, but rather as an ongoing effort to refine the data. Global statistics remain incomplete, methodologies are not harmonised, and the different studies used are of uneven quality. These numbers are based on a wide range of studies, focused primarily on the years 2012–2013.

Source: See Endnote 83 for this section.

JOBS IN RENEWABLE ENERGY

TABLE 1. ESTIMATED DIRECT AND INDIRECT JOBS IN RENEWABLE ENERGY WORLDWIDE, BY INDUSTRY

	World	China	Brazil	United States	India	Bangla-desh	European Union[m]		
							Germany	Spain	Rest of EU
	Thousand Jobs								
Biomass[a,b]	782	240		152[h]	58		52	44	210
Biofuels	1,453	24	820[f]	236[i]	35		26	3	82
Biogas	264	90			85	9.2	49	0.5	19
Geothermal[a]	184			35			17	1.4	82
Hydropower (Small)[c]	156		12	8	12	4.7	13	1.5	18
Solar PV	2,273	1,580[e]			112	100[k]	56	11	153
CSP	43			143[j]			1	28	0
Solar Heating / Cooling	503	350	30[g]		41		11	1	31
Wind Power	834	356	32	51	48	0.1	138	24	166
Total	**6,492[d]**	**2,640**	**894**	**625**	**391**	**114**	**371[l]**	**114**	**760**

Data source: IRENA

a - Power and heat applications. **b** - Traditional biomass is not included. **c** - Employment information for large-scale hydropower is incomplete, and therefore focuses on small hydro. Although 10 MW is often used as a threshold, definitions are inconsistent across countries. **d** - The total for "World" is calculated by adding the individual totals of the technologies. **e** - Previous estimates were substantially lower (in the 300,000–500,000 range), but installation jobs have expanded massively. **f** - About 331,000 jobs in sugar cane and 208,000 in ethanol processing in 2012; also includes 200,000 indirect jobs in equipment manufacturing, and 81,800 jobs in biodiesel. **g** - Equipment manufacturing; installation jobs not included. **h** - Biomass power direct jobs run only to 15,500. **i** - Includes 173,667 jobs for ethanol and 62,200 jobs for biodiesel in 2013. **j** - All solar technologies combined, with solar PV estimated at close to 100,000 jobs. **k** - Direct jobs only. **l** - Data for 2013. Includes 8,000 jobs in publicly funded R&D and administration; not broken down by technology. **m** - All data are from 2012, except for Germany. The "World" total and the "Rest of EU" total are calculated using the EU country data for 2012 (even if 2013 data for a specific country are available, e.g., Germany).

Note: Data are principally for 2012–2013, with dates varying by country and technology. Some of the data for India and China are older. Totals may not add up due to rounding.

Figure 22. Jobs in Renewable Energy

i - Employment information for large-scale hydropower is incomplete and not included.

TABLE 2. STATUS OF RENEWABLE ENERGY TECHNOLOGIES: CHARACTERISTICS AND COSTS

TECHNOLOGY	TYPICAL CHARACTERISTICS	CAPITAL COSTS USD / kW	TYPICAL ENERGY COSTS LCOE – U.S. cents / kWh
POWER GENERATION			
Bio-power from solid biomass (including co-firing and organic MSW)	Plant size: 1–200 MW Conversion efficiency: 25–35% Capacity factor: 50–90%	800–4,500 Co-fire: 200–800	4–20 Co-fire: 4.0–12
Bio-power from gasification	Plant size: 1–40 MW Conversion efficiency: 30–40% Capacity factor: 40–80%	2,050–5,500	6–24
Bio-power from anaerobic digestion	Plant size: 1–20 MW Conversion efficiency: 25–40% Capacity factor: 50–90%	Biogas: 500–6,500 Landfill gas: 1,900–2,200	Biogas: 6–19 Landfill gas: 4–6.5
Geothermal power	Plant size: 1–100 MW Capacity factor: 60–90%	Condensing flash: 1,900–3800 Binary: 2,250–5,500	Condensing flash: 5–13 Binary: 7–14
Hydropower: Grid-based	Plant size: 1 MW–18,000+ MW Plant type: reservoir, run-of-river Capacity factor: 30–60%	Projects >300 MW: 1,000–2,250 Projects 20–300 MW: 750–2,500 Projects <20 MW: 750–4,000	Projects >20 MW: 2–12 Projects <20 MW: 3–23
Hydropower: Off-grid/rural	Plant size: 0.1–1,000 kW Plant type: run-of-river, hydrokinetic, diurnal storage	1,175–6,000	5–40
Ocean power: Tidal range	Plant size: <1 to >250 MW Capacity factor: 23–29%	5,290–5,870	21–28
Solar PV: Rooftop	Peak capacity: 3–5 kW (residential); 100 kW (commercial); 500 kW (industrial) Capacity factor: 10–25% (fixed tilt)	Residential costs: 2,200 (Germany); 3,500–7,000 (United States); 4,260 (Japan); 2,150 (China); 3,380 (Australia); 2,400–3,000 (Italy) Commercial costs: 3,800 (United States); 2,900–3,800 (Japan)	21–44 (OECD) 28–55 (non-OECD) 16–38 (Europe)
Solar PV: Ground-mounted utility-scale	Peak capacity: 2.5–250 MW Capacity factor: 10–25% (fixed tilt) Conversion efficiency: 10–30% (high end is CPV)	1,200–1,950 (typical global); as much as 3,800 including Japan. Averages: 2,000 (United States); 1,710 (China); 1,450 (Germany); 1,510 (India)	12–38 (OECD) 9–40 (non-OECD) 14–34 (Europe)
Concentrating solar thermal power (CSP)	Types: parabolic trough, tower, dish Plant size: 50–250 MW (trough); 20–250 MW (tower); 10–100 MW (Fresnel) Capacity factor: 20–40% (no storage); 35–75% (with storage)	Trough, no storage: 4,000–7,300 (OECD); 3,100–4,050 (non-OECD) Trough, 6 hours storage: 7,100–9,800 Tower: 5,600 (United States, without storage) 9,000 (United States, with storage)	Trough and Fresnel: 19–38 (no storage); 17–37 (6 hours storage) Tower: 12.5–16.4 (United States; high end of range is with storage)
Wind: Onshore	Turbine size: 1.5–3.5 MW Capacity factor: 25–40%	925–1,470 (China and India) 1,500–1,950 (elsewhere)	4–16 (OECD) 4–16 (non-OECD)
Wind: Offshore	Turbine size: 1.5–7.5 MW Capacity factor: 35–45%	4,500–5,500	15–23
Wind: Small-scale	Turbine size: up to 100 kW	Average 6,040 (United States); 1,900 (China)	15–20 (United States)

TECHNOLOGY	TYPICAL CHARACTERISTICS	INSTALLED COSTS OR LCOE USD / kW or U.S. cents / kWh
DISTRIBUTED RENEWABLE ENERGY IN DEVELOPING COUNTRIES		
Biogas digester	Digester size: 6–8 m^3	Unit cost: USD 612 / unit (Asia); USD 886 / unit (Africa)
Biomass gasifier	Size: 20–5,000 kW	LCOE: 8–12
Solar home system	System size: 20–100 W	LCOE: 160–200
Household wind turbine	Turbine size: 0.1–3 kW	Capital cost: 10,000 / kW (1 kW turbine); 5,000 / kW (5 kW); 2,500 / kW (250 kW) LCOE: 15–35+
Village-scale mini-grid	System size: 10–1,000 kW	LCOE: 25–100

TECHNOLOGY	TYPICAL CHARACTERISTICS	CAPITAL COSTS USD / kW	TYPICAL ENERGY COSTS LCOE – U.S. cents / kWh
HOT WATER / HEATING / COOLING			
Biomass heat plant	Plant size: 0.1–15 MW_{th} Capacity factor: ~50–90% Conversion efficiency: 80–90%	400–1,500	4.7–29
Domestic pellet heater	Plant size: 5–100 MW_{th} Capacity factor: 15–30% Conversion efficiency: 80–95%	360–1,400	6.5–36
Biomass CHP	Plant size: 0.5–100 kW_{th} Capacity factor: ~60–80% Conversion efficiency: 70–80% for heat and power	600–6,000	4.3–12.6
Geothermal space heating (buildings)	Plant size: 0.1–1 MW_{th} Capacity factor: 25–30%	1,865–4,595	10–27
Geothermal space heating (district)	Plant size: 3.8–35 MW_{th} Capacity factor: 25–30%	665–1,830	5.8–13
Ground-source heat pumps	Plant size: 10–350 kW_{th} Load factor: 25–30%	500–2,250	7–13
Solar thermal: Domestic hot water systems	Collector type: flat-plate, evacuated tube (thermosiphon and pumped systems) Plant size: 2.1–4.2 kW_{th} (single-family); 35 kW_{th} (multi-family) Efficiency: 100%	Single-family: 1,100–2,140 (OECD, new build); 1,300–2,200 (OECD, retrofit) 147–634 (China) Multi-family: 950–1,850 (OECD, new build); 1,140–2,050 (OECD, retrofit)	1.5–28 (China)
Solar thermal: Domestic heat and hot water systems (combi)	Collector type: same as water only Plant size: 7–10 kW_{th} (single-family); 70–130 kW_{th} (multi-family); 70–3,500 kW_{th} (district heating); >3,500 kW_{th} (district heat with seasonal storage) Efficiency: 100%	Single-family: same as water only Multi-family: same as water only District heat (Europe): 460–780; with storage: 470–1,060	5–50 (domestic hot water) District heat: 4 and up (Denmark)
Solar thermal: Industrial process heat	Collector type: flat-plate, evacuated tube, parabolic trough, linear Fresnel Plant size: 100 kW_{th}–20 MW_{th} Temperature range: 50–400 °C	470–1,000 (without storage)	4–16
Solar thermal: Cooling	Capacity: 10.5–500 kW (absorption chillers); 8–370 kW (adsorption chillers) Efficiency: 50–70%	1,600–5,850	n/a

TECHNOLOGY	FEEDSTOCKS	FEEDSTOCK CHARACTERISTICS	ESTIMATED PRODUCTION COSTS U.S. cents / litre[1]
TRANSPORT FUELS			
Biodiesel	Soy, rapeseed, mustard seed, palm, jatropha, waste vegetable oils, animal fats	Range of feedstocks with different crop yields per hectare; hence, production costs vary widely among countries. Co-products include high-protein meal.	Soybean oil: 56–72 (Argentina); 100–120 (Global average) Palm oil: 100–130 (Indonesia, Malaysia, and other) Rapeseed oil: 105–130 (EU)
Ethanol	Sugar cane, sugar beets, corn, cassava, sorghum, wheat (and cellulose in the future)	Range of feedstocks with wide yield and cost variations. Co-products include animal feed, heat and power from bagasse residues. Advanced biofuels are not yet fully commercial and have higher costs.	Sugar cane: 82–93 (Brazil) Corn (dry mill): 85–128 (United States)

[1] Litre of diesel of gasoline equivalent

Notes: To the extent possible, costs provided are indicative economic costs, levelised, and exclusive of subsidies or policy incentives. Several components determine the levelised costs of energy/heat (LCOE/H), including: resource quality, equipment cost and performance, balance of system/project costs (including labour), operations and maintenance costs, fuel costs (biomass), the cost of capital, and productive lifetime of the project. The costs of renewables are site specific, as many of these components can vary according to location. Costs for solar electricity vary greatly depending on the level of available solar resources. It is important to note that the rapid growth in installed capacity of some renewable technologies and their associated cost reductions mean that data can become outdated quickly; solar PV costs, in particular, have changed rapidly in recent years. Costs of off-grid hybrid power systems that employ renewables depend largely on system size, location, and associated items such as diesel backup and battery storage.

Source: See Endnote 115 for this section for sources and assumptions.

Various **stakeholder groups** share their insights and experiences to capture the global status of renewable energy.

03

03 INVESTMENT FLOWS

Global new investment in renewable power and fuels (not including hydropower projects >50 MW) was USD 214.4 billion in 2013, as estimated by Bloomberg New Energy Finance (BNEF).[i] This was down 14% relative to 2012, and 23% lower than the record level in 2011. (See Figure 23.) Including the unreported investments in hydropower projects larger than 50 MW, total new investment in renewable power and fuels was at least USD 249.4 billion in 2013.[ii] Note that these estimates do not include investment in renewable heating and cooling technologies.

The second consecutive year of decline in investment—after several years of growth—was due in part to uncertainty over incentive policies in Europe and the United States, and to retroactive reductions in support in some countries. Europe's investment was down 44% from 2012, and, for the first time ever, China alone invested more in renewable energy than all of Europe combined. The year 2013 also saw an interruption to the eight consecutive years of rising renewable energy investment in developing countries.

Yet the global decline also resulted from sharp reductions in technology costs. This was particularly true for solar PV, which saw record new installations in 2013, despite a 22% decline in dollars invested. Lower costs and efficiency improvements made it possible to build onshore wind and solar PV installations in several locations around the world in 2013 without subsidy support, particularly in Latin America. Considering only net investment in new power capacity, renewables outpaced fossil fuels for the fourth year running.

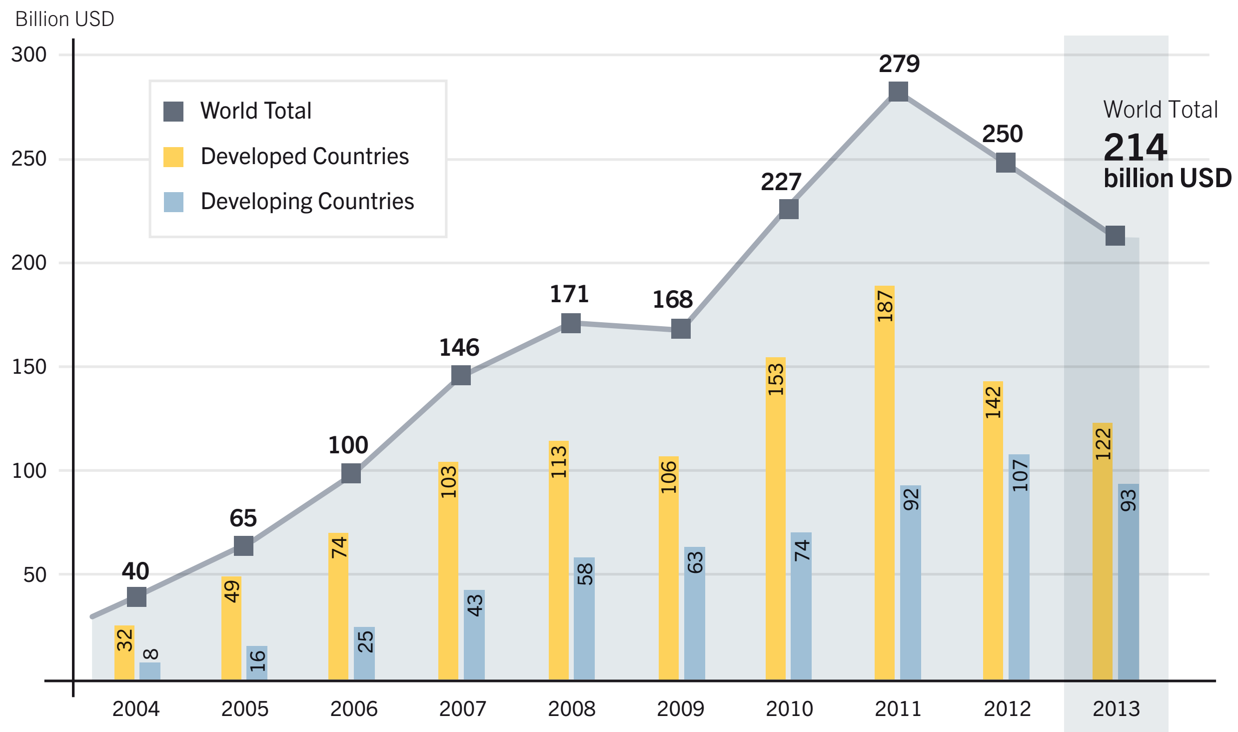
Further, despite the overall downward trend in world investment, there were significant exceptions at the country level. The most notable was Japan, where renewable energy investment (excluding R&D) increased by 80% relative to 2012. Other countries that increased their investment in 2013 included Canada, Chile, Israel, New Zealand, the United Kingdom, and Uruguay.

INVESTMENT BY ECONOMY

Developing and developed countries alike saw reductions in renewable energy investments in 2013. Developing country investments fell for the first time since tracking began in 2004. Their outlays of USD 93 billion were down 14% from the record investment made in 2012, and just above the 2011 level. This compares with USD 122 billion in developed countries, the lowest investment level in the past four years. China accounted for 61% of developing-country investment in renewables in 2013, up from 55% in 2012.

Most regions of the world experienced reductions in investment relative to 2012. The exceptions were the Americas, excluding the United States and Brazil (both of which saw reductions),

Figure 23. Global New Investment in Renewable Power and Fuels, Developed and Developing Countries, 2004–2013



Source: See Footnotes i and ii for this section.

i - This section is derived from Frankfurt School–UNEP Collaborating Centre for Climate & Sustainable Energy Finance (FS-UNEP) and Bloomberg New Energy Finance (BNEF), *Global Trends in Renewable Energy Investment 2014* (Frankfurt: 2014), the sister publication to the GSR. Data are based on the output of the Desktop database of BNEF, unless otherwise noted, and reflect the timing of investment decisions. The following renewable energy projects are included: all biomass, geothermal, and wind generation projects of more than 1 MW; all hydro projects of between 1 and 50 MW; all solar power projects, with those less than 1 MW estimated separately and referred to as small-scale projects or small distributed capacity; all ocean energy projects; and all biofuel projects with an annual production capacity of 1 million litres or more. For more information, please refer to the FS-UNEP/BNEF *Global Trends* report. Where totals do not add up, the difference is due to rounding.

ii - Investment in large hydropower (>50 MW) is not included in the overall total for investment in renewable energy. BNEF tracks only hydropower projects of between 1 MW and 50 MW.

and Asia-Oceania, excluding China and India, where annual investment in renewable energy continued its uninterrupted rise. The Asia-Oceania region saw investment increase 47% over 2012, to a record high of USD 43.3 billion, due largely to the solar boom in Japan. (See Figure 24.) Europe and China continued to be the most significant investors, despite declines in each region; together they accounted for just short of half (49%) of the world total, down from a 59% share in 2012. Most of this decline was seen in Europe, where investment dropped by 44% in 2013 relative to 2012.

At the national level, the top 10 investors consisted of three developing countries (all BRICS countries) and seven developed countries. China was again in the lead, with an investment of USD 54.2 billion, excluding R&D. It was followed by the United States (USD 33.9 billion), Japan (USD 28.6 billion), the United Kingdom (USD 12.1 billion), and Germany (USD 9.9 billion). The next five were Canada (USD 6.4 billion), India (USD 6 billion), South Africa (USD 4.9 billion), Australia (USD 4.4 billion), and Italy (USD 3.6 billion).[i]

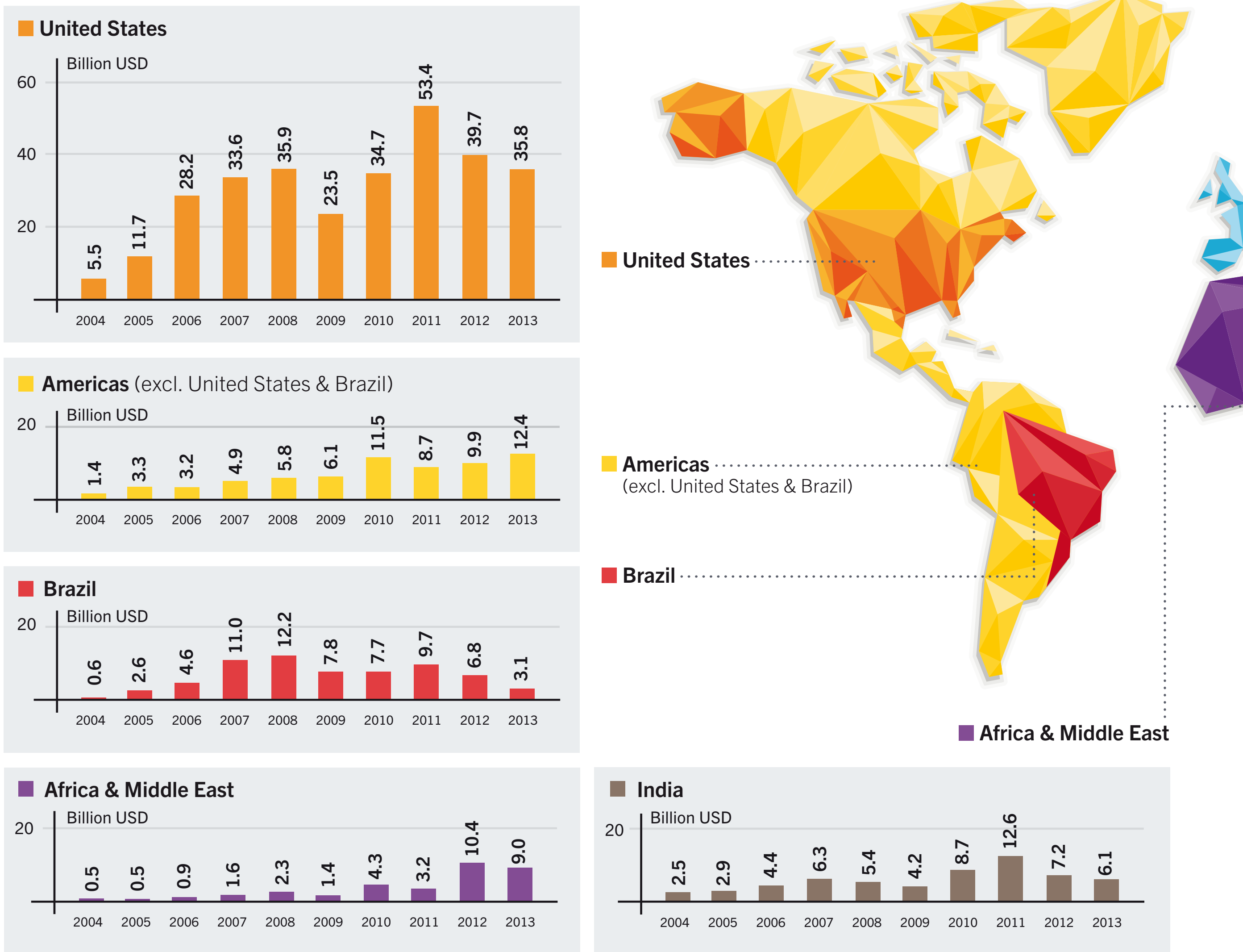
China accounted for USD 56.3 billion (including R&D) of new investment in renewable energy, down 6% from 2012. Asset financing increased, but contributions from public markets and private equity shrank to low levels. Despite the overall decline, China's investment in additional renewable power capacity surpassed fossil fuel capacity additions in 2013 for the first time. The vast majority of the country's investment was for solar and wind power projects, and China was the top country by far for spending on utility-scale[ii] projects, followed distantly by the United States and the United Kingdom. China also invested significant sums in hydropower, bringing about 29 GW of new capacity into operation during the year, of which a large portion was projects >50 MW.[iii 1] (See Hydropower section.)

i - National investment totals do not include government and corporate R&D because such data are not available for all countries. The South Africa number also does not include small-scale projects. Note, however, that data in Figure 24 do include government and corporate R&D.

ii - "Utility-scale" in this section refers to wind farms, solar parks, and other renewable power installations of 1 MW or more in size, and to biofuel plants of more than 1 million litres' capacity.

iii - The Chinese government estimates that China invested more than USD 20 billion (CNY 124.6 billion) in hydropower during 2013, including hydropower facilities of all sizes (this number may also include pumped storage).

Figure 24. Global New Investment in Renewable Power and Fuels, by Region, 2004–2013



The United States, which invested USD 35.8 billion (including R&D), continued to be the largest individual investor among the developed economies. This was despite a decline in investment of nearly 10% in 2013, attributed largely to the impact of low natural gas prices caused by the shale gas boom, and to uncertainty over the continuation of policy support for renewables. U.S. venture capital and private equity investment in renewables fell to just USD 1 billion, the lowest since 2005, indicative of a loss of confidence among early-stage capital providers. However, this decline was offset by a big jump in U.S. public markets investment, from USD 949 million in 2012 to USD 5.3 billion in 2013 (mainly for solar power and biofuels).

Japan saw a record increase in renewable energy investment, up 80% from 2012 to USD 28.6 billion, excluding R&D. The largest part of that commitment was for small-scale solar PV projects, as investors sought to capitalise on the generous feed-in tariff that was introduced in 2012. An increase of 76% in 2013, to USD 23 billion, made Japan the top country for investments in small-scale distributed renewables, followed distantly by the United States and Germany. Japan's asset finance in utility-scale projects nearly doubled, to USD 5.6 billion.

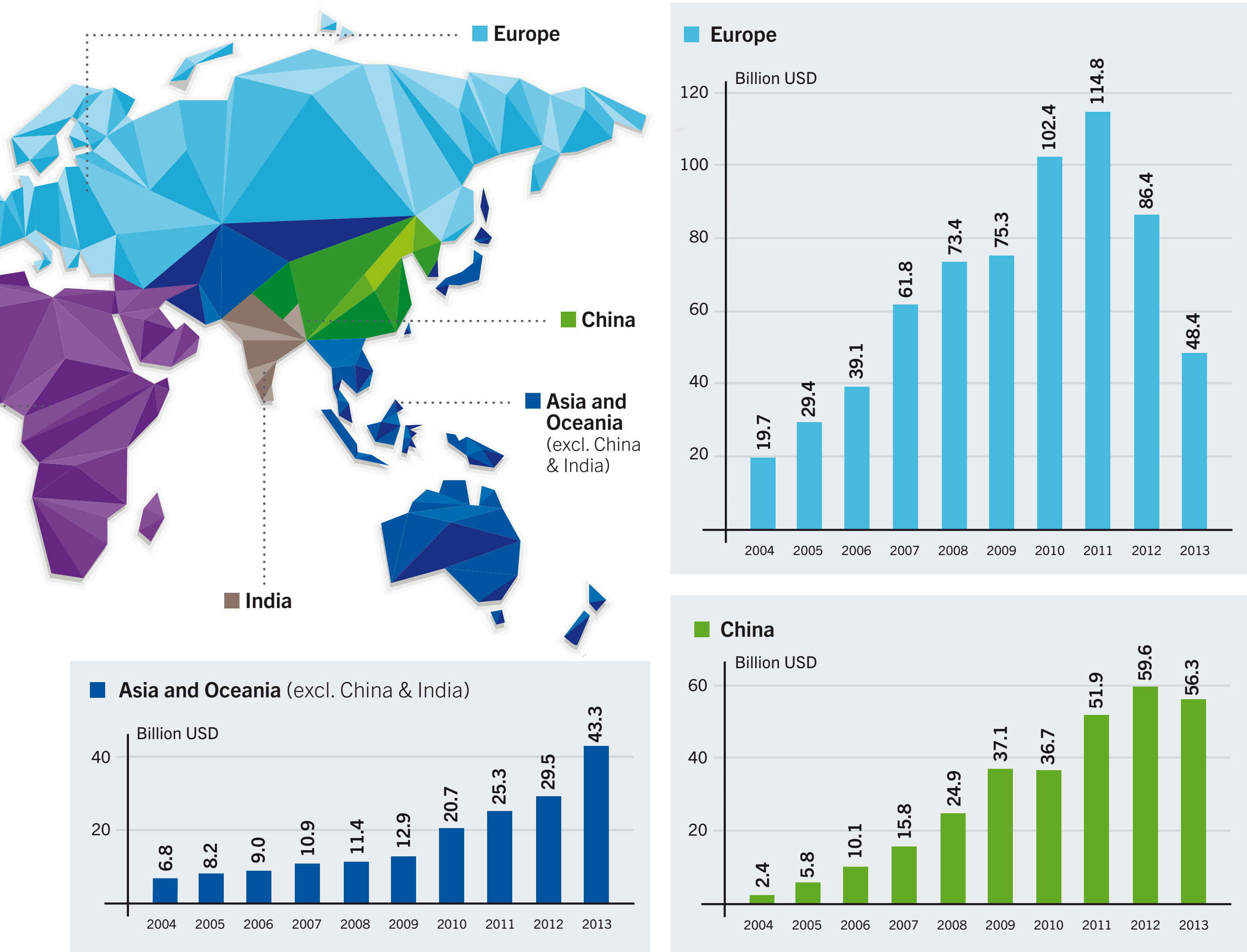
The United Kingdom also saw investments rise, by 14%, with the largest component coming from asset financing of utility-scale projects. This was followed by public markets, where a new breed of funds that owns and operates wind and solar power assets raised significant money during the year.

In stark contrast to these increases, Germany's investment declined again in 2013, landing at less than one-third of its 2010 peak (USD 33.7 billion), and bringing it from third to fifth position globally for renewable energy investment. The low investment level in 2013 can be attributed in part to the policy uncertainty faced by investors ahead of the general election in September 2013. However, other factors contributed to the dampened activity levels, including reduced prices of solar PV and a shortage of good quality, unexploited wind sites on land.

Canada has been a steady investor in renewable energy in recent years and, in 2013, moved into the list of top 10 countries. Investment increased relative to the period 2007–2012, with most of this from asset finance—principally for large-scale wind and solar PV projects in Ontario.

Investment in India in 2013 fell to just under half of the peak total recorded in 2011 (USD 12.5 billion). Almost all of the decline was due to a slowdown in asset finance, which was particularly apparent in the solar power market. However, small-scale project investment increased in 2013 to a record USD 0.4 billion. Beyond the top three countries in Asia, Thailand, Hong Kong,

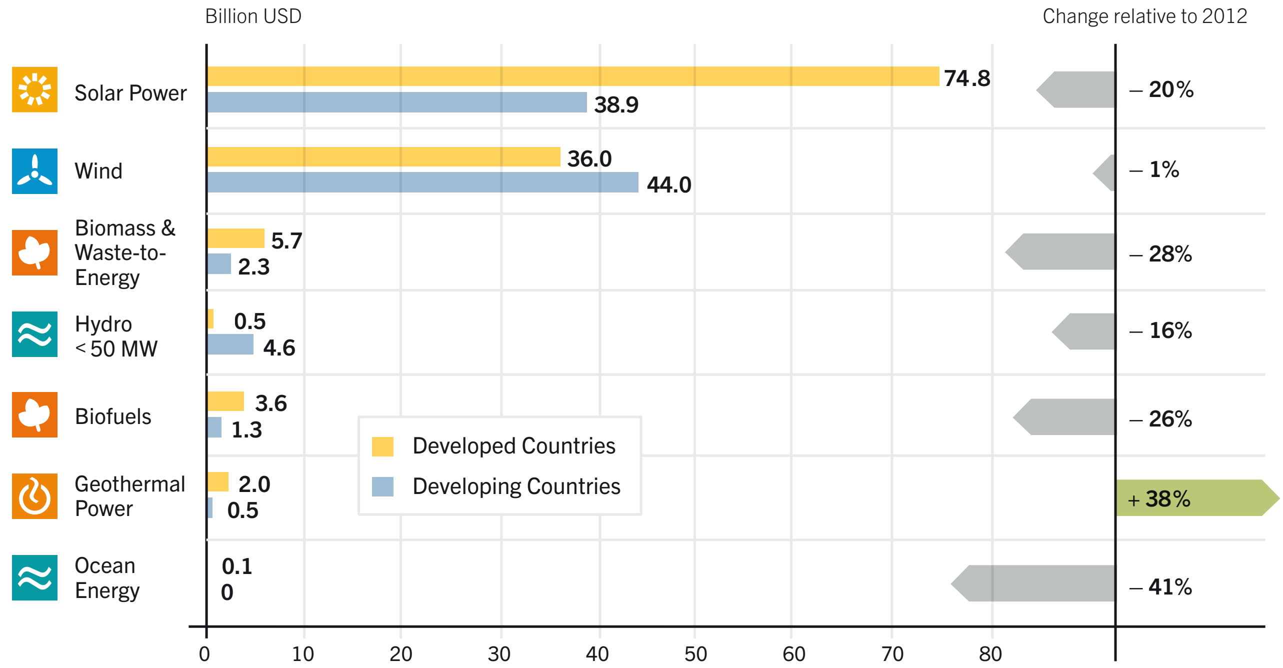
Data include government and corporate R&D.



Source: BNEF

Source: BNEF

Figure 25. Global New Investment in Renewable Energy by Technology, Developed and Developing Countries, 2013



and the Philippines dominated investment in renewable energy in emerging Asia (collectively investing over USD 3 billion).

South Africa led the African continent, although it was down from USD 5.7 the previous year, recording investment of USD 4.9 billion (excluding R&D and small-scale projects). This was almost entirely in the form of asset financing for wind and solar power, including CSP; overall, South Africa was one of the world's most active CSP markets in 2013. The second largest investor in Africa was Kenya (USD 249 million), followed by Mauritius and Burkina Faso.

The countries holding the ninth- and tenth-place positions in the investor country list were Australia and Italy. Australia led in the Pacific, with USD 4.4 billion split roughly evenly between small-scale solar PV and utility-scale asset finance. Italy remained in the top 10, but it recorded a 75% decline in renewable energy investment relative to 2012. This was due largely to the government's cap on the amount of solar PV capacity that is eligible for feed-in tariffs. Other European countries investing more than USD 1 billion included Denmark, France, Greece, the Netherlands, Sweden, and Switzerland.

Brazil continued to lead in Latin America, despite a 54% drop relative to 2012, which made it the country's weakest year since 2005, and took it out of the list of top 10 investing countries. Brazil's investment, totalling USD 3.1 billion, was dominated by asset finance, with the vast majority (USD 2.1 billion) going towards wind power projects and most of the remainder towards biofuel plant capacity. Outside of Brazil, the region's USD 6 billion invested in renewable energy was widely distributed, with Chile up 72% to USD 1.6 billion in 2013, followed by Mexico, Uruguay, Costa Rica, and Peru.

INVESTMENT BY TECHNOLOGY

Solar power was again the leading sector by far in terms of money committed during 2013, accounting for USD 113.7 billion, or 53% of total new investment in renewable power and fuels (not including hydro >50 MW). Wind power followed with USD 80.1 billion, about level with investment in 2012 and accounting for more than 37% of total investment. The remaining 10% was made up of biomass and waste-to-energy[i] power (USD 8 billion), small-scale hydropower (<50 MW) (USD 5.1 billion), biofuels (USD 4.9 billion), geothermal power (USD 2.5 billion), and ocean energy (USD 0.1 billion). Investment declined relative to 2012 in all renewable technology sectors tracked by BNEF, with the lone exception being geothermal power, which saw a 38% increase. (See Figure 25.)

As in 2012, about 90% of all solar power investment went to solar PV (USD 102.3 billion), with the remaining share going to CSP. Solar power saw one of the largest declines in 2013, with investment dollars falling 20% below 2012 levels. Most of the decline, however, was attributable to reductions in installed costs of solar PV systems.

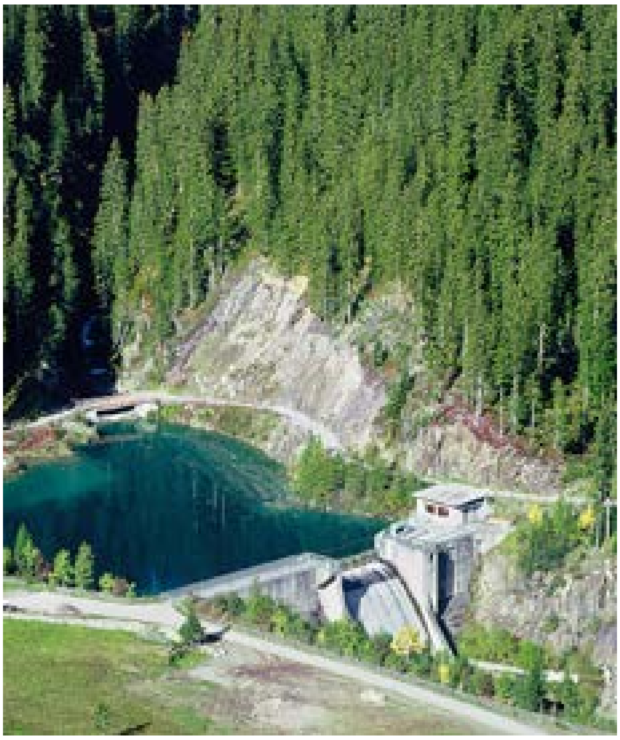
Bioenergy accounted for a larger share of total renewables investment in past years, representing 29% of investment in 2007. By contrast, in 2013 it made up only 6%, with biomass and waste-to-energy seeing their lowest investment level since 2005, and biofuels the lowest since 2004.

Developing economies continued to represent the majority of investments made in wind power and small-scale hydropower, whereas developed countries outweighed them in all other technologies. This was despite the fact that solar investment was down 21% in developed economies and up significantly in China, the second largest solar power investor after Japan.

i - Includes all waste-to-power technologies, but not waste-to-gas.

The top investors in wind power were China, followed distantly by the United States, the United Kingdom, Germany, Canada, and India. The smaller technologies showed contrasting trends, with investment in biomass, small-scale hydro, and geothermal power up in developed economies but down significantly in developing countries, and biofuels down everywhere.

Detailed statistics are not available for large hydropower projects over 50 MW in size, although they represent the third most important sector for renewable energy investment after solar and wind power. Translating hydropower capacity additions into asset finance dollars per year is not straightforward because the average project takes four years to build. However, BNEF estimates that asset financing for large-scale hydro projects commissioned in 2013 totalled at least USD 35 billion—more than a quarter of the USD 133.4 billion value of asset finance excluding large-scale hydro. Considering hydropower data provided by the industry and reported elsewhere in this GSR, investment in hydropower >50 MW may have been considerably higher.[2]



INVESTMENT BY TYPE

Global research and development[ii] declined 2% in 2013, to USD 9.3 billion, a modest reduction given that most "green stimulus" programmes expired during the 2011–2012 period. Nearly every region held steady or saw growth, with the exception of Asia-Oceania (excluding China and India), where R&D investment fell by 12%. Globally, the private sector invested more than the public sector for the third consecutive year, although the difference was marginal, with private investment falling by USD 300 million to USD 4.7 billion, and public investment rising USD 100 million to USD 4.6 billion.

Total R&D spending on solar power declined 2% in 2013, to USD 4.7 billion, but the sector still received more funding than did all other technologies combined for the fourth consecutive year. R&D investment in wind and ocean power declined slightly, while it was up slightly for bio-power, geothermal, and small-scale hydropower, and stable for biofuels.

Asset finance of utility-scale projects accounted for the vast majority (62%) of total investment in renewable energy, totalling USD 133.4 billion. However, it declined (13.5%) for the second consecutive year, to the lowest level since 2009. The decline is attributed largely to falling equipment costs, uncertainty over future energy support policies, and reduced investments by utilities.

Project funding declined in Brazil, India, Europe, and the United States, but it increased modestly in other regions. China saw the largest amount of asset finance investment, accounting for 40% of the global total, thus consolidating its position as the world leader in deployment as well as manufacturing.

Wind power (USD 75.4 billion) accounted for more than half of global asset finance, even though it declined for the third consecutive year; solar power (USD 44.4 billion) followed, but it was down for the second year running, with the decline reflecting lower costs per MW installed.

Small-scale distributed capacity accounted for 28% of total investment, but it was down 25% to USD 59.9 billion in 2013, ending a six-year period of uninterrupted growth. This was a result of continued downward revisions of subsidies in Europe, as well as reductions in average system costs. Most of the major markets saw large declines in new investment: China, Germany, Italy, France, and the United Kingdom all recorded falls of between 50% and 80%. These were partially offset by a 76% increase in Japan, to USD 23 billion, driven by a generous solar feed-in tariff; and an 11% increase in the United States, to nearly USD 8 billion.

Public market equity raised by renewable energy companies and funds was the bright spot in 2013, rising sharply after its 2012 slump and recovering to the average level of the previous five years. Spurred by renewed interest in clean energy stock offerings, investment in public markets increased by more than 200% to USD 11.1 billion. All technologies experienced growth, with the exception of small hydropower and ocean energy, which saw declines of 81% and 71%, respectively. Solar power (up 111%) was far ahead of others, with USD 4.8 billion, followed by wind (USD 2.6 billion), geothermal power (USD 1.6 billion), and biofuels (USD 1.5 billion). The WilderHill New Energy

ii - See Sidebar 5 in GSR 2013, "Investment Types and Terminology," for an explanation of investment terms used in this section.

Global Innovation Index (NEX), which tracked 96 clean energy companies, rose 53.9%, making 2013 its best year since 2007.

Venture capital and private equity investment (VC/PE) in renewable energy fell sharply in 2013, down 46% to USD 2.2 billion. This was the third consecutive year of decline, and investment reached the lowest level since 2005. The decline reflected the shortage of successful exits by VC/PE-backed companies in recent years, and by the depleted cash holdings of many clean energy venture funds. Although the United States saw VC/PE capital raisings fall from USD 2.8 billion to USD 1 billion, it remained the largest venture capital and private equity market, with twice the VC/PE investments of Europe.

Solar power was the biggest loser, with venture capital and private equity investment down more than two-thirds from its 2012 level, to USD 549 million. This was an indication that investors remained scarred by the insolvencies resulting from chronic global overcapacity since 2008. For the first time in a decade, VC/PE investment in wind exceeded that in solar power. Wind power was the only technology to see an increase in 2013—it rose by 70% to USD 1 billion.

Mergers and acquisition (M&A) activity—which is not counted as part of the USD 214.4 billion in new investment—continued the decline that began in 2012, to its lowest volume since 2006. Total acquisition funding in 2013 stood at USD 53.7 billion, down 11% since 2012, and nearly USD 20 billion below the peak level reached in 2011. The nominal value of renewable power assets acquired or refinanced declined by 18% to USD 39.9 billion. In contrast, the corporate buying and selling of companies increased by 45% to USD 11.5 billion, reversing the dynamic seen in 2012. Trade in renewable power projects still accounted for the largest share of overall activity—some 75% of the total—but this was down from 81% in 2012.

RENEWABLE ENERGY INVESTMENT IN PERSPECTIVE

In 2013, gross investment in new renewable electric generating capacity (not including hydro >50 MW) amounted to USD 192 billion[i], down from USD 234 billion in 2012 due to lower technology costs and policy uncertainty.[3] This compares with gross investment in fossil fuel-based capacity of USD 270 billion, down from USD 309 billion in 2012. By this measure, the gap between renewable and fossil fuels increased slightly in 2013, with investment in renewable power capacity down 18% relative to 2012 and fossil fuels down nearly 13%.

However, much of the investment in fossil fuels went to replacing existing coal-, oil-, and gas-fired power stations, while only USD 102 billion went to establishing additional fossil fuel capacity. By contrast, almost all investment in renewable capacity is net, meaning that it adds to overall generating capacity. Considering only net investment in 2013, renewable power was ahead for the fourth consecutive year, with its USD 192 billion taking a wide lead over fossil fuels' estimated USD 102. Taking into account investment in hydropower projects >50 MW, global investment in renewable power capacity was well over twice the net investment in fossil fuel power capacity in 2013.

i - This number is for renewable power asset finance and small-scale projects. It differs from the overall total for renewable energy investment (USD 214.4 billion) provided elsewhere in this section because it excludes biofuels and types of non-capacity investment such as equity raising on public markets, and development R&D.

SOURCES OF INVESTMENT

Clean energy funds had a strong year in 2013, with an asset-weighted average gain of 17.1% compared with the 1.5% increase in 2012. The best performer saw its share price more than double, due to its concentration in solar stocks. Much of the capital raising of 2013 involved project-oriented funds and took place in Europe.

North America saw the emergence of innovative yield-oriented financing vehicles, which pass a high share of earnings to shareholders and provide stable, long-term cash flows. Two "yield companies"[i] came to the market, raising a total of USD 631 million in 2013 for solar, wind, and hydropower projects.

Crowd funding continued to become a more mainstream means of raising money in an increasing number of countries. Crowd funding enables small companies and start-ups to raise capital from many small investors in exchange for an equity stake, structured payments, and/or products.

Clean energy project bonds set a new record in 2013, with over USD 3.2 billion raised through 10 confirmed transactions; solar power projects dominated the top 10 bonds by size, accounting for just under half of the total. A consortium of banks, representing eight of the top 10 corporate bond underwriters, released its "Green Bond Principles" in January 2014, establishing voluntary guidelines on what constitutes a green bond, the potential types of bond, the issuance process, and the need for companies to detail their plans for the proceeds.[4]

Institutional investors, including pension funds, insurance companies, and wealth managers, continued to play an increasing role, particularly in Europe. A record volume of investment was seen, thanks to the appeal of project yields that are double those of government bonds, combined with a high level of predictability. However, the total volume of institutional finance deployed on projects remained small compared to the overall institutional asset allocation, due to political, regulatory, and other hurdles.

Development banks were again an important source of clean energy investment in 2013.[ii] Germany's KfW—the largest lender for clean energy projects in 2012—reduced its renewable energy commitments by 41% to USD 6.5 billion[iii] (EUR 4.7 billion). By contrast, the European Investment Bank (EIB) raised its lending to renewables by 98%, to USD 8.8 billion (EUR 6.4 billion), to set a record high. Also in 2013, several development banks—including the World Bank, EIB, and European Bank for Reconstruction and Development—curtailed their funding for coal-fired power, pledging to support it only if no other fuel is viable. They were joined by the overseas aid departments of the United States and several northern European countries.[iv]

EARLY INVESTMENT TRENDS IN 2014

Hopes for the beginnings of a recovery in renewable energy investment in 2014 rose with the release of first quarter (Q1) numbers, which showed a 4% gain compared to the same period of 2013. Renewable energy investment worldwide in Q1 2014 was USD 44.4 billion. This was lower than the USD 57.3 billion recorded in the fourth quarter of 2013, but the first quarter usually sees the lowest activity level of the year, so the more meaningful comparison was with Q1 2013's USD 42.6 billion.

Among the highlights of Q1 2014 were small-scale solar power in Japan and the United States, and renewable power financings in emerging markets such as Kenya and Indonesia. Globally, small-scale project investment rose by 42% compared to Q1 2013, reaching USD 21.2 billion, while asset finance of utility-scale projects fell 13% to USD 22.8 billion.

Total U.S. investment was up 32% compared to a very subdued figure in Q1 2013, at USD 4.8 billion, while China was up 18% at USD 9.9 billion, and Europe was down 29% at USD 10.9 billion. The leading region was Asia-Oceania excluding China and India, with a 27% rise to USD 12.1 billion.

i - A yield company is a corporate entity created specifically to hold high-yielding investments in operating-stage projects.

ii - Note that investment data were not available for most development banks when the UNEP/BNEF Global Trends report was published.

iii - The USD number provided here differs from that in the Global Trends Report (USD 6.2 billion); it was converted to be comparable with other values throughout the GSR, using the date 31 December 2013 and the OANDA Currency Converter (http://www.oanda.com/currency/converter/). The same is true for the EIB number.

iv - European countries include Denmark, Finland, Iceland, Norway, Sweden, and the United Kingdom.

04

The annual GSR process serves as **a platform** to share and disseminate dispersed and diverse renewable energy data.

04 POLICY LANDSCAPE

Renewable energy technologies continue to receive significant attention from policymakers around the world. The number of countries with policies to promote the development and deployment of these technologies increased yet again in 2013.

Policymakers have turned to renewable energy to achieve a number of goals. The primary objective is generally to maintain or expand energy services. Other social, political, and economic objectives may include reducing health and environmental impacts of energy use, including greenhouse gas emissions, and enhancing energy access and security, as well as secondary benefits such as improving opportunities for education, job creation, rural economic development, poverty reduction, and gender equality.

By early 2014, renewable energy support policies were in place at the national or state/provincial level in 138 countries, up from the 127 countries reported in GSR 2013.[1] (See Table 3 and Figures 26 and 27.) As in recent years, however, the pace of policy adoption was again slow in 2013 relative to the early-to-mid 2000s; the slowing rate of adoption is due partially to the fact that so many countries have enacted renewable energy support policies already. While the early expansion of policies was driven by developed countries, many of which now have several policy measures in place, developing and emerging economies have led the expansion in recent years, accounting for 95 of the countries with renewable support policies in place by early 2014, up from an estimated 15 in 2005.[i 2] (See Figures 29 and 30.)

In 2013, there was an increasing focus on revisions to existing policies—including retroactive changes. Some adjustments were made to improve the effectiveness and efficiency of supporting policies, while others were aimed to curtail further growth of renewables for a variety of reasons. Particularly in Europe, decisions were taken in several countries to reduce support in the electricity sector. At the same time, however, policies are being further developed and differentiated, moving towards convergence of features across the different types of policy mechanisms. For example, technology-specific support has been introduced into certificate trading and quota systems that were originally technology-neutral, and feed-in policies have been moving from fixed minimum payments to premiums paid on top of a market price.

In many countries, policymakers have continued to adapt legislation to respond to changing circumstances. Some countries have adjusted policies in response to rapidly evolving domestic and international market conditions, including declining technology costs and perceived unfair trade practices. Others have revised policies to address continuingly tight national budgets or shifting public opinion, which in some instances has blamed renewables for increases in energy prices. Some countries are also providing guidance by enacting policies to advance or manage the integration of high shares of renewable electricity in existing power systems. For the first time, this section of the report presents a brief overview of these policies.

The section aims to give a picture of new policy developments at the national, state/provincial, and local levels, and does not attempt to assess or analyse the effectiveness of specific policies or policy mechanisms.

POLICY TARGETS

Policy targets for the increased deployment of renewable energy technologies existed in 144 countries as of early 2014, up from the 138 countries reported in GSR 2013. (See Reference Tables R12–R15.)

Renewable energy targets take many forms. Although the majority continue to focus on the electricity sector, targets for renewable heating and cooling and for transport are becoming increasingly important tools for policymakers. (See later sections on Heating and Cooling, and Transportation.) Other forms of targets include renewable shares of primary and final energy, as well as capacities of specific renewable technologies or their energy output. Targets most often focus on a specific future year, but some are set for a range of years or with no year reported. In addition, targets for expanding energy access, although not direct renewable energy targets, are increasingly specifying the use of renewable sources. (See Section 5 on Distributed Renewable Energy in Developing Countries.)

At least 12 countries had historical targets aimed at the year 2013. Algeria installed 10 MW of wind in 2013 to meet its targeted capacity of 10 MW, and China met its goal to add 49 GW of renewable capacity in 2013.[3] However, eight countries failed to meet their targets by year's end. For example, in early 2014, India was short of its targeted 4,325 MW of additional renewable power capacity in fiscal year 2013–14.[ii 4] Both Tonga and Fiji failed to meet goals for 100% of final energy from renewables; subsequently, Fiji reduced its targets to 100% of electricity and 23% of final energy from renewable sources by 2030.[5] France fell short of its goal of adding 1,000 MW of solar power[iii]; Nepal failed to meet its goal of 1 MW of installed wind capacity; St. Lucia failed to meet its target of 5% renewable electricity; South Africa did not meet its goal to generate 10,000 GWh of renewable electricity in 2013; and South Korea ended the year short of its goal to add 100 MW of wind power during 2013.[6]

As of early 2014, data were not yet available to determine whether several other targets were achieved, including: Algeria (cumulative 25 MW of solar PV, 25 MW of CSP); Côte d'Ivoire (3% of primary energy); Nepal (cumulative 3 MW of solar, 15 MW of micro hydro); Peru (5% of electricity demand from hydropower projects smaller than 20 MW each).[7]

New policy targets were introduced by at least six countries in 2013. Azerbaijan approved a target for renewables to account for 9.7% of total primary energy and 20% of electricity by 2020; Bhutan set a target of 20 MW of renewable power capacity by 2025; and Kazakhstan targeted a 1% share of electricity from

i - The estimate of 15 countries in 2005 was based on the best information available to REN21 at the time. As of early 2014, there were 138 developing and emerging economies, defined as countries in the low-income, lower-middle income, and upper-middle income classifications of the World Bank Country and Lending Groups, out of a total of 188 countries overall (per World Bank).

ii - India does not classify hydropower installations larger than 25 MW as renewable energy sources. Therefore, throughout the Policy Landscape section, national targets and data for India do not include hydro facilities greater than 25 MW. The Indian government's fiscal year runs from 1 April through 31 March.

iii - Throughout the Policy Landscape section, the term "solar power" refers to solar PV and/or CSP.

renewables by 2014 and a 3% share by 2020.[8] Kenya enacted a plan to expand total electric capacity by 5,000 MW by 2016, up from 1,660 MW in late 2013, including 794 MW of hydropower capacity, 1,887 MW of geothermal, 635 MW of wind, and 423 MW of solar PV.[9] Qatar set a goal of generating 2% of its electricity from renewables by 2020, and Russia targeted roughly 6 GW of solar, wind, and small-scale hydropower capacity by 2020.[10]

A number of countries revised existing targets for renewable power capacity and generation during the year, with most targets increasing. As of January 2014, China adopted a range of targets to be met by 2015, including 18 GW of wind and 35 GW of cumulative solar PV capacity (up from the previous 20 GW target), including 20 GW of distributed solar PV.[11] China also set a target to achieve 200 MW of wind installed by 2020.[12] India announced plans to more than double its renewable capacity, from 25 GW in 2012 to 55 GW by 2017.[13] Thailand increased its existing long-term targets for electricity from solid biomass, agricultural waste-to-energy, solar, and wind power, and raised its overall target for renewable shares of final energy consumption to 25% by 2021.[14] In the near term, Thailand plans to add 1 GW of solar PV by the end of 2014.[15] Vanuatu added to its existing goal of 23% renewable electricity by end-2014 by establishing targets to achieve a 40% share by 2015, and 65% by 2020.[16]

In Europe, Portugal enacted a number of technology-specific targets for cumulative electric capacity by 2020, including 769 MW of bio-power from solid biomass; 59 MW of biogas power; 29 MW of geothermal power; 400 MW of small-scale hydropower; 6 MW of wave energy; 670 MW of solar PV; 50 MW of CSP; 5,273 MW of onshore wind power; and 27 MW of offshore wind power.[17] The United Kingdom set a target to deploy 39 GW of offshore wind capacity by 2030.[18] Germany, however, lowered its offshore wind targets from 10 GW to 6.5 GW by 2020, and from 25 GW to 15 GW by 2030.[19]

In the MENA region, Egypt adopted a new five-year plan that calls for the addition of 700 MW of solar PV and 2,800 MW of CSP by 2017; Libya increased its existing 2020 target for renewable electricity from 7% to 20%; and Saudi Arabia set a near-term goal of 6 GW of solar PV by 2020 as a step towards its existing 2032 goal of 16 GW.[20] In Latin America, Chile doubled its existing target, calling for a 20% renewables share of electricity by 2025, and Uruguay set a new higher target to generate 90% of its electricity from renewable sources by 2015.[21]

On the regional level, the Caribbean Community (CARICOM[i]) Secretariat adopted a trans-national target on behalf of its 15 member states, calling for a regional renewable electricity share of 20% by 2017, 28% by 2022, and 47% by 2027.[22] The shares are to be achieved by country-differentiated targets that were yet to be defined as of early 2014. The EU and the ECOWAS region of West Africa also have trans-national targets in place. At the sub-national level, the U.S. state of California set new standards requiring the deployment of an additional 600 MW of renewable capacity beyond the 33% renewable portfolio standard (RPS) goal to make it possible for small consumers to purchase up to 100% renewable electricity from their utilities.[23] Also in the United States, Massachusetts raised its 2020 solar PV capacity target to 1.6 GW after achieving its goal of 250 MW four years early, and Minnesota set a goal for solar power to generate 10% of the state's electricity by 2030.[24]

POWER GENERATION POLICIES

Most renewable energy support policies that were enacted or revised during 2013 focus on the power sector, as in past years.[25] (See Figure 28). Around the world, a mix of regulatory policies, fiscal incentives, and public financing mechanisms—including feed-in policies, renewable portfolio standards (RPS), net metering, tax reductions or exemptions, grants, low-interest loans, and public competitive bidding /tendering—continued to be adopted to promote increased renewable power capacity or generation. In the majority of cases, countries have adopted a variety of mechanisms to produce the policy mix best tailored to their unique domestic circumstances.

As in recent years, the majority of actions relating to feed-in policies centered on modifications to existing feed-in tariffs (FITs) and feed-in premiums (FIPs), and only two countries added such policies in 2013. Kazakhstan enacted a new feed-in policy, and Ecuador relaunched its FIT scheme (which expired in 2012) with a revised incentive structure. Ecuador's feed-in rates for bioenergy and geothermal were unchanged, but tariffs were amended for wind power (up 28.6%), CSP (down 19.4%), and tidal energy (down 27.3%), and support for solar PV was eliminated.[26] Ghana established rates for the FIT scheme that was adopted as part of the Renewable Energy Act of 2011.[27]

Reductions in feed-in rates continued in several countries. Many of these reductions were planned previously—often through mechanisms that were built into policy design—and were intended to ensure that financial support remained in line with changing market conditions. However, several European countries legislated reductions (or even removals) of support that were previously unplanned and in many cases enforced retroactively (i.e., on existing capacity), as noted below.

Germany continued to implement scheduled quarterly reductions to its FIT for solar PV (in addition to annual reductions for most other technologies), with solar PV rates falling monthly. (New rates are set every three months, and reductions depend on actual installations in the previous quarter.) Further reductions in support are expected as amendments to the Renewable Energy Act are pursued, with changes anticipated in 2014.[28] The United Kingdom strengthened several FIT incentives (see below), but the degression mechanism, which is applied quarterly, resulted in reduced rates for solar PV systems of up to 50 kW.[29] Italy ceased feed-in support for new solar PV projects when the

i - CARICOM comprises Antigua and Barbuda, The Bahamas, Barbados, Belize, Dominica, Grenada, Guyana, Haiti, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Suriname, and Trinidad and Tobago.

POLICY MAPS

Figure 26. Countries with Renewable Energy Policies, Early 2014

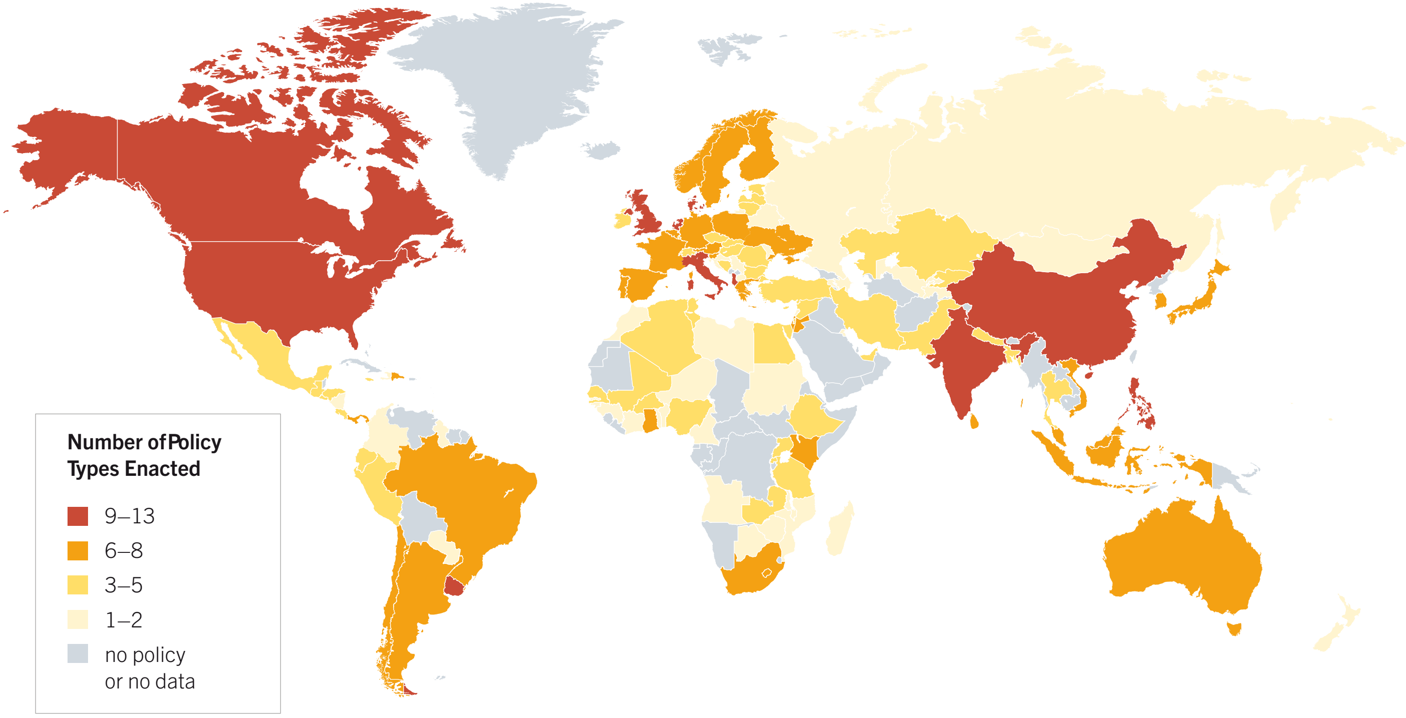
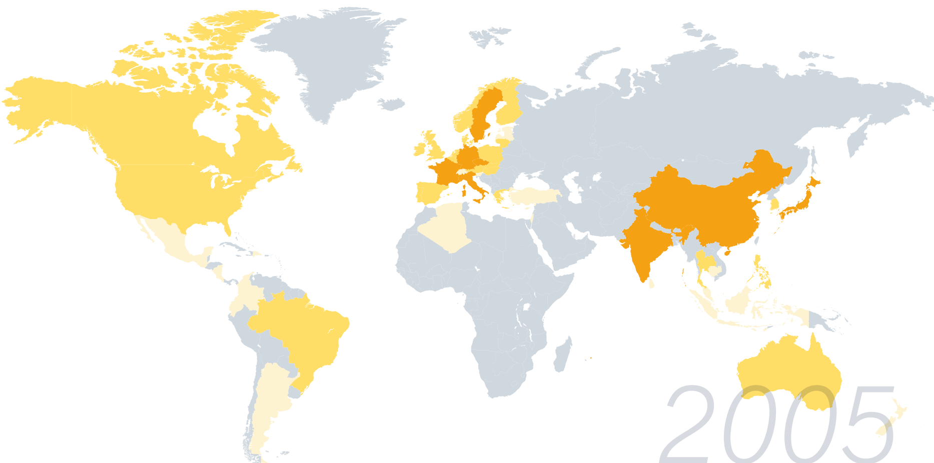


Figure 27. Countries with Renewable Energy Policies, 2005



144

COUNTRIES HAVE DEFINED RENEWABLE ENERGY TARGETS

Figure 28. Number of Countries with Renewable Energy Policies, by Type, 2010–Early 2014

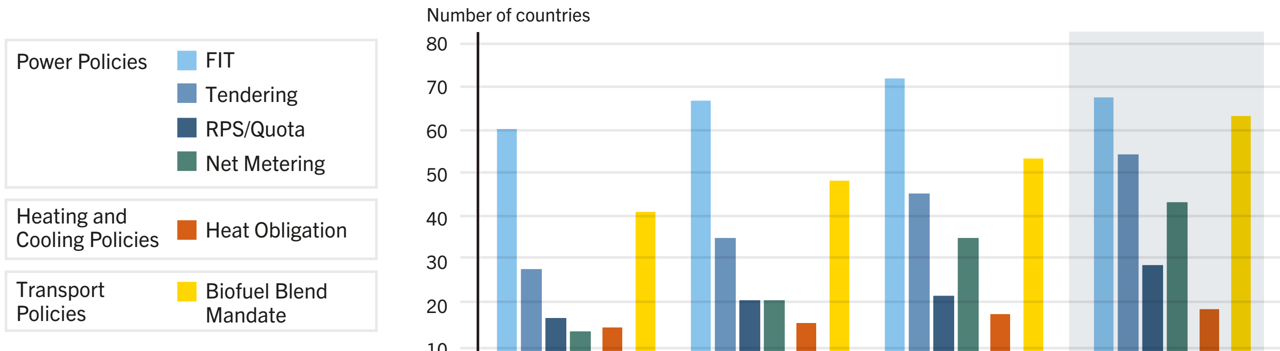


Figure does not show all policy types in use. Countries considered when at least one national or sub-national policy is in place.

04

predetermined USD 9.22 billion (EUR 6.7 billion)[i] maximum support level was reached, and offered current operators the option to extend financial support for existing projects for an additional seven years, but at a reduced rate.[30] The Netherlands revised technology support categories for the existing FIP support scheme and, separately, suspended support for new solar PV projects after the budget cap was reached in August 2013.[31]

Elsewhere in Europe, new steps were taken to weaken or remove feed-in policies. The Czech Republic passed legislation to remove FIT support for all renewable technologies as of January 2014; Greece enacted FIT cuts to be enforced retroactively as of June 2013, with an additional round of retroactive cuts proposed in early 2014; and Lithuania reduced FIT rates significantly in early 2013.[32] Portugal abolished the FIT system for new projects.[33] In addition, the scheme for existing wind facilities was revised such that operators can choose to provide an annual contribution—USD 6,900–8,000 / MW (EUR 5,000–5,800 / MW) over the period 2013–2020—in exchange for an extension of FIT terms from five to seven years. In late 2013, Portugal also reduced its 2014 rates for existing small-scale solar PV by an additional 60%.[34]

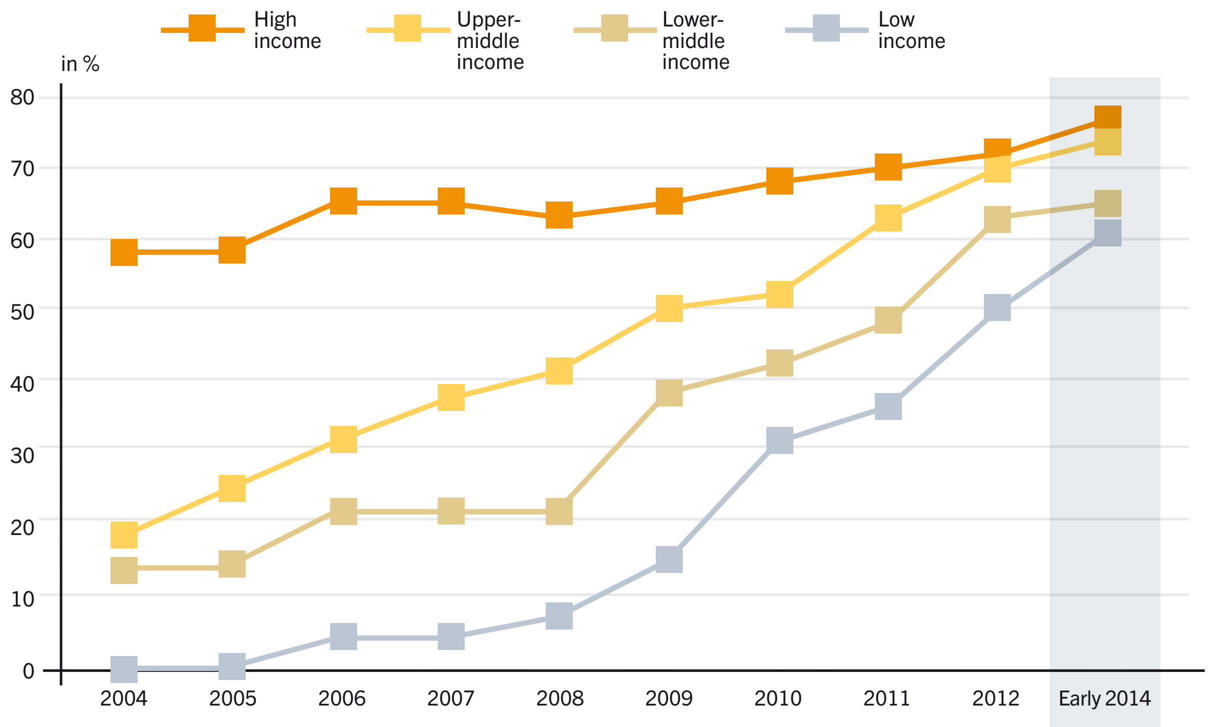
Slovakia halved preferential support for renewables, reducing the cap under its FIT from 10 MW to only 5 MW of grid-connected capacity; however, the full incentive remains available for wind power.[35] Spain removed support for existing capacity that qualified for the FIT prior to the moratorium on new projects, which was set in 2012; the country replaced FIT payments with market prices backed by a guaranteed pre-tax return of 7.5%.[36] Ukraine required that, in order to qualify under the feed-in policy, projects use technologies with a domestically sourced share of 30% as of January 2013, and 50% as of January 2014.[37]

China amended its existing solar PV FIT to allow for three regionally differentiated support schemes with reduced rates for ground-mounted solar PV projects in solar-rich regions.[38] Japan reduced solar PV FIT rates by 10% in 2013, and by an additional 11% in early 2014.[39] As of early 2013, the degression rate for Malaysia's FIT was set to 8% for plants smaller than 24 kW, and to 20% for larger plants.[40]

A few countries with feed-in policies increased their tariffs and extended support during 2013. Denmark introduced a higher FIP tariff for small-scale solar PV and raised the revised wind tariffs from USD 0.04 / kWh (EUR 0.03 / kWh) to rates capped at USD 0.11 / kWh (EUR 0.08 / kWh).[41] France raised FIT rates for rooftop solar PV systems by 5%, and enacted a 10% FIT bonus for systems manufactured in Europe. Despite an initial ruling by the European Court of Justice that France's wind FIT constituted unlawful state aid, the European Commission upheld its legality.[42] Ireland introduced FITs to support the development of 30 MW of ocean energy capacity.[43] In the U.K., the 5 MW project capacity cap was doubled in order to extend FIT support to community projects of up to 10 MW in size.[44]

In Asia, China adopted a new incentive that provides distributed solar PV projects with an additional USD 0.07 / kWh (CNY 0.42 / kWh).[45] Indonesia expanded its FIT scheme to include support for solar PV projects that meet a 40% local content requirement.[46] Japan raised FIT rates for offshore wind by 63%.[47] Thailand introduced a new FIT category to support distributed solar generation, with the goal of installing 200 MW of rooftop solar PV in 2013; extended the contract term for FIT support from 10 to 25 years; and defined a three-tiered FIT rate system (based on building size and classification) to support residential and commercial solar PV installations.[48]

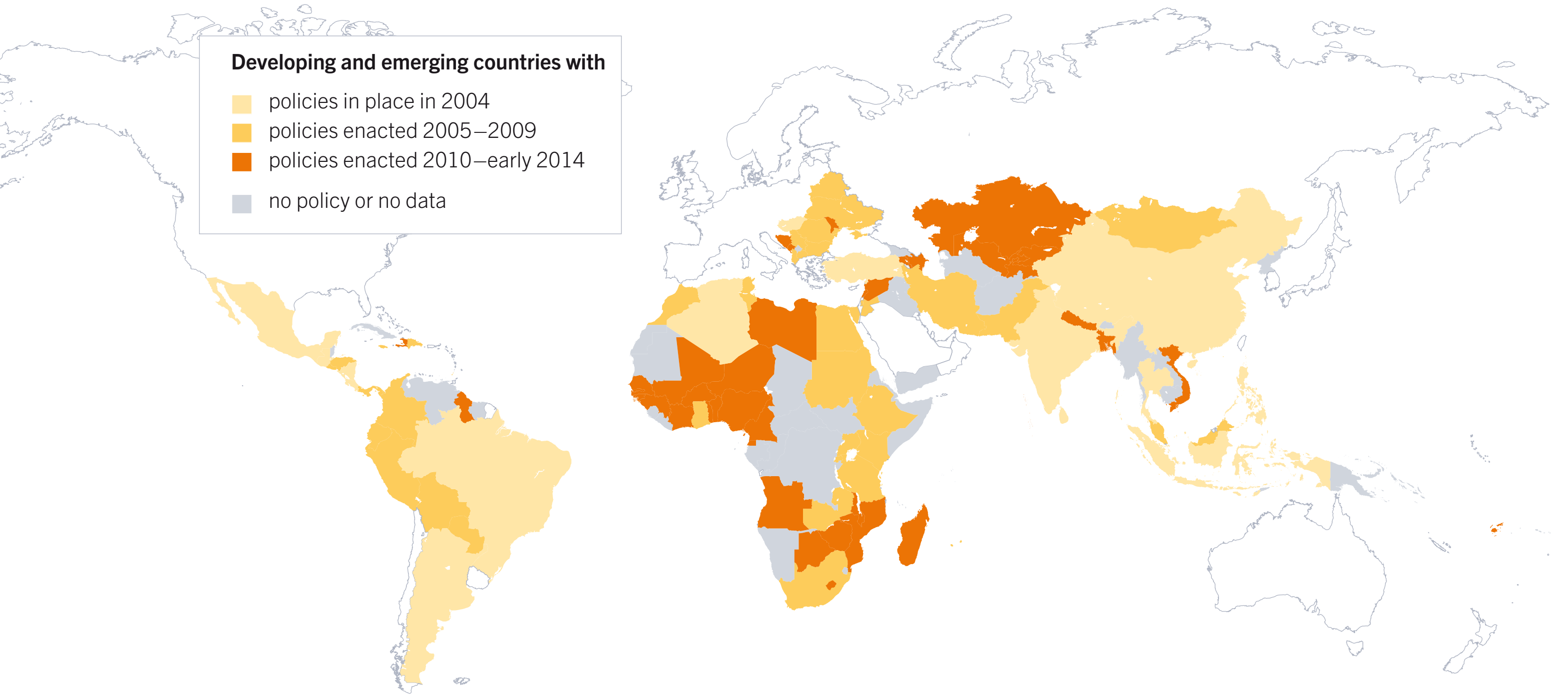
Figure 29. Share of Countries with Renewable Energy Policies by Income Group, 2004–Early 2014



Countries according to annual GNI per capita levels, per World Bank, 2014.

i - All exchange rates in this section and elsewhere in the GSR are as of 31 December 2013, and are calculated using the OANDA currency converter (http://www.oanda.com/currency/converter/).

Figure 30. Developing and Emerging Countries with Renewable Energy Policies, 2004, 2009, and Early 2014



Elsewhere, Algeria extended FIT support for solar and wind power technologies by introducing a two-tiered payment structure offering fixed-rate tariffs for 5 years and an adjusted rate for the following 15 years; South Africa introduced new time-of-day differentiated tariffs to spur the development of CSP.[49] Uganda revised its existing FIT programme to offer additional incentives, access to long-term commercial financing, and security to project developers, and also reinstated solar PV as a qualifying technology for 2014.[50] In Turkey, applications opened for solar PV and CSP (600 MW) for the first time under the FIT scheme that was enacted in 2011.[51]

A number of feed-in policy changes were made at the sub-national level in 2013 and early 2014 in Australia, Canada, India, and the United States. South Australia amended its FIT to reduce rates for existing projects and eliminated support for new projects as of October 2013.[52] Over the course of four days in 2013, Western Australia enacted and then reversed a decision to halve FIT rates for residential solar PV systems, while Australia's Northern Territory cancelled its FIT as of January 2013, with support now coming from renewable energy credits.[53]

Nova Scotia, Canada, added FIT rates for tidal arrays to its existing programme. Ontario revised its FIT in response to an internal review and to the World Trade Organization (WTO) ruling on the province's domestic content requirement: the requirement was reduced to a local content share of 19–28% (depending on technology) in mid-2013, and then removed entirely in December.[54] While Ontario maintained existing rates for wind power, it increased rates for hydropower, bioenergy, and biogas, and reduced them for solar PV (down as much as 39%) and landfill gas (down 31%).[55] For all renewable energy projects larger than 500 kW, Ontario replaced FIT support with a competitive bidding scheme.[56]

In India, the Gujarat Electricity Regulatory Commission retained its FIT despite the state government's pressure to reduce rates.[57] In the United States, no new FITs were added for the second consecutive year (although legislation was introduced to establish a statewide FIT in Maine), keeping the number of states with FITs at five. Rhode Island amended its existing FIT to require that small-scale (50 kW to 1.5 MW, depending on the technology) distributed generation projects submit competitive bids to determine the rate of financial support, as is required for large-scale projects.[58]

RPS laws or "quotas" mandating the use of specific shares or quantities of renewable power are in place in 25 countries at the national level and 54 states/provinces in the United States, Canada, and India. No new countries, states, or provinces adopted RPS laws in 2013, but several states and provinces enacted revisions.

In the United States, although the number of states with RPS policies remained at 29 by year's end, RPS policies came under increasing political pressure during 2013.[59] There were efforts to weaken or eliminate existing laws in many states, and reviews were undertaken in 16 states.[60] In response to these reviews, several states introduced changes that were both positive and negative for renewables. California revised its regulations to allow its Public Utilities Commission to raise the RPS requirement without legislation, but as of early 2014, the RPS goal remained at 33%.[61] Minnesota revised its RPS policy to include a 1.5% solar PV requirement for utilities.[62] Colorado doubled its renewable requirement for co-operative utilities and created a distributed renewable generation requirement, although the revised legislation also expanded the list of eligible technologies to include coal-mine methane, synthetic gas, and fuel cells.[63]

The Energy Act adopted in the U.K. in 2013 established a number of new provisions, including the 2017 phaseout of the Renewables Obligation for new participants.[64] Tamil Nadu, India, overturned its requirement for solar power to meet 3–6% of industrial electricity demand.[65]

New net metering policies were adopted in 5 countries at the national level in 2013, bringing the total to 43 countries. In Europe, Greece enacted a net metering programme for small-scale solar

SIDEBAR 7. INNOVATING ENERGY SYSTEMS: TRANSFORMATION OF THE ELECTRIC UTILITY INDUSTRY

The rise of a variety of "disruptive" energy technologies (new products or markets that replace existing ones, such as distributed solar PV and wind power) as well as of demand-side efficiency measures is challenging the traditional business model of electric utilities in many liberalised electricity markets. Shifting and disappearing power loads and changing relative costs of various generating technologies undermine the economic viability of some existing generating assets, which may become stranded in a changing market.

Competition from new technologies can be disruptive in any industry and is not problematic in itself. Distributed generation, for example, can help reduce the load on the transmission and distribution network during peak demand periods, minimizing both the investment needed in these systems and the potential for outages (in turn reducing associated costs to the distribution utility). Moreover, many utilities faced challenges even before the rapid growth of wind and solar power, due to overinvestment in fossil generating capacity, declining natural gas prices in some countries, sluggish electricity demand growth, and a further slowdown in demand caused by the financial crisis. Europe's top 20 utilities, for example, have lost more than half of their value since their peak in 2008. Solar and wind power have simply added to the disruption.

Rising shares of wind and solar power have reduced electricity prices and the number of kilowatt-hours needed from thermal generation, particularly at times of peak mid-day demand (in the case of PV) when many utilities profit the most from higher market prices. Some wholesale markets have seen significant reductions in power prices (even negative pricing) during periods of high generation and low demand, which has squeezed out of the merit order (relatively) clean and flexible natural gas as well as coal/lignite. In response, many large utilities in Australia, Europe, the United States, and elsewhere are pushing back against renewables, claiming that they are increasing electricity costs and arguing for an end to policy support for renewable power.

The dramatic decline in solar PV module prices, in particular, has furthered a shift from conventional electricity models—with a one-way flow of electricity (supply-demand model)—towards a bidirectional model in which power consumers can also become producers. By 2013, more than 3 million EU households produced their own electricity using solar PV, and, by early 2014, 16% of Germany's businesses were electricity self-sufficient, up 50% from a year earlier.

The rapid loss of revenue from ratepayers raises questions such as who will pay for the system reliability and reserve power that utilities have always provided? Who will invest in needed infrastructure improvements? And what share of ancillary services can renewable energy provide? Some say that a new utility business model is needed, and many utilities agree. A recent global survey of utility executives showed expectations of the need to change business models to survive, with the highest anticipation of transformation in Asia. German utility giant EnBW went so far as to declare that its conventional business model could "no longer work."

Some utilities are responding by increasing their investment in renewables. Whereas a decade ago, utilities in Europe accounted for less than 10% of investment in large-scale renewable energy projects, they now make up more than half of the pipeline of future projects. Coal India has begun developing solar PV projects across India. Other utilities are shifting away from traditional centralised power generation and moving into "downstream" activities, or joining forces with renewable energy interests. Some utilities in the United States are creating new business models to profit from solar power: for example, Duke Energy and Edison International have invested in a firm that is financing solar projects, and PSE&G of New Jersey is making loans to solar PV customers.

Increasingly, stakeholders contend that the business of meeting energy needs is moving away from a volume-based supply model, underpinned by asset ownership, to a service-based

PV and small-scale wind plants; Latvia enacted a net metering policy that entered into force on 1 January 2014; and Ukraine launched a net metering programme that requires utilities, as of 1 January 2014, to connect residential solar PV systems to the grid within five days of project completion and the filing of an interconnection request.[66] In Central America, Honduras approved net metering for systems smaller than 250 kW.[67] Additionally, the Philippines adopted new interconnection standards, bringing into effect the net metering policy that was legally established in 2008.[68]

Only two countries revised net metering policies at the national level in 2013: Denmark restricted the availability of payments for self-generation by moving from yearly to hourly net metering and setting an eligibility cap of 20 MW worth of solar PV systems, and the Netherlands removed its 5,000 kW incentive cap, thereby increasing the amount of electricity generation that is eligible to receive support under its net metering scheme.[69]

At the state level, there were a number of developments in 2013 and early 2014, with four Indian states—Andhra Pradesh, Kerala, Gujarat, and Uttarakhand—all starting net metering programmes for rooftop solar PV systems.[70] Uttarakhand introduced net metering for rooftop solar PV at a rate of USD 0.15/kWh (INR 9.20/kWh) for installations of 300 W–100 kW with battery backup, and up to 500 kW systems without batteries; total installations are limited to 5 MW.[71] Tamil Nadu set a cap on its existing net metering scheme for solar PV systems, limiting it to 90% of a consumer's electricity consumption.[72]

In the United States, net metering policies remained in 43 states, Washington, D.C., and 4 territories. While no new policies were added in 2013, four states revised existing laws. California extended net metering (it was scheduled to be suspended in 2014), provided clarity on how to calculate the 5% capacity cap, and laid the foundation for the development of a new uncapped net metering scheme.[73] New York tripled its solar PV capacity model that builds on existing customer relationships, finds new ways to meet people's needs, and captures the values associated with renewable energy and distributed generation. Instead of earning revenue for the energy consumed (USD per MWh), revenues would be based on the energy services provided, demand charges, and/or capacity-based pricing (USD per MW).[i] In Germany, both RWE and EnBW plan to adopt a business model that accommodates distributed self-generation, with EnBW planning to divest up to 80% of its generation and trading business by 2020. However, capacity-based pricing can also undermine energy efficiency efforts and discourage investments in renewables, leading some to argue in favour of a hybrid model.

Innovation in the private sector will require an effective enabling policy framework. In many countries, discussions are under way about regulatory reforms needed to support this transition. This begs the questions: What future functions should utilities provide? Which mechanism can appropriately compensate companies for performing those functions? Energy market design reforms include incentivising ancillary services through mechanisms like capacity payments and flexibility premiums, and establishing the right price signals to address misalignments between incentives to distributed electricity system customers, and the cost and value to the electricity system (e.g., network benefit payments, network tariffs that reflect the transmission and distribution costs, and network service charges).

The United Kingdom, for example, has introduced a common pricing methodology for electricity networks, whereby decentralised electricity generators are offered a positive network tariff (credit) for feeding power into local networks. The U.S. state of California is experimenting with "on-bill financing" of high-value energy efficiency and on-site renewable energy. Electric utility customers select pre-qualified technologies and service providers, while the utility loses power sales but still profits by "lending" its money.

Countries with an "energy-only" power market, such as Germany, plan increasingly to implement "capacity markets" that address the need for system balancing. To integrate higher shares of variable renewables into electricity markets, more dispatchable capacity is also needed. Yet traditional peaking plants are being used less—and thereby becoming less profitable—as shares of renewable energy increase. New market designs are needed to incentivise this reserve capacity or increase flexible generation.

Power markets should be designed to provide the proper economic incentive for a least-cost and efficient mix of peaking, cycling, and baseload generating units in a system that accommodates ever-growing shares of variable renewables. New market designs will need to balance the choice between currently available solutions to system balancing (such as increasing peaking capacity) and developing alternatives, such as increasing the flexibility of new gas plants, installing diverse types of energy storage at various scales, and pursuing demand-side response options mediated by smart-grid solutions.

The "Innovating Energy Systems" sidebar is a regular feature of the Global Status Report that focuses on advances in energy systems related to renewable energy integration and system transformation.

i - This would entail reforming the process of retailing decentralised electricity/competitive and liberalised markets, particularly for retail power; enacting enabling regulations for self-generation; and adopting incentives such as time-of-use tariffs, dynamic pricing, peak pricing, and the delivery of new energy services.

Source: See Endnote 99 for this section.

cap, thereby opening the programme to more consumers; and Vermont raised the net metering cap from 4% of peak demand to 15%.[74] In several other states, net metering faced significant utility opposition. In Arizona, net metering was retained, but with a monthly fee of USD 0.70/kW to be applied for all new solar PV systems.[75]

Public competitive bidding, or tendering, continues to gain prominence, with the number of countries turning to public auctions increasing from 9 in 2009 to 55 by early 2014.[76] Central and South American countries continue to be global leaders in renewable energy tenders. Brazil, which has held tenders for wind power for several years, included solar power projects for the first time in November, with 2.7 GW of solar power qualifying for the A-3 auction, although no contracts were awarded in that auction. Overall, Brazil's auctions awarded 4.7 GW of new wind capacity, 122 MW of solar PV, 700 MW of small hydropower, and 162 MW of bio-power during 2013.[77] Chile held its first CSP tender in 2013; Ecuador held its first auction for solar PV; Peru allocated USD 3.6 billion for tendering of renewable energy projects designated to come on line by 2016; and Uruguay launched multiple solar power tenders throughout the year.[78] In Central America, El Salvador announced tendering for the allocation of 100 MW of wind and solar PV plants.[79]

In Europe, France launched a USD 275 million (EUR 200 million) tender for the construction of 80 MW of pilot ocean energy capacity, as well as a tender of USD 4.8 billion (EUR 3.5 billion) for 1,000 MW of offshore wind capacity.[80] Also in 2013, Italy held its second wind auction to support the development of 400 MW of new capacity; and Norway awarded USD 3.3 billion worth of onshore wind projects as part of a plan to triple its wind power capacity to over 2 GW by 2020.[81] Russia launched its first tenders for renewable energy, selecting 39 projects that totalled 504 MW of new capacity, including 399 MW of solar PV projects.[82] In addition, a USD 2.6 billion (RUB 85 billion) programme was approved to allocate 1.2 GW of solar PV projects through public tenders by 2020.[83] The United Kingdom announced plans to hold joint auctions for wind and solar power capacity for the first time in 2014.[84]

In Africa, Egypt launched a tender for the construction of the nation's first solar PV plant of 200 MW, and South Africa set dates for its third round of CSP tenders.[85] Kuwait held auctions to award licences for the construction of 50 MW of CSP capacity.[86]

In India, Phase 2 of the Jawaharlal Nehru National Solar Mission was launched with a call for bids to award 750 MW of grid-connected solar PV contracts across the country, although the tender was delayed twice as of early 2014.[87] At the sub-national level, the state of Karnataka opened bidding for 130 MW of solar power capacity, while Punjab awarded contracts to 29 solar power developers for a cumulative capacity of 250 MW.[88]

Other types of auctions also took place to advance the deployment of renewable energy. The United States awarded the nation's first licence for offshore wind development, and subsequently held two additional auctions for offshore licences.[89]

Countries continued to support the renewable energy sector through a mix of fiscal incentives and public financing aimed at helping to overcome the various cost barriers that challenge renewable energy deployment, including high upfront costs for renewables, continued high subsidies for fossil and nuclear energy, and failure to internalise environmental and social costs of energy production and use. A number of incentives were revised or introduced in 2013 and early 2014. For example, India reintroduced the Generation Based Incentive (GBI) scheme that had expired in April 2012, with payments of USD 0.01/kWh (50 paise/kWh), and applied it retroactively to include projects that were commissioned during the period of lapse.[90] China introduced a 50% value-added tax (VAT) rebate for solar power plant operators as well as tax incentives to spur the development of hydropower, and Iran established a fund to support renewable electricity projects.[91]

In Europe, Denmark launched a new grant scheme that provided USD 46.1 million (DKK 250 million) in 2013, and allocated USD 92.3 million (DKK 500 million) annually from 2014 to 2020, to promote the deployment of renewable energy technologies (as well as district heating, co-generation, and energy efficiency) in energy-intensive industries.[92] Ireland's Offshore Renewable Energy Development Plan provided a combined USD 61.9 million (EUR 45 million) for testing facilities, and R&D for ocean energy.[93] The U.K. increased the level of support for offshore wind producers under its green certificate scheme to 0.26 USD/kWh (0.155 GBP/kWh), although contract terms were reduced from 20 to 15 years.[94] In the United States, the state of New York pledged USD 1 billion in new funding to solar PV projects.[95]

Reductions to fiscal incentives also were seen during 2013. For example, France removed an 11% investment tax credit for solar PV equipment (the credit remained for solar water heaters); and the U.S. Production Tax Credit, which was extended in January 2013, expired at year's end for new renewable energy projects in the United States (but the credit still applies to projects that began construction in 2013).[96]

During 2013 and early 2014, taxes and fees on renewable energy continued to be introduced retroactively in some European countries that previously supported renewable technologies. Bulgaria enacted a 20% tax on revenues from solar PV and wind installations; the Czech Republic placed an open-ended tax of 10% on revenue from solar PV installations larger than 30 kW; and Greece enacted a 10% tax on revenue from renewable power generation, to be enforced retroactively.[97] Taxes on self-consumption are being enacted or considered as well. On top of existing grid access restrictions and fees, Spain introduced a tax on the self-consumption of solar PV, while Germany has proposed a similar levy on electricity generated from rooftop systems larger than 10 kW.[98]

A number of new policies are being enacted around the world in an effort to adapt to rapidly changing challenges that are emerging with higher shares of variable renewable electricity. Policies to advance system integration continue to gain prominence. These include promotion of energy storage, demand-side management (DMS), and regulations that aid in the integration of renewables into national grid networks and energy markets. New market mechanisms continued to be introduced and refined in 2013.[99] (See Sidebar 7.)

Singapore raised its cap on the total power provided by variable resources from 350 MW to 600 MW during periods of peak demand in 2013.[100] China introduced a mandate requiring grid companies to purchase all solar electricity generated within their coverage areas.[101] India allocated USD 6.9 billion (INR 430 billion) to a grid modernisation program—the Green Energy Corridor—to enable the integration of renewable energy sources.[102]

Policies to promote energy storage gained prominence at the national and sub-national levels in 2013 and early 2014. Japan introduced subsidies to cover two-thirds of the capital costs of lithium ion batteries installed with solar PV systems.[103] In Canada, the provisions of Ontario's Long-Term Energy Plan were amended to include 50 MW of energy storage in the province's competitive procurement process.[104] Puerto Rico's energy regulator revised its existing minimum technical requirements to mandate the incorporation of energy storage in new renewable energy projects, and the U.S. state of California introduced a mandate on investor-owned utilities to begin buying 200 MW of energy storage capacity by 2014, with a statewide goal to acquire 1.3 GW of storage capacity by 2020.[105] In addition, Massachusetts introduced requirements on utilities to develop plans to introduce smart meters and increase investments in smart-grid technology over the next decade.[106]

To reduce what is often one of the largest hurdles faced by renewable energy project developers, some countries also revised their permitting processes. In 2013, Chile passed regulations to fast-track the process for renewable energy permitting from 700 to 150 days.[107] France revised a number of wind permitting procedures; while Turkey revised electricity licensing procedures.[108] In the United States, two separate pieces of legislation were adopted to streamline the permitting process for renewables, including refining regulatory oversight procedures and raising from 5 MW to 10 MW the maximum capacity for small-scale hydropower plant classification.[109] In addition, the U.S. Federal Energy Regulatory Commission (FERC) approved guidelines to allow for a "fast-track" inter-connection process for certain renewable systems up to 5 MW in size, eliminating the need for them to undergo extensive interconnection studies.[110]

In an effort to balance utility concerns over idle generation capacity and inadequate transmission infrastructure, Gujarat, India, enacted new regulations restricting independent grid access—guaranteed in the Electricity Act of 2003 to consumers with a demand greater than or equal to 1 MW—by removing the ability of state distribution companies to enter into private power purchase agreements (PPAs) with out-of-state energy providers.[111]

HEATING AND COOLING POLICIES

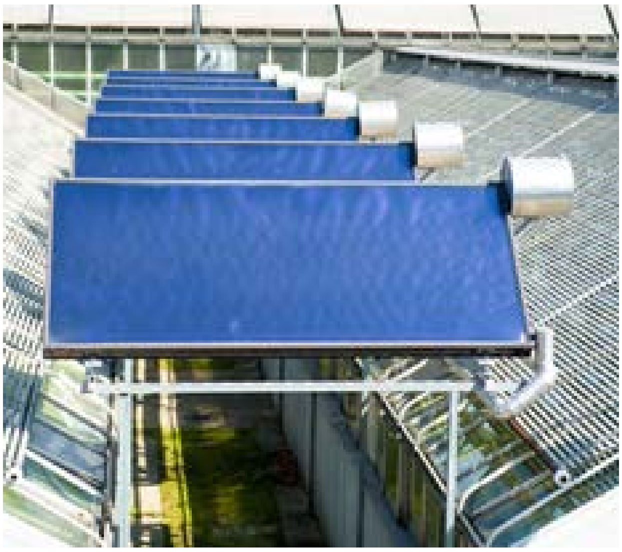
Globally, heating and cooling account for almost half of total global energy demand.[112] Modern biomass, direct geothermal, and solar thermal technologies together represent a major portion of the energy produced with non-hydro renewables, and offer vast potential for meeting the world's residential, commercial, and industrial heating and cooling needs. As a result, countries continued to enact targets, policies, and incentives for the promotion of renewable heating and cooling technologies during 2013. However, this sector still lags far behind the renewable power sector for attention from policymakers.

The 28 EU Member States have introduced targets for specific shares of renewable heating and cooling. In addition, several countries in Africa, Europe, and the Middle East target the use of solar water heating.[i 113] Overall, renewable heating and cooling targets exist in at least 41 countries worldwide (see Reference Table R14), and at least 19 countries have heat obligations/mandates in place at the national or state/provincial level to promote the use of renewable heat technologies.

As in 2012, policy adoption was relatively slow in the heat sector, but a few countries and states enacted new standards for renewable heat in 2013 and early 2014. Albania mandated the use of renewable heat technologies in new buildings, requiring that certain building types be constructed with a minimum share (to be defined by May 2014) of solar thermal heat. In addition, solar thermal systems and components were exempted from customs duties and VAT.[114] Half a world away, the Australian standards body introduced the world's first solar cooling standard in late 2013 to establish product performance benchmarks.[115] India's Energy Conservation Building Code was extended to two additional states in 2013, so that it now mandates standards for renewable energy and energy efficiency in 8 of the 28 Indian states.[116] (See Sidebar 8.)

Revisions to existing regulatory policies for heating and cooling were made by the Netherlands, which introduced technology-differentiated FIP tariffs to support the generation of heat from biogas, solid biomass, deep-geothermal, and solar thermal; and by the United Kingdom, which introduced a tariff degression mechanism to its feed-in policy for renewable heat, and began reducing rates as of mid-2013.[117]

Several countries, mostly in Europe, provide fiscal incentives, including grants and investment subsidies, to promote investment in renewable heating and cooling technologies. Austria doubled its subsidies for solar thermal systems to USD 192 / kW_{th} (EUR 140 / kW_{th}) to cover up to 30% of the costs of installation.[118] Cyprus reinstated a solar heating and cooling support programme, following its expiration in 2012, to provide investment subsidies in the form of grants of up to USD 4,129 / kW_{th} (3,000 EUR / kW_{th}).[119] The Czech Republic launched its New Green Savings programme to provide grants for up to 40% of the cost of installing a solar thermal system.[120] Germany extended incentives to a host of renewable and efficient heating and cooling technologies—including solar thermal cooling, industrial waste heat, cogeneration, and district heating—to cover 25% of the investment costs for systems ranging from 5 kW to 500 kW_{th}.[121] Italy's Conto Termico incentive scheme came into force in early 2013 to provide capital incentives to renewable heat technologies, including biomass boilers, solar thermal systems, and also heat pumps.[122] At the regional level, Wallonia, Belgium, introduced grants to cover 30–35% of the costs of installing renewable heating systems in buildings.[123]



Elsewhere, Australia provided national grants to municipal governments for the installation of solar and heat pump systems for water heating; India introduced a two-year rebate program to support solar hot water and solar process heat installations; Puerto Rico established a program to fully fund the replacement of conventional water heaters with solar thermal for low-income families; and Thailand extended subsidies for solar water heaters (SWH) to 2021, and set out a plan for a gradual degression from the current 25% subsidy.[124]

Additional forms of financial support, such as public investment, were introduced or revised during the year. South Africa

i - The 28 EU Member States all have targets for renewable heating and cooling in their National Renewable Energy Action Plans. Additional countries include Bhutan, China, India, Jordan, Kenya, Lebanon, Libya, Morocco, Mozambique, Sierra Leone, Swaziland, Thailand, and Uganda.

SIDEBAR 8. THE LINKAGE BETWEEN RENEWABLE ENERGY AND ENERGY EFFICIENCY: FOCUS ON SUSTAINABLE BUILDINGS

The critical interplay between renewable energy and energy efficiency in achieving sustainable and inclusive growth has been widely recognised in recent years.[i] It was an impetus for the United Nations Secretary General's Sustainable Energy for All (SE4ALL) initiative[ii], which resulted in important voluntary commitments from businesses, investors, and national governments during 2013 to advance renewables and energy efficiency.

High energy prices and global fossil fuel subsidies—estimated to be at least USD 544 billion in 2012—have reinforced the need for energy efficiency improvements and renewable energy, and have highlighted the potential for adding value by focussing on both areas. Energy efficiency can be considered the "primary fuel" laying the foundation for a low-carbon energy future. When employed in concert, energy efficiency and renewables offer significant economic benefits and a wide range of co-benefits, including climate change mitigation, health improvements, energy access, and job creation.

Annual relative global primary energy intensity[iii] is trending downwards again, after a sudden increase during 2009 and 2010. The developments in 2011–12 provide some optimism that energy demand can be further decoupled from GDP growth.

Assuming the full implementation of policies and measures already enacted to advance energy savings, as well as those currently under discussion, it is estimated that primary energy demand in 2035 could be 7% lower than under a business-as-usual scenario. The majority of these savings would come from efficiency gains in end-uses; industry would account for 37% of these efficiency-related savings, followed by transport (31%) and buildings (26%). Savings would still fall short of the full economic potential available in 2035, however, and it is expected that the greatest unrealised potential would be in the buildings sector.

Considering that a building's lifetime is 50 years or more, optimising efficiency and use of renewables as early as possible is critical for maximising potential energy savings while avoiding further lock-in to inefficient building stock. Integrating efficiency and renewables into the design stage is particularly relevant for emerging economies, where rates of urbanisation and building construction are high; in India, for example, about 70% of the building stock expected by 2030 has yet to be constructed. Developed countries face a different challenge in that most of the energy efficiency potential lies in retrofitting of the existing building stock.

To address these challenges, more governments around the world are focussing on the building sector. China, for example, published new policy measures in 2013 to encourage the adoption of green building practices. Two additional Indian states adopted the Energy Conservation Building Code, which integrates renewable energy and energy efficiency and mandates the use of solar water heating in specific building types. In Australia, around 100 local governing authorities received grants under the Local Government Energy Efficiency Program to install energy efficient solar and heat-pump systems for water heating in their buildings and community facilities.

Several agency initiatives and programmes were started during 2013. For example, the Renewable Energy and Energy Efficiency Partnership (REEEP) and the Global Buildings Performance Network (GBPN) launched the "1 Billion m^2 of Positive Energy Buildings" intervention, which aims to promote transformational change in the building sector by shifting the concept of buildings as energy consumers to energy producers that can meet their own energy needs. In addition, the International Partnership for Energy Efficiency Cooperation (IPEEC) conducted a survey on building rating tools in order to identify how they can help reduce energy consumption and associated greenhouse gas emissions.

Also in 2013, various national green building councils continued to promote the adoption of voluntary green building rating systems. For example, the U.S. Green Building Council launched a new, more rigorous version of the LEED rating system, which is used internationally. Bottom-up demand for green buildings expanded as well. By year's end, the Australian Green Star had been awarded to over 650 projects, and more than 50% of these were certified in the past three years. In South Africa, the green building movement has gained ground rapidly, with 36 buildings receiving a Green Star SA rating by mid-2013.

This sidebar on renewable energy and energy efficiency linkages is a regular feature of the Global Status Report.

Source: See Endnote 116 for this section.

i - For more on the interplay between energy efficiency and renewable energy, see Feature section in GSR 2012.

ii - The SE4ALL initiative targets, by 2030, universal access to modern energy services, a doubling of the share of renewable energy in the global energy mix, and a doubling of the global rate of improvement in energy efficiency. By early 2014, more than 80 governments from developing countries from all regions had joined the initiative. See http://www.se4all.org/our-vision/our-objectives/.

iii - Primary energy intensity is commonly used as a proxy for energy efficiency, even though it fails to cover the multi-dimensionality of the latter.

announced a plan to provide fully subsidised SWH to low-income households, and aims to award contracts through competitive tendering for the manufacturing of 650,000 individual SWH by 2015.[125] However, simultaneously, South Africa delayed the provision of incentives and postponed from 2014 to 2015 its target to install 1 million SWH.[126] The U.K. allocated USD 8.24 million (GBP 5 million) to the installation of renewable heating technologies such as biomass boilers as well as heat pumps in public housing; and the Flanders region of Belgium allocated USD 9.2 million (EUR 6.7 million) to promote renewable heat production, waste heat recovery, and the construction of district heat networks.[127]

At least two countries adopted or revised low-interest loans to support renewable heat. Spain approved a USD 172 million (EUR 125 million) programme to offer zero-interest loans for energy efficiency retrofits of existing buildings, which also include the incorporation of solar thermal.[128] Tunisia extended to 2016 its existing preferential low-interest loans for SWH, and began providing a 30% investment credit for solar thermal process heat systems.[129]

Although support in the sector is generally increasing, there were a few instances of policy expirations and downwards revisions. A law expiration in Chile at the end of 2013 led to the removal of tax rebates for solar thermal systems, and India's Ministry of New and Renewable Energy reduced grant support for SWH.[130]

TRANSPORT POLICIES

Most policies to increase the use of renewable energy in the transport sector focus on support for the production, promotion, or use of biofuels. During 2013, such policies continued to be enacted or revised by a number of countries that are using a mix of fiscal incentives and regulations. Common policies include biofuel production subsidies, biofuel blend mandates, and tax incentives. As of early 2014, blend mandates existed in 33 countries, with 31 national mandates and 26 additional mandates at the state/provincial level. (See Reference Table R18.)

New blend mandates were introduced in 2013 by Ukraine, which established an initial E5 mandate (5% ethanol blended with gasoline) scheduled to increase to E7 by 2017; Ecuador, which enacted a B5 mandate (5% biodiesel blended with diesel fuel) with plans for a future (undated) increase to B10; and Panama, whose current E5 mandate is set to be increased to E7 in 2015 and E10 in 2016.[131]

Many existing blend mandates were strengthened in 2013. India raised its ethanol blend mandate from E5 to E10 at the end of 2013; Malaysia began extending the B5 blend mandate to more regions with the aim of enacting it nationwide by July 2014; and the Philippines began implementing the E10 mandate, delayed since 2011.[132] In South America, Argentina increased its blend mandate from B7 to B10, and Brazil increased the national ethanol blend level from E20 to E25, and began studying a possible increase in its biofuel blend from B5 to B7.[133] In Africa, Zimbabwe raised its existing blend mandate twice, initially from the existing E5 mandate to E10 in early 2013, and subsequently from E10 to E15; it also set a goal of introducing E20 by early 2014.[134] South Africa set a date of October 2015 to begin implementing the E2 and B5 blend mandates first established in 2007.[135]

At the same time, biofuel support policies in Europe and the United States continued to be challenged by concerns about the impacts of cultivating energy crops on food production, land use, biodiversity, and water. Net lifecycle greenhouse gas emissions from biofuels are also under review.

In the United States, the Renewable Fuel Standard (RFS) was reduced for the first time since it was enacted in 2005, with a decrease in the mandated blending level from a minimum of 54 billion litres (14.4 billion gallons) of corn ethanol to 49 billion litres (13 billion gallons).[136] At the state level, Florida repealed its E10 blend mandate, and Maine adopted legislation to ban ethanol blends in the state.[137] Similar discussions are under way in the European Parliament, where critics have questioned the use of first-generation biofuels to meet the EU target of 10% renewable energy—including biofuels, electricity, and hydrogen—in total transport energy by 2020.[138]

The use of fiscal incentives and public financing for the biofuels industry continued to expand during 2013. Brazil offered tax credits and provided low-interest loans for ethanol producers at an estimated cost of USD 480 million (BRL 970 million).[139] Poland initiated a USD 3.3 million (EUR 2.4 million) tender to support the production of renewable fuels, and the United States provided USD 16.5 million in grants to advance the development of algae-based biofuels.[140] In a blow to biodiesel, China instituted tax and trade duties on imported biodiesel in an effort to support domestic petroleum diesel refineries.[141]

Many countries continue to explore additional options for integrating more renewable energy into the transport sector, such as increasing the number of vehicles fuelled with biomethane, renewable hydrogen, or electricity from renewable sources. Electric vehicles (EVs) continue to receive policy support from a number of countries, although this is seldom linked directly to renewable electricity. Examples of support schemes enacted in 2013 include China providing a subsidy of USD 9,813 (CNY 60,000) for the purchase of an EV; Germany pledging USD 247.8 million (EUR 180 million) for electro-mobility demonstration projects; India introducing plans to produce 5–6 million EVs by 2020 as part of its National Electric Mobility Mission Plan 2020; Romania enacting a subsidy programme to provide vouchers worth USD 3,697 (RON 12,000) for the purchase of an EV; South Africa adopting incentives for manufacturers to promote a domestic EV industry and, by early 2013, considering the provision of tax incentives for consumers purchasing EVs; and the U.K. providing funding to expand the EV charging network under its Plugged-in Places scheme.[142]

GREEN ENERGY PURCHASING AND LABELLING

New government policies to support green purchasing and labelling continue to advance only slowly. Green energy labelling provides consumers with the opportunity to purchase "green" electricity as well as "green" gas, heat, and transport fuels, by evaluating the generation source of available energy supply options. Green power labels are employed in a number of countries and are mostly voluntary, but some governments mandate their use. In 2013, Austria enacted mandates to ensure that suppliers label the energy that they provide.[143]

In addition to voluntary sales of green energy by energy providers to private individuals and businesses, a number of governments require that utilities and/or electricity suppliers offer green power products. Further, governments themselves have committed to purchasing renewable energy to meet their own energy needs. While this is particularly common at the local government level (see the following sub-section on City and Local Government Policies), there are examples at the national level. In 2013, Thailand established a USD 121 million (THB 4 billion) fund to encourage state agencies to deploy solar PV systems on their buildings.[144] In the United States, a 2013 Executive Order requires the federal government to source 20% of its electricity from renewable technologies by 2020.[145]

CITY AND LOCAL GOVERNMENT POLICIES

Thousands of cities and towns have active policies, plans, and targets to advance renewable energy. Policy momentum continued in 2013 as city and local governments acted to reduce emissions, support and create local industry, reduce energy demand through efficiency improvements, relieve grid capacity stress, achieve security of supply and independence from the national grid, and become more resilient to climate change. Local governments made increasing use of their authority to regulate; make expenditure and procurement decisions; facilitate and ease the financing of renewable energy projects; and influence advocacy and information sharing. (See Reference Table R19.) Increased co-ordination among local, state, and national governments is opening the door for municipalities to further accelerate the uptake of renewable energy and stimulate rapid market transformation.[146]

Local government actions often complement, and in many cases go beyond, state and national policies. By the end of 2013, 36 Indian cities had finalised solar city master plans in response to the National Solar Cities Programme, which will support a total of 60 cities development as green cities.[147] In Denmark, to help meet parallel national targets, Copenhagen is working towards the goal of 100% renewable power, heating, and cooling by 2035, and 100% renewable energy in all sectors by 2050, while Frederikshavn aims for 100% renewable energy by 2015.[148] Several U.S. cities including Greensburg (Kansas), Austin (Texas), and San Francisco (California) have implemented sector-specific 100% renewable energy targets and policies that go beyond state and national targets.[149]

In turn, national governments often observe sub-national level actions and consider using successful programmes as blueprints for national policies.[150] China, for example, is experimenting with carbon trading mechanisms on the local level before potentially launching a nationwide scheme: five cities and two provinces are testing cap-and-trade mechanisms to reduce pollution and stimulate investment in low-carbon energy.[151] Local and/or community-owned energy projects have supported a rapid increase of renewable capacity in Europe, by mobilising private investment and tackling the NIMBY (Not in My Back Yard) opposition by turning it into YIMFY (Yes in My Front Yard).[152] In turn, many national and sub-national authorities across Europe are advancing incentives for community energy projects to reach their targets. Scotland, for example, set a target of 500 MW for community- and locally owned renewable capacity in 2013, and the U.K. launched a fund to support urban community energy projects.[153]

As cities have become increasingly important for achieving national goals, their participation in the design and development of "vertically integrated" state and national policies has grown. In this way, cities are exploring how to tap into new climate financing mechanisms for emerging economies and developing countries, such as Nationally Appropriate Mitigation Actions (NAMAs).[154] In South Africa, cities are engaging with the national government to help achieve the national greenhouse gas emissions reduction target of 34% by 2020 through the use of renewables in buildings.[155] Asia-Pacific Economic Cooperation (APEC) has advanced its Low Carbon Model Town project using Yujiapu (China), Samui Island (Thailand), and Da Nang (Vietnam) as the first three case studies.[156] In 2013, eight "model cities"—in Brazil, India, South Africa, and Indonesia—began formulating low-emissions development strategies, which includes the use of renewables, using a common methodology developed by ICLEI for local governments.[157]

Local governments around the world continue to establish new climate and energy plans and targets, and to revise existing ones. In 2013, Sydney, Australia, set the goal to achieve 100% renewable energy for power, heating, and cooling by 2030, and Yamanashi, Japan, targeted local generation of 100% renewable electricity by 2050. They joined over 41 cities that have already achieved 100% renewable energy in at least one sector or aim to do so over the next few decades.[158] London, U.K., began developing a plan in 2013 to assess the city's energy delivery infrastructure, including the improvements required to enable the feed in of surplus renewable electricity to the grid.[159] By year's end, cities from across Europe had submitted 734 Sustainable Energy Action Plans under the EU Covenant of Mayors, bringing to 3,333 the number of European local governments with action plans, all aiming to reduce emissions by at least 20–40% by 2020 through the use of energy efficiency and renewables.[160]

In the United States, more than 50 local governments—including Washington (D.C.), Des Moines (Iowa), and Santa Barbara County (California)—released a plan to enhance communities' resilience to climate change through steps that include increasing use of renewable energy and energy efficiency in buildings and other infrastructure.[161] Also in 2013, Asheville, North Carolina, voted unanimously to phase out the use of coal-fired power and to move to renewable energy.[162]

Municipally controlled or -owned utilities allow local governments and citizens to play a greater role in planning and deploying renewable energy, and enable local governments to directly advance targets, incentives, and policies that encourage private or community investment in renewables. In 2013, Hamburg, Germany, held a public referendum that determined that the city council should re-acquire a controlling stake in the local electric power grid, with the aim of deploying affordable

renewable energy and avoiding high network charges.[163] At least 190 German communities have bought back their local grids since 2005.[164] In the United States, Boulder, Colorado, formed a municipal utility to reduce electric rates while increasing the share of renewables, thereby joining more than 1,000 U.S. communities with municipally owned utilities that collectively serve 50 million U.S. customers.[165]

U.S. cities with already-established locally owned utilities continued to adopt or revise feed-in tariffs to reach existing renewable electricity targets and complement state-level renewable portfolio standards. As part of its strategy to move away from coal-fired power, Los Angeles is deploying 350 MW of solar power capacity through a combination of a FIT and a request for proposals that was launched in 2013.[166] Palo Alto, California, reduced its FIT programme size, but raised its tariff for solar PV by more than 15%, and implemented a plan to supply carbon-neutral electricity for all customers starting in 2013.[167] Fort Collins, Colorado, launched a solar FIT for commercial customers.[168]

Japanese cities have started to set up community-owned electric utilities through public-private partnerships to advance renewables. In 2012, Shizuoka created a local electric utility that launched renewable community power projects in 2013 through a micro-citizens fund of around USD 200,000 (JPY 20 million) with 204 community investors. Similarly, Odawara created a local utility that became operational in 2013, and Fukushima launched a fund in early 2014 to support local renewable electricity projects.[169]

Several cities without municipal utilities work with state and national governments to advance regulatory frameworks to enable the procurement of bulk purchases of renewable electricity by local residents and businesses through the existing transmission and distribution system. Sydney, Australia, released 15 recommendations for regulatory reform to enable the sharing of excess renewable energy (both electricity and thermal energy) amongst city buildings.[170] In the United States, six states had legislated Community Choice Aggregation[i] (CCA) policies by late 2013.[171] Chicago adopted CCA in late 2012, and by 2013 it had aggregated nearly 1 million energy customers for its no nuclear/no coal contract, reducing its expected CO_2 emissions by 16% that year.[172] At least four other U.S. cities switched to CCA in 2013, and more than 30 cities initiated the process.[173] In India, Gandhinagar initiated a 5 MW rooftop solar PV programme based on a state FIT, and, as of early 2014, Bhavnagar, Mehsana, Rajkot, Surat, and Vadodara were awaiting approval for tenders totalling 25 MW each of rooftop solar PV.[174] Port Elizabeth became the first municipality in South Africa to adopt net metering for local small-scale renewable systems.[175]

Other cities are leading by example, setting targets to power their municipal operations or deploying renewable installations on their own buildings. In 2013, Guntur and Sriperumpudur in India installed renewable energy systems to help meet their targets to reduce fossil fuel consumption, and Aurangabad established targets to do the same.[176] In the United States, Kansas City, Missouri, signed a deal to install solar PV panels on 80 city buildings for their own use; Yolo County, California, generated 13.5 million kWh (152% of its electricity demand) using on-site solar PV; and Austin, Texas, achieved its own-use target, purchasing renewable energy credits to power city facilities with 100% renewable electricity.[177] Sydney is installing the largest building-mounted solar PV system (1.25 MW) in Australia on municipal buildings, a step that is expected to reduce annual carbon emissions by up to 2,250 tonnes; and the town of Palmerston North in New Zealand began constructing a 100 kW solar PV system, the largest in the country, on its administration building to generate 10% of its power demand.[178] Ameland in the Netherlands launched a local smart grid that relies on micro-CHP fuel cells; the fuel cells, which began to come on line in late 2013, can be modulated to meet peak loads and balance variable wind and solar generation.[179]

In the building sector, local governments and communities continued to set low or zero-energy or -carbon emission targets, reform building codes, and revise permitting and land-use policies to incorporate renewable energy requirements. Shanghai, China, is piloting green energy policies and business models for near-zero emission buildings as part of its low-carbon development plan.[180] In Jakarta, Indonesia, a new green building code became mandatory in early 2013.[181] Bhubaneswar, India, amended its planning and building standards, making it compulsory for large buildings to install rooftop solar PV.[182] The city also joined Bangalore, Pune, and Hyderabad in adopting the national rating system for green buildings in urban regulations.[183] In the United States during 2013, Lancaster and Sebastopol in California passed zoning ordinances requiring at least 1–1.5 kW of solar PV to be installed on all new buildings on lots above a specified minimum size.[184] Under the European Commission's POLIS research programme, six European cities have developed guidelines for maximising the potential of solar energy in urban buildings.[184]

To reduce upfront investment costs of renewable energy systems, many cities are facilitating property owners' access to low-cost, long-term financing and/or using city billing systems. Cape Town, South Africa, launched a residential solar water heater (SWH) programme through which accredited suppliers can partner with financial institutions to offer loans to residents for newly installed systems.[186] Ontario became the third Canadian jurisdiction, after Yukon and Nova Scotia, to authorise using a local improvement charge (LIC) financing tool whereby cities offer low-interest financing to property owners for energy

i - CCAs allow a city or a consortium of towns and cities to aggregate the electricity loads of residents, businesses, and municipal facilities and to negotiate electric supply contracts on their behalf.

efficiency upgrades or renewable energy installations, and loans are repaid through additional charges on property tax bills.[187] Toronto, Ontario, approved a pilot programme in 2013 to install renewable systems in 1,000 single-family homes and 10 multi-residential buildings, and to finance them through LIC.[188] Several U.S. states have adopted the Property Assessed Clean Energy (PACE) programme, with Texas being the newest member, and many cities around the country were participating as of 2013.[i 189] Several cities around the world continued to launch programmes in 2013 to move from electricity to solar energy for water heating in buildings. Santa Fe, Argentina, mandated SWH systems in all municipal childcare centres, resulting in installations at 34 refurbished nurseries in 2013.[190] Cape Town, South Africa, made SWHs more available to mid- to high-income households through monthly repayment rates that are below the cost of electricity saved through the installation. By the end of 2013, this programme had avoided 100,000 GWh of electricity consumption. Cape Town targets the installation of 60,000–150,000 high-pressure SWH systems over a five-year period.[191]To help achieve its CO_2 reduction targets, Halifax, Canada, launched a programme to provide up to 1,000 "turn-key" SWH systems per year.[192] In India, spurred on by state incentives, at least 90 cities in 8 states had amended their building by-laws to mandate SWH as of 2013.[193]

As local governments transform their buildings, they also seek to use renewable energy for space and industrial heating and/or cooling purposes. District heating and cooling are becoming best practice for the integration of renewable energy in cities. Many cities are advancing local district heating and cooling with renewables in heat-only or combined heat and power (CHP) configurations. In 2013, Sydney launched a plan to achieve its 100% renewable energy target (for electricity, heating, and cooling) with solar and wind power accounting for 30%; for the remainder, the city will use co- and tri-generation[ii] gas engines at the building or city-block level (as is the case in Güssing, Austria; Gothenburg, Sweden; and most Danish cities), to be fuelled initially by natural gas but then progressively by syngas and biogas from biomass.[194]

An increasing number of cities is transitioning towards more sustainable transport systems by promoting the use of electric or plug-in vehicles powered by renewable energy, or by using biofuels in public transport systems. In 2013, Indianapolis, in the U.S. state of Indiana, mandated that all new vehicles purchased for its municipal fleets be EV or plug-in hybrids, and New York City required the use of at least B5 in all 6,000 diesel-fuelled city vehicles.[195] Bogota, Colombia, implemented a pilot project consisting of 50 EV taxis and introduced hybrid buses as part of its mass transportation system (200 units planned for 2014).[196] São Paulo launched Brazil's first battery-electric bus, and Lublin, Poland, launched solar-powered buses in 2013.[197] Kapiti, New Zealand, began operating the first electric rubbish collection truck in the southern hemisphere; Johannesburg, South Africa, announced plans to purchase some 175 new buses to be fuelled by biogas and biodiesel; and London, U.K., announced plans to fuel city buses with biodiesel processed from used cooking oil.[198]

Cities are also adopting regulations and legislation to advance the infrastructure that will be needed to support electric-powered transport systems. For example, Palo Alto, California, revised its building codes in 2013 to require that all new homes be pre-wired for EV charging, and New York City amended its zoning and building code to mandate that all new public parking spaces be wired for EVs.[199]

As cities seek to share and scale up best practices, highlight their commitments to renewable energy, and account for their achievements, local governments are increasingly prioritising systematic measurement and reporting of climate and energy data. By the end of 2013, the carbon*n* Cities Climate Registry (cCCR) had 836 registered energy and climate commitments in 414 cities in over 45 countries, amounting to 4,208 reported mitigation and adaption actions (double the 2012 number).[200] As of early 2014, ICLEI, C40, the World Resources Institute, and the Joint Work Programme of the Cities Alliance among the World Bank Group, UN-HABITAT, and UNEP worked together to pilot the Global Protocol for Community-scale Greenhouse Gas Emissions (GPC) in 35 global cities.[201] C40 announced a new partnership with Siemens to help cities measure, plan, and mitigate their greenhouse gas emissions, and C40 and the Carbon Disclosure Project (CDP) announced a joint programme to increase the number of cities that report annually on climate actions and to standardise emissions accounting, enabling cities to track their progress and identify effective climate and energy actions.[202]

The year 2013 also saw the consolidation and strengthening of city participation in the formal international climate negotiations. The first-ever "Cities Day" was held during the high-level segment in the UNFCCC 19th Conference of Parties (COP19), bringing national ministers and city mayors together to strengthen multi-level governance on climate change.[203]

i - Similar to LIC, PACE financing allows property owners to borrow money from a local government to pay for renewable energy systems and/or energy efficiency improvements. The amount borrowed is typically repaid via a special assessment on property taxes, or another locally collected tax or bill, such as a utility bill.

ii - Tri-generation (or combined cooling, heat, and power, CCHP) adds an extra service to CHP, whereby the thermal energy is converted to chilled water for air conditioning and/or refrigeration, which further displaces electricity used for these services. Cooling can be delivered via central thermal chiller stations combined with district cooling pipes, or via hot water pipes to decentralised thermal chillers in individual buildings.

REN21 Renewable Energy Policy Network for the 21st Century

TABLE 3. RENEWABLE ENERGY SUPPORT POLICIES

COUNTRY	Renewable energy targets	REGULATORY POLICIES: Feed-in tariff / premium payment	Electric utility quota obligation / RPS	Net metering	Tradable REC	Tendering	Heat obligation / mandate	Biofuels obligation / mandate	FISCAL INCENTIVES AND PUBLIC FINANCING: Capital subsidy or rebate	Investment or production tax credits	Reductions in sales, energy, CO_2, VAT, or other taxes	Energy production payment	Public investment, loans, or grants
HIGH INCOME COUNTRIES													
Andorra												○	
Australia	○	R*	●		○			●	○				○
Austria	○	○			○			○	○	○			○
Barbados	○			○							○		○
Belgium	○		●	●	○	○		○	★*	○	○		
Canada	●	R*	●	●		○		○	○	○	○		○
Chile	R		○	○		★	○		○		R		○
Croatia	○	○						○					
Cyprus	○	○		★		○		○	R				
Czech Republic	○	×			○			○	○	○	○		
Denmark	○	○		○	○	○		○	○	○	○		R
Estonia	○	○						○				○	○
Finland	○	○			○			○	○		○	○	
France	R	R			○	R		○	○	R	○		○
Germany	○	R					○	○	○	○	○		○
Greece	○	R		★				○	○	○	○		○
Ireland	○	○			○	○	●	○					
Israel	○	○	○			○	○				○		○
Italy	○	R	○	○	○	R	○	○	○	○	○		○
Japan	○	○	○	○	○	○			○				○
Kuwait	○					★							
Latvia	○	○		★		○		○			○		
Lithuania	○	R	○					○					○
Luxembourg	○	○						○	○				
Malta	○	○		○					○		○		
Netherlands	○	R		R	○			○	○	○	○	○	○
New Zealand	○								○				
Norway	○		○		○	★		○	○		○		○
Poland	○		○		○	R		○			○		○
Portugal	R	R	○			○	○	○	×	×	○		×
Russia	★					★			○				
Singapore				○		○					○		○
Slovakia	○	R			○			○			○		
Slovenia	○	○			○	○			○	○	○		○
South Korea	○		○	○	○			○	○	○	○		○
Spain[1]	○			○	○			○	○	○		○	
Sweden	○		○		○			○	○	○	○		○
Switzerland	○	○							○		○		
Trinidad and Tobago	○									○	○		
United Arab Emirates	●		●			●	●					●	●
United Kingdom	R	R	○		○		○	○	R		○	○	○
United States	R*	R*	R*	R*	●	R	●	R	○	×	○	○	R
Uruguay	R	○		○		R	○	○	○		○	○	○

○ – existing national, ● – existing sub-national, ★ – new, R – revised, × – removed/expired, * – sub-national

04

[1] Spain removed FIT support for new projects in 2012. Incentives for projects that had previously qualified for FIT support continue to be revised.

TABLE 3. RENEWABLE ENERGY SUPPORT POLICIES (continued)

COUNTRY		REGULATORY POLICIES							FISCAL INCENTIVES AND PUBLIC FINANCING				
	Renewable energy targets	Feed-in tariff / premium payment	Electric utility quota obligation / RPS	Net metering	Tradable REC	Tendering	Heat obligation / mandate	Biofuels obligation / mandate	Capital subsidy or rebate	Investment or production tax credits	Reductions in sales, energy, CO_2, VAT, or other taxes	Energy production payment	Public investment, loans, or grants
UPPER-MIDDLE INCOME COUNTRIES													
Albania	○	○	○	○	○	○	★			○	★	○	○
Algeria	○	○				○				○			
Angola								○					○
Argentina	○	○				○		R	○	○	○	○	○
Azerbaijan	★												○
Bahrain													○
Belarus											○		○
Bosnia and Herzegovina	○	○				○			○				
Botswana	○								○		○		
Brazil	○			○		R	●	R		○	R		R
Bulgaria	○	○						○					○
China	R	R	○			○	○	○	○	○	○	○	○
Colombia	○							○			R		
Costa Rica	○			●		○		○			○		
Dominican Republic	○	○		○		○	○		○	○	○		
Ecuador[2]		★				★		★			○		○
Fiji	○									○	○		
Grenada	○			○							○		
Hungary	○	○						○	○		○		○
Iran		○								○		○	★
Jamaica	○			○		○		○		○	○		
Jordan	○	○		○		○		○			○		○
Kazakhstan	★	★			○				★				
Lebanon	○			○							○		
Libya	R										○		
Macedonia	○	○											
Malaysia	○	R	○			○		R			○		○
Maldives	○	○				○							
Marshall Islands	○										○		
Mauritius	○	×				○			○				
Mexico	○			○		○	○			○			○
Palau	○		○										
Panama		○		○		○		○		○	○	○	
Peru		○				○		○			○		★
Romania	○		○		○			○					○
Serbia	○	○							○				
South Africa	○		○	○		R		★	○		○		○
St. Lucia	○			○									
Thailand	R	R						○	○		○		○
Tunisia	○			○					○		○		R
Turkey	○	R						○	○				○

○ – existing national, ● – existing sub-national, ★ – new, R – revised, × – removed/expired, * – sub-national

[2] Ecuador's FIT that expired in 2012 was re-launched in 2013.

[3] The area of the Palestinian Territories is included in the World Bank country classification as "West Bank and Gaza." They have been placed in the table using the 2009 "Occupied Palestinian Territory" GNI per capita provided by the United Nations (USD 1,483).

Note: Countries are organised according to annual GNI per capita levels as follows: "high" is USD 12,616 or more, "upper-middle" is USD 4,086 to USD 12,615, "lower-middle" is USD 1,036 to USD 4,085, and "low" is USD 1,035 or less. Per capita income levels and group classifications from World Bank, 2014. Only enacted policies are included in the table; however, for some policies shown, implementing regulations may not yet be developed or effective, leading to lack of implementation or impacts. Policies known to be discontinued in 2013 are marked with an X; historic discontinuations have been omitted from the table.. Many feed-in policies are limited in scope of technology. In cases where a national and sub-national policy exist within the same policy category, the national policy is displayed.

Source: See Endnote 1 for this section.

TABLE 3. RENEWABLE ENERGY SUPPORT POLICIES (continued)

COUNTRY		REGULATORY POLICIES							FISCAL INCENTIVES AND PUBLIC FINANCING				
	Renewable energy targets	Feed-in tariff / premium payment	Electric utility quota obligation / RPS	Net metering	Tradable REC	Tendering	Heat obligation / mandate	Biofuels obligation / mandate	Capital subsidy or rebate	Investment or production tax credits	Reductions in sales, energy, CO_2, VAT, or other taxes	Energy production payment	Public investment, loans, or grants
LOWER-MIDDLE INCOME COUNTRIES													
Armenia		○											
Cameroon											○		
Cape Verde	○			○		○					○	○	
Côte d'Ivoire	○										○		
Egypt	R			○		R			○		○		
El Salvador						R				○	○	○	○
Federated States of Micronesia	○			●									
Ghana	○	R	○		○		○	○	○		○		○
Guatemala	○			○		○		○		○	○		
Guyana	○										○		
Honduras	○	○		★		○				○	○		
India	R	○	○	★*	○	R	●	R	R	○		R	○
Indonesia	○	R	○			○		○	○	○	○		○
Lesotho	○			○		○			○	○		○	○
Moldova	○	○											○
Mongolia	○	○				○							
Morocco	○					○							○
Nicaragua	○	○									○		
Nigeria	○	○							○		○		○
Pakistan	○	○		○					●				○
Palestinian Territories[3]	○	○		○							○		
Paraguay								○			○		
Philippines	○	○	○	○		○		R	○	○	○	○	○
Senegal	○		○				○				○		
Sri Lanka	○	○	○	○				○	○		○	○	○
Syria	○	○		○		○				○			
Ukraine	○	R		★				★	○		○		○
Uzbekistan						○							
Vanuatu	○										○		
Vietnam	○	○			○			○	○	○	○		
LOW INCOME COUNTRIES													
Bangladesh	○								○		○		○
Benin	○										○		
Burkina Faso						○				○	○	○	
Ethiopia	○							○			○		○
Gambia											○		
Guinea	○										○		
Guinea-Bissau	○										○		
Haiti													○
Kenya	○	○				○	○				○	○	○
Kyrgyzstan			○						○		○		
Madagascar	○										○		
Malawi	○							○			○		
Mali	○							○			○		○
Mozambique	○							○					○
Nepal	○					○			○	○	○		○
Niger	○										○		
Rwanda	○	○									○		○
Sudan	○							○					
Tajikistan	○	○											
Tanzania		○							○		○		
Togo											○		
Uganda	○	R							○		○		○
Zambia								○	○		○		
Zimbabwe	○							R					

REN21 global renewable energy data are based on input and statistics received for **177 countries**.

05

05 DISTRIBUTED RENEWABLE ENERGY IN DEVELOPING COUNTRIES

Access to modern energy services is indispensable to sustainable development. Yet as many as 1.3 billion people lack access to electricity and more than 2.6 billion rely on traditional biomass for cooking and heating.[1] (See Reference Tables R20 and R21.) Further, an estimated 200–300 million people[i] use coal in traditional cookstoves to meet their cooking and heating needs.[2] Between 2011 and 2013, the total number of people globally without electricity access remained essentially unchanged even as some countries made great leaps forward.[ii] Latin America and developing Asia[iii] advanced, while other regions fell further behind. In India, the number of people without access rose by 17 million to 306 million, and Africa is now home to half of the world's population without electricity.[3] (See Figure 31, page 97.)

In many rural areas of developing countries, connections to central electric grids are economically prohibitive and may take decades to materialise, if at all. Moreover, grid connectivity does not address the need for access to sustainable heating and cooking options. Renewable energy systems offer an unprecedented opportunity to accelerate the transition to modern energy services in remote and rural areas, by increasing access to sustainable cooking and heating devices; affordable lighting, communications, and refrigeration; improved public health; and energy for processing and other productive activities. These objectives can be achieved by establishing and strengthening institutional, financial, legal, and regulatory support mechanisms for renewable energy deployment. In turn, these mechanisms can help by improving access to financing, developing the necessary infrastructure, and building awareness about renewable energy and the challenges posed by a lack of access to sustainable sources of energy.[4]

This section focuses on the wide array of viable and cost-competitive options that can provide reliable and sustainable energy services to displace traditional biomass, carbon-based fuels, and fossil fuel grid-based electricity. Technologies available include: renewables-based, isolated, small-scale electricity generation systems and mini-grids—for battery charging, communications, and water pumping—as well as renewable energy systems for space and water heating, cooling, and clean cooking solutions[iv] that replace open fires and inefficient stoves. A variety of innovative, modular, sustainable, and locally relevant renewable energy-based solutions are available to meet the energy needs of individuals and communities, while also increasing energy security, lowering fuel-related costs (including fossil fuel subsidies), up-skilling the labour force, and easing the burden of collecting fuelwood.

Developing countries in Africa, Asia, and Latin America are acknowledging the wide array of economic, environmental, and health benefits that accrue from the inclusion of renewable energy in their energy access programmes. These include reductions in air pollution and greenhouse gas emissions, the formation of new industries, and the creation of jobs.[5] To realise these benefits, many countries are moving away from traditional fossil fuel-based systems and adopting decentralised renewable-based systems to expand energy access.[6]

In recent years, the mini-grid sector has become one of the most dynamic and fastest growing distributed renewable energy sectors.[7] Mini-grids are expected to contribute an estimated 45% of the additional generation capacity needed to achieve universal access to energy by 2030. As such, they are expected to play a major role in enabling countries to meet the objectives set by the United Nations Secretary General's Sustainable Energy for All (SE4ALL) initiative.[8]

One of the aims of the SE4ALL initiative is to help achieve the goal of universal access to modern energy services by 2030. SE4ALL has brought energy access issues to the political forefront, while highlighting the potential for renewable energy combined with energy efficiency improvements. More than 80 developing countries had joined the initiative by early 2014, encompassing about one-half of the target population; however, neither China nor India was on board, and donor countries and agencies were yet to make sizable financial commitments.[9] Although progress has been significant in the last few years, there is still a long way to go to reach the goal of clean energy access for all.

Distributed renewable energy markets in developing countries vary greatly among countries and regions in their levels of electrification, access to clean cookstoves, as well as financing models and supporting policies. Markets are shaped by various actors at multiple levels of operation, including: international and regional development agencies, which support

i - Predominantly in China, Uruguay, North Korea, and several countries in Eastern Europe.

ii - In Latin America, the absolute number of people without electricity access declined from 31 million to 24 million over this period, while the population without electricity in developing Asia declined by 60 million, per IEA, *World Energy Outlook 2011* (Paris: IEA/OECD, 2011) and IEA, *World Energy Outlook 2013* (Paris: IEA/OECD, 2013).

iii - Developing Asia is defined by the IEA to include Afghanistan, Bangladesh, Brunei, Cambodia, China, Chinese Taipei, DPR Korea, East Timor, India, Indonesia, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, PDR Laos, Philippines, Singapore, Sri Lanka, Thailand, Vietnam, and Other Asia.

iv - As defined by the International Finance Corporation, this includes all solar portable lanterns, hand crank, and pedal power technology.

SIDEBAR 9. DISTRIBUTED RENEWABLE ENERGY: DEFINITION AND SCOPE

In this edition of the GSR, the former Rural Renewable Energy section has been renamed "Distributed Renewable Energy in Developing Countries" to describe more accurately its scope of energy-related developments in developing countries that are of a distributed nature.

Energy systems are considered to be distributed if (1) the systems of production are relatively small and dispersed (such as small-scale solar PV on rooftops), rather than relatively large and centralised; (2) generation and distribution occur independently from a centralised network; or (3) both. For the purpose of this section, "distributed energy" meets both conditions. It provides energy services for electrification, cooking, heating, and cooling that are generated and distributed independent of any centralised system, in urban and rural areas of the developing world.

Electricity systems fall into three main categories: large centralised grid systems, mini-grids, and isolated systems. All three may have distributed components, but only the latter two are entirely distributed in nature. Most people around the world, and particularly in developed countries, are serviced by the electric grid, which is a large-scale integrated generation, transmission, and distribution network. Mini-grids vary in size and usually service a cluster of households and businesses through an independent distribution network, and most commonly in remote areas. Isolated systems are employed in individual homes or businesses, with all energy being consumed at the site of generation.

Distributed electricity systems serve a variety of objectives. In developed countries, distributed generating assets are often used to reinforce power systems, thereby increasing reliability. In developing countries, where centralised grid systems fail to reach millions of people in rural and remote locations, distributed systems are crucial to providing access to electricity. Mini-grids offer a viable solution in densely populated areas where, despite the small per-household level of demand, the large number of households and businesses provide a load sufficient enough to justify the cost of mini-grid development. Isolated home electricity systems are often the most viable options for those rural households whose demand is currently limited to a few hundred watts, primarily for lighting and phone charging.

and fund large programmes that often cover several countries, particularly in Africa and Asia; country-level programmes, generally planned and implemented by national governments; and community-level businesses and practitioners who work with households directly and may represent the most innovative operational level of the distributed renewable energy market.

The large diversity and number of actors in the field, the decentralised nature of production and consumption of energy, as well as the lack of co-ordination, make data collection and impact assessment challenging, resulting in the absence of consolidated, reliable data. However, data are available for many individual programmes and countries. This section seeks to provide a picture of the current status of distributed renewable energy markets in rural and urban areas in developing countries, and to present an overview of the major networks and programmes that were operational in 2013 in the field of distributed renewable energy. (See Reference Tables R22 and R23.)

DISTRIBUTED RENEWABLE ENERGY TECHNOLOGIES

People in rural and remote regions are acquiring improved access to energy in three ways: (1) at the household level, using isolated devices and systems for power generation, heating, and cooking; (2) through community-level mini-grid systems; and (3) through grid-based electrification, where the grid is extended beyond urban areas.[10] This section focuses on the first two (distributed) means of improving energy access. (See Sidebar 9.)

The installation and use of distributed renewable energy technologies in remote and rural areas for electricity, cooking, heating and cooling increased during 2013. This expansion was a direct result of improved affordability, greater access to financing, greater knowledge about local resources, and more-advanced technologies that can be tailored to meet customers' specific needs.

The dramatic price reductions of the past few years have rendered solar PV more affordable, even for very small-scale applications. The popularity of solar lanterns, solar-pico PV systems (SPS) (1–10 W capacity), and slightly larger solar home systems (SHS) (10–200 W), continued to rise in 2013. SPS can be easily self-installed and are now commonly available for providing basic services such as lighting, communications, and battery or mobile phone charging. The availability of end-user appliances that can be powered by SHS continues to expand, raising interest in these systems in rural areas. One of the most successful SHS programmes has been carried out in Bangladesh, where more than 2 million systems were installed as of May 2013.[11]

Small-scale wind turbines (up to 50 kW) have experienced performance improvements due to the emergence of advanced materials and wireless technologies in recent years. During 2013, small-scale wind turbines were being used predominantly for battery charging, telecommunications, irrigation, and water pumping, where the variable nature of their generation can be managed easily.[12]

One of the most successful programmes promoting the deployment of small-scale, decentralised wind turbines is in Inner Mongolia, China. In this area around 130,000 systems, each 200–1,000 W, were in operation as of early 2013, providing electricity to more than 500,000 people. The programme's success has been attributed to the stability of the institutional frameworks over the last two decades.[13]

Micro- and pico-hydro stations as small as 1 kW are common in many countries, providing local communities with affordable electricity.[14] Typically, such hydro systems operate reliably for at least 20 years and require minimal maintenance (other than keeping the intake screen free of debris). Nepal had more than 2,500 micro- and pico-hydro systems installed by the end of 2012, with a total capacity of 20 MW.[15] In addition, several 1 kW systems have been installed in southern India, mostly by private parties and without government support.[16]

To fuel engine-powered generators in a rising number of countries, vegetable oils from coconut, jatropha, and other sources are being used to displace diesel. In Thailand, biodiesel for electricity generation is being produced on a small scale from used cooking oil.[17] In India, Vietnam, and elsewhere, biogas produced from dry wood, weeds, and rice husks is used increasingly to fuel engines, driving generator sets to supply electricity to mini-grids.[18]

Mini-grids are becoming increasingly prevalent around the world.[19] Their technical evolution in the last few years, including the use of modular technology to integrate renewables, has led to a scaling up of renewables powered mini-grids. In addition, advances in information and communication technology applications for power management and end-user services are improving metering and billing, load management, and remote diagnostics.[20] As part of India's programme to increase access to electricity, over 80 villages had operating mini-grids using gasifiers and locally available biomass residues (including mustard stems, corn cobs, and grasses procured from local farmers) by mid-2013.[21]

The rural heating and cooling sector has progressed due to advances in technology, as well as to the increasing popularity of programmes educating rural populations about the benefits of using modern biomass and solar thermal systems for clean cooking, and water and space heating.[22] The Africa Clean Cooking Energy Solutions Initiative was established to promote enterprise-based large-scale dissemination and adoption of clean cooking solutions in sub-Saharan Africa. The phased implementation of this programme began in 2013 in consultation with over 130 stakeholders from 26 African countries.[23] To date, however, there have been very few successful cases of international, large-scale deployment of improved cookstoves.[24]

Clean cookstove designs are tremendously diverse, and new ones are still emerging. Some models use alternative clean fuels, whereas other advanced stove designs rely on traditional biomass but increase the efficiency of the combustion process, thereby reducing the amount of fuel consumed to provide the same amount of heat. Biomass cookstove designs that can achieve high levels of performance include forced air and gasifier stoves, which lower emissions significantly and reduce fuel use by 40–60% relative to an open fire.[25] Such efficient biomass cookstoves are being sold for as little as USD 5–25 each.[26]

These advanced cookstoves rely primarily on the use of traditional biomass from forest fuelwood, crop residues, and animal dung. A wide variety of other fuels are also being used for household cooking purposes (although at a far smaller scale). These include ethanol, biogas, wood pellets, and solar energy, as well as non-renewable fuels such as coal, kerosene, and liquefied petroleum gas (LPG).[27]

Simple anaerobic digester technology can produce clean biogas fuel for cooking from animal manure, crop residues, and other organic waste feedstocks. These biogas systems perform better in warmer climates, but they can function under a variety of conditions, and their numbers continue to increase. Biogas is best suited for the estimated 155 million households and commercial farms where sufficient animal manure (and human waste) can be collected on a daily basis.[28] Widespread acceptance and dissemination of biogas technologies have yet to materialise in many countries, due mainly to the high capital cost, which makes even small-scale units unaffordable for poor households.[29]

However, domestic-scale biogas installations have surged in some countries in recent years, driven by a number of international programmes.[30] In 2013, China added 1.8 million units to bring the total to more than 43.5 million, thereby remaining the leader in the use of small-scale biogas plants.[31] India constructed about 125,000 units during 2012, bringing the total to nearly 4.7 million by early 2013.[32] By the middle of 2013, Nepal had more than 290,500 biogas plants in use, due at least in part to a multi-year government consumer subsidy, and Kenya had more than 9,000 units in place.[33]

Under suitable circumstances, solar thermal cookers can save time, work, money, and the need for combustible fuels. A large number of solar cookers have been deployed in Nepal, especially in refugee camps and small villages in the Himalayas.[34] However, solar cookers, once considered a popular choice, are now on a waning trend.[35] The cookers are unfamiliar to those accustomed to preparing food over an open flame, often after the heat of the day has passed, so adaptation to these stoves requires training and follow-up.[36]

The same is true for other cooking technologies. The transition of advanced cookstoves from the laboratory to households is not an easy task. Awareness-raising, targeted product trials, demonstrations, and feasible financing mechanisms are often all required to encourage people to move away from their traditional cooking methods. Improved cookstoves that are designed to operate similarly to traditional stoves have been accepted culturally by many developing country households. However, they continue to face severe market challenges in communities with relatively easy access to traditional biomass fuels.[37] In cold climates, cookstoves are also often used to provide space heating, which can influence the choice of stove design and fuel.

POLICY FRAMEWORKS

Across the developing world, there is an increasing realisation that expanding electricity access cannot be achieved through grid extension alone. There is also a growing recognition that national policies, regulations, and targets play a pivotal role in determining the investment and financing models that become prevalent in distributed renewable energy markets.[38] As a result, more and more countries are integrating off-grid energy solutions into broader rural development policies and frameworks.[39] Increasingly, governments are moving away from top-down approaches and towards frameworks that are broad-based, support local private sector participation in the development and management of energy systems, and provide environments conducive to new investment.

Thus far, most policy frameworks developed for improving energy access have emphasised electrification, with only limited focus on clean cooking, heating, and cooling. Policies that promote renewable energy and address barriers to their use have played a critical role in accelerating deployment and attracting investment to this sector. Programmes also continue to advance as institutional, legal, and regulatory frameworks evolve.[40] For example, in response to favourable government policy combined with rising consumer demand, Bangladesh has been installing more than 1,000 SHS a day. Similarly, sub-Saharan Africa saw the number of manufacturers selling pico-powered lighting systems increase fourfold between 2008 and the end of 2012.[41]

Brazil, China, India, and South Africa have taken the lead in developing large-scale, off-grid renewable energy programmes that are making significant inroads into addressing the dual challenges of energy access and sustainability.[42] An important success factor for renewable energy initiatives in these countries has been their inclusion in broader long-term rural electrification programmes that are supported politically and backed by substantial and sustained public resource allocations.

For example, Brazil's Light for All programme, completed in late 2013, was a decade-long effort to provide renewable electricity to 15 million people in rural areas. The initiative included an 85% capital subsidy for mini-grids with a focus on renewable energy, allowances for the use of prepaid metering, and the inclusion of rural co-operatives as implementing agencies.[43] It was conceptualised and co-ordinated at the ministerial level and implemented through rural electricity co-operatives, with nearly 75% of funding coming from the federal government and the remainder from state governments and executor agents.[44]

In China, 36 million people acquired access to electricity through off-grid sources between 1998 and 2012. As part of China's 12th National Five-Year Plan, numerous Chinese local power utilities are expected to install individual off-grid PV power plants by the end of 2014 to ensure the establishment of a long-term operation and maintenance management system for these PV plants before the end of 2015.[45]

Fiscal incentives—such as loans, grants, and tax reductions—have been used successfully by many countries in their off-grid renewable electricity programmes to address the barrier of high upfront costs. While approaches vary by country, the most common practice is to provide subsidies to encourage operators to adopt renewable energy technologies when developing electrification schemes in remote communities.[46] Bangladesh, for example, provides grants that cover up to one-third of the capital costs of renewable energy systems along with long-term, low-interest loans with five-year grace periods.[47] Mali and Senegal established rural electrification funds to provide financing for renewable energy concessions, with investment subsidies of up to 80% of the upfront capital costs.[48] Thailand provides investment grants of 10–30% for biogas and solar water heating projects, including off-grid village-based projects in remote areas.[49] In several Brazilian states and a number of other developing countries, distributed renewable energy markets benefit from tax exemptions.[50]

Long-term and stable policy frameworks are important to encourage the development of mini-grids, as are regimes in which tariffs allow an attractive return on investment.[51] A number of countries now support the development of mini-grids with public financing, usually in the form of capital subsidies. Subsidies can encourage private developers to enter markets in which tariffs alone are not commercially sustaining, consumers cannot support the revenues required, or low population density increases the costs of constructing distribution networks.[52] Countries with subsidies for mini-grids include Mali, which offers subsidies of up to 80% of investment costs, India (up to 90%), and Afghanistan (90%).[53] An increasing number of isolated communities with mini-grids and stand-alone systems relies on renewable energy resources rather than imported diesel fuel.[54] However, not all countries support the development of mini-utilities and mini-grids, and in some countries mini-grids are subject to onerous regulations or tariffs that do not reflect actual costs.[55]

To finance incentives and programmes that support distributed renewable energy, developing countries rely on a blend of public and private sector resources. The most notable public-private partnership projects—based on the volume of SHS and number of solar kits delivered—are in Argentina, Bangladesh, China, India, Indonesia, Mongolia, and Vietnam.[56] They are carried out jointly by national governments and major donor bodies, and focus on replacing kerosene lanterns and diesel generators with portable, sustainable, and affordable alternatives.[57] Thailand has a particularly progressive strategy in that renewable energy deployment is financed partly through taxes on fossil fuel-based energy consumption, helping to internalise some of the social and environmental costs of fossil fuels and to level the playing field for renewable energy.[58]

Formal targets remain a fundamental building block of initiatives seeking to expand energy access using renewable energy. Countries with electrification targets include Bangladesh, Botswana, China, Ethiopia, Ghana, Malawi, the Marshall Islands, Nepal, Rwanda, South Africa, Tanzania, and Zambia. (See Reference Table R20.)

Several countries set new targets for electrification and clean cooking in 2013. For example, China announced plans to provide electricity to the remaining 2.7 million people without access by the end of 2015. Approximately 1.5 million of these people will be supplied with electricity through grid extension, and the others through local solar PV power stations.[59] Ghana was the first country to join the SE4ALL initiative, with a goal to achieve 100% access by 2020 (10 years ahead of the SE4ALL target). Currently, 35% of Ghana's population (more than 6.2 million people) still lacks access to electricity.[60] In 2013, Fiji also set a target of 100% access to clean cooking fuels and stoves (up from the current 82%) by 2015.[61]

However, deployment of small-scale subsidised projects has contributed only marginally to increasing energy access—due primarily to high transaction costs, a lack of long-term strategy, and a focus on meeting only basic energy needs.[62] Thus, it is now widely accepted that electrification programmes should involve a package of dedicated activities for promoting productive uses of electricity if the goal is to significantly increase the incomes of target populations.[63] Further, the active participation of local residents and capacity building of local and national organisations and agencies is now recognised as being crucial for the successful implementation of decentralised energy solutions.[64]

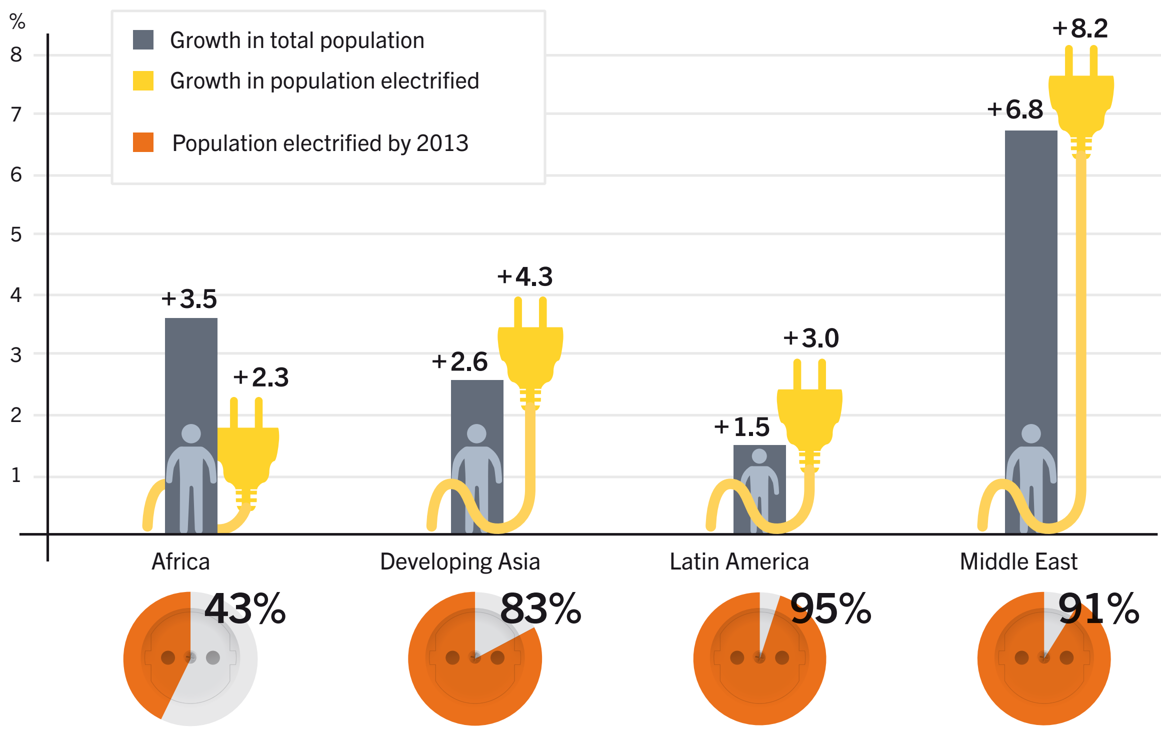
To this end, several countries are actively engaging local people in energy planning and decision making, promoting energy literacy, and investing in capacity building of local and

national organisations and agencies.[65] Nepal, for example, has emphasized community mobilisation, sustainable rural energy development, and advancement of institutional and human resources, with efforts to increase public awareness and develop human capacity through micro-hydro-related training and workshops.[66]

Although the majority of policies enacted to date have focussed on electrification, many developing countries have also adopted programmes focussed on improving cooking and heating systems as part of their efforts to achieve 100% energy access. In Latin America and the Caribbean, where several countries have achieved or are close to full electricity access, emphasis is turning to the cooking and heating sector.[67]

Honduras, for example, includes the dissemination of clean cook-stoves in its national Scaling up Renewable Energy programme, which aims to transform the clean cookstove market by enabling

Figure 31. Share of Population with Electricity Access, and Rate of Electrification versus Population Growth



Source: See Endnotes 1 and 3 for this section.

05

the development of new business models and strengthening private sector capacity.[68] The programme focusses on improving cookstove design and quality, including component durability and performance; developing a combination of standards and rigorous monitoring and supervision; and achieving affordability through a mix of direct incentives, micro-loans, and payments for environmental services.[69]

India has also supported the dissemination of clean cookstoves, and revisited its programme in 2013. India's National Programme on Improved Cookstoves had some success at the state level, but it faced challenges nationally due to lack of consumer awareness, a dearth of sustainable financing sources, and issues related to stove quality and upkeep.[70] The focus was changed from disbursement of cookstoves to a broader programme aimed at delivering health benefits through clean biomass combustion with quality control and monitoring efforts. Use of traditional biomass, charcoal, and coal-fuelled cookstoves can result in severe adverse health and environmental impacts from black carbon and other particulate emissions. These emissions cause as many as 4 million premature deaths globally every year. Further, use of traditional biomass can accelerate rates of land degradation and deforestation.[71] Hence, the new initiative has been well received even at the national level.[72]Markets and Business Models

Historically, energy access programmes were developed and implemented by national and local governments, international development agencies, and non-governmental organisations. In the last decade, the provision of energy services to rural markets has evolved from a centralised, public sector-led approach to one more focussed on public-private partnerships and private ventures in which renewable energy plays a key role.

With the increasing awareness that off-grid, low-income customers represent fast-growing markets for goods and services—as in the mobile phone market—and with the emergence of new business and financing models for serving them, rural energy markets are increasingly being recognised as potential business opportunities.[73] Further, there is a growing awareness that isolated cooking and electricity systems, particularly those based on renewables, are often the most cost-effective options available for providing energy services to households and businesses in remote areas. This is increasingly the case as technologies continue to improve and costs decline.

As a result, a growing number of parties—ranging from international businesses to small- and medium-scale businesses and initiatives—have established themselves in the distributed renewable energy market.[74] Many companies are now active across Africa, Asia, and Latin America, selling household-level energy systems and devices, with several already serving tens to hundreds of thousands of customers.[75] Commercial lenders and banks, social venture capitalists, local development banks, philanthropists, governments, and international development agencies are all actively engaged in the financing of distributed renewable energy. However, participation varies from country to country depending on political stability, support policies, broader legal frameworks, and other factors.

Innovative multi-stakeholder business models continue to emerge for providing customised and financially sustainable services based on renewable energy across the spectrum of rural energy needs. Characteristics of these business models include public-private partnerships, pay-as-you-go micro-payment

options, one-stop-shops, leasing, franchise, and service models.

The public-private partnership model first gained popularity in the 1990s, when public and private partners collaborated in the implementation and financing of energy access projects. All movable assets were owned by the private sector, while fixed assets, such as power plants and distribution lines, were publicly owned. The plant was managed by the village committee and designed based on customer needs, with customers being allotted energy blocks according to their energy demand requirements and capacity to pay. This model is being replicated in the Philippines, Nepal, and other Asian countries.[76]

Pay-as-you-go (PAYG) micro-payment schemes have become one of the most popular business models. They are especially effective for solar technologies such as solar-powered charger kits because price levels and schedules are set to match customers' variable cash flows and their energy consumption patterns.[77] Under such schemes, customers typically pay a small upfront fee for a solar charger kit, a portable system that includes a 2–5 W solar PV panel, and a control unit that can be used for powering LED lights and charging devices such as mobile phones. They then pay for the energy they need, either in advance or on a regular basis, depending on consumption. Pre-existing distribution systems for mobile phones increase the efficiency of PAYG schemes because customers can make payments in small increments by phone as they do for mobile usage. Usually, solar kits are paid off after about 18 months, at which time customers own the kits and receive the subsequent electricity for free.[78]

An increasing number of households in sub-Saharan Africa are accessing energy through the PAYG system, paying about half of what it would cost them to get the same services with kerosene.[79] Such schemes were also used in India during 2013 to provide off-grid and decentralised solar power. However, some challenges still need to be addressed. For example, companies face severe cash flow constraints when consumers default on payments because the market currently lacks debt-servicing instruments.[80]

One-stop-shop models are also expanding in use. Under this model, a single organisation both sells the renewable energy home systems and provides loans to pay for them. This is common in Bangladesh, where one organisation sells SHS with a 15% down-payment, provides customers with three-year loans at 6%, after-sale services, and long-term product warranties. It also provides technical training across rural Bangladesh and trains entrepreneurs, particularly women, to become owners of their own renewable energy businesses.[81]

Under leasing arrangements, the customer leases the energy system for extended periods of time, or leases it for a fixed period before eventually owning it and so is spared the high upfront costs. In Honduras and the Dominican Republic, companies provide SHS services via either direct lease or lease-to-own arrangements.[82]

In franchise models, local entrepreneurs in rural areas are trained to run micro-enterprises. A variation of this model is used for the Lighting a Billion Lives campaign in India, which is helping to set up solar businesses that rent out charged solar lanterns on a daily basis in poorly electrified villages.[83]

Rural customers can be difficult to reach, particularly in regions where roads are poor or non-existent, or during rainy seasons. Establishing rural supply chains and after-sales service through franchise and other business models, with technicians and engineers living and working near their customers, helps to develop trust in a product and supplier while also ensuring that systems keep operating and that needed repairs are carried out quickly.[84]

Mini-utilities—small, decentralised businesses that run mini-grids—are also found increasingly in poor rural areas across the developing world. They vary significantly in size, rely on a range of generation technologies, and often provide enough power for productive uses such as water pumping, milling, and grinding, in addition to meeting basic household needs. Many such companies use renewables in mini-grid systems to keep costs down and make them more stable relative to diesel, although renewable-based mini-utilities can have high maintenance requirements.[85] Monthly charges can represent significant expenditures for households, but they are attractive in many locations where people are already paying similar amounts for kerosene and appliance-charging services.[86]

Business models used in the cooking and heating markets also vary. Often, cookstove companies are indigenous enterprises that employ members of the local community to manufacture clean stoves that are adapted to local conditions and norms.[87] Increasingly, international players that provide high-quality but generally more expensive products are becoming engaged in the sector. They often work with public sector partners to help market the stoves and to educate consumers about their benefits.[88]

Crowdfunding[i] is also starting to play a role in providing energy access. It is a potentially significant source of financing for the distributed off-grid market, which relies on small-scale investments typically of a few thousand dollars per system.[89] To date, many mainstream investors have tended to avoid small levels of funding since they carry high transaction costs. Crowdfunding allows individual private investors to make payments to local partners via an online platform; over time, the partner makes repayments to the funder who, in turn, repays investors.[90] A recent example is a portal that raised more than USD 15,000 to fund solar kits for lighting and mobile phone charging systems for 19,000 households in Uganda.[91]

Throughout the developing world, technological advancements and falling prices are enabling renewables to spread rapidly to new markets in rural and remote areas.[92] Renewable energy technologies, combined with business models adapted to specific countries or regions, have proven to be reliable and affordable methods for achieving access to modern energy services, advancing quality of life, and improving human and environmental health.

i - Crowdfunding is the mechanism by which small companies and start-ups raise capital from many small investors, in return for an equity stake, structured payments, products, or a combination thereof.

The GSR drives **informed decisions** by providing timely and reliable renewable energy data.

06

06 TRACKING THE GLOBAL ENERGY TRANSITION

A DECADE OF UNPRECEDENTED MOMENTUM FOR RENEWABLES

Christine Lins (Executive Secretary of REN21)
Hannah Murdock (REN21 Secretariat)

The evolution of renewable energy over the past decade has surpassed all expectations. Global installed capacity and production from all renewable technologies have increased substantially, and supporting policies have continued to spread to more countries in all regions of the world.

REN21 was the first international organisation to begin tracking renewable energy development after its founding in 2004, and it has continued to provide the most comprehensive global outlook on the state of renewables each year. The REN21 *Renewables Global Status Report (GSR)* has become increasingly comprehensive during the past decade as the landscape of renewable energy has become ever-more complex. While the first GSR was written by a single person with input from a small network of experts, today it draws on an international network of over 500 people, who participate collaboratively in its production.

REN21's 10th anniversary this year provides the opportunity to reflect on the remarkable advances of renewable energy technologies over the past decade and to consider their promise for the future.

EXPANSION BEYOND EXPECTATIONS

Developments in the early 2000s showed upwards trends in global renewable energy investment, capacity, and integration across all sectors. Yet most mainstream projections did not predict the extraordinary expansion of renewables that was to unfold over the decade ahead. Scenarios from the renewable energy industry, the International Energy Agency, the World Bank, Greenpeace, and others all projected levels of renewable energy for the year 2020 that were already well exceeded by 2010.[1]

Several factors set the foundation for this rapid growth. Energy crises beginning in the 1970s, and economic downturns following each global oil shock, underscored the role of energy in national and economic security. At the same time, a handful of pioneering countries—such as Germany, Denmark, Spain, and the United States—created critical early markets for renewables, which drove early technological advances and economies of scale, setting the stage and helping to fuel the past decade of explosive market expansion. Growing emphasis on mitigating climate change and adapting to its impacts has further contributed to the momentum.

Renewable energy's contribution to the global heat, power, and transport sectors has increased steadily; growth in renewables' share of total energy use has been moderated by increases in both population and world energy demand, most notably in developing and emerging economies.[2] Renewable energy markets and technology developments have accelerated quickly, even compared to other rapidly developing technologies such as mobile phones.

Hydropower continues to claim the largest share of renewable electric capacity and generation worldwide.[3] In 2004, hydropower dwarfed all other renewable electricity technologies, but today non-hydro renewables generate large and growing shares of electricity in an increasing number of countries. While hydropower leads globally in terms of electricity generation, biomass accounts for the largest portion of renewable energy production. The share of traditional biomass in global primary energy has held steady or declined in the past decade, while modern biomass has gained ground.[4]

Wind capacity has grown by a factor of more than eight since the beginning of 2004. Dynamic wind power markets are now located throughout the world rather than just in a few countries in Europe and the United States, as they were back in 2004. By the end of 2013, 24 countries had more than 1,000 MW of wind capacity, including emerging economies such as China, India, and Brazil, which have experienced rapid growth.[5] The average size of installed wind turbines has doubled over the past 10 years, and technological improvements have reduced the costs of wind-generated electricity significantly, making wind power competitive with new fossil fuels in many markets today.[6]

Solar PV has been the fastest growing energy technology by far, with global capacity experiencing an extraordinary 53-fold increase between the beginning of 2004 and the end of 2013.[7] The last decade has seen a spectacular decline in solar PV costs due to technology advances, the increasing scale of industrial production, and improved efficiency of solar PV cells and modules. With a learning rate of 18–22% for each doubling of installed capacity, solar PV module prices have dropped dramatically over the past two decades; prices fell 60% during 2011–2012 alone.[8] In the solar PV industry, the most striking development has been seen in China, which now dominates global module production. Also, China has risen from near-zero levels 10 years ago to become the world's largest market in 2013.[9]

During the same period, concentrating solar thermal power (CSP) capacity increased nearly 10-fold.[10] Investment has moved beyond the traditional markets of Spain and the United States, with increasing development in South Africa, the Middle East and North Africa (MENA) region, Asia, and Latin America.

The use of geothermal energy for the generation of electricity and heat has seen steady expansion. Furthermore, ocean technologies for electricity generation have evolved significantly throughout the last 10 years.

Although the last decade has seen tremendous advances in the electricity sector, the renewable heating and cooling sector has lagged behind. This is despite the marked significant growth over the past decade in the use of geothermal, solar thermal, and biomass heating technologies for water and space heating, process heat, and cooling.[11] Given that the share of heating and cooling in final energy demand is much higher than that of electricity, fostering growth of renewable energy in this sector is of particular importance.

In the transport sector, the use of renewable energy in the form of biofuels grew at a rapid pace for much of the decade ending with 2013. Biodiesel production increased 15-fold, while ethanol production grew nearly fourfold (from much higher levels).[12] Over the past decade, gaseous biofuels have seen small but growing markets in the transport sector, and initiatives to link renewable energy with electric transport also have emerged.[13]

A DECADE OF CHANGE

Global perceptions of renewable energy have shifted considerably since 2004, when people widely acknowledged the potential of renewable energy, but large-scale deployment still had to be demonstrated. Over the last 10 years, continuing technology advances and rapid deployment of many renewable energy technologies, particularly in the electricity sector, have demonstrated that their potential can be achieved.

Today, renewable energy technologies are not only viewed as tools for improving energy security and mitigating and adapting to climate change, but are also increasingly being recognised as investments that can provide direct and indirect economic advantages by reducing dependence on imported fuels, improving local air quality and safety, advancing energy access and security, propelling economic development, and creating jobs.[14]

Declining costs have played a significant role in the expansion of renewable energy deployment in recent years. Now, several renewable energy technologies are cost competitive with conventional generation technologies, even before considering environmental and other externalities.[15]

As a result, companies have begun to realise that making the switch to renewable energy in conjunction with energy efficiency measures can reduce their energy costs while helping them to tackle sustainability concerns. An increasing number of companies, large and small, are either purchasing renewable electricity from utilities and other providers, or installing and operating renewable energy capacity at their own facilities. Furthermore, recent years have seen the rise of self-generation at the household level, as well as the spread of cooperative and community-owned renewable energy projects.

Extraordinary growth in renewable energy markets and their global spread have led to a significant rise in the number of manufacturers, the scale of manufacturing, and the number of jobs in installation and servicing of renewable energy technologies, as well as expansion into new markets. This is particularly true for the solar PV and wind power industries, which have experienced industry consolidation simultaneously.

Ten years ago, most deployment and manufacturing of renewable energy occurred in Europe, the United States, and Japan. Since then, markets, manufacturing, and investment have shifted to other regions. China has become the world leader in renewables manufacturing and installed capacity, having increased investment in the sector nearly every year for the past decade.[16] Increasing amounts of money are now flowing to developing and emerging countries across Africa, Asia, Latin America, and the Middle East, in response to the rapid growth in energy demand and growing interest in renewables in these regions.

Foreign direct investment in renewable energy and the mobilisation of private capital in emerging economies has also contributed to the past decade of growth across technologies and regions. Nonetheless, many of the countries that led global markets in 2004 continue to do so. These paved the way for technology advances and market expansion through early investment in technology and policy design.

As renewables have spread across the globe, they have seen growing use in remote and rural areas of the developing world. Renewable electricity in rural areas has continued to become more affordable and diversified in both application and size as technology has advanced, prices have decreased, knowledge of local renewable resources has improved, and new business and financing models have emerged.[17] Parallel advances in electronics, management systems, mobile phones, and other technologies have also reduced the costs of renewable energy systems and services while extending their reach.

Over the past decade, the share of people who lack access to modern energy services has fallen by nearly 10 percentage points (down from almost 25%), even as the global population has expanded significantly.[18] Renewables have played a role in this advancement. However, advances are not spread evenly geographically, leaving large areas of Africa still without access to modern energy services. Renewables are uniquely positioned to provide energy access in a sustainable manner, more rapidly and generally at lower cost than their alternatives. The UN Secretary General's Sustainable Energy for All (SE4ALL) initiative, launched in 2012, aims to further boost international development in the fields of energy access, renewable energy deployment, and energy efficiency. While some countries had already established targets for 100% energy access, SE4ALL has encouraged many more countries to commit to this goal.[19]

The last decade has also brought a series of institutional changes. REN21—the Renewable Energy Policy Network for the 21st Century—was created as an outcome of the Renewables 2004 conference in Bonn, Germany. REN21 was established as the multi-stakeholder "coalition of the willing," bringing together key actors from both the private and public sector to facilitate a rapid global transition to renewable energy. Five years later, the International Renewable Energy Agency (IRENA) was founded and, by early 2014, it already counted 130 member countries, demonstrating the interest of most countries around the world in advancing renewable energy. Throughout the decade, the International Energy Agency has scaled up its analytical work on renewable energy, and all of these organisations work together closely to raise the profile of renewable energy.

INVESTMENT ON THE RISE

Reflecting these developments, global investment in renewable power capacity and fuels increased more than fivefold over the period 2004–2013.[20] In terms of net additions to electric generating capacity, global annual investments in renewable energy have exceeded those for fossil fuels since 2009.[21] Total global investment (both public and private) in R&D for renewable energy technologies has nearly doubled over the past decade.[22]

Investment in utility-scale electricity projects (asset finance) has played the largest role in the growth of the renewable energy sector, with a 33% compound annual growth rate from 2004 to 2011, although investment in this area has fallen slightly in recent years. Investment in small-scale distributed generating capacity has seen significant growth since 2004, decreasing only slightly since record levels were reached in 2011.[24] Declines have resulted from policy uncertainty in several countries, but have also reflected a steep decline in system prices for solar PV.[25] While public market investment in renewables has fluctuated over the past decade, it has maintained multibillion-dollar levels since taking off in 2005.[26]

Commercial banks were just starting to enter the renewable energy sector in 2004, at a time when the majority of financiers and other investors considered most renewable technologies to be unproven and too risky. Today commercial banks are joined by pension funds, insurance companies, major corporations (including several outside of the energy industry), and others looking for stable, long-term returns.

Now that renewables are becoming economically competitive and investors are increasingly recognising their value, a key to further development will be the design of effective financing tools to overcome initial investment costs. Several financial innovations have been developed since 2004. Recently, investment firms introduced tools such as Sustainable Yield Bonds in the United States, Green Bonds in France and the United States, and the Renewable Financing Company Bonds in the United Kingdom.[27] Further innovations, ranging from crowd funding to new ownership models (such as leasing), are making it possible for individuals and communities to invest in renewable energy.

THE EVOLVING POLICY LANDSCAPE

The global policy landscape has largely driven the expansion of renewable energy technologies by attracting investment and creating markets that brought about economies of scale and supported technology advances. This in turn, led to decreasing costs, which ultimately fuel sustained growth. A handful of countries—particularly Germany, Denmark and Spain—led the way and created innovative policies that drove much of the change witnessed over the past decade. Today, Germany's commitment to the "Energiewende"—the transition to a sustainable economy based on renewable energy and energy efficiency—as well as Denmark's commitment to 100% renewable energy by 2050, are inspiring many other countries around the globe to aim high for the coming decades.

Since 2004, the number of countries promoting renewable energy with direct policy support has tripled, from 45 to 137, and an ever-increasing number of developing and emerging countries is setting renewable energy targets and enacting support policies.[28] Policy targets have become increasingly ambitious, while their focus has expanded to include heating, cooling, and transport, in addition to electricity.

In parallel, policy mechanisms have continued to evolve, including the use of policy instruments differentiated by technology, the evolution of feed-in policies towards premium payments, as well as the spreading of policy frameworks to promote renewable energy use for heating and cooling. Globally, renewable energy targets together with feed-in tariffs have had the biggest impact on renewable energy market introduction. Feed-in policies now exist on every continent, with Jordan, Nigeria, Rwanda, Uganda, the Palestinian Territories, Kazakhstan, and Ecuador being among the most recent countries to enact them.[29]

In many countries, particularly in Europe, variable renewables have achieved high shares of penetration in the electricity sector very rapidly. Existing power systems were not designed to cope with such a situation. In response, policy mechanisms that focus on market design are emerging to address needs relating to balancing and increased system flexibility, as well as financial compensation for these services. Policies are also starting to address the need for expanded and improved grid infrastructure, and increasingly they include new tools and technologies to support renewables, such as energy storage and smart grids.

While Europe has been the centre of most such changes to date, countries in other regions are moving quickly in this direction as their shares of renewable energy increase. Policies that encourage local value creation (such as capacity building) also have begun to emerge in many countries. Recently, as renewable energy shares continue to rise, regulations that focus on mandatory grid connection and priority dispatch are becoming increasingly important.

The past decade has witnessed profound change on the local level as well. Ten years ago, the majority of local governments did not consider the potential role for renewables in their energy supply. Over the past decade, many of them have become leaders in the advancement of renewable energy—particularly in combination with energy efficiency improvements—regularly exceeding efforts taken by state, provincial, and national governments. Hundreds of local governments worldwide have set renewable energy targets and enacted fiscal incentives or other policies to foster the deployment of renewables, driven by the desire to create local jobs, reduce energy costs, address pollution issues, and advance their sustainability goals.[30] International organisations dedicated to supporting sustainability measures in local governments, such as the Covenant of Mayors and ICLEI–Local Governments for Sustainability, have seen their memberships skyrocket and their influence spread around the globe.

Around the world, governments at the community, city, regional, island, and even country levels have begun to forge their own transition pathways towards a 100% renewable energy future. They are debunking myths about renewables and proving that 100% renewable energy—in close conjunction with energy efficiency and conservation—is technically feasible, economically advantageous, and socially desirable.[31]

While the picture in much of the world has grown increasingly bright, some countries—particularly in Europe—have reduced renewable energy support, sometimes retroactively, in the past few years. This is the case especially where electricity demand has declined in response to economic slowdown, and where an overcapacity of conventional power exists. To date, however, the European Union is on track to meet its member-agreed binding target to increase the share of renewables in final energy consumption to 20% by 2020.[32] Reportedly, three EU Member States (Bulgaria, Estonia, and Sweden) already reached their 2020 targets in 2012.[33] Discussions about setting 2030 EU climate and energy targets are ongoing.

A PROMISING FUTURE FOR RENEWABLES

In contrast to 2004, the use of renewable energy technologies to provide electricity, heating and cooling, and transportation is now widely spread across the globe, and recent trends suggest sustained growth worldwide. A decade ago, renewables had a strong appeal to those who were interested in moving away from conventional fuels for environmental reasons. Today, renewables have demonstrated that, in addition to their environmental benefits, they are also economic drivers, creating jobs, helping to diversify revenue streams, and stimulating new technological developments.

The share of renewables in global electricity generation continues to increase while the share of nuclear power has been declining over the past decade.[34] The idea of achieving very high shares of non-hydro renewable energy was quite radical 10 years ago, yet today it is considered feasible by many experts. Several local, regional, and national governments around the world have committed to 100% renewable energy in one or more sectors within the coming decades.

Nonetheless, the renewable energy sector still faces numerous challenges. Enormous subsidies for fossil fuels and nuclear power persist, and they continue to vastly outweigh financial incentives for renewables. Many countries are directing increasing resources towards the exploration and extraction of unconventional fossil resources, while most governments remain reluctant to internalise the external costs associated with the extraction and use of fossil fuels.

Further advances and investment in renewable energy, as well as improvements in energy efficiency, must continue if the increase in global temperature is to be limited to 2°C. For this to happen, stable and predictable policy frameworks are key. Integrated policy approaches that incorporate energy efficiency—considered as the low-hanging fruit on the path to sustainability—will further facilitate the global transition to renewable energy.

The past decade has set the wheels in motion for this transition, but a concerted and sustained effort will be required to fully achieve it. With increasingly ambitious targets, innovative policies, and technological advances, renewables can continue to surpass expectations and foster a cleaner energy future.

TABLE R1. GLOBAL RENEWABLE ENERGY CAPACITY AND BIOFUEL PRODUCTION, 2013

	ADDED DURING 2013	EXISTING AT END-2013
POWER GENERATION (GW)		
Bio-power	5	88
Geothermal power	0.5	12
Hydropower	40	1,000
Ocean power	~0	0.5
Solar PV	39	139
Concentrating solar thermal power (CSP)	0.9	3.4
Wind power	35	318
HEATING / HOT WATER (GW_{th})		
Modern bio-heat	3	296
Geothermal heating[1]	1.3	23
Solar collectors for water heating[2]	44	326
TRANSPORT FUELS (billion litres/year)		
Ethanol production	4.6	87
Biodiesel production	2.7	26
Hydrotreated vegetable oil (HVO)	0.4	3

[1] Estimates for 2013 do not include ground-source heat pumps in the geothermal direct use total. See Methodological Notes on page 142.

[2] Solar collector capacity is for glazed and unglazed water systems only (not including air collectors, which account for another estimated 3.6 GW_{th} total at end-2013). Additions are net; gross additions were estimated at 57 GW_{th}. Note that past editions of this table have not considered unglazed water collectors.

Note: Numbers are rounded to nearest GW/GW_{th}/billion litres, except for numbers <5, which are rounded to nearest decimal point; where totals do not add up, the difference is due to rounding. Rounding is to account for uncertainties and inconsistencies in available data. For more precise data, see Reference Tables R2–R10, Market and Industry Trends section and related endnotes.

Source: See Endnote 1 for this section.

TABLE R2. RENEWABLE ELECTRIC POWER GLOBAL CAPACITY, TOP REGIONS/COUNTRIES, 2013

TECHNOLOGY	World	EU-28	BRICS	China	United States	Germany	Spain	Italy	India
	GW			GW					
Bio-power	88	35	24	6.2	15.8	8.1	1	4	4.4
Geothermal power	12	1	0.1	~0	3.4	~0	0	0.9	0
Hydropower	1,000	124	437	260	78	5.6	17.1	18.3	44
Ocean power	0.5	0.2	~0	~0	~0	0	~0	0	0
Solar PV	139	80	21	19.9	12.1	36	5.6	17.6	2.2
Concentrating solar thermal power (CSP)	3.4	2.3	0.1	~0	0.9	~0	2.3	~0	0.1
Wind power	318	117	115	91	61	34	23	8.6	20
Total renewable power capacity (including hydropower)	**1,560**	**360**	**599**	**378**	**172**	**84**	**49**	**49**	**71**
Total renewable power capacity (not including hydropower)	**560**	**235**	**162**	**118**	**93**	**78**	**32**	**31**	**27**
Per capita capacity (Watts / inhabitant, not including hydropower)	80	470	50	90	300	960	690	510	20

Note: Global total reflects additional countries not shown. Table shows the top six countries by total renewable power capacity, not including hydropower; if hydro were included, countries and rankings would differ somewhat. Numbers are based on best data available at time of production. To account for uncertainties and inconsistencies in available data, numbers are rounded to the nearest 1 GW, with the exception of the following: global data for total renewable power capacity with and without hydropower are rounded to nearest 10 GW, totals below 20 GW are rounded to the nearest decimal point, and per capita numbers are rounded to the nearest 10 W. Where totals do not add up, the difference is due to rounding. Capacity amounts of <50 MW (including pilot projects) are designated by "~0." For more precise data, see Global Overview and Market and Industry Trends sections and related endnotes. Numbers should not be compared with prior versions of this table to obtain year-by-year increases, as some adjustments are due to improved or adjusted data rather than to actual capacity changes. Hydropower totals, and therefore the total world renewable capacity (and totals for some countries), do not include pure pumped storage capacity. Also note that the GSR 2013 reported a global total of 990 GW of hydropower capacity at the end of 2012; this figure has been revised downward, affecting also the global total for all renewables. Bio-power data reflect an effort to include only the organic component that is not incinerated.
For more information see Methodological Notes on page 142.

Source: See Endnote 2 for this section.

TABLE R3. WOOD PELLETS GLOBAL TRADE, 2013

EXPORTER	IMPORTER	VOLUME
		kilotonnes
Australia	EU-27	31
Belarus	EU-27	134
Bosnia and Herzegovina	EU-27	187
Canada	EU-27	2,093
Canada	Japan	50
Canada	South Korea	50
Canada	United States	30
Croatia	EU-27	165
Egypt	EU-27	16
EU-27	Switzerland	39
EU-27	Norway	18
Norway	EU-27	60
Russia	EU-27	642
Serbia	EU-27	55
Southeast Asia[1]	Japan	100
Southeast Asia[1]	South Korea	100
Ukraine	EU-27	159
United States	EU-27	2,828
Other	EU-27	19

[1] Primarily China, Malaysia, Thailand, and Vietnam.
Source: See Endnote 3 for this section.

TABLE R4. BIOFUELS GLOBAL PRODUCTION, TOP 16 COUNTRIES AND EU-27, 2013

COUNTRY	FUEL ETHANOL	BIODIESEL	HVO	TOTAL	COMPARISON WITH TOTAL VOLUMES PRODUCED IN 2012
	billion litres				
United States	50.3	4.8	0.3	**55.4**	+1.2
Brazil	25.5	2.9		**28.4**	+4.1
Germany	0.8	3.1		**3.9**	+0.2
France	1.0	2.0		**3.0**	+0.1
Argentina	0.5	2.3		**2.7**	-0.3
The Netherlands	0.3	0.4	1.7	**2.5**	no change
China	2.0	0.2		**2.2**	-0.1
Indonesia	0.0	2.0		**2.0**	+0.2
Thailand	1.0	1.1		**2.0**	+0.5
Canada	1.8	0.2		**2.0**	+0.1
Singapore	0	0.93	0.9	**1.8**	+0.9
Poland	0.2	0.9		**1.2**	+0.3
Colombia	0.4	0.6		**0.9**	no change
Belgium	0.4	0.4		**0.8**	no change
Spain	0.4	0.3		**0.7**	-0.2
Australia	0.3	0.4		**0.6**	no change
EU-27	**4.5**	**10.5**	**1.8**	**16.8**	**1.3**
World	**87.2**	**26.3**	**3.0**	**116.6**	**7.7**

Note: All figures are rounded to the nearest 0.1 billion litres; comparison column notes "no change" if difference is less than 0.05 billion litres. Ethanol numbers are for fuel ethanol only. Table ranking is by total volumes of biofuel produced in 2013 (from preliminary data), and not by energy content. Where numbers do not add up, it is due to rounding.

Source: See Endnote 4 for this section.

TABLE R5. GEOTHERMAL POWER GLOBAL CAPACITY AND ADDITIONS, TOP 6 COUNTRIES, 2013

	NET ADDED 2013	TOTAL END-2013
	MW	GW
TOP COUNTRIES BY TOTAL CAPACITY		
United States	84	3.4
Philippines	20	1.9
Indonesia	0	1.3
Mexico	10	1.0
Italy	1	0.9
New Zealand	196	0.9
TOP COUNTRIES BY NET ADDITIONS		
New Zealand	196	0.9
Turkey	112	0.3
United States	84	3.4
Kenya	36	0.2
Philippines	20	1.9
Mexico	10	1.0
World Total	**465**	**12**

Source: See Endnote 5 for this section.

TABLE R6. HYDROPOWER GLOBAL CAPACITY AND ADDITIONS, TOP 6 COUNTRIES, 2013

	NET ADDED 2013	Total End-2013
	GW	GW
TOP COUNTRIES BY TOTAL CAPACITY		
China	28.7	260
Brazil	1.5	86
United States	0.2	78
Canada	0.5	76
Russia	0.7	47
India	0.8	44
TOP COUNTRIES BY NET ADDITIONS		
China	28.7	260
Turkey	2.9	22
Brazil	1.5	86
Vietnam	1.3	14
India	0.8	44
Russia	0.7	47
World Total	**40**	**1,000**

Note: Capacity additions are rounded to the nearest 0.1 GW and totals are rounded to the nearest 1.0 GW. Data reflect a variety of sources, some of which differ quite significantly, reflecting variations in accounting and methodology. For more information and statistics, see Hydropower text and related endnotes in Markets and Industry Trends section and Methodological Notes on page 142.

Source: See Endnote 6 for this section.

TABLE R7. SOLAR PV GLOBAL CAPACITY AND ADDITIONS, TOP 10 COUNTRIES, 2013

COUNTRY	TOTAL END-2012	ADDED 2013	TOTAL END-2013
		GW	
Germany	32.6	3.3	35.9
China	7.0	12.9	19.9
Italy	16.4	1.5	17.6
Japan	6.6	6.9	13.6
United States	7.2	4.8	12.1
Spain	5.4	0.2	5.6
France	4.0	0.6	4.6
United Kingdom	1.8	1.5	3.3
Australia	2.4	0.8	3.3
Belgium	2.7	0.2	3.0
Rest of World	**13.8**	**6.5**	**20.2**
World Total	**100**	**39**	**139**

Note: Countries are ordered according to total operating capacity at the end of 2013. Top countries for capacity added in 2013 were China, Japan, United States, Germany, United Kingdom, Italy, India (added 1.1 GW for total of 2.3 GW), Romania (added 1.1 GW for total of 1.2 GW), Greece (added 1 GW for total of 2.6 GW), and Australia. The top 10 countries for total year-end 2012 capacity were Germany, Italy, United States, China, Japan, Spain, France, Belgium, Australia, and the Czech Republic (see GSR 2013, Reference Table R5). Country and Rest of World data are rounded to the nearest 0.1 GW; World totals are rounded to nearest 1 GW. Rounding is to account for uncertainties and inconsistencies in available data; where totals do not add up, the difference is due to rounding. Data for Japan and Spain are converted from data reported in direct current (DC). Data reflect a variety of sources, some of which differ quite significantly, reflecting variations in accounting or methodology. For more information, see Solar PV text and related endnotes in Market and Industry Trends section.

Source: See Endnote 7 for this section.

TABLE R8. CONCENTRATING SOLAR THERMAL POWER (CSP) GLOBAL CAPACITY AND ADDITIONS, 2013

COUNTRY	TOTAL END-2012	ADDED 2013	TOTAL END-2013
		MW	
Spain	1,950	350	2,300
United States	507	375	882
United Arab Emirates	0	100	100
India	0	50	50
Algeria	25	0	25
Egypt	20	0	20
Morocco	20	0	20
Australia	12	0	12
China	0	10	10
Thailand	5	0	5
World Total	**2,540**	**885**	**3,425**

Note: Table includes countries with operating commercial CSP capacity at end-2013. Several additional countries had small pilot plants in operation by year's end, including France (at least 0.75 MW), Germany (1.5 MW), Israel (6 MW), Italy (5 MW), and South Korea (0.2 MW). GSR 2013 also included 10 MW in Chile; this was removed because capacity is actually for process heat. National data are rounded to nearest MW, and world totals are rounded to nearest 5 MW. Rounding is to account for uncertainties and inconsistencies in available data; where totals do not add up, the difference is due to rounding.

Source: See Endnote 8 for this section.

TABLE R9. SOLAR WATER HEATING COLLECTORS GLOBAL CAPACITY AND ADDITIONS, TOP 12 COUNTRIES, 2012

	ADDED 2012 GW$_{th}$			TOTAL 2012 GW$_{th}$		
COUNTRY	Glazed	Unglazed	Total	Glazed	Unglazed	Total
China	44.7	0	44.7	180.4	0	180.4
United States	0.2	0.5	0.7	1.9	14.3	16.2
Germany	0.8	0	0.8	11.4	0.4	11.8
Turkey	1.1	0	1.1	10.8	0	10.8
Brazil	0.4	0.4	0.8	4.2	1.6	5.8
Australia	0.2	0.5	0.6	2.1	3.0	5.1
India	1.0	0	1.0	4.5	0	4.5
Austria	0.1	~0	0.1	3.1	0.4	3.4
Japan	0.1	0	0.1	3.1	0	3.1
Israel	0.2	~0	0.2	2.9	~0	2.9
Greece	0.2	0	0.2	2.9	0	2.9
Italy	0.2	0	0.2	2.4	~0	2.4
Rest of World	**4.3**	**0.3**	**4.6**	**28.2**	**4.0**	**32.1**
World Total	**54**	**1.7**	**55**	**258**	**24**	**282**

Note: Countries are ordered according to total installed capacity. Data are for glazed and unglazed water collectors; air collectors add almost 1.7 GW$_{th}$ to the year-end world total. Additions represent gross capacity added; total numbers include allowances for retirements. Country and rest of world data are rounded to nearest 0.1 GW$_{th}$; world totals are rounded to nearest 1 GW$_{th}$, with the exception of added unglazed capacity. Where totals do not add up, the difference is due to rounding. Small amounts, on the order of a few MW$_{th}$, are designated by "~0." By accepted convention, 1 million square metres = 0.7 GW$_{th}$. The year 2012 is the most recent one for which firm global data and most country statistics are available. It is estimated, however, that 330 GW$_{th}$ of solar thermal capacity (including 325.9 GW$_{th}$ of water collectors and 3.6 GW$_{th}$ of air collectors) was in operation worldwide by the end of 2013. For 2013 details and source information, see Solar Thermal Heating and Cooling text and related endnotes in Market and Industry Trends section.

Source: See Endnote 9 for this section.

TABLE R10. WIND POWER GLOBAL CAPACITY AND ADDITIONS, TOP 10 COUNTRIES, 2013

COUNTRY	TOTAL END-2012	ADDED 2013	TOTAL END-2013
		GW	
China[1]	60.8 / 75.3	14.1 / 16.1	75.5 / 91.4
United States	60.0	1.1	61.1
Germany[2]	31.3	3.2 / 3.6	34.3 / 34.7
Spain	22.8	0.2	23
India	18.4	1.7	20.2
United Kingdom	8.6	1.9	10.5
Italy	8.1	0.4	8.6
France	7.6	0.6	8.3
Canada	6.2	1.6	7.8
Denmark	4.2	0.7	4.8
Rest of World	**41**	**7**	**48**
World Total	**283**	**35**	**318**

[1] For China, left-hand data are the amounts officially classified as connected to the grid and operational by year's end; right-hand data are total installed capacity. The world totals include the higher figures for China.

[2] For Germany, left-hand data are grid-connected at year's end, and right-hand data are total installed capacity. Note that about 355 MW of capacity that was added offshore during the year was not connected to the grid by year's end; 236 MW of added capacity was for repowering.

Note: Countries are ordered according to total installed capacity at the end of 2013. Top countries for capacity added in 2013 were China, Germany, the United Kingdom, India, Canada, the United States, Brazil, Poland, Sweden, and Romania. The top 10 countries for total year-end 2012 capacity were the same with the exception of the 10th spot, which was held by Portugal. Country data are rounded to nearest 0.1 GW; Rest of World and World data are rounded to nearest GW. Rounding is to account for uncertainties and inconsistencies in available data; where totals do not add up, the difference is due to rounding or repowering/removal of existing projects. Data reflect a variety of sources, some of which differ quite significantly, reflecting variations in accounting or methodology. For more information, see Wind Power text and related endnotes in Market and Industry Trends section.

Source: See Endnote 10 for this section.

TABLE R11. GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT, 2004–2013

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
	Billion USD									
NEW INVESTMENT BY STAGE										
Technology Research										
Government R&D	1.9	2.1	2.3	2.7	2.8	5.1	4.6	4.6	4.5	4.6
Corporate R&D	3.2	2.9	3.1	3.5	4.0	4.1	4.2	5.1	5.0	4.7
Development / Commercialisation										
Venture Capital	0.4	0.6	1.2	2.2	3.3	1.6	2.5	2.5	2.4	0.8
Manufacturing										
Private Equity Expansion Capital	0.3	1.0	3.0	3.6	6.7	2.9	3.1	2.6	1.7	1.4
Public Markets	0.3	3.7	9.0	22.2	11.5	13.0	11.4	10.7	3.7	11.1
Projects										
Asset Finance	24.8	44.1	72.3	100.9	124.3	109.8	144.2	180.3	154.2	133.4
(re-invested equity)	0.0	(0.1)	(0.7)	(3.0)	(3.6)	(1.7)	(5.8)	(3.7)	(1.8)	(1.5)
Small Distributed Capacity	8.6	10.3	9.5	14.1	22.3	33.6	62.5	77.2	80.0	59.9
Total New Investment	**39.5**	**64.5**	**99.6**	**145.9**	**171.2**	**168.4**	**226.7**	**279.4**	**249.5**	**214.4**
Merger & Acquisition Transactions	8.9	26.2	35.7	58.5	59.3	64.2	58.4	73.4	60.3	53.7
Total Investment	**48.3**	**90.8**	**135.3**	**204.3**	**230.6**	**232.7**	**285.2**	**352.8**	**309.9**	**268.2**
NEW INVESTMENT BY TECHNOLOGY										
Solar power	12.1	16.3	21.7	38.7	59.5	62.9	100.3	157.8	142.9	113.7
Wind power	14.5	25.1	32.1	56.6	69.3	73.0	94.8	85.9	80.9	80.1
Biomass and waste-to-energy	6.2	8.0	10.6	13.2	14.1	13.6	14.2	15.5	11.1	8.0
Hydropower <50 MW	1.7	4.9	5.4	5.5	7.2	5.4	4.8	6.8	6.0	5.1
Biofuels	3.7	9.2	27.6	29.3	19.2	10.4	8.9	9.4	6.6	4.9
Geothermal power	1.3	1.0	1.4	1.9	1.8	2.7	3.5	3.7	1.8	2.5
Ocean energy	0.0	0.1	0.9	0.7	0.2	0.3	0.2	0.3	0.2	0.1
Total New Investment	**39.5**	**64.5**	**99.6**	**145.9**	**171.2**	**168.4**	**226.7**	**279.4**	**249.5**	**214.4**

Note: Data are based on the output of the Desktop database of Bloomberg New Energy Finance (BNEF), unless otherwise noted, and reflect the timing of investment decisions. The following renewable energy projects are included: all biomass, geothermal, and wind generation projects of more than 1 MW; all hydro projects of between 1 and 50 MW; all solar power projects, with those less than 1 MW estimated separately and referred to as small distributed capacity; all ocean energy projects; and all biofuel projects with an annual production capacity of 1 million litres or more. Where totals do not add up, this is due to rounding. For more information about the categories in this table, see Sidebar 5 in GSR 2013.

Source: See Endnote 11 for this section.

TABLE R12. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2011/2012 AND TARGETS

COUNTRY	PRIMARY ENERGY Share (2011/2012)[1]	PRIMARY ENERGY Target	FINAL ENERGY Share (2012)[1]	FINAL ENERGY Target
EU-28			14%	→ 20 % by 2020
Albania		→ 18% by 2020		→ 38% by 2020
Algeria				→ 40% by 2030
Angola	62%			
Argentina			38.9%	
Austria[2]				→ 45% by 2020
Azerbaijan		→ 9.7% by 2020		
Barbados		→ 10% by 2012 → 20% by 2016		
Belgium				→ 13% by 2020
Belize			63%	
Bosnia and Herzegovina				→ 40% by 2020
Botswana				→ 1% by 2016
Brazil			42%	
Bulgaria				→ 16% by 2020
Burundi				→ 2.1% by 2020
Canada	11%			
Chile			8.1%	
China			9.2% (2013)	→ 9.5% by 2015
Colombia	7.1%		12%	
Côte d'Ivoire		→ 3% by 2013 → 5% by 2015		
Croatia				→ 20% by 2020
Cyprus				→ 13% by 2020
Czech Republic[2]				→ 13.5% by 2020
Democratic Republic of the Congo			96%	
Denmark				→ 35% by 2020 → 100% by 2050
Dominican Republic			5.2%	
Ecuador			66%	
Egypt		→ 14% by 2020		
El Salvador			54%	
Estonia				→ 25% by 2020
Fiji				→ 23% by 2030
Finland				→ 25% by 2015 → 38% by 2020 → 40% by 2025
France			7.9% (2011)	→ 23% by 2020
Gabon				→ 80% by 2020
Germany[2]			12% (2013)	→ 18% by 2020 → 30% by 2030 → 45% by 2040 → 60% by 2050
Greece[2]				→ 20% by 2020
Grenada		→ 20% by 2020		
Guatemala			60%	→ 80% by 2026

REN21 Renewable Energy Policy Network for the 21st Century

TABLE R12. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2011 / 2012 AND TARGETS (continued)

COUNTRY	PRIMARY ENERGY Share (2011 / 2012)[1]	PRIMARY ENERGY Target	FINAL ENERGY Share (2012)[1]	FINAL ENERGY Target
Guyana			8.7%	
Honduras			44%	
Hungary[2]				→ 14.65% by 2020
India			5.5%	
Indonesia		→ 25% by 2025		
Ireland				→ 16% by 2020
Israel				→ 50% by 2020
Italy				→ 17% by 2020
Jamaica			5.1%	→ 15% by 2020 → 20% by 2030
Japan	7.1%	→ 10% by 2020		
Jordan	0.1%	→ 7% by 2015 → 10% by 2020		
Kosovo				→ 25% by 2020
Laos				→ 30% by 2025
Latvia				→ 40% by 2020
Lebanon				→ 12% by 2020
Libya		→ 10% by 2020		
Lithuania		→ 20% by 2025		→ 23% by 2020
Luxembourg				→ 11% by 2020
Macedonia				→ 28% by 2020
Madagascar				→ 54% by 2020
Malawi		→ 7% by 2020		
Mali		→ 15% by 2020		
Malta				→ 10% by 2020
Mauritania		→ 15% by 2015 → 20% by 2020		
Mauritius	15%	→ 35% by 2025		
Moldova		→ 20% by 2020		→ 17% by 2020
Mongolia		→ 20–25% by 2020		
Montenegro				→ 33% by 2020
Netherlands[2]				→ 16% by 2020
New Zealand	39% (2013)		31% (2013)	
Nicaragua			52%	
Niger		→ 10% by 2020		
Norway				→ 67.5% by 2020
Palau		→ 20% by 2020		
Palestinian Territories				→ 25% by 2020
Panama			61%	
Peru			48%	
Poland		→ 12% by 2020		→ 15% by 2020
Portugal			25%	→ 31% by 2020
Romania				→ 24% by 2020
Samoa		→ 20% by 2030		
Senegal			0.6%	

TABLE R12. SHARE OF PRIMARY AND FINAL ENERGY FROM RENEWABLES, EXISTING IN 2011/2012 AND TARGETS (continued)

COUNTRY	PRIMARY ENERGY		FINAL ENERGY	
	Share (2011/2012)[1]	Target	Share (2012)[1]	Target
Serbia				→ 27% by 2020
Slovakia				→ 14% by 2020
Slovenia				→ 25% by 2020
South Korea	3.2%	→ 4.3% by 2015 → 6.1% by 2020 → 11% by 2030		
Spain[2]			14%	→ 20.8% by 2020
St. Lucia		→ 20% by 2020		
Suriname			50%	
Sweden[2]			48% (2011)	→ 50% by 2020
Switzerland		→ 24% by 2020		
Thailand			18%	→ 25% by 2021
Togo			3.4%	
Tonga				→ 100% by 2013
Turkey	3%	→ 30% by 2023		
Ukraine				→ 11% by 2020
United Kingdom				→ 15% by 2020
United States			9.3%	
Uruguay		→ 50% by 2015		
Venezuela			53%	
Vietnam		→ 5% by 2020 → 8% by 2025 → 11% by 2050		

[1] National share is for 2011/2012 unless otherwise noted.

[2] Final energy targets for all EU-28 countries are set under EU Directive 2009/28/EC. The governments of Austria, the Czech Republic, Germany, Greece, Hungary, Spain, and Sweden have set higher targets, which are shown here. The government of the Netherlands has reduced its more ambitious target to the level set in the EU Directive.

Note: Actual percentages are rounded to the nearest whole decimal for numbers over 10% except where associated targets are expressed differently. Some countries shown have other types of targets (see Tables R13, R14, and R15).

Source: See Endnote 12 for this section.

TABLE R13. SHARE OF ELECTRICITY GENERATION FROM RENEWABLES, EXISTING IN 2012 AND TARGETS

COUNTRY	SHARE (2012)[1]	TARGET
EU-27	23.8%	
Algeria	0.8%	→ 5% by 2017 → 40% by 2030
Antigua and Barbuda	0%	→ 5% by 2015 → 10% by 2020 → 15% by 2030
Argentina[2]		→ 8% by 2016
Australia	9.6%	→ 20% by 2020
Austria	75%	→ 70.6% by 2020
Azerbaijan		→ 20% by 2020
Bahamas, The	0%	→ 15% by 2020 → 30% by 2030
Bangladesh	3.8%	→ 5% by 2015 → 10% by 2020
Barbados		→ 29% by 2029
Belgium	14%	→ 20.9% by 2020
Belize		→ 50% (no date)
Bulgaria	12%	→ 20.6% by 2020
Cape Verde	21%	→ 50% by 2020
Chile[3]	38%	→ 20% by 2025
Cook Islands		→ 50% by 2015 → 100% by 2020
Costa Rica	92%	→ 100% by 2021
Croatia	48%	→ 39% by 2020
Cyprus	4.9%	→ 16% by 2020
Czech Republic	10%	→ 14.3% by 2020
Denmark[4]	48%	→ 50% by 2020 → 100% by 2050
Djibouti		→ 100% by 2020
Dominica	14%	→ 100% (no date)
Dominican Republic	14%	→ 25% by 2025
Egypt	9.2%	→ 20% by 2020
Eritrea		→ 50% (no date)
Estonia	12%	→ 18% by 2015
Fiji	67%	→ 100% by 2030
Finland	40%	→ 33% by 2020
France	16%	→ 27% by 2020
Gabon	40%	→ 70% by 2020
Germany	25% (2013)	→ 40–45% by 2025 → 55–60% by 2035 → 65% by 2040 → 80% by 2050
Ghana[2]	0%	→ 10% by 2020
Greece	16%	→ 40% by 2020
Guatemala	64%	→ 80% by 2027
Guyana		→ 90% (no date)
Honduras	44%	→ 60% by 2022 → 80% by 2038

COUNTRY	SHARE (2012)[1]	TARGET
Hungary	7.8%	→ 11% by 2020
Indonesia	12%	→ 26% by 2025
Iraq	8.6%	→ 2% by 2030
Ireland	20%	→ 42.5% by 2020
Israel	0.4%	→ 5% by 2014 → 10% by 2020
Italy	31%	→ 26% by 2020
Jamaica	4.7%	→ 15% by 2020
Kazakhstan	15%	→ 1% by 2014 → 3% by 2020
Kiribati		→ 10% (no date)
Kuwait		→ 15% by 2030
Latvia	64%	→ 60% by 2020
Lebanon		→ 12% by 2020
Liberia		→ 30% by 2021
Libya	0%	→ 20% by 2020
Lithuania	23%	→ 21% by 2020
Luxembourg	36%	→ 11.8% by 2020
Madagascar	0% non-hydro 49% total	→ 75% by 2020
Malaysia	5%	→ 5% by 2015 → 9% by 2020 → 11% by 2030 → 15% by 2050
Maldives		→ 16% by 2017
Mali[5]	57%	→ 10% by 2015 → 25% by 2033
Malta	0.8%	→ 3.8% by 2020
Marshall Islands		→ 20% by 2020
Mauritius		→ 35% by 2025
Mexico	15%	→ 35% by 2026
Mongolia		→ 20–25% by 2020
Netherlands	12%	→ 37% by 2020
New Zealand	72%	→ 90% by 2025
Nicaragua	43%	→ 74% by 2018 → 90% by 2020
Nigeria[6]	16.4%	→ 10% by 2020
Niue		→ 100% by 2020
Palestinian Territories	0.4%	→ 10% by 2020
Philippines	29%	→ 40% by 2020
Poland	11%	→ 19.3% by 2020
Portugal	48%	→ 45% by 2020
Qatar		→ 2% by 2020 → 20% by 2030
Romania	25%	→ 43% by 2020
Russia[7]	16%	→ 2.5% by 2015 → 4.5% by 2020

TABLE R13. SHARE OF ELECTRICITY GENERATION FROM RENEWABLES, EXISTING IN 2012 AND TARGETS (continued)

COUNTRY	SHARE (2012)[1]	TARGET
Senegal	10%	→ 15% by 2021
Seychelles		→ 5% by 2020 → 15% by 2030
Solomon Islands		→ 50% by 2015
Slovakia	20%	→ 24% by 2020
Slovenia	29%	→ 39.3% by 2020
South Africa	2.6%	→ 9% by 2030
Spain	7.9% non-hydro 30% total	→ 38.1% by 2020
Sri Lanka		→ 10% by 2016 → 20% by 2020
St. Kitts and Nevis		→ 20% by 2015
St. Lucia		→ 5% by 2013 → 15% by 2015 → 30% by 2020
St. Vincent and the Grenadines	17%	→ 30% by 2015 → 60% by 2020
Sudan		→ 10% by 2016
Sweden	58%	→ 62.9% by 2020
Thailand[8]	7.6%	→ 10% by 2021
Timor-Leste		→ 50% by 2020
Tokelau		→ 100% (no date)
Tonga		→ 50% by 2015
Tunisia	1.6%	→ 16% by 2016 → 40% by 2030
Turkey	3% non-hydro 27% total	→ 30% by 2023
Tuvalu		→ 100% by 2020
Uganda	79%	→ 61% by 2017
United Kingdom Scotland	12%	→ 50% by 2015 → 100% by 2020
Ukraine	8%	→ 20% by 2030
Uruguay	60%	→ 90% by 2015
Vanuatu		→ 23% by 2014 → 40% by 2015 → 65% by 2020
Vietnam		→ 5% by 2020
Yemen		→ 15% by 2025

[1] National share is for 2012 unless otherwise noted. – [2] National target(s) exclude(s) large hydropower. – [3] Chile's target excludes hydropower plants over 40 MW. – [4] Denmark set a target of 50% electricity consumption supplied by wind power by 2020 in March 2012. – [5] Mali's target excludes large hydropower. – [6] Nigeria's target excludes hydropower plants over 30 MW. – [7] Russia's targets exclude hydropower plants over 25 MW. – [8] Thailand does not classify hydropower installations larger than 6 MW as renewable energy sources, so large-scale hydro >6 MW is excluded from national shares and targets. [9] India does not classify hydropower installations larger than 25 MW as renewable energy sources, so large-scale hydro >25 MW is excluded from national shares and targets.

TABLE R13 ANNEX. COUNTRIES WITHOUT TARGETS FOR SHARES OF ELECTRICITY PRODUCTION

COUNTRY	SHARE (2012)[1]
Albania	100%
Belarus	0.5%
Bosnia and Herzegovina	30%
Brazil	85%
Canada	53%
Cambodia	2.4%
Cameroon	74%
China	21%
Colombia	81%
Côte d'Ivoire	23%
Cuba	3.7%
Ecuador	55%
El Salvador	62%
Ethiopia	93%
Grenada	1%
Honduras	40% (2011)
Iceland	100%
India[9]	14%
Iran	5%
Japan	13%
Jordan	0.4%
Kenya	73%
Lesotho	100%
Macedonia	17%
Mauritius	21%
Moldova	2% (2011)
Montenegro	52%
Morocco	8.9%

COUNTRY	SHARE (2012)[1]
Mozambique	90%
Norway	98%
Papua New Guinea	38%
Peru	55%
Senegal	10%
Serbia	27%
South Korea	3.7%
Sri Lanka	28%
St. Kitts and Nevis	0.4%
St. Vincent and the Grenadines	17%
Sudan	47%
Switzerland	60%
Taiwan	5.3%
Tanzania	4.9%
Togo	8.5%
Tunisia	1.2%
United States	13%
Uzbekistan	21%
Venezuela	64%
Zambia	96%

Note: Unless otherwise noted, all targets and corresponding shares represent all renewables including hydropower. Actual percentages are rounded to the nearest whole decimal for numbers over 10% except where associated targets are expressed differently. A number of state/provincial and local jurisdictions have additional targets not listed here. The United States and Canada have de facto state and provincial-level targets through existing RPS policies, but no national targets (see Tables R17 and R19). Some countries shown have other types of targets (see Tables R12, R14, and R15). See Policy Landscape section (Section 4) and Reference Table R19 for more information about sub-national targets. Existing shares are indicative and may need adjusting if more accurate national statistical data are published. Sources for reported data often do not specify the accounting method used, therefore shares of electricity are likely to include a mixture of different accounting methods and thus are not directly comparable or consistent across countries. Where shares sourced from Observ'ER differed from those provided to REN21 by country contributors, the latter were given preference.

Source: See Endnote 13 for this section.

TABLE R14. SHARE OF HEATING AND COOLING FROM MODERN RENEWABLE TECHNOLOGIES, EXISTING IN 2012 AND TARGETS

COUNTRY	SHARE	TARGET
Austria		Austria 32.6% renewables in total heating and cooling supply by 2020
Belgium		11.9% renewables in total heating and cooling supply by 2020
Bhutan		Solar heating and cooling: 3 MW equivalent by 2025
Bulgaria		23.8% renewables in total heating and cooling
Brazil	9.1% (2012)	
China		Solar water heating: 280 GW_{th} (400 million m^2) by 2015
Croatia		19.6% renewables in total heating and cooling
Cyprus		23.5% renewables in total heating and cooling
Czech Republic		14.1% renewables in total heating and cooling
Denmark		39.8% renewables in total heating and cooling supply by 2020
Estonia		17.6% renewables in total heating and cooling supply by 2020
Finland		47% renewables in total heating and cooling supply by 2020
France	16.5%	33% renewables in total heating and cooling supply by 2020
Germany	9.3%	14% renewables in total heating and cooling supply by 2020
Greece		20% renewables in total heating and cooling supply by 2020
Hungary		18.9% renewables in total heating and cooling supply by 2020
India		Solar water heating 5.6 GW_{th} (8 million m^2) of new capacity to be added between 2012 and 2017
Ireland		15% renewables in total heating and cooling supply by 2020
Italy		Heating and cooling: 17.1% renewables in total supply by 2020 Bioenergy: 5,670 ktoe for heating and cooling by 2020 Geothermal: 300 ktoe for heating and cooling by 2020 Solar water and space heating: 1,586 ktoe by 2020
Jordan		Solar water heating: 30% of households by 2020 (up from 13% in 2010)
Kenya		Solar water heating: 60% of annual demand for buildings using over 100 litres of hot water per day
Latvia		53.4% renewables in total heating and cooling supply by 2020
Lebanon		Solar water heating: 133 MW_{th} (190,000 m^2) newly installed capacity during 2009–2014
Libya		Solar water heating: 80 MW_{th} by 2015; 250 MW_{th} by 2020
Lithuania		39% renewables in total heating and cooling supply by 2020
Luxembourg		8.5% renewables in gross final consumption in heating and cooling in 2020
Malta		6.2% renewables in total heating and cooling supply by 2020
Morocco		Solar water heating: 280 MW_{th} (400,000 m^2) by 2012; 1.2 GW_{th} (1.7 million m^2) by 2020
Mozambique		Solar water and space heating: 100,000 systems installed in rural areas (no date)
Netherlands		8.7% renewables in total heating and cooling supply by 2020
Poland		17% renewables in total heating and cooling supply by 2020
Portugal	33%	30.6% renewables in total heat supply by 2020
Romania		22% renewables in total heating and cooling supply by 2020
Sierra Leone		1% penetration of solar water heaters in hotels, guest houses, and restaurants by 2015; 2% by 2020; and 5% by 2030 1% penetration of solar water heaters in the residential sector by 2030
Slovakia		14.6% renewables in total heating and cooling supply by 2020
Slovenia		30.8% renewables in total heating and cooling supply by 2020
Spain	7.6% (2012)	18.9% renewables in total heating and cooling supply by 2020 Bioenergy: 4,653 ktoe by 2020 Geothermal: 9.5 ktoe by 2020 Heat pumps: 50.8 ktoe by 2020 Solar water and space heating: 644 ktoe by 2020
Swaziland		Solar water heating: Installed in 20% of all public buildings by 2014
Sweden		62.1% renewables in total heating and cooling supply by 2020
Thailand		Bioenergy: 8,200 ktoe by 2022 Biogas: 1,000 ktoe by 2022 Organic MSW: 35 ktoe by 2022 Solar water heating: 300,000 systems in operation and 100 ktoe by 2022
Uganda		Solar water heaters: 4.2 MW_{th} (6,000 m^2) by 2012; 21 MW_{th} (30,000 m^2) by 2017
United Kingdom		12% renewables in total heating and cooling supply by 2020

Note: Because heating and cooling targets are not standardised across countries, the table presents a variety of targets for the purpose of general comparison.
Source: See Endnote 14 for this section.

TABLE R15. OTHER RENEWABLE ENERGY TARGETS

COUNTRY	SECTOR / TECHNOLOGY SHARE	TARGET
EU-28	Transport	All EU-28 countries are required to meet 10% of transport final energy demand by 2020
Algeria	Solar PV	25 MW by 2013; 241 MW by 2015; 946 MW by 2020; 2.8 GW by 2030
	CSP	25 MW by 2013; 325 MW by 2015; 1,500 MW by 2020; 7,200 MW by 2030
	Wind	10 MW by 2013; 50 MW by 2015; 270 MW by 2020; 2,000 MW by 2030
Argentina	Electricity	3 GW by 2016
	Geothermal power	30 MW by 2016
Australia *State of South Australia*	Electricity	33% of generation by 2020
State of Tasmania	Electricity	100% of generation by 2020
Austria	Bio-power from solid biomass and biogas	200 MW added 2010–2020
	Hydropower	1,000 MW added 2010–2020
	Solar PV	1,200 MW added 2010–2020
	Wind	2,000 MW added 2010–2020
	Transport	11.4% of transport final energy demand by 2020
Bangladesh	Bio-power from solid biomass	2 MW by 2014
	Bio-power from biogas	4 MW by 2014
	Biogas digesters	150,000 plants by 2016
	Solar PV	500 MW by 2015
	Solar PV (off-grid and rural)	2.5 million units by 2015
Belgium	Transport	10.14% of transport final energy demand by 2020
State of Wallonia	Final energy	20% share from renewables by 2020
	Electricity	8 TWh / year by 2020
Benin	Electricity (off-grid and rural)	50% of rural electricity by 2025
Bhutan	Electricity	20 MW by 2025
	Bio-power from solid biomass	5 MW by 2025
	Solar PV	5 MW by 2025
	Wind	5 MW by 2025
Brazil	Bio-power	19.3 GW by 2021
	Hydropower (small-scale)	7.8 GW by 2021
	Wind	15.6 GW by 2021
Bulgaria	Hydropower	80 MW capacity commissioned by 2011; three 174 MW plants by 2017–18
	Solar PV	80 MW solar PV park operational by 2014
	Transport	7.8% of transport final energy demand by 2020
Canada *Province of New Brunswick*	Electricity	Increase renewable share 10% by 2016 ; 40% of generation by 2020
Province of Nova Scotia	Electricity	25% of generation by 2015; 40% by 2020
Prince Edward Island	Wind	30 MW increase by 2030 (base year 2011)
Province of Ontario	Electricity	10.7 GW by 2022
	Hydropower	1.5 GW by 2025
	Solar PV	40 MW by 2025
	Wind	5 GW by 2025

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY SHARE	TARGET
China	Bio-power	13 GW by 2015
	Hydropower	290 GW by 2015
	Solar PV	10 GW added in 2014; 35 GW by 2015 (including 20 GW distributed generation)
	CSP	1 GW by 2015; 3 GW by 2020
	Wind	100 GW grid-connected by 2015; 200 GW by 2020
Colombia	Electricity (grid-connected)	3.5% of generation by 2015; 6.5% by 2020
	Electricity (off-grid)	20% of generation by 2015; 30% by 2020
Croatia	Transport	10% of transport final energy demand by 2020
Cyprus	Transport	4.9% of transport final energy demand by 2020
Czech Republic	Transport	10.8% of transport final energy demand by 2020
Denmark	Wind	50% share in electricity by 2020
	Transport	10% of transport final energy demand by 2020
Djibouti	Solar PV	30% of rural electrification by 2017
Egypt	Solar PV	700 MW by 2017
	CSP	2.8 GW by 2017
	Wind	12% of electricity generation and 7,200 MW by 2020
Eritrea	Wind	50% of electricity generation (no date)
Estonia	Transport	2.7% of transport final energy demand by 2020
Ethiopia	Bio-power from bagasse	103.5 MW (no date)
	Geothermal power	75 MW by 2015; 450 MW by 2018; 1 GW by 2030
	Hydropower	10.6 GW (>90% large-scale) by 2015; 22 GW by 2030
	Wind	770 MW by 2014
Finland	Bio-power	13.2 GW by 2020
	Hydropower	14.6 GW by 2020
	Wind	884 MW by 2020
	Transport	20% of transport final energy demand by 2020
France	Ocean power and offshore wind	6 GW by 2020
	Wind	25 GW by 2020
	Transport	10.5% of transport final energy demand by 2020
Germany	Wind	6.5 GW offshore by 2020; 15 GW offshore by 2030
	Transport	20% of transport final energy demand by 2020
Greece	Solar PV	2.2 GW by 2030
	Transport	10.1% of transport final energy demand by 2020
Guinea	Solar power	6% of electricity by 2025
	Wind	2% of electricity by 2025
Guinea-Bissau	Solar PV	2% of primary energy by 2015
Hungary	Transport	10% of transport final energy demand by 2020
India[1]	Electricity	4.3 GW added in 2014
	Electricity	30 GW added 2012–2017
	Bio-power	2.7 GW added 2012–2017
	Hydropower (small-scale)	2.1 GW added 2012–2017
	Solar PV and CSP	10 GW added 2012–2017; 20 GW grid-connected added 2010–2022; 2 GW off-grid added 2010–2020; 20 million solar lighting systems added 2010–2022
	Wind	15 GW added 2012–2017

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY SHARE	TARGET
Indonesia	Hydropower, solar PV, wind	1.4% share in primary energy (combined) by 2025
	Biofuels	10.2% share of primary energy by 2025
	Geothermal power	12.6 GW electricity by 2025
	Hydropower	2 GW by 2025, including 0.43 GW micro-hydropower
	Pumped storage[2]	3 GW by 2025
	Solar PV	156.8 MW by 2025
	Wind	0.1 GW by 2025
Iraq	Solar PV	240 MW by 2016
	CSP	80 MW by 2016
	Wind	80 MW by 2016
Ireland	Transport	10% of transport final energy demand by 2020
Italy	Bio-power	19,780 GWh / year generation from 3.8 GW capacity by 2020
	Geothermal power	6,750 GWh / year generation from 920 MW capacity by 2020
	Hydropower	42,000 GWh / year generation from 17.8 GW capacity by 2020
	Solar PV	23 GW by 2017
	Wind (onshore)	18,000 GWh / year generation and 12 GW capacity by 2020
	Wind (offshore)	2,000 GWh / year generation and 680 MW capacity by 2020
	Transport	10.1% transport final energy demand (2,899 ktoe) from biofuels by 2020
Japan	Bio-power	3.3 GW by 2020; 6 GW by 2030
	Geothermal power	0.53 GW by 2020; 3.88 GW by 2030
	Hydropower	49 GW by 2020
	Ocean power (wave and tidal)	1.5 GW by 2030
	Solar PV	28 GW by 2020
	Wind	5 GW by 2020; 8.03 GW offshore by 2030
Jordan	Electricity	1 GW capacity by 2018
	Solar PV	300 MW by 2020
	CSP	300 MW by 2020
	Wind	1 GW by 2020
Kazakhstan	Electricity	1.04 GW by 2020
Kenya	Geothermal power	1,887 MW by 2016; 5,000 MW by 2030
	Hydropower	794 MW by 2016
	Solar PV	423 MW by 2016
	Wind	635 MW by 2016
Kuwait	Solar PV	3.5 GW by 2030
	CSP	1.1 GW by 2030
	Wind	3.1 GW by 2030
Latvia	Transport	10% of transport final energy demand by 2020
Lebanon	Bio-power from biogas	15–25 MW by 2015
	Hydropower	40 MW by 2015
	Wind	60–100 MW by 2015
Lesotho	Electricity	260 MW by 2030
	Electricity (off-grid and rural)	35% of rural electrification by 2020
Liberia	Biofuels	5% of total transport fuel by 2015
Libya	Solar PV	129 MW by 2015
	CSP	125 MW by 2020; 375 MW by 2025
	Wind	260 MW by 2015; 600 MW by 2020; 1,000 MW by 2025
Lithuania	Transport	10% of transport final energy demand by 2020

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY SHARE	TARGET
Luxembourg	Transport	10% of transport final energy demand by 2020
Malawi	Hydropower	346.5 MW by 2014
Malaysia	Electricity	2.1 GW (excluding large-scale hydropower), 11.2 TWh / year, or 10% of national supply (no date given); 6% of total capacity by 2015; 11% by 2020; 14% by 2030; 36% by 2050
Malta	Transport	10.7% of transport final energy demand by 2020
Micronesia	Electricity	10% in urban centers and 50% in rural areas by 2020
Morocco	Electricity	42% of total capacity
	Hydropower	2 GW by 2020
	Solar PV and CSP	2 GW by 2020
	Wind	2 GW by 2020
Mozambique	Bio-digesters for biogas	1,000 systems installed (no date)
	Hydropower, solar PV, wind	2 GW each (no date)
	Solar PV	82,000 solar home systems installed (no date)
	Wind turbines for water pumping	3,000 stations installed (no date)
	Renewable-energy based productive systems	5,000 installed (no date)
Nepal	Hydropower (micro)	15 MW by 2013
	Solar PV	3 MW by 2013
	Wind	1 MW by 2013
Netherlands	Transport	5% of transport final energy demand by 2013; 10% by 2020
Nigeria	Bio-power	50 MW 2015; 400 MW by 2025
	Hydropower (small-scale)	600 MW by 2015; 2,000 MW by 2025
	Solar PV (large-scale, >1 MW)	75 MW by 2015; 500 MW by 2025
	Wind	20 MW by 2015; 40 MW by 2025
	CSP	1 MW by 2015; 5 MW by 2025
Norway	Electricity	30 TWh / year generation by 2016
	Electricity	26.4 TWh common electricity certificate market with Sweden by 2020
Palestinian Territories	Bio-power	21 MW by 2020
	Solar PV	45 MW by 2020
	CSP	20 MW by 2020
	Wind	44 MW by 2020
Philippines	Electricity	Triple the 2010 renewable power capacity by 2030
	Bio-power	277 MW added 2010–2030
	Geothermal power	1.5 GW added 2010–2030
	Hydropower	5,398 MW added 2010–2030
	Ocean power	75 MW added 2010–2030
	Solar PV	284 MW added 2010–2030
	Wind	2.3 GW added 2010–2030
Poland	Wind (offshore)	1 GW by 2020
	Transport	10% of transport final energy demand by 2020
Portugal	Electricity	15.8 GW by 2020
	Bio-power from solid biomass	769 MW by 2020
	Bio-power from biogas	59 MW by 2020
	Geothermal power	29 MW by 2020
	Hydropower (small-scale)	400 MW by 2020

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY SHARE	TARGET
Portugal (continued)	Ocean power (wave)	6 MW by 2020
	Solar PV	670 MW by 2020
	CSP	50 MW by 2020
	Wind	5.3 GW onshore by 2020; 27 MW offshore by 2020
	Transport	10% of transport final energy demand by 2020
Qatar	Solar PV	1.8 GW by 2014
	Transport	10% of transport final energy demand by 2020
Romania	Transport	10% of transport final energy demand by 2020
Russia	Hydropower (small-scale), solar PV, wind	6 GW combined by 2020
Rwanda	Biogas power	300 MW by 2017
	Geothermal power	310 MW by 2017
	Hydropower	340 MW by 2017
	Hydropower (small-scale)	42 MW by 2015
	Electricity (off-grid)	5 MW by 2017
Samoa	Final Energy	Increase by 20% the current share of total energy supply by 2030
Saudi Arabia	Electricity	24 GW by 2020; 54 GW by 2032
	Solar PV and CSP	6 GW solar PV by 2020; 16 GW by 2032; 41 GW by 2032 (25 GW CSP and 16 GW PV)
	Geothermal, waste-to-energy[3], wind	13 GW combined by 2032
Serbia	Solar PV	150 MW by 2017
	Wind	1.4 GW (no date)
Slovakia	Transport	10% of transport final energy demand by 2020
Slovenia	Transport	10.5% of transport final energy demand by 2020
South Africa	Electricity	17.8 GW by 2030
South Korea	Electricity	(all generation targets are annual) 13,016 GWh (2.9% total generation) by 2015; 21,977 GWh (4.7%) by 2020; 39,517 GWh (7.7%) by 2030
	Bio-power from solid biomass	2,628 GWh by 2030
	Bio-power from biogas	161 GWh by 2030
	Bio-power from landfill gas	1,340 GWh by 2030
	Geothermal power	2,046 GWh by 2030
	Hydropower (large-scale)	3,860 GWh by 2030
	Hydropower (small-scale)	1,926 GWh by 2030
	Ocean power	6,159 GWh by 2030
	Solar PV	2,046 GWh by 2030
	CSP	1,971 GWh by 2030
	Wind	100 MW by 2013; 900 MW by 2016; 1.5 GW by 2019; 16,619 GWh / year by 2030
Spain	*Final energy*	
	Bioenergy from solid biomass, biogas, and organic MSW	0.1% by 2020
	Geothermal energy, ocean power, and heat pumps	5.8% by 2020
	Hydropower	2.9% by 2020

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY SHARE	TARGET
Spain (continued)	Solar PV	3% by 2020
	Wind	6.3% by 2020
	Electricity	
	Bio-power from solid biomass	1.4 GW by 2020
	Bio-power from organic MSW	200 MW by 2020
	Bio-power from biogas	400 MW by 2020
	Geothermal power	50 MW by 2020
	Hydropower	13.9 GW by 2020
	Pumped storage[2]	8.8 GW by 2020
	Ocean power	100 MW by 2020
	Solar PV	7.30 GW by 2020
	CSP	4.8 GW by 2020
	Wind (onshore)	35 GW by 2020
	Wind (offshore)	750 MW by 2020
	Transport	
	Biodiesel	11.3% of transport final energy demand by 2020
	Ethanol/bio-ETBE	7% of transport final energy by 2012 and 2013; 2,313 ktoe by 2020
	Electricity in transport	4.7 GWh / year by 2020 (501 ktoe from renewable sources by 2020)
Sri Lanka	Electricity	10% of generation by 2015
	Transport	20% of transport final energy demand from biofuels by 2020
Sudan	Bio-power from solid biomass	80 MW by 2031
	Bio-power from biogas	150 MW by 2031
	Hydropower	54 MW by 2031
	Solar PV	350 MW by 2031
	CSP	50 MW by 2031
	Wind	320 MW by 2031
Sweden	Electricity	25 TWh more renewable electricity annually by 2020 (base year 2002)
	Electricity	26.4 TWh common electricity certificate market with Norway by 2020
	Transport	Vehicle fleet that is independent from fossil fuels by 2030
Switzerland	Electricity	12 TWh / year by 2035; 24.2 TWh by 2050
	Hydropower	43 TWh / year by 2035
Syria	Bio-power	140 MW by 2020; 260 MW by 2025; 400 MW by 2030
	Solar PV	45 MW by 2015; 380 MW by 2020; 1.1 GW by 2025; 1.8 GW by 2030
	CSP	50 MW by 2025
	Wind	150 MW by 2015; 1 GW by 2020; 1.5 GW by 2025; 2 GW by 2030
Taiwan	Solar PV	130 MW in 2013
Tajikistan	Hydropower (small-scale)	100 MW by 2020
Thailand	*Transport*	
	Ethanol	9 million litres / day by 2022
	Biodiesel	6 million litres / day by 2022
	Advanced biofuels	25 million litres / day by 2022
	Electricity	
	Bio-power from solid biomass	4.8 GW by 2021
	Bio-power from biogas	600 MW by 2021
	Bio-power from organic MSW	400 MW by 2021

TABLE R15. OTHER RENEWABLE ENERGY TARGETS (continued)

COUNTRY	SECTOR / TECHNOLOGY SHARE	TARGET
Thailand (continued)	Geothermal power	1 MW by 2021
	Hydropower	6.1 GW by 2021
	Ocean power (wave and tidal)	2 MW by 2021
	Solar PV	3 GW by 2021; 1 GW added in 2014
	Wind	1.8 GW by 2021
Trinidad and Tobago	Electricity	5% of peak demand (or 60 MW) by 2020
Tunisia	Electricity	1 GW (16%) by 2016; 4.6 GW (40%) by 2030
	Bio-power from solid biomass	300 MW by 2030
	Solar PV	1.9 GW by 2030
	CSP	300 MW by 2030
	Wind	1.5 GW by 2030
Turkey	Wind	20 GW by 2023
Uganda	Bio-power from organic MSW[3]	15 MW by 2012; 30 MW by 2017
	Geothermal power	25 MW by 2012; 45 MW by 2017
	Hydropower (large-scale)	830 MW by 2012; 1,200 MW by 2017
	Hydropower (mini- and micro-scale)	50 MW by 2012; 85 MW by 2017
	Solar PV (solar home systems)	400 kW by 2012; 700 kW by 2017
	Biofuels	720 million litres / year by 2012; 2,200 million litres / year by 2017
United Arab Emirates		
Abu Dhabi	Electricity	7% of capacity by 2020
Dubai	Electricity	5% of capacity and 1 GW by 2030
United Kingdom	Wind	39 GW offshore by 2030
	Transport	5% of transport final energy demand by 2014; 10.3% by 2020
Uruguay	Bio-power	200 MW by 2015
	Wind	1 GW by 2015
Vietnam	Bio-power	50 MW by 2020
	Hydropower	19.2 GW by 2020
	Wind	1 GW by 2020
	Biofuels	1% of transport petroleum energy demand by 2015; 5% by 2025
Yemen	Bio-power	6 MW by 2025
	Geothermal power	200 MW by 2025
	Solar PV	4 MW by 2025
	CSP	100 MW by 2025
	Wind	400 MW by 2025
Zimbabwe	Transport	10% of transport final energy demand by 2015

[1] India does not classify hydropower installations larger than 25 MW as renewable energy sources. Therefore, national targets and data for India do not include hydropower facilities >25 MW.

[2] Pumped hydro plants are not energy sources but a means of energy storage. As such, they involve conversion losses and are powered by renewable or non-renewable electricity. Pumped storage is included here because it can play an important role as balancing power, in particular for variable renewable resources.

[3] It is not always possible to determine whether municipal solid waste (MSW) data include non-organic waste (plastics, metal, etc.) or only the organic biomass share. Uganda utilises predominantly organic waste.

Note: All capacity targets are for cumulative capacity unless otherwise noted. Targets are rounded to the nearest tenth decimal. Renewable energy targets are not standardised across countries; therefore, the table presents a variety of targets for the purpose of general comparison. Countries on this list may also have primary/final energy, electricity, or heating/cooling targets (see Tables R12, R13, and R14). Table R15 lists transport energy targets; biofuel blend mandates can be found in Table R18: National and State/Provincial Biofuel Blend Mandates. It is not always possible to determine whether transportation targets are limited to road transportation. Additionally, targets may cover only the use of biofuels or a wider array of renewable transport options (i.e., renewable electricity with electric vehicles, hydrogen).

Source: See Endnote 15 for this section.

TABLE R16. CUMULATIVE[1] NUMBER OF COUNTRIES / STATES / PROVINCES ENACTING FEED-IN POLICIES

YEAR	CUMULATIVE #	COUNTRIES / STATES / PROVINCES ADDED THAT YEAR
1978	1	United States[2]
1990	2	Germany
1991	3	Switzerland
1992	4	Italy
1993	6	Denmark; India
1994	9	Luxembourg; Spain; Greece
1997	10	Sri Lanka
1998	11	Sweden
1999	14	Portugal; Norway; Slovenia
2000	14	
2001	17	Armenia; France; Latvia
2002	23	Algeria; Austria; Brazil; Czech Republic; Indonesia; Lithuania
2003	29	Cyprus; Estonia; Hungary; South Korea; Slovak Republic; Maharashtra (India)
2004	34	Israel; Nicaragua; Prince Edward Island (Canada); Andhra Pradesh and Madhya Pradesh (India)
2005	41	Karnataka, Uttaranchal, and Uttar Pradesh (India); China; Turkey; Ecuador; Ireland
2006	46	Ontario (Canada); Kerala (India); Argentina; Pakistan; Thailand
2007	56	South Australia (Australia); Albania; Bulgaria; Croatia; Dominican Republic; Finland; Macedonia; Moldova; Mongolia
2008	70	Queensland (Australia); California (USA); Chhattisgarh, Gujarat, Haryana, Punjab, Rajasthan, Tamil Nadu, and West Bengal (India); Iran; Kenya; Philippines; Tanzania; Ukraine
2009	80	Australian Capital Territory, New South Wales, and Victoria (Australia); Hawaii, Oregon, and Vermont (USA); Japan; Serbia; South Africa; Taiwan
2010	85	Bosnia and Herzegovina; Malaysia; Mauritius; Malta; United Kingdom
2011	92	Rhode Island (USA); Nova Scotia (Canada); Ghana; Montenegro; Netherlands; Syria; Vietnam
2012	97	Jordan; Nigeria; Palestinian Territories; Rwanda; Uganda
2013	98	Kazakhstan
	98	**Total existing[3]**

[1] "Cumulative number" refers to number of jurisdictions that had enacted feed-in policies as of the given year.

[2] The U.S. PURPA policy (1978) is an early version of the feed-in tariff, which has since evolved.

[3] "Total existing" excludes seven countries that are known to have subsequently discontinued policies (Brazil, Czech Republic, Mauritius, Spain, South Africa, South Korea, and the United States) and adds seven countries that are believed to have feed-in tariffs but with an unknown year of enactment (Honduras, Maldives, Peru, Panama, Senegal, Tajikistan, and Uruguay).

Source: See Endnote 16 for this section.

TABLE R17. CUMULATIVE[1] NUMBER OF COUNTRIES / STATES / PROVINCES ENACTING RPS/QUOTA POLICIES

YEAR	CUMULATIVE #	COUNTRIES / STATES / PROVINCES ADDED THAT YEAR
1983	1	Iowa (USA)
1994	2	Minnesota (USA)
1996	3	Arizona (USA)
1997	6	Maine, Massachusetts, and Nevada (USA)
1998	9	Connecticut, Pennsylvania, and Wisconsin (USA)
1999	12	New Jersey and Texas (USA); Italy
2000	13	New Mexico (USA)
2001	15	Flanders (Belgium); Australia
2002	18	California (USA); Wallonia (Belgium); United Kingdom
2003	21	Japan; Sweden; Maharashtra (India)
2004	34	Colorado, Hawaii, Maryland, New York, and Rhode Island (USA); Nova Scotia, Ontario, and Prince Edward Island (Canada); Andhra Pradesh, Karnataka, Madhya Pradesh, and Orissa (India); Poland
2005	38	District of Columbia, Delaware, and Montana (USA); Gujarat (India)
2006	39	Washington State (USA)
2007	45	China; Illinois, New Hampshire, North Carolina, and Oregon (USA); Northern Mariana Islands (USA)
2008	52	Michigan, Missouri, and Ohio (USA); Chile; India; Philippines; Romania
2009	53	Kansas (USA)
2010	56	British Columbia (Canada); South Korea; Puerto Rico (USA)
2011	58	Albania; Israel
2012	59	Norway
2013	59	[None identified]
	79	**Total existing[2]**

[1] "Cumulative number" refers to number of jurisdictions that had enacted RPS/Quota policies as of the given year. Jurisdictions are listed under year of first policy enactment. Many policies shown have been revised or renewed in subsequent years, and some policies shown may have been repealed or lapsed.

[2] "Total existing" adds 20 jurisdictions believed to have RPS/Quota policies but whose year of enactment is not known (Ghana, Indonesia, Kyrgyzstan, Lithuania, Malaysia, Palau, Portugal, Senegal, South Africa, Sri Lanka, United Arab Emirates, and the Indian states of Chhattisgarh, Haryana, Kerala, Punjab, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh, and West Bengal). In the United States, there are 10 additional states and territories with policy goals that are not legally binding RPS policies (Guam, Indiana, North Dakota, Oklahoma, South Dakota, U.S. Virgin Islands, Utah, Vermont, Virginia, and West Virginia). Three additional Canadian provinces also have non-binding policy goals (Alberta, Manitoba, and Quebec). The Italian RPS is being phased out according to new directives from the government, but it was still in place as of early 2013.

Source: See Endnote 17 for this section.

TABLE R18. NATIONAL AND STATE / PROVINCIAL BIOFUEL BLEND MANDATES

COUNTRY	MANDATE
Angola	E10
Argentina	E5 and B10
Australia	E4 and B2 in New South Wales; E5 in Queensland
Belgium	E4 and B4
Brazil	E20 and B5
Canada	*National:* E5 and B2 *Provincial:* E5 and B4 in British Columbia; E5 and B2 in Alberta; E7.5 and B2 in Saskatchewan; E8.5 and B2 in Manitoba; E5 in Ontario
China	E10 in nine provinces
Colombia	E8
Costa Rica	E7 and B20
Ecuador	B5
Ethiopia	E5
Guatemala	E5
India	E10
Indonesia	B2.5 and E3
Jamaica	E10
Malawi	E10
Malaysia	B5
Mozambique	E10 in 2012–2015; E15 in 2016–2020; E20 from 2021
Panama	E5; E7 by April 2015; E10 by April 2016
Paraguay	E24 and B1
Peru	B2 and E7.8
Philippines	E10 and B5
South Africa	E2 and E5 as of October 2015
South Korea	B2.5
Sudan	E5
Thailand	E5 and B5
Turkey	E2
Ukraine	E5; E7 by 2017
United States	*National:* The Renewable Fuels Standard 2 (RFS2) requires 136 billion litres (36 billion gallons) of renewable fuel to be blended annually with transport fuel by 2022. The RFS for 2013 was reduced to 49.21 billion litres (13 billion gallons). *State:* E10 in Missouri and Montana; E10 in Hawaii; E2 and B2 in Louisiana; B4 by 2012, and B5 by 2013 (all by July 1 of the given year) in Massachusetts; E10 and B5, B10 by 2013, and E20 by 2015 in Minnesota; B5 after 1 July 2012 in New Mexico; E10 and B5 in Oregon; B2 one year after in-state production of biodiesel reaches 40 million gallons, B5 one year after 100 million gallons, B10 one year after 200 million gallons, and B20 one year after 400 million gallons in Pennsylvania; E2 and B2, increasing to B5 180 days after in-state feedstock and oil-seed crushing capacity can meet 3% requirement in Washington.
Uruguay	B5; E5 by 2015
Vietnam	E5
Zambia	E15 and B5; E20 in 2014
Zimbabwe	E5, to be raised to E10 and E15

Note: The Philippines' B2 mandate is set to be raised to B5 following approval from the National Biofuels Board. Mexico has a pilot E2 mandate in the city of Guadalajara. The Dominican Republic has targets of B2 and E15 for 2015 but has no current blending mandate. Chile has targets of E5 and B5 but has no current blending mandate. Fiji approved voluntary B5 and E10 blending in 2011 with a mandate expected. The Kenyan city of Kisumu has an E10 mandate. Nigeria has a target of E10 but has no current blending mandate.

Table R18 lists only biofuel blend mandates; additional transport and biofuel targets can be found in Table R15: Other Renewable Energy Targets.

Source: See Endnote 18 for this section.

TABLE R19. CITY AND LOCAL RENEWABLE ENERGY POLICIES: SELECTED EXAMPLES

TARGETS FOR RENEWABLE SHARE OF ENERGY[1], ALL CONSUMERS	
Boulder, Colorado, USA	30% of total energy by 2020
Calgary, Alberta, Canada	30% of total energy by 2036
Cape Town, South Africa	10% of total energy by 2020
Fukushima Prefecture, Japan	100% of total energy by 2040
Hamburg, Germany	20% of total energy by 2020; 100% by 2050
Howrah, India[2]	10% of total energy by 2018
Nagano Prefecture, Japan	70% of total energy by 2050
Paris, France	25% of total energy by 2020
Skellefteå, Sweden	Net exporter of biomass, hydro, or wind energy by 2020
Växjö, Sweden	100% of total energy by 2030

TARGETS FOR RENEWABLE SHARE OF ELECTRICITY, ALL CONSUMERS	
Adelaide, Australia	15% by 2014
Amsterdam, Netherlands	25% by 2025; 50% by 2040
Aspen, Colorado, USA	100% by 2015
Austin, Texas, USA	35% by 2020
Cape Town, South Africa	15% by 2020
Lancaster, California, USA	100% by 2020
Malmö, Sweden	100% by 2020
Munich, Germany	100% by 2025
Nagano Prefecture, Japan	10% by 2020 ; 20% by 2030; 30% by 2050
San Francisco, California, USA	100% by 2020
San Jose, California, USA	100% by 2022
Skellefteå, Sweden	100% by 2020
Taipei City, Taiwan	12% by 2020
Ulm, Germany	100% by 2025
Wellington, New Zealand	78–90% by 2020

TARGETS FOR RENEWABLE ELECTRIC CAPACITY OR GENERATION	
Adelaide, Australia	2 MW of solar PV on residential and commercial buildings by 2020
Eskilstuna, Sweden	48 GWh of wind, 9.5 GWh of solar by 2020
Los Angeles, California, USA	1.3 GW of solar PV by 2020
San Francisco, California, USA	100% of peak demand (950 MW) by 2020

TARGETS FOR GOVERNMENT OWN-USE PURCHASES OF RENEWABLE ENERGY	
Cockburn, Australia	20% of own-use energy in city buildings by 2020
Ghent, Belgium	50% of own-use energy by 2020
Hepburn Shire, Australia	100% of own-use energy in public buildings; 8% of electricity for public lighting
Kristianstad, Sweden	100% of own-use energy by 2020
Malmö, Sweden	100% of own-use energy by 2030
Portland, Oregon, USA	100% of own-use electricity by 2030
Sydney, Australia	100% of own-use electricity in buildings; 20% for street lamps

[1] Targets for Hamburg, and Växjö include transport energy; targets for Fukushima Prefecture, Howrah, and Nagano Prefecture do not include transport energy, while other targets do not specify.

[2] Howrah's target includes 5% reduction of projected energy consumption by energy efficiency measures.

TABLE R19. CITY AND LOCAL RENEWABLE ENERGY POLICIES: SELECTED EXAMPLES (continued)

HEAT-RELATED MANDATES	
Amsterdam, Netherlands	District heating for at least 200,000 houses by 2040 (using biogas, woody biomass, and waste heat)
Chandigarh, India	Mandatory use of solar water heating (SWH) in industries, hotels, hospitals, prisons, canteens, housing complexes, and government and residential buildings as of 2013
Loures, Portugal	Solar thermal systems mandated as of 2013 in all sports facilities and schools that have good sun exposure
Munich, Germany	80% reduction of heat demand by 2058 (base 2009) through passive solar design (includes heat, process heat, and water heating)
Nantes, France	Extend the district heating system to source heat from biomass boilers for half of city inhabitants by 2017

FOSSIL FUEL REDUCTION TARGETS, ALL CONSUMERS	
Göteborg, Sweden	100% of total energy fossil fuel-free by 2050
Madrid, Spain	20% reduction in fossil fuel use by 2020 (base 2004)
Seoul, South Korea	30% reduction in fossil fuel and nuclear energy use by 2030 (base 1990)
Växjö, Sweden	100% of total energy fossil fuel-free by 2030
Vijayawada, India	10% reduction in fossil fuel use by 2018 (base 2008)

CO_2 EMISSIONS REDUCTION TARGETS, ALL CONSUMERS	
Aarhus, Denmark	Carbon-neutral by 2030
Bottrop, Germany	50% reduction by 2020 (base 2010)
Chicago, Illinois, USA	80% reduction by 2050 (base 1990)
Copenhagen, Denmark	20% reduction by 2015 (base 2005); carbon-neutral by 2025
Dallas, Texas, USA	Carbon-neutral by 2030
Hamburg, Germany	40% reduction by 2020, 80% by 2050 (base 1990)
Malmö, Sweden	Zero net emissions by 2020
New York, New York, USA	30% reduction by 2030 (base 2005)
Oslo, Norway	50% reduction by 2030 (base 1991); carbon-neutral by 2050
Seattle, Washington, USA	Carbon-neutral by 2050
Stockholm, Sweden	Reduce emissions to 3 tons of $CO_{2\text{-eq}}$ per capita by 2015 (baseline 5.5 tons per capita in 1990)
Tokyo, Japan	25% reduction by 2020 (base 2000)
Toronto, Ontario, Canada	30% reduction by 2020; 80% by 2050 (base 1990)

TABLE R19. CITY AND LOCAL RENEWABLE ENERGY POLICIES: SELECTED EXAMPLES (continued)

URBAN PLANNING	
Glasgow, Scotland, U.K.	”Sustainable Glasglow” aims for a 30% reduction in CO_2 by 2020 (baseline 2006) and breaks down emission reduction targets as follows: CHP/ district heating 9%; biomass 2%; biogas and waste 6%; other renewable energy 3%; transport 3%; fuel switching 3%; and energy management systems 6%. The plan requires all new buildings to source their heating from the district heating system or propose a lower-carbon alternative; 76 GWh of annual wind generation; and fiscal incentives for low-carbon transport such as biogas-powered vehicles or EVs.
Hong Kong, China	Hong Kong's strategy to become China's "greenest region" includes limiting the contribution of coal to <10% of the electricity generation mix by 2020; phasing out existing coal plants by 2020–30; investing in construction/operation of district cooling infrastructure using seawater; meeting the power demand of 100,000 households using biogas from landfills and sewage water treatment by 2020; installing SWH on all government buildings and swimming pools; installing wind turbines to meet 1–2% of total electricity demand by 2020; achieving E10 and B10 by 2020; and raising awareness by demonstrating solar PV arrays on government buildings, developing a website to provide information on renewable energy technologies suitable for local use, and providing news/ events, educational resources, and information on suppliers of renewable energy equipment.
Malmö, Sweden	“Climate Neutral by 2020” outlines a plan to transform the energy mix to mainly solar, wind, hydro, and biogas. The city also targets a 20% decrease in per capita energy consumption by 2020 (baseline: average annual use during 2001–05). Key strategies include expansion of district heating and cooling; development of 100% renewable energy districts; replacement of older vehicles with a 100% “green fleet”; and deployment of EV infrastructure.
Seoul, South Korea	By 2030, the city targets 20% of total energy from renewables; 20% reduction in energy consumption; 40% reduction in greenhouse gas emissions (base 1990); and 1 million new green jobs by promoting 10 major green technologies suitable for the city, including solar PV, waste-heat recovery, and green buildings. To foster a domestic market, Seoul is providing seed funding, capital loans, and trust guarantees to small and medium-sized businesses; a USD 100 million investment (USD 20,000 per technology/year) in R&D by 2030; and support for overseas marketing.
Sydney, Australia	The “Decentralised Energy Master Plan 2030” outlines how the city can reduce greenhouse gas emissions and take a holistic approach to planning. The vision targets a 70% reduction in emissions (base 2006) and a 100% renewable share of electricity, heating, and cooling by 2030. The planned technology mix is 30% solar and wind power plus 70% tri-generation of power and thermal energy from waste recovery. Tri-generation using 360 MW electricity biogas plants will power 15 “low-carbon zones” by 2030; a decentralised generation and distribution network will be developed to deliver power/heat/cooling using natural gas and biogas; and 11 “energy-plus” buildings will be constructed in central park.
Vancouver, British Columbia, Canada	“Greenest City 2020,” an action plan to achieve goals of zero carbon, zero waste, and healthy ecosystems by 2020, consists of 10 smaller plans, each with a long-term goal and 2020 targets. These include a requirement for all new buildings to be carbon-neutral from 2020 onwards; financial incentives for the installation of SWH; EV charging stations in buildings; a district energy strategy; and a target to double the number of green jobs by 2020 (base 2010).
Yokohama, Japan	The ”Yokohama Energy Vision” targets greenhouse gas emissions reductions of more than 30% per person by 2020, and more than 80% by 2050 (base 1990), through green buildings and the use of: EVs; power from solar PV, wind, solid biomass, and biogas; and SWH. It includes mid-term targets of 1,300 EVs in operation; 4,000 smart meters installed; 4,400 solar PV systems deployed; subsidies for SWH installations and EV purchases; provision of low-interest loans for renewables and energy efficiency; and a pilot demonstration ”Yokohama Smart City Project.”

Source: See Endnote 19 for this section.

TABLE R20. ELECTRICITY ACCESS BY REGION AND COUNTRY

REGION/COUNTRY	ELECTRIFICATION RATE	PEOPLE WITHOUT ACCESS TO ELECTRICITY	TARGET
	Share (%) of population with access (2011)[1]	Million (2011)[1]	Share (%)
All Developing Countries	**77.0**	**1,257**	
Africa	**43.0**	**600**	
North Africa	**99.0**	**1**	
Sub-Saharan Africa	**31.8**	**599**	
Developing Asia[2]	**83.0**	**615**	
Southeast Asia	**77.6**	**134**	
Latin America	**95.0**	**24**	
Middle East	**91.0**	**19**	
Afghanistan	16.0	23.8	
Algeria	99.3	0.2	
Angola	38.0	12.0	
Argentina	97.0	1.1	
Bahrain	99.0	0.0	
Bangladesh	60	61	
Barbados	98.0		→ 100% by 2021
Belize	96.2		
Benin	28.0	7.0	
Bolivia	87.0	1.3	
Botswana	55.0	1.1	
Brazil	99.0	1.4	→ 80% by 2016
Brunei	99.7	0.0	
Burkina Faso	13.0	14.0	
Cambodia	34.0	9	
Cameroon	54.0	9.0	
Cape Verde	87.0	64.0	
Chile	99.5	0.0	
China	99.8	3.0	→ 100% by 2015
Colombia	97.0	1.2	
Costa Rica	99.2	0.0	
Côte d'Ivoire	59.0	8	
Cuba	98.0	0.3	
Democratic People's Republic of Korea	26.0	18.0	
Democratic Republic of the Congo	9.0	62.0	
Dominican Republic	96.0	0.4	
Ecuador	96.0	0.7	
Egypt	>99.0	0.3	
El Salvador	92.0	0.5	
Eritrea	32.0	4.0	
Ethiopia	23.0	65.0	
Federated States of Micronesia[3]	4.0 (rural)		→ 75% by 2015
Gabon	60.0	1.0	
Ghana	72.0	7.0	→ 100% by 2020
Grenada	82.0		
Guatemala	82.0	2.7	

TABLE R20. ELECTRICITY ACCESS BY REGION AND COUNTRY (continued)

REGION/COUNTRY	ELECTRIFICATION RATE	PEOPLE WITHOUT ACCESS TO ELECTRICITY	TARGET
	Share (%) of population with access (2011)[1]	Million (2011)[1]	Share (%)
Guinea	15.0	8	
Guinea-Bissau	15.0	1	
Guyana	82.0		
Haiti	28.0	7.3	
Honduras	83.0	1.3	
India	75.3	306.0	
Indonesia	73.0	66.0	
Iran	98.0	1.3	
Iraq	98.0	0.7	
Israel	99.7	0.0	
Jamaica	93.0	0.2	
Jordan	99.0	0.0	
Kenya	19.0	34.0	
Kuwait	100	0.0	
Laos	78.0		
Lebanon	100	0.0	
Lesotho	19.0	2.0	
Liberia	15.0	3	
Libya	99.0	0.0	
Madagascar	14.0	18.0	
Malawi	7.0	14.0	
Malaysia	100	0.0	
Mali	18.0	13	
Marshall Islands	100 (urban)		
Mauritius	99.0	0.0	→ 95% rural by 2015
Mexico	97.6		
Mongolia	88.0	0.0	
Morocco	97.0	1.0	
Mozambique	20.0	19.0	
Myanmar	13.0	43.5	
Namibia	60.0	1.0	
Nepal	76.0	7.0	
Nicaragua	78%	1.3	→ 30% by 2030
Niger	8.0	14.0	
Nigeria	52.0	84.0	
Oman	98	0.1	
Pakistan	69.0	56.0	
Palestinian Territories[4]	99.4		
Panama	88.0	0.4	
Paraguay	98.0	0.1	
Peru	90.0	3.0	
Philippines	70.0	28.0	
Qatar	100.0	0.0	
Saudi Arabia	99.0	0.3	→ 16% by 2012
Senegal	42.0	7.3	

TABLE R20. ELECTRICITY ACCESS BY REGION AND COUNTRY (continued)

REGION/COUNTRY	ELECTRIFICATION RATE	PEOPLE WITHOUT ACCESS TO ELECTRICITY	TARGET
	Share (%) of population with access (2011)[1]	Million (2011)[1]	Share (%)
Sierra Leone	15.0	5	
Singapore	100	0.0	
South Africa	85.0	8.0	→ 100% by 2019
South Sudan	1.0		→ 100% by 2014
Sri Lanka	85.0	3.0	
Sudan	29.0	25.0	
Suriname	90.0		
Syria	93.0	1.5	
Tanzania	15.0	39.0	
Thailand	99	1	
Timor Leste	22.0	0.9	
Togo	27.0	5.0	
Trinidad and Tobago	99.0	0.0	
Tunisia	99.5	0.1	
Uganda	15.0	30.0	
United Arab Emirates	100	0.0	
Uruguay	99.0	0.0	
Venezuela	99.9	0.1	
Vietnam	96.0	4.0	
Yemen	40.0	14.9	
Zambia	22.0	11.0	
Zimbabwe	37.0	8.0	→ 51% (rural) → 90% (urban) → 66% (national) by 2030

Note: Rates and targets are national unless otherwise specified. For other targets that relate to off-grid and rural electrification, see Reference Table R15.

[1] All data are for 2011 with the exception of China, Ghana, and South Africa, which reflect 2013 data.

[2] Developing Asia is divided as follows: China and East Asia includes Brunei, Cambodia, China, Indonesia, Laos, Malaysia, Mongolia, Myanmar, the Philippines, Singapore, South Korea, Taiwan, Thailand, Timor Leste, Vietnam, and other Asian countries; South Asia includes Afghanistan, Bangladesh, India, Nepal, Pakistan, and Sri Lanka.

[3] For the Federated States of Micronesia, rural electrification rate is defined by electrification of all islands outside of the four that host the state capital (which is considered urban).

[4] The Palestinian Territories' rate is defined by number of villages connected to the national electricity grid.

Source: See Endnote 20 for this section.

TABLE R21. POPULATION RELYING ON TRADITIONAL BIOMASS FOR COOKING

REGIONS AND SELECTED COUNTRIES	POPULATION	
	Millions	Share in 2011 (%)
Africa	**696**	**67%**
Nigeria	122	75%
Ethiopia	77	93%
Democratic Republic of the Congo	62	94%
Tanzania	41	94%
South Africa	6	13%
Kenya	33	83%
Other Sub-Saharan Africa	335	74%
North Africa	1	1%
Developing Asia[1]	**1,869**	**51%**
India	818	66%
China	446	33%
Bangladesh	143	88%
Indonesia	103	42%
Pakistan	112	63%
Myanmar	48	9%
Rest of Developing Asia	648	36%
Latin America	**68**	**15%**
Brazil	12	6%
Middle East	**9**	**4%**
All Developing Countries	**2,642**	**49.4%**
World[2]	**2,642**	**38.1%**

[1] Developing Asia is divided as follows: China and East Asia includes Brunei, Cambodia, China, Indonesia, Laos, Malaysia, Mongolia, Myanmar, the Philippines, Singapore, South Korea, Taiwan, Thailand, Timor Leste, Vietnam, and other Asian countries; South Asia includes Afghanistan, Bangladesh, India, Nepal, Pakistan, and Sri Lanka.

[2] Includes countries in the OECD and Eastern Europe/Eurasia.

Source: See Endnote 21 for this section.

TABLE R22. PROGRAMMES FURTHERING ENERGY ACCESS: SELECTED EXAMPLES

NAME	BRIEF DESCRIPTION
ACP-EU Energy Facility	A co-financing instrument that works to increase access to sustainable and affordable energy services in impoverished rural and peri-urban areas of African, Caribbean and Pacific (ACP) countries by involving local authorities and communities.
Africa-EU Renewable Energy Cooperation Programme (RECP)	A programme that contributes to the African EU Energy Partnership's political targets of increasing renewable energy use and bringing modern access to at least an additional 100 million people by 2020. It provides policy advice, private sector co-operation, project preparation support activities, and capacity development.
African Renewable Energy Fund (AREF)	A private equity fund that invests in small to medium-sized renewable energy projects in sub-Saharan Africa, excluding South Africa. It aims to assist governments in meeting their renewable energy and carbon emission targets, while creating jobs. AfDB and SE4ALL are co-sponsors and anchor investors.
Asian Development Bank – Energy for All Initiative	An initiative that strengthens ADB's investments on energy access. From 2008 to 2013, ADB's USD 4.8 billion investment benefitted more than 15.6 million households (78 million people).
Capital Access for Renewable Energy Enterprises Programme (CARE2)	A USD 7 million programme that aims to expand renewable energy markets in Kenya, Tanzania, Uganda, and Rwanda through interventions designed to increase the supply of capital to businesses and the effective deployment of capital. CARE2 is supported by the Swedish International Development Cooperation Agency.
CleanStart	A programme developed by UNCDF and UNDP to help poor households and micro-entrepreneurs access micro-financing for low-cost clean energy. It aims to help lift at least 2.5 million people out of energy poverty by 2017, in ways that can be replicated and scaled up by others.
Energising Development (EnDev)	An initiative of Australia, Germany, the Netherlands, Norway, Switzerland, and the United Kingdom that co-operates with 24 countries in Asia, Africa, and Latin America to provide sustainable access to modern energy services to at least 15 million people by the end of 2018. By mid-2013, EnDev reached 11 million people.
Energy, Ecodevelopment and Resilience in Africa (EERA)	A project that supports energy decision makers in assessing national energy policy frameworks and identifying how energy policies can support climate resilience and sustainable energy objectives in Benin, Mali, and Togo.
EU-Africa Infrastructure Trust Fund (ITF)	A fund that combines grants and loans from the EU and its Member States and as well as banks to support local infrastructure projects, notably in electricity generation. By end-2013, 36 grants had been approved for projects totalling USD 333 million (EUR 240 million) in investments.
GIZ – HERA Poverty-orientated Basic Energy Services	A programme that promotes access to renewable energy and its sustainable and efficient use. With its support, 2.5 million efficient stoves have been successfully produced and sold in the last six years.
Global Alliance for Clean Cookstoves	A public-private partnership that works to save lives, improve livelihoods, empower women, and protect the environment by creating a thriving global market for clean and efficient household cooking solutions. Its goal is for 100 million households to be using clean cook stoves and fuels by 2020.
Global Energy Efficiency and Renewable Energy Fund (GEEREF)	A sustainable development tool sponsored by the EU, Germany, and Norway, advised by the European Investment Bank Group, to mobilise public and private capital to support small and medium-sized renewable energy and energy efficiency projects.
Global LEAP Awards for Outstanding Off-Grid Products	An international competition to identify the world's best low-voltage direct-current off-grid appliances, with the first round (to be awarded in May 2014) aiming to identify energy efficient, high quality, off-grid LED appliances for room lighting and flat-panel colour televisions.
Global Lighting and Energy Access Partnership (Global LEAP)	An initiative of the Clean Energy Ministerial whose members include more than 10 governments and development partners. It provides support for quality assurance frameworks and programmes that encourage market transformation towards super-efficient technologies for off-grid use.
IDEAS – Energy Innovation Contest	An initiative that supports the implementation of innovative projects in the areas of renewable energy, energy efficiency, and energy access in Latin America and the Caribbean by promoting innovative energy solutions that can be replicated and scaled up in the region.

TABLE R22. PROGRAMMES FURTHERING ENERGY ACCESS: SELECTED EXAMPLES (continued)

NAME	BRIEF DESCRIPTION
IRENA – Abu Dhabi Fund for Development (ADFD)	A fund that supports renewable energy projects that: offer innovative and replicable approaches to broaden energy access; address several socioeconomic issues identified in the Millennium Development Goals and SE4ALL objectives; and address energy security issues.
Latin America and Caribbean (LAC SE4ALL)	A programme under way in 26 LAC countries to prepare a supporting platform for the LAC SE4ALL Initiative, financed by the Inter-American Development bank. It is integrated and co-ordinated with the UN global SE4ALL initiative.
Lighting Africa	An IFC and World Bank programme that seeks to accelerate the development of sustainable markets for affordable, modern off-grid lighting solutions for low-income households and micro-enterprises across Africa. As of early 2014, Lighting Africa had provided access to clean, safe lighting for more than 7.7 million people.
Lighting Asia	A programme to provide modern off-grid lighting to the 400 million people in rural India who live off the grid, with the goal of reaching at least 2 million people by the end of 2015.
Power Africa	A U.S. government initiative to address access to electricity in sub-Saharan Africa with a commitment of more than USD 7 billion in financial support and loan guarantees. It aims to bridge the gap between Africa's power shortage and its economic potential.
Scaling Up Renewable Energy in Low Income Countries (SREP)	This Strategic Climate Fund (SCF) programme was established to expand renewable energy markets and scale up renewables deployment in the world's poorest countries. Piloting in Ethiopia, Honduras, Kenya, Liberia, Maldives, Mali, Nepal, and Tanzania.
SNV Netherlands Development Organisation – Biogas Practice	Through a multi-actor sector development approach, SNV supports the preparation and implementation of national biogas programmes throughout the world. In co-operation with its partners, SNV had installed 579,000 biogas plants in 18 developing countries in Asia, Africa, and Latin America by end-2013 (with 74,000 in 2013 alone).
Sustainable Energy Fund for Africa (SEFA)	A fund administered by the African Development Bank, anchored by a Danish government commitment of USD 57 million, to support small- and medium-scale clean energy and energy efficiency projects in Africa through grants for technical assistance and capacity building, investment capital, and guidance.
Sustainable Energy for All Initiative (SE4ALL)	A global initiative of UN Secretary-General Ban Ki-moon with three objectives for 2030: achieving universal access to electricity and clean cooking solutions; doubling the share of the world's energy supplied by renewable sources; and doubling the rate of improvement in energy efficiency.

TABLE R23. NETWORKS FURTHERING ENERGY ACCESS: SELECTED EXAMPLES

NAME	BRIEF DESCRIPTION
African Bioenergy Development Platform	A platform launched by UNCTAD to assist interested African countries to develop their bioenergy potentials for advancing human and economic development through interactive, multi-stakeholder analytical exercises.
African Renewable Energy Alliance (AREA)	A global multi-stakeholder platform to exchange information and consult about policies, technologies, and financial mechanisms for the accelerated uptake of renewable energy in Africa.
Clean Energy for Africa (CLENA)	A Youth Volunteers for the Environment project with a five-year action plan (2012–2016) to promote sustainable energy and alleviate energy poverty in Africa.
CTI – Private Financing Advisory Network	A network that identifies promising clean energy projects at an early stage and provides mentoring for development of a business plan, investment pitch, and growth strategy, etc.
ENERGIA International	An international network focused on gender issues, women's empowerment, and sustainable energy that by early 2014 included 22 organisations working in Africa and Asia.
Global 100% RE	The first global campaign to advocate for 100% renewable energy; its aims to prove that this goal is urgent and achievable in developed as well as developing countries.
HEDON Household Energy Network	A network aimed at empowering practitioners to unlock barriers to household energy access by addressing knowledge gaps, facilitating partnerships, and fostering information sharing.
RedBioLAC	A multinational network of institutions involved in research and dissemination of anaerobic bio-digestion, and the treatment and management of organic waste in Latin America and the Caribbean.
UN Foundation Energy Access Practitioner Network	A network with more than 1,600 members from over 190 countries that supports market-led decentralised energy activities towards achieving universal energy access by 2030. It serves as a "network of networks" to help develop a global approach for scaling towards universal energy access.

1 Estimated shares are from the following sources: total 2012 final energy demand (estimated at 8,265 Mtoe) based on 8,098 Mtoe for 2011 from International Energy Agency (IEA), "World Energy Statistics" (Paris: Organisation for Economic Co-operation and Development (OECD)/IEA, 2013) and escalated by the 2.06% increase in global primary energy demand from 2011 to 2012, derived from BP, *Statistical Review of World Energy 2013* (London: 2013), http://www.bp.com/content/dam/bp/pdf/statistical-review/statistical_review_of_world_energy_2013.pdf. Traditional biomass use in 2012 of 31.3 EJ based on the same value for 2011 from IEA, *Medium-Term Renewable Energy Market Report 2013* (Paris: OECD/IEA, 2013), p. 217. Elsewhere, traditional biomass use in 2011 was estimated at 744 Mtoe (31.15 EJ), and expected to decline by 2020, from IEA, *World Energy Outlook* (Paris: OECD/IEA, 2013), pp. 200–201. In 2011, the Intergovernmental Panel on Climate Change (IPCC) indicated a higher range for traditional biomass of 37–43 EJ, and a proportionately lower figure for modern biomass use, per O. Edenhofer et al., eds., *IPCC Special Report on Renewable Energy Resources and Climate Change Mitigation* (Cambridge, U.K. and New York: Cambridge University Press, 2011), Table 2.1, http://srren.ipcc-wg3.de/report. Bio-heat energy values for 2012 (industrial, residential, commercial, and other uses, including heat from heat plants) based on 315 Mtoe (12.8 EJ) for 2011 and projected 3.1% annual growth for bioenergy use for heat to 2018, from IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. this note, p. 223. Bio-power generation was estimated at 32 Mtoe (373 TWh), from idem, p. 172. Wind power generation of 50 Mtoe (582 TWh) based on global capacity of 283.2 GW from Global Wind Energy Council (GWEC), *Global Wind Report – Annual Market Update 2013* (Brussels: April 2014), http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf, and a capacity factor (CF) of 23.44%, calculated from 2012 global capacity and output as reported by Navigant Research, *World Market Update 2013: International Wind Energy Development. Forecast 2014-2018* (Copenhagen: March 2014). Solar PV generation was estimated at 9.9 Mtoe (116 TWh), based on 99.7 GW capacity from European Photovoltaic Industry Association (EPIA), *Market Report 2013* (Brussels: March 2014), http://www.epia.org/uploads/tx_epiapublications/Market_Report_2013_02.pdf, and average CF of 13.24%, based on 2013 capacity of 139 GW from Gaëtan Masson, IEA-Photovoltaic Power Systems Programme (IEA-PVPS), and iCARES Consulting, personal communication with REN21, February-May 2014; and EPIA, *Global Market Outlook for Photovoltaics 2014-2018* (Brussels: forthcoming 2014); 2013 generation of 160 TWh from IEA-PVPS, *PVPS Report – Snapshot of Global PV 1992–2013: Preliminary Trends Information from the IEA PVPS Programme* (Brussels: March 2014), http://www.iea-pvps.org/fileadmin/dam/public/report/statistics/PVPS_report_-_A_Snapshot_of_Global_PV_-_1992-2013_-_final_3.pdf. CSP was 0.5 Mtoe (6 TWh), based on 2.54 GW capacity from REN21, *Renewables 2013 Global Status Report* (Paris: REN21 Secretariat, 2013), and CF of 25.9% based on preliminary 2013 capacity and generation from IEA, *Medium-Term Renewable Energy Market Report 2014* (Paris: OECD/IEA, forthcoming 2014). Ocean power was 0.1 Mtoe (1.1 TWh), based on 530 MW capacity and CF of 23.3% based on 2013 capacity and generation from idem. Geothermal electricity generation was 6.2 Mtoe (72 TWh), from IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. this note. Hydropower was 318 Mtoe (3,700 TWh), from International Hydropower Association (IHA), personal communication with REN21, May 2014. Solar thermal heating/cooling of 20.6 Mtoe (0.86 EJ) from Franz Mauthner, AEE – Institute for Sustainable Technologies, Gleisdorf, Austria, personal communication with REN21, March-May 2014, and from Franz Mauthner and Werner Weiss, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2012* (Gleisdorf, Austria: IEA Solar Heating and Cooling Programme (SHC), forthcoming 2014). Note that the estimate does not consider air collectors. Geothermal heat was estimated at 7.8 Mtoe (0.33 EJ), derived from the average of two estimated values. The first (376 PJ) was derived from global annual direct use in 2011 of 335 PJ, from IEA, "World Energy Statistics," op. cit. this note, and escalated at the observed two-year average growth rate (2009–2011) to 2012 and 2013; the second (281 TJ) was derived from global direct use in 2009 of 223 PJ, from John W. Lund, Derek H. Freeston, and Tonya L. Boyd, "Direct Utilization of Geothermal Energy 2010 Worldwide Review," *Proceedings World Geothermal Congress 2010* (Bali, Indonesia: 25–29 April 2010), which was escalated first at the annual growth rate from IEA data ("World Energy Statistics," op. cit. this note) to 2011 and then by the two-year average growth rate (2009–2011) to 2012 and 2013, as above. For liquid biofuels, ethanol use was estimated at 43.8 Mtoe (1.83 EJ) and biodiesel use at 19.4 Mtoe (0.81 EJ), based on 82.6 billion litres and 23.6 billion litres, respectively, from F.O. Licht, "Fuel Ethanol: World Production, by Country (1000 cubic metres)," 2014, and F.O. Licht, "Biodiesel: World Production, by Country (1000 t)," 2014, used with permission from F.O. Licht / Licht Interactive Data; average conversion factors from Oak Ridge National Laboratory, "Bioenergy Conversion Factors," https://bioenergy.ornl.gov/papers/misc/energy_conv.html. Nuclear power generation was assumed to contribute 213 Mtoe (2,477 TWh) of final energy, from BP, op. cit. this note.

2 Ibid.

3 IEA, *World Energy Outlook 2013*, op. cit. note 1, p. 200.

4 Data and **Figure 1** based on sources in Endnote 1.

5 **Figure 2** based on the following sources (see also relevant sections and endnotes for more details regarding 2013 data and sources): **Solar PV** based on 15,795 MW in operation at the end of 2008, and 99,690 MW at the end of 2012, from EPIA, *Market Report 2013*, op. cit. note 1, and more than 139 GW at the end of 2013. **CSP** based on 485 MW in operation at the end of 2008, from Fred Morse, Abengoa Solar, personal communication with REN21, 4 May 2012, and from Red Eléctrica de España (REE), "Potencia Instalada Peninsular (MW)," updated 29 April 2013, https://www.ree.es/ingles/sistema_electrico/series_estadisticas.asp; on about 2,540 MW at the end of 2012, from REN21, op. cit. note 1, from Luis Crespo, European Solar Thermal Electricity Association (ESTELA), personal communication with REN21, February 2014, from Fred Morse, Morse Associates, Inc., personal communication with REN21, February 2014, from "CSP World Map," CSP World, http://www.csp-world.com/cspworldmap, and from "CSP Today Global Tracker," CSP Today, http://social.csptoday.com/tracker/projects; and on 3,425 MW at the end of 2013. **Wind power** based on 120.6 GW at the end of 2008 and 283 GW at the end of 2012, from GWEC, op. cit. note 1, and on 318 GW at the end of 2013. **Hydropower** based on an estimated 833 MW (not including pumped storage) in operation at the end of 2008 based on data from U.S. Energy Information Administration (EIA), "Table: Hydroelectricity Installed Capacity (Million kilowatts)," www.eia.gov/cfapps/ipdbproject/iedindex3.cfm, viewed 11 May 2014, and adjusted downward by 20 GW to account for difference between 2011 data from EIA and from IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1, and on 960 GW at the end of 2012, from IHA, Hydropower Database (unpublished), personal communication with REN21, February-March 2014, and on 1,000 GW at the end of 2013. **Geothermal** based on 10.3 GW in operation at the end of 2008, and about 11.5 GW at the end of 2012, from U.S. Geothermal Energy Agency (GEA), unpublished database, provided by Benjamin Matek, GEA, personal communication with REN21, March 2014, and 12 GW at the end of 2013. **Solar water heaters** based on 169.1 GW_{th} capacity (not including air collectors) in operation at the end of 2008, 281.6 GW_{th} at the end of 2012, and an estimated 326 GW_{th} at the end of 2013, from Mauthner, op. cit. note 1, and on Mauthner and Weiss, op. cit. note 1. **Biofuels** based on 15.6 billion litres of biodiesel and 66 billion litres of fuel ethanol produced in 2008, 23.6 billion litres of biodiesel and 82.6 billion litres of fuel ethanol in 2012, and 26.3 billion litres of biodiesel and 87.2 billion litres of fuel ethanol in 2013, all from F.O. Licht, "Fuel Ethanol: World Production, by Country (1000 cubic metres)," 2013, and F.O. Licht, "Biodiesel: World Production, by Country (1000 T), 2013, from Helena Chum, U.S. National Renewable Energy Laboratory (NREL), personal communication with REN21, May 2013 and March 2014, with permission from F.O. Licht/ Licht Interactive Data.

6 **Sidebar 1** from the following sources: observations of GSR report authors; International Renewable Energy Agency (IRENA), *Statistical Issues: Bioenergy and Distributed Renewable Energy* (Abu Dhabi: 2013), http://www.irena.org/DocumentDownloads/Publications/Statistical%20issues_bioenergy_and_distributed%20renewable%20_energy.pdf; United Nations Sustainable Energy for All (SE4ALL), *Global Tracking Framework* (Washington, DC: 2013), http://www.worldbank.org/en/topic/energy/publication/Global-Tracking-Framework-Report. The Global Tracking Framework provides a system for regular reporting over the years leading to 2030, to monitor advances towards SE4ALL targets. Currently, the tracking framework draws from available global databases, but over the medium term, the framework aims to improve existing databases. At the regional level, initiatives include those by the ECOWAS Observatory for Renewable Energy and Energy Efficiency, http://www.ecowrex.org/, and the RCREEE Arab Future Energy Index, http://www.rcreee.org/projects/arab-future-energy-index%E2%84%A2-afex.

7 IEA, *World Energy Outlook 2013*, op. cit. note 1, p. 199. Also see Bioenergy section of this report.

8 Sven Teske, Greenpeace International, personal communication with REN21, 13 January 2014.

9 Eurostat, "Renewable Energy in the EU28 – Share of Renewables in Energy Consumption Up to 14% in 2012," press release (Brussels: 10 March 2014), http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/8-10032014-AP/EN/8-10032014-AP-EN.PDF.

10 Energy subsidies cause inefficient energy use and hinder investment, from World Economic Forum, *The Global Energy Architecture Performance Index Report 2014* (Geneva: December 2013), p. 22, http://www3.weforum.org/docs/WEF_EN_NEA_Report_2014.pdf, and from International Monetary Fund (IMF), "Reforming Energy Subsidies Summary Note," 2013, http://www.imf.org/external/np/fad/subsidies/pdf/note.pdf.

11 Estimate of USD 544 billion to fossil fuels and USD 101 billion to renewables in 2012, from IEA, "World Energy Outlook 2013 Factsheet," http://www.iea.org/media/files/WEO2013_factsheets.pdf, viewed 23 March 2014; according to the IMF, subsidies are USD 1.9 trillion if considering total post-tax subsidies, per IMF, op. cit. note 10.

12 In Latin America, for example, wind power projects are being delayed due to lack of grid infrastructure, per Gonzalo Bravo, Fundación Bariloche, personal communication with REN21, 14 January 2014; grid connection is a problem in Brazil, per "Energia Eólica: A Culpa da Chesf," *Diário do Nordeste*, 25 February 2014, http://www.portalabeeolica.org.br/index.php/noticias/1612-energia-eólica-a-culpa-da-chesf.html (using Google Translate); in Colombia, the cost of transmission lines required to move wind power from the areas with greatest potential (in La Guajira) is a main barrier for wind power development, as is variability of the wind resource, per Javier Eduardo Rodriguez, UPME – Colombian Mining and Energy Planning Unit, personal communication with REN21, 15 April 2014; grid-connection remains a major challenge for offshore wind, particularly off Germany's coast, where 43% of the turbines installed in 2013 (or nearly 395 MW) lacked grid connection by year's end, per B. Neddermann, "German Offshore Market Growing Despite Problems with Grid Connection," *DEWI Magazin*, February 2014, p. 55, http://www.dewi.de/dewi/fileadmin/pdf/publications/Magazin_44/09.pdf; curtailment and inability to integrate in several countries, including China and India, from Shruti Shukla, GWEC, personal communication with REN21, 19 March 2014.

13 Masson, op. cit. note 1; PV Grid, *Initial Project Report*, July 2013, http://www.pvgrid.eu/fileadmin/PV_GRID_INITIAL_REPORT_version2.1_July_2013.pdf; PV Grid, *Prioritisation of Technical Solutions Available for the Integration of PV into the Distribution Grid*, 26 June 2013, http://www.pvgrid.eu/fileadmin/130626_PVGRID_D3_1_Final.pdf; IEA, *World Energy Outlook 2013*, op. cit. note 1, p. 213; C. Mitchell et al., "Policy, Financing and Implementation," Chapter 11 in Edenhofer et al., eds., op. cit. note 1, p. 925; R. Sims et al., "Integration of Renewable Energy into Present and Future Energy Systems," Chapter 8 in idem.

14 Paolo Frankl, IEA, personal communication with REN21, 6 March 2014.

15 See, for example, Stephen Jewkes, "Enel Green Power Looks to Africa, Latin America for Growth," *Reuters*, 7 November 2013, http://planetark.org/wen/70282. See also all other sections of this report.

16 Frankfurt School–United Nations Environment Programme Collaborating Centre for Climate & Sustainable Energy Finance (FS-UNEP Centre) and Bloomberg New Energy Finance (BNEF), *Global Trends in Renewable Energy Investment 2014* (Frankfurt: 2014); James Montgomery, "Third-Party Residential Solar Surging in California; Nearly a Billion-Dollar Business," Renewable Energy World, 15 February 2013, http://www.renewableenergyworld.com/rea/news/article/2013/02/third-party-residential-solar-surging-in-california-nearly-a-billion-dollar-business; Scott Sklar, Stella Group, personal communication with REN21, 20 February 2013; Rainer Hinrichs-Rahlwes, German Renewable Energies Federation (BEE), personal communication with REN21, 2 May 2014.

17 SE4ALL, http://www.se4all.org/, viewed April 2014; IEA, *World Energy Outlook 2013*, op. cit. note 1, p. 197; Mitchell et al., op. cit. note 13, pp. 878–80.

18 See, for example, Mitchell et al., op. cit. note 13, p. 879; accelerating economic development in rural and remote areas is emerging as a major driver for renewables in developing countries, from Shirish Garud, The Energy and Resources Institute (TERI), personal communication with REN21, 15 April 2014; job creation potential is becoming increasingly important in justifying public investments in renewable energy, per David A. Quansah, The Energy Center, Knust, Ghana, personal communication with REN21, 15 April 2014.

19 Business opportunities from International Finance Corporation (IFC), *From Gap to Opportunity: Business Models for Scaling Up Energy Access* (Washington, DC: 2012), http://www1.ifc.org/wps/wcm/connect/b7ce4c804b5d10c58d90cfbbd578891b/ExecutiveSummary.pdf?MOD=AJPERES; new business models for all types of technologies from M. Wiemann, Alliance for Renewable Energy, personal communication with REN21, 16 April 2014.

20 Frankl, op. cit. note 14; Bravo, op. cit. note 12. **Sidebar 2** from the following sources: "90% Renewable Electricity by 2015 Is Uruguay's Goal," Clean Technica, 1 January 2013, http://cleantechnica.com/2013/01/08/90-renewable-electricity-by-2015-is-uruguays-goal/; Grenada from IRENA, *Renewable Readiness Assessment Grenada* (Abu Dhabi: 2012), https://www.irena.org/DocumentDownloads/Publications/Grenada_RRA.pdf, and from REN21 database; regional renewable energy shares from Multilateral Investment Fund (MIF), *Climatescope 2013* (Washington, DC: 2013), http://www.iadb.org/intal/intalcdi/PE/2013/13205en.pdf; hydrological vulnerability from Inter-American Development Bank (IDB), *Rethinking Our Energy Future* (Washington, DC: June 2013), http://www.iadb.org/en/publications/publication-detail,7101.html?dctype=All&dclanguage=en&id=69434; IEA, *World Energy Outlook 2013*, op. cit. note 1; reducing fossil fuel reliance from Caribbean Community and Common Market, *Energy Policy* (Georgetown, Guyana: March 2013), www.caricom.org/jsp/community_organs/energy_programme/CARICOM_energy_policy_march_2013.pdf; electrification rates (average global electrification rate is 82%) from IEA, *World Energy Outlook 2013*, op. cit. note 1; solar and geothermal potential based on technically feasible potential, per Monique Hoogwijk and Wina Graus, *Global Potential of Renewable Energy Sources* (London: ECOFYS, March 2008), http://www.ecofys.com/files/files/report_global_potential_of_renewable_energy_sources_a_literature_assessment.pdf; wind resources from IDB, op. cit. this note; non-hydro renewable potential assumes current electricity consumption of 1.3 petawatt-hour (PWh) (1 trillion kWh) and a regional non-hydro technical potential of over 80 PWh, per idem; geothermal capacity from idem; solar PV market from EPIA, *Global Market Outlook for Photovoltaics until 2016* (Brussels: 2012), http://large.stanford.edu/B7E2C175-E70B-491E-B969-D77E62985EFE/FinalDownload/DownloadId-A574F187CAFD51815145012048BC7166/B7E2C175-E70B-491E-B969-D77E62985EFE/courses/2012/ph240/vidaurre1/docs/masson.pdf; solar thermal collectors from Franz Mauthner and Werner Weiss, *Solar Heat Worldwide* (Paris: IEA, 2013), http://www.iea-shc.org/solar-heat-worldwide; Chile from Abengoa Solar, "Industrial installation of concentrating solar power in Chile," http://www.abengoasolar.com/web/en/nuestras_plantas/plantas_para_terceros/chile/index.html; Jamaica from Annabel Homer, "Agricultural drying Jamaica uses innovative solar alternative and renewable energy technologies," 21 August 2013, http://www.gvepinternational.org/en/business/news/agricultural-drying-jamaica-uses-innovative-solar-alternative-and-renewable-energy-tec; Peru from Andina "Inauguran 40 secadores solares para la poscosecha de café en Satipo, Junín," 1 November 2013, http://www.andina.com.pe/espanol/noticia-inauguran-40-secadores-solares-para-poscosecha-cafe-satipo-junin-480812.aspx; Mexico from Adrián Vidal Santo et al., "Diseño y construcción de un secador solar portátil," *Congreso Internacional de Investigacion*, vol. 4, no. 2 (2012), http://www.uv.mx/personal/avidal/files/2013/06/Secador-Solar.pdf; urbanisation from IDB Emerging and Sustainable Cities Initiative, "What Do We Do?" http://www.iadb.org/en/topics/emerging-and-sustainable-cities/responding-to-urban-development-challenges-in-emerging-cities,6690.html, viewed February 2014; biofuel promotion from IDB, *Low Carbon Technologies Can Transform Latin America's Bus Fleets* (Washington, DC: 25 April 2013), http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=37907926; Brazil's biofuel share from Energy and Mines Ministry, Empresa de Pesquisa Energetica, *Brazil Energy Balance 2013* (Brasilia: 2013), https://ben.epe.gov.br/downloads/S%C3%ADntese%20do%20Relat%C3%B3rio%20Final_2013_Web.pdf; regional biofuel leaders from MIF, op. cit. this note; renewable support measures from Bravo, op. cit. note 12; El Salvador issued tenders for 100 MW of wind and solar power, per BNEF, "El Salvador Solicits Bids for 100 Megawatts of Wind, Solar Power," 2 October 2013, http://www.bloomberg.com/news/2013-10-02/el-salvador-solicits-bids-for-100-megawatts-of-wind-solar-power.html; Peru issued tenders for 240 MW of hydropower, per "Perú adjudica 19 proyectos generación hidroeléctrica con recursos renovables,"

La Informacion, 13 December 2013, http://noticias.lainformacion.com/economia-negocios-y-finanzas/energia-alternativa/peru-adjudica-19-proyectos-generacion-hidroelectrica-con-recursos-renovables_TbZsx0zWtSrd5zlkVxfGo6/; Brazil issued tenders for 6.124 GW of renewables, from Auction A-3 has 868 MW of wind per BNEF, "Wind Farms Dominating Brazil Power Auction Set for Record Year," 18 November 2013, http://www.bloomberg.com/news/2013-11-18/wind-farms-dominating-brazil-power-auction-set-for-record-year.html; has 4.7 GW of wind during the year per BNEF, "Brazil Energy Auction Sells 2.3 Gigawatts of Wind-Power Projects," 13 December 2013, http://www.bloomberg.com/news/2013-12-13/brazil-energy-auction-sells-2-3-gigawatts-of-wind-power-projects.html; has 123 MW of solar power from "Brazilian state approves 123 MW of solar developments in energy auction," PV tech, January 2014, http://www.pv-tech.org/news/brazil_gains_122mw_of_solar_developments_after_state_energy_auction; has 481.2 MW small-scale hydro and 808 MW biomass, per Brazil Energy Research Office EPE from Beatriz Monteiro, communication with Sandra Chavez, IRENA, 20 February 2014; Uruguay has 200 MW of solar power, per Alejandro Diego Rosell, "One of the lowest solar rates in the world?" *PV Magazine*, December 2013, http://www.pv-magazine.com/archive/articles/beitrag/one-of-the-lowest-solar-rates-in-the-world-_100013587/#axzz2rt4Y3PqY; Barbados, Brazil, Chile, Costa Rica, the Dominican Republic, Jamaica, Mexico, and Uruguay all have promoted net metering, per MIF, op. cit. this note; improved investment environment from Bravo, op. cit. note 12; investment commitments from BNEF, "Clean Energy Investment Falls for Second Year," press release (London: 15 February 2014), http://about.bnef.com/press-releases/clean-energy-investment-falls-for-second-year/; spread of manufacturing from MIF, op. cit. this note; factors behind development delays from Bravo, op. cit. note 12; challenges of low demand from Caribbean Community and Common Market, op. cit. this note.

21 Anna Leidreiter, World Future Council, personal communication with REN21, 10 April 2014. See also European Commission, "Siena Starts the New Year as Europe's First Carbon Free City," 22 January 2014, http://ec.europa.eu/environment/europeangreencapital/siena-starts-new-year-carbon-free/.

22 See Market and Industry Trends section.

23 U.S. International Trade Commission, *Renewable Energy and Related Services: Recent Developments* (Washington, DC: August 2013), Executive Summary, http://www.usitc.gov/publications/332/pub4421.pdf.

24 Back toward profitability from FS-UNEP Centre and BNEF, op. cit. note 16, p. 16, and from Alessandro Marangoni, Mario Iannotti, and Sofia Khametova, *The Strategies of the 50 Leading Companies in the Global Renewable Energy Industry*, Edition II (Milan: Althesys Strategic Consultants, 2014), Summary, http://www.althesys.com/wp-content/uploads/2014/03/Althesys-IREX-International-2014-.pdf.

25 FS-UNEP Centre and BNEF, op. cit. note 16.

26 Global investment in fossil fuel power capacity was USD 270 billion; however, most of this was to replace previously existing capacity, and investment in additional fossil power capacity was an estimated USD 102 billion. This compares with USD 192 billion for renewables not including hydro plants larger than 50 MW, and at least USD 227 billion if all hydro is included, from ibid., pp. 30–32.

27 Ibid., p. 13; financing from Michael Eckhart, CitiGroup, Inc., personal communication with REN21, 13 January 2014.

28 Louise Downing, "Record Renewable Energy Transfers Illustrate Investors' Appetites, Utilities' Pain," *Bloomberg*, 7 November 2013, http://www.renewableenergyworld.com/rea/news/article/2013/11/record-renewable-energy-transfers-illustrate-investors-appetites-utilities-pain; for interest among institutional investors, see also Vera Eckert, "Green energy in Europe vies now with conventional energy: Allianz," *Reuters*, 26 April 2013, http://planetark.org/wen/68514; other new investors include insurance and reinsurance firms (e.g., Allianz, Munich Re), which are pouring billions of Euros into renewable energy projects, from "Green Makeover Will Be Struggle for Germany's RWE," *Reuters*, 1 November 2013, http://planetark.org/wen/70238; Kelvin Ross, "London Array Wind Farm the Highlight of 'Exceptional Year' for Masdar," Renewable Energy World, 24 January 2014, http://www.renewableenergyworld.com/rea/news/article/2014/01/london-array-wind-farm-the-highlight-of-exceptional-year-for-masdar; Sally Bakewell, "Citi Sees Capital Markets Reviving Renewables as Banks Bow Out," *Bloomberg*, 27 January 2014, http://www.renewableenergyworld.com/rea/news/article/2014/01/citi-sees-capital-markets-reviving-renewables-as-banks-bow-out; Tildy Bayar, "Trend Spotting in Renewables Investment," *Renewable Energy World*, May-June 2013, p. 53.

29 Use of crowd funding in China from Eric Ng, "Solar Farm Taps Crowd Funding for 10 m Yuan Project," *South China Morning Post*, 20 February 2014, http://www.scmp.com/business/commodities/article/1431397/solar-farm-taps-crowd-funding-10m-yuan-project; Africa and Asia from Felicity Carus, "Crowdfunding Aims to Prove that Solar Power in a Bankable Sector," *The Guardian*, 20 December 2013, http://www.theguardian.com/sustainable-business/crowdfunding-solar-power-bankable-sector; risk-guarantee schemes from Franck Jesus, Global Environment Facility (GEF), personal communication with REN21, 16 April 2014. See also FS-UNEP Centre and BNEF, op. cit. note 16.

30 See Distributed Renewable Energy in Developing Countries section.

31 See Reference Table R1 and related endnote for details and references.

32 Ibid.

33 Based on total additions of approximately 120 GW, with an estimated 40 GW from hydropower, more than 39 GW from solar PV, and more than 35 GW from wind. For details and references see Reference Table R1, Market and Industry Trends section, and related endnotes.

34 Based on estimates ranging from at least 36.9 GW to most likely 39–40 GW of solar PV added during 2013 from Masson, op. cit. note 1, from IEA-PVPS, op. cit. note 1, from EPIA, *Global Market Outlook for Photovoltaics 2014-2018*, op. cit. note 1, and from FS–UNEP Centre and BNEF, op. cit. note 16; from estimates of 35.3–36.1 GW of wind power capacity added during 2013 from GWEC, op. cit. note 1, from World Wind Energy Association (WWEA), *World Wind Energy Report 2013* (Bonn: 2014), and from Navigant Research, op. cit. note 1, Executive Summary; from data on global solar PV capacity additions back to 1990, from Paul Maycock, *PV News*, various years, and from EPIA, *Market Report 2013*, op. cit. note 1; and from data on net global wind capacity additions back to 1981 from GWEC, op. cit. note 1, and from Janet L. Sawin, "The Role of Government in the Development and Diffusion of Renewable Energy Technologies: Wind Power in the United States, California, Denmark and Germany, 1970-2000," Doctoral Dissertation, Fletcher School, Tufts University, September 2001.

35 Growing share based on data from REN21, *Renewables Global Status Report*, previous editions, and from EIA and BNEF data, provided in FS–UNEP Centre and BNEF, op. cit. note 16, p. 31.

36 Figure of 56% based on a total of approximately 120 GW of renewable capacity added, as noted in this report; on 4 GW of nuclear power capacity added and 5.4 GW of capacity permanently shutdown, for a net reduction of 1.4 GW, from International Atomic Energy Agency (IAEA) PRIS Database, http://www.iaea.org/pris/, viewed 11 May 2014; net increase in fossil generating capacity of an estimated 95 GW, from FS¬–UNEP Centre and BNEF, op. cit. note 16, p. 30. Based on these data, total global net capacity additions in 2013 were estimated to be about 213.6 GW, putting the renewable share at just over 56%. Higher shares in several countries based on the following: IEA-PVPS, op. cit. note 1; New Zealand from Ralph Sims, Massey University, New Zealand, personal communication with REN21, 30 March 2014; countries in Europe based on the fact that 72% of newly installed EU capacity was renewable, from European Wind Energy Association (EWEA), *Wind in Power: 2013 European Statistics* (Brussels: February 2014), p. 7, http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA_Annual_Statistics_2013.pdf; France decommissioned fossil capacity and adding no nuclear power capacity, therefore adding only renewables, per Romain Zissler, Institute for Sustainable Energy Policies (ISEP), personal communication with REN21, 15 April 2014; nearly all capacity added in Italy was renewable, from Alessandro Marangoni, Althesys Strategic Consultants, personal communication with REN21, 16 April 2014.

37 EWEA, op. cit. note 36, p. 7.

38 Renewable share of total global electric generating capacity is based on renewable total of 1,560 GW and on total global electric capacity in the range of 5,898.3 GW. Estimated total world capacity for end-2013 is based on 2011 total of 5,456 GW, from IEA, *World Energy Outlook 2013*, op. cit. note 1, p. 574; on about 116 GW of renewable power capacity added in 2012, from REN21, op. cit. note 1, and adjusted data for 2012; on 109 GW net additions of fossil fuel-fired capacity in 2012, from FS–UNEP Centre and BNEF, *Global Trends in Renewable Energy Investment 2013* (Frankfurt: 2013); on a net increase in nuclear power capacity of 3.7 GW in 2012, from IAEA, cited in "Nuclear Power Capacity Grew Again in 2012: IAEA," *Agence France Presse*, 5 March 2013; and on a net

total of 213.6 GW of global power capacity added from all sources in 2013 (see Endnote 36 for details).

39 Estimates based on the following sources: Total global electricity generation in 2013 is estimated at 22,921 TWh, based on 22,504 TWh in 2012 from BP, op. cit. note 1, and an estimated 1.85% growth in global electricity generation for 2013. The growth rate is based on the weighted average actual change in total generation for the following countries (which together account for two-thirds of global generation in 2012): United States (+0.26% net generation), EU-28 (-4.73% gross generation), Russia (-0.85%), India (+4.70%), China (+7.50%), and Brazil (+2.58%). Sources for 2011 and 2012 electricity generation are: EIA, *Monthly Energy Review*, April 2014, Table 7.2a (Electricity Net Generation); European Commission, Eurostat database, http://epp.eurostat.ec.europa.eu; System Operator of the Unified Power System of Russia, http://www.so-ups.ru; Government of India, Ministry of Power, Central Electricity Authority (CEA), "Monthly Generation Report," http://www.cea.nic.in/monthly_gen.html; China Electricity Council (CEC), "CEC Released the Country's Electricity Supply and Demand Analysis and Forecasting 2014 Annual Report," 25 February 2014, http://www.cec.org.cn/guihuayutongji/gongxufenxi/dianligongxufenxi/2014-02-25/117272.html (using Google Translate); National Operator of the Electrical System of Brazil (ONS), http://www.ons.org.br/historico/geracao_energia.aspx. Hydropower generation in 2013 is estimated at 3,775 TWh, based on input from IHA, op. cit. note 1, from IEA, *Medium-Term Renewable Energy Market Report 2014*, op. cit. note 1;,and from a projection based on 2012 hydropower output of 3,673 TWh from BP, op. cit. note 1, as well as observed weighted average year-on-year change in output (+2.8%) for top producing countries (China, Brazil, Canada, the United States, EU-27, Russia, India, and Norway), which together accounted for over 70% of global hydropower output: United States (-2.6% in annual output), Canada (+3.0%), EU-27 (+12.2% for January through September), Norway (-8.1%), Brazil (-6.0%), Russia (+12.7%), India (+13.2%) for facilities larger than 25 MW), and China (+4.7%). The combined hydropower output of these countries was up by about 2.8% relative to 2012. Hydropower generation by country: United States from EIA, op. cit. this note; Canada from Statistics Canada, http://www5.statcan.gc.ca; EU-27 from European Commission, op. cit. this note; Norway from Statistics Norway, http://www.ssb.no; Brazil from ONS, op. cit. this note; System Operator of the Unified Power System of Russia, op. cit. this note; Government of India, op. cit. this note; CEC, op. cit. this note. Non-hydro renewable generation of 1,311 TWh was based on 2013 year-end generating capacities shown in Reference Table R1 and representative capacity factors in Endnote 1, or other specific estimates as detailed by technology in Section 2. **Figure 3** based on sources in this endnote.

40 Denmark met 33.2% of electricity demand with wind power, based on 11.1 billion kWh of wind power generation in 2013 and 33.5 billion kWh of total electricity consumption, from Carsten Vittrup, "2013 Was a Record-Setting Year for Danish Wind Power," Energinet.DK, 15 January 2014, http://www.energinet.dk/EN/El/Nyheder/Sider/2013-var-et-rekordaar-for-dansk-vindkraft.aspx; Spain from REE, per Asociación Empresarial Eólica (AEE), "Spain Was in 2013 the First Country Where Wind Energy Was the First Source of Electricity for an Entire Year," press release (Madrid: 15 January 2014), http://www.aeeolica.org/en/new/spain-was-in-2013-the-first-country-where-wind-energy-was-the-first-source-of-electricity-for-an-entire-year/; Italy from IEA-PVPS, op. cit. note 1. Other countries meeting large shares included Australia; wind met 38% of South Australia's power demand and 8% of national demand during August 2013, from Clean Energy Council, "August Windy Enough to Light Up 155,000 Homes," 4 September 2013, http://www.cleanenergycouncil.org.au/media-centre/media-releases/september-2013/130904-windy-august.html; Portugal occasionally reaches 90% of electricity from wind power, from Steve Sawyer, GWEC, personal communication with REN21, 14 April 2014; Michael Goggin, "US Wind Energy Output Breaks Records," Renewable Energy World, 4 April 2014, http://www.renewableenergyworld.com/rea/news/article/2014/04/us-wind-energy-output-breaks-records; RenewableUK, "Record Breaking Month for Wind Energy," press release (London: 2 January 2014), http://www.renewableuk.com/en/news/press-releases.cfm/2014-01-02-record-breaking-month-for-wind-energy; Note that renewable energy provided 70% of Portugal's electricity supply for the first quarter of 2013; hydropower and wind power were the largest contributors, with hydro providing 37% and wind 27%, from Peter Bronski, "Is a High Renewables Future Really Possible? Part 2," RMI Outlet, 23 May 2013, http://blog.rmi.org/blog_05_23_2013_is_a_high_renewables_energy_really_possible_part_two.

41 Orkutölur 2013, *Orkustofnun* (Energy Statistics in Iceland 2013) (Reykjavik: April 2014), http://www.os.is/gogn/os-onnur-rit/orkutolur_2013-islenska.pdf; BP, "Renewables in this Review," http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy-2013/review-by-energy-type/renewable-energy/renewables-in-this-review.html, viewed 11 May 2014.

42 IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1, Executive Summary, p. 5; Jason Channell, Timothy Lam, and Shahriar Pourreza, *Shale & Renewables: A Symbiotic Relationship* (London: Citi Research, September 2012); BNEF, "Australia LCOE Update: Wind Cheaper than Coal and Gas," *Asia & Oceania Clean Energy Research Note*, 31 January 2013; Sourabh Sen, "Assessing Risk and Cost in India: Solar's Trajectory Compared to Coal," Renewable Energy World, 17 April 2013, http://www.renewableenergyworld.com/rea/news/article/2013/04/risk-and-cost-solars-trajectory-compared-to-coal; Sarasin, *Working Towards a Cleaner and Smarter Power Supply: Prospects for Renewables in the Energy Revolution* (Basel, Switzerland: December 2012), p. 9; Bridge to India, *India Solar Compass*, April 2013, p. 26; IRENA, *Renewable Power Generation Costs in 2012: An Overview* (Abu Dhabi: January 2013), http://costing.irena.org/media/2769/Overview_Renewable-Power-Generation-Costs-in-2012.pdf; IEA, *Tracking Clean Energy Progress 2013* (Paris: OECD/IEA, 2013), http://www.iea.org/publications/tcep_web.pdf. Note that offshore wind levelised costs increased between the second quarter of 2009 and the first quarter of 2013, as project developers moved farther from shore and into deeper waters, and some CSP and geothermal power technologies also saw cost increases during this period, from FS–UNEP Centre and BNEF, op. cit. note 38. Other renewables are becoming cost competitive in several west African countries, including Burkina Faso, Liberia, and The Gambia, per Quansah, op. cit. note 18.

43 FS-UNEP Centre and BNEF, op. cit. note 16, pp. 36–37. According to BNEF, conventional generation sources general saw per MWh costs increase over the period from early 2009 to early 2014, with the exception of gas-fired generation in the United States, and capital costs for coal- and gas-fired and nuclear power plants has generally increased as well, reflecting materials and labour costs.

44 Latin America, Africa, and the Middle East without any subsidy support from ibid., pp. 36–37, 41–43; many renewables are already competitive relative to new fossil fuel plants, and wind and solar PV have reached or are approaching competitiveness without generation-based incentives in a number of markets, per IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1, p. 5; Steve Sawyer, GWEC, personal communication with REN21, 15 January 2014.

45 Ernesto Macías Galán, Alliance for Rural Electrification (ARE), personal communication with REN21, 15 January 2014; Sven Teske, Greenpeace International, personal communication with REN21, 13 January 2014; Clint Wilder, "2014: The Maturation of Clean Tech," Renewable Energy World, 13 January 2014, http://www.renewableenergyworld.com/rea/news/article/2014/01/2014-the-maturation-of-clean-tech; Giles Parkinson, "Australian utilities erect barricades in bid to halt solar storm," Renew Economy, 23 October 2013, http://reneweconomy.com.au/2013/australian-utilities-erect-barricades-in-bid-to-halt-solar-storm-91715; Europe from Rainer Hinrichs-Rahlwes, BEE, personal communication with REN21, 12 January 2014; Marc Gunther, "With Rooftop Solar on Rise, U.S. Utilities Are Striking Back," *Yale Environment360*, 3 September 2013, http://e360.yale.edu/feature/with_rooftop_solar_on_rise_us_utilities_are_striking_back/2687/.

46 See, for example, Mark Osborne, "Hareon Solar Teaming with Shanghai Electric Power on 800 MW of PV Projects," PV tech, 13 March 2014, http://www.pv-tech.org/news/hareon_solar_teaming_with_shanghai_electric_power_on_800mw_of_pv_projects; "How to lose half a trillion euros," *The Economist*, October 2013, http://www.economist.com/news/briefing/21587782-europes-electricity-providers-face-existential-threat-how-lose-half-trillion-euros; Gunther, op. cit. note 45; Ron Pernick, Clint Wilder, and James Belcher, *Clean Energy Trends 2014*, March 2014, p. 10, http://cleanedge.com/reports/Clean-Energy-Trends-2014.

47 Rankings were determined by gathering data for the world's top countries for hydropower, wind, solar PV, CSP, biomass, and geothermal power capacity. **China** based on 260 GW hydropower (not including pure pumped storage capacity) from CEC, op. cit. note 39; 91,412 MW installed by the end of 2013, from Chinese Wind Energy Association (CWEA), provided by Shi Pengfei,

CWEA, personal communication with REN21, 14 March 2014, and from GWEC, op. cit. note 1; almost 20 GW of solar PV based on data from China National Energy Administration, provided by Masson, op. cit. note 1, from EPIA, *Global Market Outlook for Photovoltaics 2014-2018*, op. cit. note 1, and from Masson, op. cit. note 1; 6.2 GW of bio-power (excluding 2.3 GW of incineration) from China National Renewable Energy Centre, "CNREC 2013 Activities within China National Renewable Energy Centre" (Beijing: March 2014); 26.6 MW geothermal from GEA, op. cit. note 5, and from CNREC, op. cit. this note; 10 MW of CSP from Geng Dan, "Review and Outlook on China Renewable Energy," presentation for REvision2014: Global Energy Turnarounds and Japan's Path, Tokyo, 25 February 2014, http://jref.or.jp/en/images/pdf/20140225/Geng_Dan_REvision2014_Session1_2.pdf; also from Luis Crespo, ESTELA, personal communication with REN21, February 2014; and small amounts of ocean energy capacity. **United States** based on 78.4 GW hydropower from 2012 capacity from EIA, *Electric Power Annual*, Table 4.3 Existing Capacity by Energy Source, http://www.eia.gov/electricity/annual/html/epa_04_03.html; projected net additions in 2013 of 201 MW from idem, Table 4.5 Planned Generating Capacity Changes by Energy Source, 2013-2017, http://www.eia.gov/electricity/annual/html/epa_04_05.html; 61,110 MW of wind from American Wind Energy Association (AWEA), "U.S. Capacity & Generation," in *U.S. Wind Industry Annual Market Report 2013* (Washington, DC: 10 April 2014), http://www.awea.org/AnnualMarketReport.aspx?ItemNumber=6305&RDtoken=35392&userID=; 12.1 GW of solar PV from GTM Research and U.S. Solar Energy Industries Association (SEIA), *U.S. Solar Market Insight Report: 2013 Year-in Review* (Washington, DC: 2014), Executive Summary, http://www.seia.org/research-resources/solar-market-insight-report-2013-year-review; 15.8 GW bio-power from U.S. Federal Energy Regulatory Commission (FERC), Office of Energy Projects Energy Infrastructure Update for December 2013, https://www.ferc.gov/legal/staff-reports/2013/dec-energy-infrastructure.pdf; 3,442 MW of geothermal power from GEA, op. cit. this note; 882 MW of CSP from Morse, op. cit. note 5; "CSP World Map," op. cit. note 5; "CSP Today Global Tracker," op. cit. note 5; SEIA, "Solar Energy Facts: 2013 Year in Review," 5 March 2014, http://www.seia.org/sites/default/files/YIR%202013%20SMI%20Fact%20Sheet.pdf; SEIA, "Major Solar Projects in the United States: Operating, Under Construction, or Under Development," 6 March 2014, http://www.seia.org/sites/default/files/resources/Major%20Solar%20Projects%20List%203.6.14.pdf; "NextEra dedicates 250 MW Genesis CSP Plant," Solar Server, 25 April 2014, http://www.solarserver.com/solar-magazine/solar-news/current/2014/kw17/nextera-dedicates-250-mw-genesis-csp-plant.html; Abengoa Solar, "Mojave Solar Project," http://www.abengoasolar.com/web/en/nuestras_plantas/plantas_en_construccion/estados_unidos/; "NextEra dedicates 250 MW Genesis CSP plant," SolarServer, http://www.solarserver.com/solar-magazine/solar-news/current/2014/kw17/nextera-dedicates-250-mw-genesis-csp-plant.html; U.S. National Renewable Energy Laboratory (NREL), "Concentrating Solar Power Projects: Solana Generating Station," 17 March 2014, http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=23. **Brazil** based on 85.7 GW of hydropower from National Agency for Electrical Energy (ANEEL), "Fiscalização dos serviços de geração," February 2013, http://www.aneel.gov.br/area.cfm?idArea=37; 80 MW of solar PV from "20131106_PVcapacity_2009-2012," unpublished database provided by Christopher Werner, Hanergy, personal communication with REN21, 15 October 2013; 11,423 MW of bio-power from ANEEL, 2013, provided by Maria Beatriz Monteiro, CENBIO, personal communication with REN21, 16 April 2014; 3,456 MW of wind from GWEC, op. cit. note 5; Francine Martins Pisni, Associação Brasileira de Energia Eólica (ABEEólica), communication with REN21 via Suani Coelho, CENBIO, 29 April 2014. **Canada** based on 76.2 GW of hydropower from the following: Canadian Hydropower Association, communication with REN21, February 2014, and Hydropower Equipment Association (HEA) data based on its members' aggregated input, personal communication with REN21, April 2014; also on 7,803 MW wind from Canadian Wind Energy Association (CanWEA), "Installed Capacity," http://canwea.ca/wind-energy/installed-capacity/, viewed 11 April 2014, and GWEC, op. cit. note 1; 1,284 MW solar PV from IEA-PVPS, op. cit. note 1; 2.5 GW of bio-power from Canadian Industrial Energy End-Use Data and Analysis Centre, Simon Fraser University, provided by Farid Bensebaa, National Resource Council Canada, personal communication with REN21, 12 May 2014; 20 MW of ocean from IEA Implementing Agreement on Ocean Energy Systems (IEA-OES), "Ocean Energy in the World," http://www.ocean-energy-systems.org/ocean_energy_in_the_world/, and from IEA-OES, *Annual Report 2012* (Lisbon: 2012), Table 6.1, http://www.ocean-energy-systems.org/oes_reports/annual_reports/. **Germany** based on 5.6 GW of hydropower, 35.9 GW of solar PV, 34.7 GW total installed wind capacity, and 8.1 GW of bio-power from Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), *Erneuerbare Energien im Jahr 2013* (Berlin: Bundesministerium für Wirtschaft und Energie (BMWi), 2014), http://www.bmwi.de/BMWi/Redaktion/PDF/A/agee-stat-bericht-ee-2013,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf; 28.5 MW geothermal power from GEA, op. cit. this note.

48 China share based on data and references provided elsewhere in this section; 260 GW of hydropower from CEC, "CEC Publishes the Demand/Supply Analysis and Forecast of China Power Industry 2014," 19 March 2014, http://english.cec.org.cn/No.105.1534.htm.

49 China, United States, and Germany from Endnote 47, all references. **Spain** based on 17.1 GW of hydropower from REE, op. cit. note 5, updated March 2014; 22,959 GW of wind from GWEC, op. cit. note 1; 5,566 MW solar PV from IEA-PVPS, op. cit. note 1; 981 MW bio-power, and 2,300 MW CSP from REE, op. cit. note 5, updated March 2014. **Italy** based on 18.2 GW hydropower from Gestore Servizi Energetici (GSE), "Impianti a fonti rinnovaili in Italia: Prima stima 2012," 28 February 2013, and no additions identified for 2013; 4 GW of bio-power is preliminary data from GSE, provided by Noemi Magnanini, GSE, personal communication with REN21, 16 May 2014; 8,551 MW of wind from EWEA, op. cit. note 36; 17,600 MW of solar PV from IEA-PVPS, op. cit. note 1; 900 MW of geothermal power from GEA, op. cit. note 5; and 5 MW (demonstration) of CSP from Crespo, op. cit. note 5. **India** based on 43.7 GW of hydropower from CEA, "Installed capacity as of 31 December 2013," http://www.cea.nic.in/reports/monthly/inst_capacity/dec13.pdf, and idem, "List of H.E. Stations in the Country with Station Capacity Above 25 MW," http://www.cea.nic.in/reports/hydro/list_he__stations.pdf; capacity additions in 2013 (>25 MW) of 554 MW from CEA, "Executive Summary of the Power Sector (monthly)," http://www.cea.nic.in/exesum_cood.html; installed capacity in 2013 (<25 MW) of 3,763.15 MW from Government of India, Ministry of New and Renewable Energy (MNRE), "Physical Progress (Achievements)," http://www.mnre.gov.in/mission-and-vision-2/achievements/, viewed 18 January 2014; capacity additions in 2013 (<25 MW) of 267 MW based on difference of year-end 2013 figure (above) and year-end 2012 figure (3,496.15 MW) from MNRE, *Annual Report 2012-2013* (New Delhi: undated), Table 3.7, http://www.mnre.gov.in/mission-and-vision-2/publications/annual-report-2; 20,150 MW of wind from GWEC, op. cit. note 1; 2,319 MW of solar PV from IEA-PVPS, op. cit. note 1; about 4.4 GW of bio-power from MNRE, "Physical Progress (Achievements)," op. cit. this note. **Figure 4** based on sources in this note and on the following sources for EU-28 and BRICS: EU-28 based on 123.5 GW hydropower in 2012 (although this includes some mixed pumped storage plants for Austria), from International Journal on Hydropower & Dams (IJHD), *Hydropower & Dams World Atlas 2013* (Wallington, Surrey, U.K.: 2013), and from hydropower data provided in previous notes for Germany, Italy and Spain; 117,289 MW of wind from EWEA, op. cit. note 36; 80 GW of solar PV from EPIA, *Global Market Outlook for Photovoltaics 2014-2018*, op. cit. note 1; and from Masson, op. cit. note 1; 34.5 GW of bio-power from the following: AGEE-Stat, op. cit. note 47; Luca Benedetti, Energy Studies and Statistics, GSE, Rome, personal communication with REN21, 16 May 2014; REE, op. cit. note 5, updated March 2014; Directorate General for Energy and Geology (DGEG), provided by Lara Ferreira, Portuguese Renewable Energy Association, personal communication with REN21, May 2014; U.K. Department of Energy and Climate Change (DECC), *Statistics, Energy Trends Section 6: Renewables, Department of Energy and Climate Change*, March 2014 (updated 10 April 2014), p. 6, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295356/6_Renewables.pdf; Réseau de Transport d'Électricité, (RTE), *Bilan Électrique 2013* (Paris: 2014), p. 21; http://www.rte-france.com/uploads/Mediatheque_docs/vie_systeme/annuelles/Bilan_electrique/bilan_electrique_2013.PDF; Government Offices of Sweden, "Sweden's second progress report on the development of renewable energy pursuant to Article 22 of Directive 2009/28/EC," 23 December 2013, http://ec.europa.eu/energy/renewables/reports/2013_en.htm; E-Control Austria, "Entwicklung der anerkannten 'sonstigen' Ökostromanlagen (exclusive Kleinwasskraft) von 2002–2013," http://www.e-control.at/portal/page/portal/medienbibliothek/oeko-energie/dokumente/pdfs/Entwicklung%20anerkannter%20%C3%96kostromanlagen%202002-2013_Tabelle_Stand%20Mai%202014.pdf, updated May 2014; preliminary data from IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1; 960 MW of geothermal from GEA, op. cit. note 5; 2,300 MW of

CSP from REE, op. cit. note 5, updated March 2014; 241 MW of ocean energy from IEA-OES, *Annual Report 2011* (Lisbon: OES Secretary, 2011), Table 6.1, p. 122. In addition to references for Brazil, India, and China, BRICS from the following: Russia based on 46.7 GW of hydropower from System Operator of the Unified Energy System of Russia, *Report on the Unified Energy System in 2013* (Moscow: undated), http://www.so-ups.ru/fileadmin/files/company/reports/disclosure/2014/ups_rep2013.pdf; 15 MW wind from EWEA, op. cit. note 36; 1.5 GW bio-power from IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1; 97 GW geothermal power from GEA, op. cit. note 5; and a small amount of ocean energy capacity. South Africa based on about 680 MW of hydropower (not including pumped storage), from Hydro4Africa, "African Hydropower Database—South Africa," http://hydro4africa.net/HP_database/country.php?country=South%20Africa, viewed 9 May 2014; 102 MW of wind from WWEA, op. cit. note 34; 30 MW solar PV from EScience Associates, Urban-Econ Development Economists, and from Chris Ahlfeldt, *The Localisation Potential of Photovoltaics (PV) and a Strategy to Support Large Scale Roll-Out in South Africa*, prepared for the South African Department of Trade and Industry, March 2013, p. x, http://www.sapvia.co.za; 25 MW bio-power based on IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1.

50 Based on data and sources in previous endnotes in this section for Germany and Spain, population data for 2012 from World Bank, "World development indicators – Population (total)," 2014, http://data.worldbank.org/indicator/SP.POP.TOTL, viewed 7 March 2014. Sources also include the following: **Denmark** based on 9 MW of hydropower from IJHD, op. cit. note 49; 4,772 MW of wind power from EWEA, op. cit. note 36; 532 MW of solar PV from IEA-PVPS, op. cit. note 1; 1.6 GW of bio-power is a projection from 2013 from IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1, p. 75, based on 1.4 GW in 2012 from idem. **Portugal** based on 5 GW of hydropower from IJHD, op. cit. note 49; 4,724 MW of wind power from EWEA, op. cit. note 36; 284 MW of solar PV from IEA-PVPS, op. cit. note 1; 2,591 MW of bio-power from DGEG, op. cit. note 49. **Sweden** based on 16.2 GW of hydropower from IJHD, op. cit. note 49; 4,470 MW of wind power from EWEA, op. cit. note 36; 43 MW of solar PV from IEA-PVPS, op. cit. note 1; about 4.3 GW of bio-power based on 4,055 MW in 2012, up from 3,401 MW in 2011, from Government Offices of Sweden, op. cit. note 49, and on additions in 2013 including: 180 MW (CHP) from "Biomass Power Plants in Sweden," Power plants around the world, based on data from Platts UDI World Electric Power Plants Data Base, updated 27 April 2014, http://www.industcards.com/biomass-sweden.htm, and a CHP plant (20 MW electric/60 MW heat), from Fortum, "Fortum inaugurates new waste-to-energy combined heat and power plant in Sweden," press release (Stockholm: 29 November 2013), http://www.fortum.com/en/mediaroom/pages/fortum-inaugurates-new-waste-to-energy-combined-heat-and-power-plant-in-sweden.aspx

51 Based on investment data in FS-UNEP Centre and BNEF, op. cit. note 16, and on 2012 gross domestic product (GDP) in current U.S. dollars, from World Bank, "World development indicators - GDP (current US$)", updated April 2014, http://data.worldbank.org/indicator/NY.GDP.MKTP.CD.

52 Based on data and sources in previous endnotes in this section, and global data including the following: 1,000 GW of hydropower from IHA, op. cit. note 1; from preliminary estimates in IEA, *Medium-Term Renewable Energy Market Report 2014*, op. cit. note 1; and from HEA, op. cit. note 47; 318 GW of wind from GWEC, op. cit. note 1, from WWEA, op. cit note 34, and from Navigant Research, op. cit. note 1, Executive Summary; 139 GW of solar PV from IEA-PVPS, op. cit. note 1, from Masson, op. cit. note 1; 88 GW of bio-power based on based on 83 GW of capacity at end-2012 (see GSR 2013), preliminary data from IEA, M*edium-Term Renewable Energy Market Report 2014*, op. cit. note 1, and national level data from the following: FERC, op. cit. note 47; AGEE-Stat, op. cit. note 47; CNREC, op. cit. note 47; ANEEL, op. cit. note 47; IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1; REE, op. cit. note 5, updated March 2014; MNRE, "Physical Progress (Achievements)," op. cit. note 49; DGEG, op. cit. note 48; DECC , op. cit. note 49, p. 6; ISEP, *Renewables Japan Status Report 2014* (Tokyo: March 2014) (in Japanese), data provided by Hironao Matsubara, ISEP, personal communication with REN21, 23 April 2014; Benedetti, op. cit. note 49; Government Offices of Sweden, op. cit. note 49; 12 GW of geothermal from GEA, op. cit. note 5; 3.4 GW of CSP from REN21, op. cit. note 1; Crespo, op. cit. note 5; Fred Morse, Morse Associates, Inc., personal communication with REN21, February and May 2014; "CSP World Map," op. cit. note 5; "CSP Today Global Tracker," op. cit. note 5; NREL, "Concentrating Solar Power Projects," http://www.nrel.gov/csp/solarpaces/; SEIA, "Solar Energy Facts: 2013 Year in Review," op. cit. note 47; SEIA, "Major Solar Projects in the United States: Operating, Under Construction, or Under Development," op. cit. note 47; "NextEra dedicates 250 MW Genesis CSP Plant," op. cit. note 47; Abengoa Solar, "Mojave Solar Project," op. cit. note 47; and 0.5 GW of ocean energy from OES, *Annual Report 2012* (Lisbon: 2012), Table 6.1, http://www.ocean-energy-systems.org/oes_reports/annual_reports/2012_annual_report/; OES, *Annual Report 2013* (Lisbon: 2013), Table 6.2, http://www.ocean-energy-systems.org/documents/82577_oes_annual_report_2013.pdf/; IEA, op. cit. note 5, p. 179, and other sources provided in Ocean Energy section.

53 CEC, op. cit. note 39; FS-UNEP Centre and BNEF, op. cit. note 16, p. 25.

54 More than 20% from Geng Dan, op. cit. note 47. Note that electricity generation from wind power was up 36.3% and from solar PV up 143% over 2012, from CEC, op. cit. note 39.

55 EWEA, op. cit. note 36, p. 6.

56 Union of the Electricity Industry–EURELECTRIC, *Utilities: Powerhouses of Innovation* (Brussels: 2013), p. 14, http://www.eurelectric.org/media/79178/utilities_powerhouse_of_innovation_full_report_final-2013-104-0001-01-e.pdf. In 2013, total fossil power capacity declined by 11 GW due to decommissioning, whereas total renewable capacity increased by more than 24 GW, based on 35,181 MW of gross power capacity additions, 21,834 MW of capacity decommissioned (of which 10,146 MW was natural gas; 7,723 MW was coal; 2,792 MW was fuel oil; and the remainder a combination of biomass, wind power, hydropower, and waste), and an estimated 25,450 MW of renewable capacity from EWEA, op. cit. note 36, p. 6.

57 Hydropower output was down 2.6% over the year; non-hydro renewables represented just under half of total renewable output, from EIA, *Monthly Energy Review*, March 2014, Table 7.2a "Electricity Net Generation: Total (All Sectors)," p. 95, http://www.eia.gov/totalenergy/data/monthly/previous.cfm.

58 Coal's share was down 18.9% based on all electricity generation in the United States, including the electric power sector and other sectors, from ibid.

59 Sofia Martinez, Instituto para la Diversificación y Ahorro de la Energía (IDAE), Spain, personal communication with REN21, 7 April 2014. Wind generated 20.9% versus nuclear's 20.8%, according to advance report of the system operator REE, op. cit. note 40.

60 Capacity added based on nearly 0.4 GW of bio-power capacity from MNRE, "Physical Progress (Achievements)," op. cit. note 49; 554 MW of large-scale hydropower (>25 MW) from CEA, Executive Summary of the Power Sector (monthly), at www.cea.nic.in/exesum_cood.html; 267 MW of small-scale hydropower based on difference of year-end 2013 figure (above) and year-end 2012 figure (3,496.15 MW) from MNRE, *Annual Report 2012-2013*, op. cit. note 49, Table 3.7; 1,115 MW of solar PV from IEA-PVPS, op. cit. note 1; 50 MW of CSP from Jenny Muirhead, "MENA Shows Patience Towards Delay in CSP Projects," *Weekly Intelligence Brief: July 15–July 22*, CSP Today, 22 July 2013, http://social.csptoday.com/markets/weekly-intelligence-brief-july-15-%E2%80%93-july-22; 1,729 MW of wind from GWEC, op. cit. note 1. Total capacity based on about 4.4 GW of bio-power from MNRE, "Physical Progress (Achievements)," op. cit. note 49; total large-scale hydro capacity of 39,893.4 MW from CEA, installed capacity as of 31 December 2013, http://www.cea.nic.in/reports/monthly/inst_capacity/dec13.pdf, and http://www.cea.nic.in/reports/hydro/list_he__stations.pdf; small hydropower facilities capacity of 3,763.15 MW from MNRE, *Annual Report 2012-2013*, op. cit. note 49; 2,200 MW of solar PV from IEA-PVPS, op. cit. note 1; 50 MW of CSP from Muirhead, op. cit. this note; and 20,150 MW of wind from GWEC, op. cit. note 1.

61 Based on data in previous endnote.

62 Ibid., and total electric generating capacity added during 2013 of 22,977.9 MW, from CEA, provided by Shirish Garud, TERI, personal communication with REN21, 27 April 2014.

63 Sawyer, op. cit. note 40.

64 Figure of 4.7 GW from Sawyer, op. cit. note 40, 14 April 2014; year-end commissioned capacity from GWEC, op. cit. note 1, p. 24; grid-connected from ANEEL, cited in "Capacidade instalada para energia eólica cresce 20% no Brasil," *Jornal da Energia*, 1 April 2014, http://www.portalabeeolica.org.br/index.php/noticias/1739-capacidade-instalada-para-energia-eólica-cresce-20-no-brasil.html (using Google Translate).

65 Decline in investment from in FS-¬UNEP Centre and BNEF, op. cit. note 16; increase in capacity added in 2013 relative to 2012 from Masson, op. cit. note 1, and EPIA, *Global Market Outlook for*

Photovoltaics 2014-2018, op. cit. note 1.

66 Fifteen countries and 8 in 2010 from BP, "Renewable Power," http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy-2013/review-by-energy-type/renewable-energy/renewable-power-.html, viewed 11 May 2014; three additional based on information from BP, "Renewables in this Review," http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy-2013/review-by-energy-type/renewable-energy/renewables-in-this-review.html, viewed 11 May 2014. The countries are Austria, Belgium, Denmark, El Salvador, Finland, Germany, Iceland, Republic of Ireland, Italy, Kenya, Lithuania, Netherlands, Portugal, Spain, Sweden, and the United Kingdom, from idem, and based on BP, "Statistical Review of World Energy 2013 Workbook," data from "Electricity Generation," and "Other Renewables TWh," http://www.bp.com/en/global/corporate/about-bp/energy-economics/statistical-review-of-world-energy-2013.html.

67 Leidreiter, op. cit. note 21; 100ee-Regionen, http://100ee.deenet.org/, viewed 27 April 2014; Institut dezentrale Energietechnologien (IdE) GmbH, 100 RE Regions in Germany, Europe and the World (Kassel: IdE, January 2014), http://100ee.deenet.org/fileadmin/redaktion/100ee/Downloads/broschuere/Good-Practice_Broschuere_Inhalt_Web.pdf. Also, see Energy Agency of Upper Austria, "The Upper Austrian Energy Strategy 'Energy Future 2030'," April 2013, http://www.esv.or.at/english/energy-in-upper-austria/; "Spanish Island to be Fully Powered by Wind, Water," Earthtechling.com, 28 April 2014, http://earthtechling.com/2014/04/spanish-island-to-be-fully-powered-by-wind-water/. See also Reference Tables R12–R15 for targets.

68 Djibouti from "Djibouti—Vers une croissance verte," *La Nation ler Quotidien Djiboutien*, 5 May 2014, http://www.lanationdj.com/djibouti-vers-croissance-verte/#; Scotland and Tuvalu from GWEC, op. cit. note 1, p. 15.

69 Joß Bracker, Oeko-Institut e.V. - Institute for Applied Ecology, personal communication with REN21, 17 and 22 April 2014.

70 Ibid; and Hungary, based on domestic hydropower, from M. Prantner, Wuppertal Institute for Climate, Environment, and Energy, personal communication with REN21, 10 April 2014.

71 Australia from "GreenPower," viewed 1 May 2013, http://www.greenpower.gov.au; South Africa from "How to Buy Green Electricity Certificate (GECs)," http://www.capetown.gov.za/en/electricity/GreenElectricity/Pages/Howtopurchasegreenelectricitycertificates.aspx, viewed 15 February 2013; Canada from, for example, Bullfrog Power, http://www.bullfrogpower.com/index.cfm; Japan from United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Low Carbon Green Growth Roadmap for Asia and the Pacific. Case Study: Stimulating Consumer Interest in Businesses That Go Green—Japan's Green Power Certificate Scheme," 2012, http://www.unescap.org.

72 The capacity equivalent of this demand is about 17 GW, from J. Heeter and T. Nicholas, *Status and Trends in the U.S. Voluntary Green Power Market* (2012 Data) (Golden, CO: NREL, October 2013), p. v, http://www.nrel.gov/docs/fy14osti/60210.pdf. Note that total green power market sales in the United States rose 36% from 2010 to 2012. The vast majority comes from wind power, from idem.

73 Ambitious targets from Chris Meehan, "US Companies' Use of Solar Increases 40% Over 2012," Renewable Energy World, 23 October 2013, http://www.renewableenergyworld.com/rea/blog/post/2013/10/companies-use-of-solar-in-u-s-increases-40-over-2012; for companies installing and operating their own systems see, for example, "Google's Still a Big Fan of Renewable Energy," Renewable Energy World, 18 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/googles-still-a-big-fan-of-renewable-energy?cmpid=SolarNL-Saturday-October19-2013; "Apple Owns Biggest Private Solar Power System in US," Fox News, 22 March 2013, http://www.foxnews.com/tech/2013/03/22/apple-owns-biggest-private-solar-power-system-in-us/; corporate long-term power purchase agreements, from James Montgomery, "Microsoft vs. Apple Still Making Headlines—in Renewable Energy," Renewable Energy World, 5 November 2013, http://www.renewableenergyworld.com/rea/news/article/2013/11/microsoft-vs-apple-still-making-headlines-in-renewable-energy; Rahul Sachitanand, "Big business groups to push renewable energy space by raising capacity," *Economic Times* (India), 13 February 2013, http://articles.economictimes.indiatimes.com/2013-02-14/news/37100144_1_renewable-energy-kiran-energy-k-subramanya; Stefan Nicola, "BMW Taps Wind to Guard Profits in Merkel's Nuclear Switch," Renewable Energy World, 19 February 2013, http://www.renewableenergyworld.com/rea/news/article/2013/02/bmw-taps-wind-to-guard-profits-in-merkels-nuclear-switch; Christopher Martin, "US Auto Factory Chooses Wind Energy for On-Site Power Generation," *Bloomberg*, 10 January 2014, http://www.renewableenergyworld.com/rea/news/article/2014/01/u-s-auto-factory-chooses-wind-energy-for-on-site-power-generation; Meg Cichon, "IKEA Enters US Wind Market with Largest Renewables Investment to Date," Renewable Energy World, 10 April 2014, http://www.renewableenergyworld.com/rea/news/article/2014/04/ikea-sticks-with-renewables-commitment-makes-largest-investment-to-date; Nathan Paluck, "Mexico's New Opened Energy Market Attracts Renewables," Renewable Energy World, 8 May 2014, http://www.renewableenergyworld.com/rea/news/article/2014/05/mexicos-newly-opened-energy-market-attracts-renewables?cmpid=WNL-Friday-May9-2014

74 "Australia's First Community-Owned Wind Farm in Daylesford," *Castlemaine Independent*, 18 October 2013, http://www.castlemaineindependent.org/2013/10/australias-community-owned-wind-farm-daylesford/; "Australian Community Solar Project Begins Operation," *PV News*, January 2013, p. 11; The Greens, "Unleashing Community-Owned Energy," http://greens.org.au/community-energy, viewed 3 March 2014. In Japan, community-owned power has been important since 2011, and this trend is accelerating, per Tetsu Iida, ISEP, personal communication with REN21, 14 January 2014. Thailand from IEA-PVPS, *Trends in Photovoltaic Applications: Survey Report of Selected IEA Countries Between 1992 and 2012* (Brussels: 2013). North America from, for example, "CAW Owned and Operated Wind Turbine Begins Operation in Port Elgin, Ontario," 25 March 2013, http://www.caw.ca/en/12003.htm; as of July 2013, the capacity of existing community solar projects in the United States exceeded 14 MW, with an additional 13 MW of projects under development, from Heeter and Nicholas, op. cit. note 72. Europe based on information available at Communitypower.eu, viewed 20 March 2014; more than 80,000 people in Germany hold shares in collectively run electricity and heat systems; in Denmark, more than 100 wind energy co-operatives have combined ownership of three-fourths of Denmark's turbines, from Anna Leidreiter, "The Last Word: Local Development Through Community-led Renewable Energy," *Renewable Energy World*, March–April 2013, pp. 54–55; Andrew Williams, "Sharing Renewable Energy: Solar Power Co-operatives in the UK," Renewable Energy World, 8 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/sharing-renewable-energy-solar-power-co-operatives-in-the-uk.

75 In Denmark, more than 100 wind energy co-operatives have combined ownership of three-fourths of Denmark's turbines, from Leidreiter, op. cit. note 74; Craig Morris, "Citizens Own Half of German Renewable Energy," 29 October 2013, http://energytransition.de/2013/10/citizens-own-half-of-german-renewables/?pk_campaign=nl8. See also Agentur fur Erneuerbare Energien, "Energiegenossenschaften in Deutschland," http://www.unendlich-viel-energie.de/mediathek/grafiken/energiegenossenschaften-in-deutschland, viewed 9 May 2014; and Christoph Burger and Jens Weinmann, "Bioenergy in China: Can China Learn from Germany's Experience?" 10 March 2014, http://knowledge.ckgsb.edu.cn/2014/03/10/technology/bioenergy-in-china/; 20 million Germans from Leidreiter, op. cit. note 21; 100ee-Regionen, http://100ee.deenet.org/, viewed 27 April 2014; Institut dezentrale Energietechnologien (IdE), "GmbH, 100 RE Regions in Germany, Europe and the World" (Kassel: IdE, January 2014), http://100ee.deenet.org/fileadmin/redaktion/100ee/Downloads/broschuere/Good-Practice_Broschuere_Inhalt_Web.pdf; "Legambiente presenta Comuni Rinnovabili 2014. Sono 700mila gli impianti da fonti pulite distribuiti nel 100% dei Comuni," Legambiente.it, 7 May 2014, http://www.legambiente.it/contenuti/comunicati/legambiente-presenta-comuni-rinnovabili-2014-sono-700mila-gli-impianti-da-fonti (using Google Translate).

76 See, for example, A.C. Orrell et al., *2012 Market Report on Wind Technologies in Distributed Applications* (Richland, WA: Pacific Northwest Laboratory, August 2013), http://www1.eere.energy.gov/wind/pdfs/2012_distributed_wind_technologies_market_report.pdf, and Market and Industry Trends section of this report.

77 See, for example, "Microgrid Resources Coalition Launched at IDEA Campus Energy Conference," PR Web, 18 February 2014, http://www.prweb.com/releases/2014/02/prweb11594223.htm; Darrell Delamaide, "Dawn of Microgrids," *EnergyBiz Magazine*, September/October 2013, http://www.energybiz.com/magazine/article/325109/dawn-microgrids; Justin Gerdes, "How Microgrids are Bolstering the Nation's Power Infrastructure," Smithsonian, 15 November 2013, http://www.smithsonianmag.com/science-nature/how-microgrids-are-bolstering-the-nations-power-infrastructure-

180947705/?all. See also section on Distributed Renewable Energy in Developing Countries.

78 IEA, *World Energy Outlook 2013*, op. cit. note 1, p. 207.

79 Small but gradually rising share from IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1; modern renewables met 8% of global demand for heat in 2011, per IEA, *World Energy Outlook 2013*, op. cit. note 1, p. 207; the portion of modern renewable energy in total final heat demand "is currently above 10%," per idem, p. 199.

80 IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1, pp. 217–18.

81 Ibid.

82 Ibid.

83 IEA-Renewable Energy Technology Deployment (IEA-RETD), *Renewables for Heating and Cooling – Untapped Potential* (Paris: OECD/Paris, 2007); about 90% based on 12.8 EJ of heat from modern biomass out of a total 13.8 EJ in 2010, from IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1, p. 217, and considering rapid growth of solar thermal heating in recent years, from an estimated 0.7 EJ in 2010, from idem, to 1.01 EJ in 2013, from Mauthner, op. cit. note 1, and on Mauthner and Weiss, op. cit. note 1.

84 See relevant sections and endnotes in Market and Industry Trends for more details and sources.

85 Based on data from IEA, *World Energy Outlook 2011* (Paris: OECD/IEA, 2011), and IEA, *World Energy Outlook 2013*, op. cit. note 1. See also Bioenergy section in Market and Industry Trends.

86 Heinz Kopetz, World Bioenergy Association, personal communication with REN21, 13 January 2014.

87 Ibid.

88 IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1, pp. 222–24; European Biogas Association, "Six National Biomethane Registries Are Developing the Foundation for Cross-border Biomethane Trade in Europe," press release (Brussels: 25 November 2013), http://european-biogas.eu/wp-content/uploads/files/2013/11/2013.11.25_ggg_press-release_biomethane-registries.pdf; particularly in Germany, biogas is being blended with natural gas, from D. Loy, Loy Energy Consulting, Germany, personal communication with REN21, 15 April 2014. See also Bioenergy section of this report.

89 IEA, *World Energy Outlook 2013*, op. cit. note 1, Chapter 6.

90 IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1. See, also, Bioenergy and Distributed Renewable Energy sections in this report.

91 Based on data from Mauthner, op. cit. note 1, and on Mauthner and Weiss, op. cit. note 1.

92 Ibid.

93 Solar heaters cost an estimated 3.5 times less than electric water heaters and 2.6 less than gas heaters over the system lifetime, according to Chinese Solar Thermal Industry Federation, cited in Bärbel Epp, "Solar Thermal Competition Heats Up in China," Renewable Energy World, 10 September 2012, http://www.renewableenergyworld.com/rea/news/article/2012/09/solar-thermal-competition-heats-up-in-china.

94 Solar District Heating, Intelligent Energy Europe Programme of the European Union, "Solar District Heating," viewed 6 March 2014, http://www.solar-district-heating.eu/SDH.aspx; Jan-Olof Dalenbäck, "An Emerging Option: Solar District Heating and Cooling," *Euro Heat & Power*, Vol. 10, No. (2013), pp. 26–29; Jan-Olof Dalenbäck, Chalmers University of Technology and Solar District Heating (SDH), personal communication with REN21, 12 April 2014; Solar Heat for Industrial Processes—SHIP Database, IEA-SHC Task 49/IV, http://ship-plants.info/projects, viewed 10 April 2014; Eva Augsten, "The world of solar process heat," *Sun & Wind Energy*, March 2014, pp. 36–45; Uli Jacob, Green Chiller, "Status and Perspective of Solar Cooling in Europe," Australian Solar Cooling 2013 Conference, Sydney, Australia, April 2013.

95 See, for example, Lund, Freeston, and Boyd, op. cit. note 1.

96 See, for example, Bundesverband Geothermie, "The Altheim Rankine Cycle Turbogenerator," www.geothermie.de/wissenswelt/archiv/englisch/the-altheim-rankine-cycle-turbogenerator.html; also see Geothermal Power and Heat section of this report.

97 Burkhard Sanner et al., *Strategic Research and Innovation Agenda for Renewable Heating & Cooling* (Luxemburg: European Commission, European Technology Platform on Renewable Heating and Cooling (ETP-RHC), 2013), p. 30, http://www.rhc-platform.org/fileadmin/user_upload/members/Downloads/RHC_SRA_epo_final_lowres.pdf. For hybrid systems, see, for example, Stephanie Banse, "Thailand: Government Continues Subsidy Programme in 2013," Solar Thermal World, 15 February 2013, http://solarthermalworld.org/content/thailand-government-continues-subsidy-programme-2013; and "Solar + Heat Pump Systems," *Solar Update* (IEA Solar Heating and Cooling Programme), January 2013.

98 Thomas Nowak, European Heat Pump Association (EHPA), personal communication with REN21, 16 April 2014.

99 Ibid.

100 Less attention from policymakers and the heat market is more fragmented and diverse than the electricity market, for example, Frankl, op. cit. note 14.

101 Economic feasibility of delivering renewable heat at competitive prices (relative to relevant alternatives) is "limited due to the unfair competition from fossil energy and high upfront investment cost," from Sanner et al., op. cit. note 97; also from Nowak, op. cit. note 98.

102 Dong Energy, "Green Heat to the Greater Copenhagen Area," press release (Fredericia, Denmark: 8 April 2013), http://www.dongenergy.com/EN/Investor/releases/Pages/omx%20feed%20list%20details.aspx?omxid=678722; UN ESCAP, "Low Carbon Green Growth Roadmap for Asia and the Pacific…," op. cit. note 71; U.K. from Dave Elliott, "Green Energy Retailing," Environmental Research Web, 28 April 2012, http://environmentalresearchweb.org/blog/2012/04/; Bullfrog Power in Canada provides green natural gas to the nation's natural gas pipeline for household and other purposes, from Bullfrog Power, "Green Natural Gas: Simple. Affordable. Climate Friendly," http://www.bullfrogpower.com/greenenergy/greennaturalgas.cfm.

103 Danish Ministry of Climate, Energy and Building, "Danish Energy Agreement," 22 March 2012, http://www.kebmin.dk/sites/kebmin.dk/files/climate-energy-and-building-policy/denmark/energy-agreements/FAKTA%20UK%201.pdf; Denmark targets from Danish Energy Agency, "Danish Climate and Energy Policy," http://www.ens.dk/en/policy/danish-climate-energy-policy, viewed 12 May 2014, and Danish Ministry of Climate, Energy and Building, "Energy Policy Report 2013," Ministry Report to the Danish Parliament, 24 April 2013, http://www.ens.dk/sites/ens.dk/files/policy/danish-climate-energy-policy/dkenergypolicyreport2013_final.pdf; U.K. Government, "Policy: Increasing the Use of Low-Carbon Technologies—Renewable Heat Incentive (RHI)," updated 9 April 2014, https://www.gov.uk/government/policies/increasing-the-use-of-low-carbon-technologies/supporting-pages/renewable-heat-incentive-rhi; European Parliament, "All New Buildings to Be Zero Energy from 2019," 31 March 2009, http://www.europarl.europa.eu/sides/getDoc.do?language=en&type=IM-PRESS&reference=20090330IPR52892.

104 Data from REN21 database compiled from all available policy references plus submissions from report contributors. For online updates, see the "Renewables Interactive Map" at http://www.ren21.net. See also Reference Table R14.

105 District systems from Jan-Olof Dalenbäck and Sven Werner, CIT Energy Management AB, *Market for Solar District Heating*, supported by Intelligent Energy Europe (Gothenburg, Sweden: September 2011, revised July 2012), http://solarthermalworld.org/sites/gstec/files/story/2013-05-21/sw_solar_markets.pdf; Jan-Olof Dalenbäck, "An Emerging Option: Solar District Heating and Cooling," *Euro Heat & Power*, vol. 10, no. III (2013), pp. 26–29; Jan-Olof Dalenbäck, Chalmers University of Technology and Solar District Heating (SDH), personal communication with REN21, 12 April 2014; Miklos Antics, Ruggero Bertani, and Burkhard Sanner, "Summary of EGC 2013 Country Update Reports on Geothermal Energy in Europe," presented at European Geothermal Congress, Pisa, Italy, 3–7 June 2013; building renovation from Nowak, op. cit. note 98; industrial processes from Mauthner, op. cit. note 1; Jacob, op. cit. note 94; Solar Heat for Industrial Processes—SHIP Database, IEA-SHC Task 49/IV, http://ship-plants.info/projects, viewed 10 April 2014. See also Bioenergy and Geothermal sections of this report.

106 Euroheat & Power, *District Heating and Cooling Country-by-Country 2013 Survey* (Brussels: 2013). European countries include Austria, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Iceland, Italy, Latvia, Lithuania, Norway, Poland, Romania, Slovakia, Slovenia, Sweden, and Switzerland, from idem. Italy, for example, has 317 municipalities with district heating plants that use renewable energy sources, including biomass and geothermal, from "Legambiente presenta Comuni Rinnovabili

2014…," op. cit. note 75.

107 Sanner et al., op. cit. note 97, p. 32.

108 Balancing variable renewables from Rachana Raizada, "Renewables and District Heating: Eastern Europe Keeps in Warm," Renewable Energy World, 13 September 2012, http://www.renewableenergyworld.com/rea/news/article/2012/09/renewables-and-district-heating; see also Peter Kelly-Detwiler, "Denmark: 1,000 Megawatts of Offshore Wind, And No Signs of Slowing Down," *Forbes*, 26 March 2013.

109 Increasing reliability from Anna Leidreiter, Diane Moss, and Markus Groth, *From Vision to Action: A Workshop Report on 100% Renewable Energies in European Regions* (Hamburg: World Future Council, Nordic Folkecenter, and Climate Service Center at the Helmholtz-Zentrum Geesthacht, March 2013), p. 12, http://www.worldfuturecouncil.org/fileadmin/user_upload/Climate_and_Energy/From_Vision_to_Action_Policy_Recommendations_for_100__RE_in_European_Regions.pdf; cornerstone of energy policy from Nowak, op. cit. note 98.

110 China's National Energy Administration issued a notice to relevant authorities in the provinces of Jilin, Hebei, Shanxi, Heilongjiang, Liaoning, and the Inner Mongolia Autonomous Region and Xinjiang Uyghur Autonomous Region to start pilot tests, from Wu Hanxuan, "Intervention Necessary to Spread Wind Power Usage," *Global Times*, 7 August 2013, http://www.globaltimes.cn/content/802300.shtml#.UiCT3yzD9aQ.

111 Sims et al., op. cit. note 13.

112 Estimate of 3% from IEA, *World Energy Outlook 2013*, op. cit. note 1, p. 24; 2.3% from IEA, *Tracking Clean Energy Progress*, op. cit. note 42, p. 90.

113 Some countries have much higher shares, including Brazil (20.1%), the United States (4.4%), and the EU (4.2%), all as of 2010, from IEA, *Tracking Clean Energy Progress*, op. cit. note 42, p. 90.

114 F.O. Licht, "Fuel Ethanol: World Production, by Country (1000 cubic metres)," 2014, and F.O. Licht, "Biodiesel: World Production, by Country (1000 t)," 2014, used with permission from F.O. Licht / Licht Interactive Data, provided by Helena Chum, U.S. National Renewable Energy Laboratory (NREL), personal communication with REN21, 4 March, 2014.

115 See, for example, "Arla Brings Milk Minus Emissions to UK," ngvglobal.com, 19 February 2014, http://www.ngvglobal.com/arla-brings-milk-minus-emissions-to-uk-0219#more-30327; "Oslo Buses to be Fueled by Liquefied Biomethane," ngvglobal.com, 12 February 2014, http://www.ngvglobal.com/oslo-buses-to-be-fueled-by-liquefied-biomethane-0212#more-30213; "Berlin's Household Waste Fuels Refuse Fleet," ngvglobal.com, 18 January 2014, http://www.ngvglobal.com/berlins-household-waste-fuels-refuse-fleet-0118#more-29935; "Bus Depot Largest Biomethane Refueller in Gothenburg," ngvglobal.com, 28 September 2013, http://www.ngvglobal.com/bus-depot-largest-biomethane-refueller-in-gothenburg-0928#more-28659; Switzerland from Dunja Hoffmann, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), personal communica¬tion with REN21, 29 April 2011; "After Completion of the Province to Start the Car Biogas Project Nissan Car 30,000 cubic meters of biogas," Hainan Shenzhou New Energy Construction & Development Co., Ltd, 14 October 2013, http://www.hainanbiogas.com/page.php?xuh=37 (using Google Translate); "'The Morale of the Shortage' Hainan's First Car Started to Crack in Sight Biogas Plant," Hainan Shenzhou New Energy Construction & Development Co., Ltd, 14 October 2013, http://www.hainanbiogas.com/page.php?xuh=32 (using Google Translate).

116 Vehicle stations from "European Biomethane Filling Station Mapping Begins with Finland," ngvglobal.com, 30 November 2013, http://www.ngvglobal.com/european-biomethane-filling-station-mapping-begins-with-finland-1130#more-29417. In Germany, for example, as overall road vehicle sales declined, sales of natural gas vehicles rose almost 40% (to 4,300 vehicles) in the first half of 2013, relative to the same period in 2012 (3,100 vehicles), from "Germany's NGV Population Grows at Record Pace," ngvglobal.com, 23 July 2013, http://www.ngvglobal.com/germanys-ngv-population-grows-at-record-pace-0723#more-27863. See also "Biomethane Fuel Gains Ground in Germany," ngvglobal.com, 31 March 2013, http://www.ngvglobal.com/biomethane-fuel-gains-ground-in-germany-0331#more-26326.

117 For example, "Distiller Methane to Power Vehicles in Philippines," ngvglobal.com, 2 December 2013, http://www.ngvglobal.com/distiller-methane-to-power-vehicles-in-philippines-1202#more-29433; "Waste Management Builds New Biomethane Facility for Fleet Refueling," ngvglobal.com, 18 October 2013, http://www.ngvglobal.com/waste-management-builds-new-biomethane-facility-for-fleet-refueling-1018#more-28867; "ENOC and Dubai Sign MoU to Convert Flared Biogas to Biomethane Fuels," ngvglobal.com, 12 February 2013, http://www.ngvglobal.com/enoc-and-dubai-sign-mou-to-convert-flared-biogas-to-biomethane-fuel-0212; "California Energy Commission Funds Biomethane and CNG Fuel Projects," ngvglobal.com, 13 February 2013, http://www.ngvglobal.com/california-energy-commission-funds-biomethane-and-cng-fuel-projects-0213; "Valtra Plans Biomethane Dual-Fuel Tractor Production in 2013," ngvglobal.com, 15 September 2012, http://www.ngvglobal.com/valtra-plans-biomethane-dual-fuel-tractor-production-in-2013-0915.

118 See, for example, Dave Hurst, "Are E-Bicycle Sales Reducing Car Sales in Europe?" Forbes, 8 May 2013, http://www.forbes.com/sites/pikeresearch/2013/05/08/are-e-bicycle-sales-reducing-car-sales-in-europe/; IEA, Clean Energy Ministerial, Electric Vehicles Initiative, *Global EV Outlook: Understanding the Electric Vehicle Landscape to 2020* (Paris: OECD/IEA, April 2013), http://cleanenergyministerial.org/Portals/2/pdfs/EVI_GEO_2013_FINAL_150dpi.pdf.

119 GIZ, prepared on behalf of Federal Ministry for Economic Cooperation and Development, "Renewables in Rail Transport: Approaches and Examples," compiled by Nicolai Bader, GIZ, April 2014.

120 BYD, "Bogotá Launches the Largest All-electric Taxi Fleet in South America," press release (Bogotá: 3 September 2013), http://www.byd.com/news/news-172.html; Nino Marchetti, "Colombian Police Turn to Electric Motorcycles," EarthTechling.com, 1 July 2013, http://earthtechling.com/2013/07/colombian-police-turn-to-electric-motorcycles/.

121 In Norway, about 1,200 EVs are sold monthly, from S. Morlin-Yron, "Norway - electric vehicles lead the car market," *The Ecologist*, 4 February 2014, http://www.theecologist.org/News/news_round_up/2266537/norway_electric_vehicles_lead_the_car_market.html.

122 U.S. Department of Energy, Energy Efficiency and Renewable Energy, "Alternative Fuels Data Center," updated 30 December 2013, http://www.afdc.energy.gov/locator/stations/. More than 20% of these are in California.

123 Leidreiter, op. cit. note 21. For example, Dardesheim, Germany, produces more energy than it needs for power, heating, cooling, and mobility, and has started to integrate electric vehicles into its energy plan, from Leidreiter, Moss, and Groth, op. cit. note 109, p. 35.

124 "Vehicle" is defined as passenger cars, lorries, and other road vehicles, and "fossil-fuel-independent vehicle fleet" as "road transport system whose vehicles are driven primarily by biofuels or electricity," from Swedish Government, "A Cohesive Swedish Climate and Energy Policy," Govt. Bill 2008/09:162, cited in *Fossilfrihet påväg*, Del 1 (Stockholm: 2013), Report no. SOU 2013: 84, http://www.regeringen.se/content/1/c6/23/07/39/1591b3dd.pdf. Executive Summary in English is available at http://www.sou.gov.se/content/1/c6/21/33/36/aa2e5cb3.pdf.

125 Heather Allen, Transport Research Laboratory, United Kingdom, personal communication with REN21, 31 March 2014.

126 Sawyer, op. cit. note 44; Samuel Shen and Kazunori Takada, "Chinese Cities Open Up Green Car Markets as Government Battles Pollution," *Reuters*, 21 March 2014, http://planetark.org/wen/71258. F. Tuffner and M. Kintner-Meyer, Using Electric Vehicles to Meet Balancing Requirements Associated with Wind Power (Richland, WA: Pacific Northwest Laboratory, 2011), prepared for U.S. Department of Energy, http://energyenvironment.pnnl.gov/pdf/PNNL-20501_Renewables_Integration_Report_Final_7_8_2011.pdf; "Innovative EV Charging System Includes Solar Power, Battery Energy Storage," Smart Grid News, 31 January 2013, http://www.smartgridnews.com/artman/publish/End_Use_Electric_Transportation/Innovative-EV-charging-system-includes-solar-power-battery-storage-5477.html; Phil Carson, "The Business of V2G: Technology and Business Case Go Hand in Hand," *Intelligent Utility Magazine*, September/October 2012, http://www.intelligentutility.com/magazine/article/284831/business-v2g; J.A. Peças Lopes et al., "Smart Charging Strategies for Electric Vehicles: Enhancing Grid Performance and Maximizing the Use of Variable Renewable Energy Resources," EVS24 International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium, Stavanger, Norway, 13-16 May 2009, http://www.altomelbilen.dk/presentationer/Smart%20Grid%20Strategies.pdf.

BIOMASS ENERGY

1 International Energy Agency (IEA), *World Energy Outlook 2013* (Paris: Organisation for Economic Co-operation and Development (OECD)/IEA, 2013), p. 200 states that traditional biomass accounted for 57% of total primary energy use from biomass in 2011. The data are very uncertain and other estimates put the share of traditional biomass consumption closer to two-thirds of total primary energy use from all biomass. For example, the Intergovernmental Panel on Climate Change (IPCC) noted that "roughly 60% share" of total biomass was deemed traditional but "in addition…there is biomass use estimated to amount to 20 to 40% not reported in official primary energy databases, such as dung, unaccounted production of charcoal, illegal logging, fuelwood gathering, and agricultural residue use"; see "Summary for Policymakers," in O. Edenhofer et al., eds., *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* (Cambridge, U.K. and New York: Cambridge University Press, 2011), p. 9, http://srren.ipcc-wg3.de/report/IPCC_SRREN_Full_Report.pdf. This would imply that total world primary energy use is higher than reported by the IEA and others. The GSR assumes here that the traditional biomass share has remained relatively unchanged over the past 2–3 years.

2 The distinction between traditional and modern biomass can be somewhat blurred, with some biomass being combusted on domestic open fires in developed-country dwellings on the one hand and modern large- to medium-scale biogas and bioenergy plants being installed in developing countries. There is a long-term ambition to create incentives for users of traditional, non-sustainable biomass in low-efficiency cookstoves (with health impacts from the smoke emissions) to use sustainably produced biomass in more efficient appliances in order to reduce losses; see Figure 5, GSR 2013, p. 27. Health issues arise from both traditional and modern use of biomass from particulates and black carbon that are formed during incomplete combustion of biomass and released as "smoke," leading to poor health and some 4 million premature deaths each year as well as to greenhouse gas emissions. The climate benefits of reducing emissions of black carbon, a short-lived climate pollutant, are becoming better understood; see, for example, World Bank, *Integration of Short-lived Climate Pollutants in World Bank Activities: A report prepared at the request of the G8* (Washington, DC: June 1013), http://documents.worldbank.org/curated/en/2013/06/18119798/integration-short-lived-climate-pollutants-world-bank-activities-report-prepared-request-g8.

3 Bioenergy Annex of Chapter 11, "Agriculture, Forests and Other Land Use Change," in IPCC, Working Group III, *Fifth Assessment Report: Climate Change – Mitigation* (Cambridge, U.K. and New York: Cambridge University Press, April 2014),https://www.ipcc.ch/report/ar5/wg3/. Also note that short-rotation energy crops grown on agricultural land specifically for energy purposes currently provide about 3–4% of the total biomass resource consumed annually, as outlined in H. Chum et al., "Bioenergy," Chapter 2 in Edenhofer et al., op. cit. note 1.

4 **Sidebar 3** from the following sources: for research and policy endeavours, see, for example: J. Fargione et al., "Land Clearing and the Biofuel Carbon Debt," *Science*, vol. 319, no. 5867 (2008), pp. 1235–38, J. Melillo et al., "Indirect Emissions from Biofuels: How Important?" *Science*, vol. 326, no. 5958 (2009), pp. 1397–99, and G. Berndes et al., "Bioenergy and Land Use Change – State of the Art," *Energy and Environment*, vol. 2, no. 3 (2013), pp. 282–303; concern about time lag from idem; consensus around biogenic emissions from Pinchot Institute for Conservation, *The Transatlantic Trade in Wood for Energy: A Dialogue on Sustainability Standards and Greenhouse Gas Emissions* (Savannah, GA: 2013), http://cif-seek.org/wp-content/uploads/2013/11/Trade-in-Wood-for-Energy_Savannah-Workshop-Summary_Final.pdf; carbon payback analysis from S.R. Mitchell, M.E. Harmon, and K.E.B. O'Connell, "Carbon Debt and Carbon Sequestration Parity in Forest Bioenergy Production," *GCB Bioenergy*, vol. 4, no. 6 (2012), pp. 818–27; review of carbon payback times, including the use of residues, from P. Lamers and M. Junginger, "The 'Debt' Is in the Detail: A Synthesis of Recent Temporal Forest Carbon Analyses on Woody Biomass for Energy," *Biofuels, Bioproducts and Biorefining*, vol. 7, no. 4 (2013), pp. 373–85, and from A. Agostini, J. Giuntoli, and A. Boulamanti, *Carbon Accounting of Forest Bioenergy* (Ispra, Italy: European Commission, Joint Research Centre, Institute for Energy and Transport, 2013), http://iet.jrc.ec.europa.eu/bf-ca/sites/bf-ca/files/files/documents/eur25354en_online-final.pdf; carbon payback from plantation pulpwood from G-J. Jonker, M. Junginger, and A. Faaij, "Carbon Payback Period and Carbon Offset Parity Point of Wood Pellet Production in the Southeastern USA," *GCB Bioenergy*, early view, DOI: 10.1111/gcbb.12056 (2014); commonly used time frames from B. Dehue, "Implications of a 'Carbon Debt' on Bioenergy's Potential to Mitigate Climate Change," *Biofuels, Bioproducts & Biorefining*, vol. 7, no. 3 (2012), pp. 228–34, and from B. Holtsmark, "Harvesting in Boreal Forests and the Biofuel Carbon Debt," *Climatic Change*, vol. 112, no. 2 (2012), pp. 415–28; carbon cycling integration in LCA from T. Helin et al., "Approaches for Inclusion of Forest Carbon Cycle in Life Cycle Assessment – A Review, *GCB Bioenergy*, vol. 5, no. 5 (2012), pp. 475–86; in addition to aforementioned carbon studies, a modelling exercise that includes afforestation and reforestation from G. Zanchi, N. Pena, and N. Bird, "Is Woody Bioenergy Carbon Neutral? A Comparative Assessment of Emissions from Consumption of Woody Bioenergy and Fossil Fuel," *GCB Bioenergy*, vol. 4, no. 6 (2012), pp. 761–72; U.K. draft calculator from Department of Energy & Climate Change (DECC), *Government Response to the Consultation on Proposals to Enhance the Sustainability Criteria for the Use of Biomass Feedstocks under the Renewables Obligation (RO)* (London: 2013), www.gov.uk/government/uploads/system/uploads/attachment_data/file/231102/RO_Biomass_Sustainability_consultation_-_Government_Response_22_August_2013.pdf.

5 Fraunhofer Institute, "Biobattery – matching energy delivery with demand through storage," *BE Sustainable*, 14 January 2014, http://www.besustainablemagazine.com/cms2/biobattery-matching-energy-delivery-with-demand-through-storage/; R. Sims et al., "Integration of Renewable Energy into Present and Future Energy Systems," Chapter 8 in Edenhofer et al., op. cit. note 1.

6 E.J. Ackom et al., "Modern bioenergy from agricultural and forestry residues in Cameroon: Potential, challenges and the way forward," *Energy Policy*, vol. 63 (2013), pp. 101–113. The issues of bioenergy data are discussed in International Renewable Energy Agency (IRENA), "Statistical issues: bioenergy and distributed renewable energy" (Abu Dhabi: 2013), http://www.irena.org/DocumentDownloads/Publications/Statistical%20issues_bioenergy_and_distributed%20renewable%20_energy.pdf. To overcome these data limitations, as of 2013 IRENA is developing an improved methodology of data collection, the World Bioenergy Association is working to improve bioenergy-related data collection, and the United Nations Economic Commission for Europe (ECE) plans to undertake surveys of households and businesses. Montenegro is one such country undertaking household and business level surveys, from Statistical Office Montenegro, "Wood fuel consumption in 2011 in Montenegro – New energy balances for wood fuels," updated February 2013, http://www.monstat.org/userfiles/file/publikacije/2013/22.2/DRVNA%20GORIVA-ENGLESKI-ZA%20SAJT%20I%20STAMPU-.pdf. **Figure 5** based on data from IEA, op. cit. note 1, and IEA, *Medium-Term Renewable Energy Market Report 2013* (OECD/IEA: 2013).

7 Calculation based on the following: 744 Mtoe of primary energy for traditional biomass in 2011, which accounted for 57% of total bioenergy (implying total bioenergy consumption of approximately 1,300 Mtoe), from IEA, op. cit. note 1, Table 6.1, p. 200; average annual growth rate of primary bioenergy consumption of around 2% over the period 2006–2011, according to data from IEA, *World Energy Outlook*, various editions (2008–2013); and a growth rate of 1.8% in 2011 based on 1,277 Mtoe consumption in 2010 and 1,300 Mtoe consumption in 2011, from idem. It is assumed that the 1.8% growth continued during 2012 and 2013, bringing the estimated supply for 2013 to 1,352 Mtoe (56.6 EJ). Note that traditional biomass demand is now fairly static as improved efficiency stoves and solar PV home systems are being deployed more widely to reduce the demand for biomass for cooking and heating. See, for example, David Appleyard, "Burn it up – is biomass about to go bang?" *Renewable Energy World*, January/February 2014, pp. 41–45.

8 It was assumed that the shares of global biomass use in 2012, as presented in Figure 5, "Biomass-to energy pathways" on p. 27 of the GSR 2013, remained similar for 2013 data. Other sources include: EurObserv'ER, *The State of Renewable Energies in Europe: Edition 2012* (Brussels: 2012); F.O. Licht, "Fuel Ethanol: World Production, by Country (1000 cubic metres)," 2014, and F.O. Licht, "Biodiesel: World Production, by Country (1000 t)," 2014, used with permission from F.O. Licht / Licht Interactive Data. Modern biomass is converted into a range of energy carriers

(solid, liquid, and gaseous fuels as well as electricity and heat), which are then consumed by end-users to provide useful energy services. Available datasets used to compile each component of Figure 5 had uncertainties in the region of +10% or more. Biomass CHP is included where possible under both electricity and heat categories. Losses that occur during a conversion process from the various "primary" biomass feedstocks to obtain useful heat, electricity, or liquid and gaseous biofuels vary with the process used. Figure of 116 billion litres from F.O. Licht, op. cit. this note, both sources. According to the IEA, primary biomass for power generation rose ~25% from 109 Mtoe in 2010 (IEA, *World Energy Outlook*, 2012, Annex A: World: New Policies Scenario, p. 552) to 136 Mtoe in 2011 (IEA, op. cit. note 1, Annex A: World: New Policies Scenario, p. 572). Global electricity generation from bioenergy increased from 331 TWh in 2010 (IEA, *World Energy Outlook*, 2012, Table 7.2, p. 216) to 424 TWh in 2011 (IEA, op. cit. note 1), and installed capacity rose 28% to reach 93 GW (IEA, op. cit. note 1, Annex A: World: New Policies Scenario, p. 574). For 2013, bio-power data are limited, preliminary, and uncertain, but based on country reports provided to REN21 for GSR 2014, it is assumed that the very high growth rate in global bio-power generation in 2011 shown by IEA data had not continued during 2012 and 2013 and reached 405 TWh by end-2013; 12.8 EJ final energy from modern bio-heat in 2011 (per IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 6, p. 215) gives around 13 EJ in 2013, assuming 2.4% annual growth. The 60% efficiency level is conservative and was broadly estimated across all biofuel conversion processes from a range of biomass feedstocks; for example, conversion of ligno-cellulose to ethanol is typically around 35% efficient (per IEA, "From 1st to 2nd generation biofuel technologies – An overview of current industry and RD&D activities" (Paris: November 2008), http://www.iea.org/publications/freepublications/publication/2nd_Biofuel_Gen.pdf), whereas 1 tonne of vegetable oil will produce around 1 tonne of biodiesel through the transesterification process (per University of Strathclyde Engineering Energy Systems Research Unit, "Biofuels and Transport – What is Biodiesel," http://www.esru.strath.ac.uk/EandE/Web_sites/02-03/biofuels/what_biodiesel.htm, viewed 15 May 2014; preliminary estimates from IEA, *Medium-Term Renewable Energy Market Report 2014* (Paris: OECD/IEA, forthcoming 2014). Conversion efficiencies vary with biomass feedstock, moisture content, plant scale, and conversion process (combustion, gasification, anaerobic digestion/combustion). Electrical energy of 30% of the primary energy contained in the biomass is assumed to be a rough estimate of conversion efficiency across all options.

9 Ibid.; EurObserv'ER, op. cit. note 8; A.J. Mathias and P.K. Balasankari, "Trends in Biomass: Opportunities for Global Equipment Suppliers in Asia," Renewable Energy World, 5 August 2010, http://www.renewableenergyworld.com/rea/news/article/2010/08/trends-in-biomass-opportunities-for-global-equipment-suppliers-in-asia; IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 6; F.O. Licht, op. cit. note 8, both sources.

10 European Biomass Association (AEBIOM), *European Biomass Association Annual Report 2013* (Brussels: January 2013), http://www.aebiom.org/wp-content/uploads/2014/01/2013-AEBIOM-Annual-Report1.pdf. Note that the European share of bioenergy was 6.5% of total end-use consumption, per IEA, op. cit. note 1.

11 For wood chip trade data, see P. Lamers et al., *Global Wood Chip Trade for Energy* (Paris: IEA Bioenergy Task 40, 2012). Wood chips and other biomass products are also traded for non-energy purposes, and these volumes need to be separated. See, for example: Robert Flynn, "RISI Viewpoint: Vietnam – no shortage of wood for the Asian woodchip markets!" RISI Wood Biomass Markets, 28 March 2014, http://www.woodbiomass.com/woodbiomass/news/Asia-Pacific/wood_products/RISI-VIEWPOINT-Vietnamu2014no-shortage-of-wood-for-the-Asian-woodchip-markets.html; RISI Wood Biomass Markets, "China drives demand for raw material to produce Bleached Hardwood Kraft Pulp (BHKP)," press release (Boston: 7 May 2014), http://www.woodbiomass.com/woodbiomass/news/East-Europe/Wood-Pellets/China-woodchip-biomass-pulpwood.html; Robert Flynn, "RISI Viewpoint: India's demand for log imports set to double over the next 10 years," RISI Wood Biomass Markets, 7 February 2013, http://www.woodbiomass.com/woodbiomass/news/Middle-East/wood_products/RISI-VIEWPOINT-Indias-demand-for-log-imports-set-to-double-over-the-next-10-years.html.

12 Informal trade from Patrick Lamers, Mountain View Research, personal communication with REN21, 24 March 2014.

13 Based on 300 PJ of solid biomass fuels (excluding charcoal) traded in 2010, from P. Lamers et al., "Developments in international solid biofuel trade - an analysis of volumes, policies, and market factors," Renewable and Sustainable Energy Reviews, vol. 16, no. 5 (2012), pp. 3176–99, and on 120–130 PJ of net trade in fuel ethanol and biodiesel in 2009, from P. Lamers et al., "International bioenergy trade – a review of past developments in the liquid biofuels market," *Renewable and Sustainable Energy Reviews*, vol. 15, no. 6 (2011), pp. 2655–76.

14 Based on 1,323 Mtoe of total primary bioenergy in 2013 (IEA, op. cit. note 1, stated that 1,300 Mtoe (54.7 EJ) of biomass was consumed globally in 2011, giving a growth rate of 1.8% from 1,277 Mtoe in 2010). The IEA *World Energy Outlook* (2008–2013 editions) shows that global primary biomass demand grew at an annual rate of around 2% during 2006–2011. Assuming that 1.8% annual growth rate continued, the estimated supply for 2013 is 1,323 Mtoe (56.6 EJ)).The 23.6 million tonnes of pellets produced in 2013 had an assumed energy content of 16 GJ/tonne. Note that pellet data are available, whereas data for the other solid biomass sources are very limited and therefore are not discussed to the same degree.

15 Calculation based on the following: 297 GW_{th} of bioenergy heat plant capacity installed as of 2008, from Chum et al., op. cit. note 2; 270 GW_{th} in 2009 from International Institute for Applied Systems Analysis (IIASA), "Global Energy Assessment – Toward a Sustainable Future," *Options Magazine* (2012), pp. 16–21, http://www.iiasa.ac.at/web/home/resources/mediacenter/FeatureArticles/Sustainable.en.html; annual growth of 1% is assumed in the absence of better data. Note that accurate heat data, including from bioenergy, are difficult to obtain as most capacity installations and output are not metered. Even if plant capacities are known, there is often no knowledge of whether a 1 MW_{th} plant, for example, is used for 80 hours or 8,000 hours per year.

16 Share of 90% based on 2011 estimates of 13.9 EJ of global final energy use of renewable heat, of which 12.8 EJ came from modern biomass, from IEA, *Medium-Term Renewable Energy Market Report*, op. cit. note 6, p. 215.

17 Eurobserv'ER, *Solid Biomass Barometer* (Paris: December 2013), http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro219_en.pdf. In IEA, op. cit. note 1, all forms of biomass provided 7.3% of European primary energy in 2011, compared with 7.1% in 2010.

18 Based on 102,530 GWh of heat from solid biomass, 500 GWh from liquid biomass, and 13,530 GWh from gaseous biomass in 2013, and a total of 112,667 in 2012, from Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), *Erneuerbare Energien im Jahr 2013* (Berlin: Bundesministerium für Wirtschaft und Energie (BMWi), 2014, pp. 7, 15.

19 Svebio, "Bioenergy for heating – Bioheat," http://www.svebio.se/english/heating, viewed 15 May 2014.

20 RISI Wood Biomass Markets, "Wood was leading fuel for Finland's district heating efforts in 2013," press release (Helsinki: 21 January 2014), http://www.woodbiomass.com/woodbiomass/news/East-Europe/Wood-Energy/Wood-fuel-Finland-district-heat.html.

21 "Eurobserv'ER Barometer: +5,4% energy from solid biomass in Europe in 2012," op. cit. note 17. In IEA, op. cit. note 1, all forms of biomass provided 7.3% of European primary energy in 2011, compared with 7.1% in 2010.

22 B. Sanner, "Strategic research and innovation agenda for renewable heating & cooling," (Luxembourg: March 2013), p. 30, http://www.rhc-platform.org/fileadmin/user_upload/members/Downloads/RHC_SRA_epo_final_lowres.pdf.

23 Lamers, op. cit. note 12.

24 See, for example, Canadian Biomass, "P.E.I. Continues Commitment to Biomass Heating," *Canadian Biomass Magazine*, 17 April 2014, http://www.canadianbiomassmagazine.ca/content/view/4530/96; RISI Wood Biomass Markets, "National Renewable Energy Laboratory (NREL) in Colorado Recognized by BTEC for its Wood-fired Heating System," 19 July 2013, http://www.woodbiomass.com/woodbiomass/news/North-America/Wood-Energy/National-Renewable-Energy-Laboratory-NREL-Colorado-BTEC-wood-fired-heating-system.html.

25 RISI Wood Biomass Markets, "Rentech buys New England Wood Pellet," 1 May 2014, http://www.woodbiomass.com/woodbiomass/news/North-America/Wood-Pellets/Rentech-buys-New-England-Wood-Pellet.html.

26 European Biogas Association (EBA), December 2013, based on contributions from the national biogas associations, provided by Agata Prządka, Technical Advisor, EBA, personal communication with REN21, 7 March 2014.

27 EBA, "Six national biomethane registries are developing the foundation for cross-border biomethane trade in Europe," press release (Brussels: 25 November 2013), http://european-biogas.eu/2013/11/25/six-national-biomethane-registries-developing-foundation-cross-border-biomethane-trade-europe/; The EU supports upgrading of biogas to biomethane, per Green Gas Grids Web site, http://www.greengasgrids.eu/, viewed 16 May 2014.

28 See, for example, Asia Biogas Group, "Asia Biogas Overview," updated 2013, http://www.eepindonesia.org/annfor2013/files/4.%20Desmond%20G._Asia%20Biogas%20Group.pdf; GE and Clarke Energy, "GE, Clarke Energy supply Jenbacher engines to Africa biogas plant," Biomass Magazine, 19 June 2013, http://biomassmagazine.com/articles/9098/ge-clarke-energy-supply-jenbacher-engines-to-africa-biogas-plant.

29 Based on 83 GW of capacity at end-2012 (see GSR 2013); preliminary data from IEA, *Medium-Term Renewable Energy Market Report 2014*, op. cit. note 6; national-level data from the following: U.S. Federal Energy Regulatory Commission (FERC), Office of Energy Projects, "Energy Infrastructure Update for December 2013," https://www.ferc.gov/legal/staff-reports/2013/dec-energy-infrastructure.pdf; AGEE-Stat, op. cit. note 18; China National Renewable Energy Centre, "CNREC 2013 Activities within China National Renewable Energy Centre" (Beijing: March 2014); Brazilian electricity regulatory agency (ANEEL), 2013, provided by Maria Beatriz Monteiro, CENBIO, personal communication with REN21, 16 April 2014; IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 6; Red Eléctrica de España (REE), "Potencia instalada Peninsular (MW)," as of 31 December 2013, http://www.ree.es; , and REE, "Demand for Electrical Energy Falls 2.1%," 20 December 2013, http://www.ree.es/en/press-office/press-release/20131220-demand-electrical-energy-falls-21; Government of India, Ministry of New and Renewable Energy (MNRE), "Physical Progress (Achievements)," 31 December 2013, http://www.mnre.gov.in/mission-and-vision-2/achievements/, viewed January 2014; Directorate General for Energy and Geology (DGEG), provided by Lara Ferreira, Portuguese Renewable Energy Association, personal communication with REN21, May 2014; U.K. DECC, *Statistics, Energy Trends Section 6: Renewables* (London: 10 April 2014), p. 6, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295356/6_Renewables.pdf; Institute for Sustainable Energy Policies (ISEP), *Renewables Japan Status Report 2014* (Tokyo: March 2014) (in Japanese), data provided by Hironao Matsubara, ISEP, personal communication with REN21, 23 April 2014; based on data for 2008–2012 from ibid.; assumption that average annual growth during the period continued, and capacity factor achieved during 2012 applied in 2013, and on preliminary estimate for bio-power output in Italy during 2013 from IEA, *Medium-Term Renewable Energy Market Report 2014*, op. cit. note 8; Government Offices of Sweden, "Sweden's second progress report on the development of renewable energy pursuant to Article 22 of Directive 2009/28/EC," 23 December 2013, http://ec.europa.eu/energy/renewables/reports/2013_en.htm.

30 Preliminary estimates from IEA, *Medium-Term Renewable Energy Market Report 2014*, op. cit. note 8.

31 Based on preliminary data from ibid.

32 Based on a recorded 794 MW added for a total of 15.8 GW, from FERC, op. cit. note 29.

33 Total power from wood and waste from biogenic sources, across all sectors, was 59.894 TWh, from U.S. Energy Information Administration (EIA), *Monthly Energy Review* (Washington, DC: April 2014), p. 95, http://www.eia.gov/totalenergy/data/monthly/pdf/mer.pdf.

34 EIA, "Electric power monthly with statistics to December 2013" (Washington, DC: 2014), Tables 1.18.B, 2.5.A, 2.6.A, 2.11.A, and 2.12.A, http://www.eia.gov/electricity/monthly/pdf/epm.pdf.

35 An estimated 10,807 MW was in operation at the end of 2012, and this increased to 11,423 MW during 2013; sugarcane bagasse increased its share of national generation from 6.7% to 6.85%, and black liquor from 0.98% to 1.12%, from ANEEL 2012 and 2013, data provided by Suani T. Coelho, CENBIO, personal communication with REN21, 16 April 2014.

36 Data based on the following sources: preliminary data from IEA, *Medium-Term Renewable Energy Market Report 2014*, op. cit. note 6; AGEE-Stat, op. cit. note 18; Luca Benedetti, Energy Studies and Statistics, Gestore dei Servizi Energetici - GSE S.p.A., Rome, personal communication with REN21, 16 May 2014; REE, op. cit. note 29; DGEG, op. cit. note 29; DECC, op. cit. note 29, p. 6; Réseau de Transport d'Électricité (RTE), *Bilan Électrique* 2013 (Paris: 2014), p. 21, http://www.rte-france.com/uploads/Mediatheque_docs/vie_systeme/annuelles/Bilan_electrique/bilan_electrique_2013.PDF; Government Offices of Sweden, op. cit. note 29; E-Control Austria, "Entwicklung der anerkannten 'sonstigen' Ökostromanlagen (exclusive Kleinwasskraft) von 2002–2013," updated May 2014, http://www.e-control.at/portal/page/portal/medienbibliothek/oeko-energie/dokumente/pdfs/Entwicklung%20anerkannter%20%C3%96kostromanlagen%202002-2013_Tabelle_Stand%20Mai%202014.pdf.

37 Ibid.

38 Ibid.

39 AGEE-Stat, op. cit. note 18, p. 14.

40 Ibid.

41 Swedish Energy Agency (SEA), "Sweden's second progress report on the development of renewable energy pursuant to Article 22 of Directive 2009/28/EC" (Stockholm: 2013); SEA, "Production and use of biogas 2012," (Eskilstuna: 2013); MSW plants generated approximately 1.66 TWh of electricity and 21.3 PJ of useful heat, landfill gas plants 11 GWh and 0.34 PJ, sewage gas plants 18 GWh and 2.11 PJ, and other biogas plants 12 GWh and 2.1 PJ. RISI Wood Biomass Markets, "Biomass provides about one-third of Sweden's power," press release (Stockholm: 22 March 2013), http://www.woodbiomass.com/woodbiomass/news/East-Europe/Wood-Pellets/Biomass-Sweden-power-bioenergy.html. However, preliminary data from the IEA (*Medium-Term Renewable Energy Market Report 2014*, op. cit. note 8) give 14.4 TWh from bioenergy in 2013, which is around 10% of total generation.

42 Lamers, op. cit. note 12.

43 Most of the remainder came from Russia, Ukraine, Belarus, and Balkan Peninsula countries. The United States exported 2.828 million tonnes of pellets to Europe in 2013, and Canada exported 2.093 million tonnes (see Reference Table R3) compared with 1.956 and 1.221 million tonnes, respectively, in 2012 (see Reference Table R3, GSR 2013); data from P. Lamers, Mountain View Research, Denver, CO, personal communication with REN 21, 9 January 2014. Pellet trading routes have changed little in the past two years; see Reference Table R4 and GSR 2012, p. 34.

44 EBA, op. cit. note 26. Details of many European biogas plants linked with biomethane injection can be found at "Biogas Partners," a project developed by the German Energy Agency (DENA), per DENA, "Biomethane Injection Projects in Germany," http://www.biogaspartner.de/en/project-map/list-of-projects-in-germany.html, viewed 15 May 2014. For example, Schmack Biogas has built a 22,000 m3 digester designed to handle silage feedstock produced from hop residues collected from 174 farms in the region after harvesting the flowers for beer making. The project is a joint venture between the energy company E.ON and the local hop producer HGV, with the biogas being scrubbed and then injected into the natural gas grid. "Biogas 2.0 – Innovative plant design," *BE Sustainable*, January 2014, p. 21, http://issuu.com/besustainablemagazine/docs/be-sustainable-january_2014-single.

45 German Biogas Association (Fachverband Biogas e.V.), "Branchenzahlen – Prognose 2013/2014" (Freising, Germany: November 2013), http://www.biogas.org/edcom/webfvb.nsf/id/DE_Branchenzahlen/$file/13-11-11_Biogas%20Branchenzahlen_2013-2014.pdf.

46 A. Sherrard, "Growth top priority," *Bioenergy International*, vol. 70, no. 1 (2014), p. 31, http://www.exakta.se/x-online/bioenergi/2014/1401/#/30/.

47 SEA, "Sweden's second progress report . . .," op. cit. note 41.

48 Economic Net Energy, "Biomass Power Industry or Out of the 'Quagmire'," *Bio on News*, 4 December 2013, http://www.bioon.com/bioindustry/bioenergy/587619.shtml (using Google Translate).

49 RISI Wood Biomass Markets, "China Ramping up Biomass Power Production Capacity," 2 April 2014, http://www.woodbiomass.com/woodbiomass/news/Asia-Pacific/Wood-Energy/China-biomass-power.html; data from CNREC, op. cit. note 29.

50 MNRE, op. cit. note 29. See also Akshay-Urja, MNRE bi-monthly magazine, September-December 2013, http://mnre.gov.in/

file-manager/akshay-urja/september-december-2013/EN/index.htm.

51 Ibid., both sources.

52 This estimate does not include co-firing and is based on data from METI, in ISEP, op. cit. note 29.

53 Joost Siteur, "Rapid Deployment of Industrial Biogas in Thailand: Factors of Success" (Washington, DC: July 2012), http://www.iipnetwork.org/IIP-10.%20BiogasCaseStudy.pdf.

54 "DP Cleantech signs contract to build coconut-to-energy power plant in Thailand," *Bioenergy Insight*, January-February 2014, p. 6, http://issuu.com/horseshoemedialtd/docs/bioenergy_jan-feb_2014.

55 In the United States, for example, operations began at a 60 MW facility in Black River, NY, that was converted to use forest residues and waste biomass as fuel, per Eldon Doody, "Second chances," *Bioenergy Insight*, January-February 2014, p. 68, http://issuu.com/horseshoemedialtd/docs/bioenergy_jan-feb_2014;

56 Kelvin Ross, "E.ON pulls plug on 150 MW biomass plant in UK," *Power Engineering*, 22 October 2013, http://www.powerengineeringint.com/articles/2013/10/eon-pulls-plug-on-150-mw-biomass-plant-in-uk.html.

57 IRENA, "Biomass Co-firing: Technology Brief" (Abu Dhabi: January 2013), http://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP%20Tech%20Brief%20E21%20Biomass%20Co-firing.pdf; landfill gas accounts for about two-thirds of total power generation from bio-gases; Kolby Hoagland, "Why Cofiring Biomass with Coal Is Hotter Than Ever," *Biomass Magazine*, 8 November 2013, http://biomassmagazine.com/articles/9653/why-cofiring-biomass-with-coal-is-hotter-than-ever; A. Mourant, "Ready to explode," *Renewable Energy Focus*, January/February 2014, p. 20; RISI Wood Biomass Markets, "Vojany Power Plant in Slovakia Replaces 20% of Coal with Wood Chips," 24 May 2013, http://www.woodbiomass.com/woodbiomass/news/East-Europe/Wood-Energy/Vojany-Slovakia-coal-wood-chips.html.

58 "CMT's Biomass Pellets Trade & Power Taps into Growing Biomass Demand in North Asia," Biomass Pellets Trade & Power Web site, http://www.cmtevents.com/aboutevent.aspx?ev=130929, viewed May 2014.

59 For example, in Spain, the co-firing of various blends of olive husks and grapeseed meal in a 335 MW coal-fired integrated gasification combined-cycle plant owned by Elcogas showed that the syngas composition was not affected when co-firing biomass levels below 4% of total fuel energy. Total CO_2 emissions were reduced as the share of biomass fuel was increased, but, as might be expected, the power output declined noticeably when higher biomass shares were fed into the gasifier due to the biomass with lower energy density than coal taking up more of the limited available space. "Gasified biomass halves IGCC carbon emissions," *Bioenergy Insight*, January-February 2014, p. 11, http://issuu.com/horseshoemedialtd/docs/bioenergy_jan-feb_2014.

60 Global production and **Figure 6** based on data from F.O. Licht, op. cit. note 8, both sources. Ethanol data converted from cubic metres to litres; biodiesel reported in 1,000 tonnes and converted to volume using a density value for biodiesel of 1,136 litres/tonne based on U.S. National Renewable Energy Laboratory (NREL), Biodiesel Handling and Use Guide, Fourth Edition (Golden, CO: January 2009). Full trade statistics for biofuels in 2013 were not available at the time of writing, but monthly data were available from F.O. Licht. See Hannu Aatola et al., "Hydrotreated Vegetable Oil (HVO) as a Renewable Diesel Fuel: Trade-off Between NOx, Particulate Emission, and Fuel Consumption of a Heavy Duty Engine," European Biofuels Technology Platform, 2008, http://www.biofuelstp.eu/downloads/SAE_Study_Hydrotreated_Vegetable_Oil_HVO_as_a_Renewable_Diesel_Fuel.pdf.

61 Ibid.

62 Ibid.

63 For details of Thailand's Ministry of Energy "Alternative Energy Development Plan for 2008-2022," which includes biofuels, see Ministry of Energy of Thailand, "Thailand's Renewable Energy and its Energy Future: Opportunities & Challenges" (Bangkok: 16 September 2009), http://nstda.or.th/pub/2012/20120523-renewable-energy-strategy-2008-2022.pdf.

64 Based on 50.3 billion litres in the United States, 25.5 billion litres in Brazil, and a global total of 87.2 billion litres, from F.O. Licht, op. cit. note 8, both sources, and from Helena Chum, NREL, personal communication with REN21, May 2013 and March 2014.

65 Data from ibid., all sources.

66 Renewable Fuels Association (RFA), "Pocket Guide to Ethanol 2014" (Washington, DC: January 2014), http://www.ethanolrfa.org/pages/rfa-pocket-guide-to-ethanol.

67 Based on 630 million gallons, from ibid., p. 12. Note that the United States also imported fuel ethanol (425 million gallons, or 1.6 billion litres, in 2013), mostly from Brazil, from idem.

68 NACS, The Association for Convenience & Fuel Retailing, "Ethanol industry enjoying resurgence," 25 February 2014, http://www.nacsonline.com/News/Daily/Pages/ND0225145.aspx#.UxSDgvl5Np9.

69 Reference Table R4 shows updated production volumes for 2012 and estimates of volumes produced in 2013 for the top 15 countries based on F.O. Licht 2014 data (see Endnote 4 in Reference Table section). The increase in Brazilian ethanol production could have been due to the continuing low sugar commodity price. Data from F.O. Licht, "Fuel Ethanol: World Production, by Country (1000 cubic metres)," 2013, and F.O. Licht, "Biodiesel: World Production, by Country (1000 T)," 2013, used with permission from F.O. Licht / Licht Interactive Data. Brazil plant data from Ministry of Agriculture, Livestock, and Supply Brazil, "Relação de instituições cadastradas no departamento de cana-de-açúcar e agroenergia" (Brasilia: 20 December 2013), http://www.agricultura.gov.br/arq_editor/file/Desenvolvimento_Sustentavel/Agroenergia/Orientacoes_Tecnicas/Usinas%20e%20Destilarias%20Cadastradas/Rela%C3%A7%C3%A3o%20de%20cadastradas%2020-12-2013.pdf.

70 Ken Joseph, "Argentine Biofuels Annual" (Washington, DC: 28 June 2013), http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Buenos%20Aires_Argentina_6-28-2013.pdf; Vogelbusch, "Argentina's largest ethanol plant begins operation," *Ethanol Producer*, 30 October 2013, http://ethanolproducer.com/articles/10403/argentinas-largest-ethanol-plant-begins-operations; Data from F.O. Licht, op. cit. note 69, both sources.

71 F.O. Licht, op. cit. note 69, both sources. But the U.S. Department of Agriculture's (USDA) Global Agricultural Information Network reported that China's 2013 biodiesel production was estimated to increase in 2013 by 5% to 966 million litres, per Ryan Scott and Jiang Junyang, "China – People's Republic of, Biofuels Annual" (Washington, DC: USDA Foreign Agriculture Service, 9 September 2013), http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Beijing_China%20-%20Peoples%20Republic%20of_9-9-2013.pdf.

72 Based on data from F.O. Licht, op. cit. note 8, both sources.

73 Ibid.

74 Ethanol and biodiesel production and comparison with 2012 based on data from ibid. See Reference Table R4.

75 EIA, *Monthly Biodiesel Production Report* (Washington, DC: 30 January 2014), Table 4, http://www.eia.gov/biofuels/biodiesel/production/table4.pdf; F.O. Licht, "Biodiesel: World Production, by Country (1000 t)," op. cit. note 8.

76 U.S. Environmental Protection Agency (EPA), "EPA Finalizes 2013 Biomass-Based Diesel Volume" (Washington, DC: September 2012).

77 Based on data from F.O. Licht, op. cit. note 8, both sources.

78 Based on data from ibid. and F.O. Licht, op. cit. note 69; duties amount to around USD 330 per tonne (EUR 240/tonne) in 2013, per "Argentina to export 39% less biodiesel due to European tariff," Global BioBusiness, March 2014, http://www.globalbiobusiness.com/nav.asp?l=36&cmd=view&wr=20208&articleid=184.

79 Jude Hua and Jessica Jaganathan, "Update 1-China levies consumption tax on biodiesel, kerosene imports," *Reuters*, 2 January 2014, http://www.reuters.com/article/2014/01/02/china-fuel-tax-idUSL3N0KC0MM20140102.

80 The consumption tax is approximately USD 0.13/litre (0.8 yuan/litre), per ibid.

81 Lamers, op. cit. note 12.

82 Dutch Ministry of Economic Affairs, Agriculture and Innovation, "Sustainable biomass and bioenergy in the Netherlands: Report 2013" (Utrecht: November 2013), http://english.rvo.nl/sites/default/files/2013/12/Sustainable%20biomass%20and%20bioenergy%20in%20the%20Netherlands%20-%20Report%202013.pdf; No S-Y, "Application of hydrotreated vegetable oil from triglyceride based biomass to CI engines – a review," *Fuel*,

vol. 15 (2014), pp. 88–96; sustainability impacts depend on the feedstock and the production process used, per European Biofuels Technology Platform, "Biodiesel in Europe," 7 April 2014, http://www.biofuelstp.eu/biodiesel.html#hvo.

83 F.O. Licht, "Biodiesel: World Production, by Country (1000 t)," op. cit. note 8. HVO is produced primarily by Neste under the trademark "NExBTL" with production capacity in Finland (380 kilotonnes/year), Rotterdam (800 kt/yr), and Singapore (800 kt/yr) from feedstocks including animal wastes and vegetable oils, and also by Preem in Sweden using forest-based tall oil as feedstock.

84 Navigant Research, "Biofuels for transportation markets," 10 February 2014, http://www.navigantresearch.com/research/biofuels-for-transportation-markets.

85 Ibid.

86 F.O. Licht, op. cit. note 8, both sources; APAC Biofuel Consultants, "Australian biofuels 2013-14; policy and growth" (Adelaide, Australia: October 2013), http://www.eccoaustralia.com/media/files/4484.pdf.

87 Natural and Biogas Vehicle Association, "Sweden," 10 September 2012, http://www.ngvaeurope.eu/sweden; BiMe-Trucks, "Infrastructure for Liquid Methane – Filling Stations,"http://www.bimetrucks.com/toppmeny/fillingstations.4.4e71cfb112f54fdc91b80002369.html, viewed May 2014.

88 "Wärtsilä to produce biofuel for buses in Oslo," Renewable Energy Focus, 20 February 2014, http://www.renewableenergyfocus.com/view/37027/w-rtsil-to-produce-biofuel-for-buses-in-norway/.

89 Sustainable Biomass Partnership Web site, http://www.sustainablebiomasspartnership.org; Roundtable on Sustainable Palm Oil Web site, http://www.rspo.org; RFA Web site, http://www.ethanolrfa.org.

90 See discussion in IPCC, op. cit. note 3.

91 See, for example, Royal Dutch Airlines, "Sustainable Biofuels – Road to sustainable aviation fuels," http://www.klm.com/csr/en/climate/footprint/biofuels/index.html, viewed 15 May 2014; African Biofuel and Emission Reduction (East Africa) Ltd, "Corporate Social Responsibility," http://africabiofuel.com/Corporate_Social_Responsibility.aspx, viewed 15 May 2014; and Sunbird Bioenergy, "Sustainability Goals," http://www.sunbirdbioenergy.com/Sunbird_Bioenergy_Sustainability_Principles.html, viewed 15 May 2014.

92 As of early 2014, most of the bio-refinery plants produce biofuels with animal feed as a co-product, and not a wide range of multi-products. RFA, "Biorefinery Locations," updated 22 March 2014, http://www.ethanolrfa.org/bio-refinery-locations/. A map showing U.S. plant locations at March 2014 is available at U.S. Department of Energy, "Integrated Biorefineries," updated 11 April 2014, http://www1.eere.energy.gov/bioenergy/integrated_biorefineries.html.

93 Amyris, "Amyris refinery successfully restarts industrial production in Brazil," 15 April 2014, http://www.amyris.com/News/381/Amyris-Biorefinery-Successfully-Restarts-Industrial-Production-in-Brazil. For biorefinery plants in other countries, see IEA Bioenergy Task 42 Web site, http://www.iea-bioenergy.task42-biorefineries.com/en/ieabiorefinery.htm. See also BP, "Largest UK Bio-Refinery Is Officially Opened in Hull," press release (London: 8 July 2013), http://www.bp.com/en/global/corporate/press/press-releases/the-uk-s-largest-bio-refinery-is-officially-opened-in-hull0.html.

94 Hu Honoa Bioenergy in Hawaii upgraded a 1972 bagasse-fed CHP plant to a 21.5 MW power plant fed by locally grown feedstocks (such as short-rotation eucalyptus) with a power purchase agreement in place with the Hawaii Electric Light Company; see "PPA approved for Hawaii biomass power plant," *Bioenergy Insight*, January-February 2014, http://issuu.com/horseshoemedialtd/docs/bioenergy_jan-feb_2014). In Wisconsin, the WE Energies, 50 MWe cogeneration plant, based on a Metso circulating fluidised bed boiler and GE steam turbine generator, began operations in November after four years of development. Approximately 500,000 tonnes/year of bark, waste wood, and sawdust will produce steam to supply Domtar Corporation's century-old paper mill on demand; see "Wisconsin cogeneration plant now operational," *Biomass Magazine*, 30 December 2013, http://biomassmagazine.com/articles/9827/wisconsin-cogeneration-plant-now-operational/. Leidos Holdings, an engineering company, acquired the Plainfield 37.5 MW power plant in Virginia in October 2013 from previous owner Enova Energy after it failed to complete construction of the USD 225 million facility. It has now been completed and, using demolition timber for fuel, a 15-year power purchase agreement has been negotiated with Connecticut Light and Power; see "Plainfield biomass plant substantially complete and operational," *Bioenergy Insight*, January-February 2014, http://issuu.com/horseshoemedialtd/docs/bioenergy_jan-feb_2014. In the small town of Covington, TN, (population ~ 9,000), a PHG Energy downdraft gasifier fed with sewage sludge and wood waste and linked with a GE 125 kW organic Rankine cycle generator came on line in September 2013 after only six months of construction; see "Trash to cash for Covington," *Bioenergy International*, vol. 70, no. 1 (2014), p. 15, http://www.exakta.se/x-online/bioenergi/2014/1401/#/16/.

95 Mourant, op. cit. note 57, p. 20.

96 Preliminary 2012 data in GSR 2013, Figure 6, p. 28, have since been lowered to 21.0 million tonnes due to unexpected plant closures including a Norwegian plant of 450,000 tonnes capacity. Preliminary data for 2013, also used for Reference Table R3, from the following: P. Lamers et al., "Woody biomass trade for energy," in M. Junginger, C.S. Goh, and A. Faaij eds., *International Bioenergy Trade: History, status & outlook on securing sustainable bioenergy supply, demand and markets* (Berlin: Springer, 2013), pp. 41–64; AEBIOM, *European Bioenergy Outlook – Statistical Report* (Brussels: 2013); Hawkins Wright, "The Outlook for Wood Pellet Demand," presented at The U.S. Industrial Pellet Association's 3rd Annual Exporting Pellets Conference, Miami, FL, 28 October 2013; C.S. Goh et al., "Wood pellet market and trade: a global perspective," *Biofuels, Bioproducts and Biorefining*, vol. 7 (2013), pp. 24–42; P. Lamers et al., "Developments in international solid biofuel Trade…," op. cit. note 13.

97 Data and **Figure 7** from ibid.

98 Canadian Biomass, "North American Pellet Export Growth Continues," *Canadian Biomass Magazine*, 23 April 2014, http://www.canadianbiomassmagazine.ca/content/view/4533/96/.

99 AEBIOM, "International Biomass Torrefaction Council," http://www.aebiom.org/?p=6442, viewed May 2014; below 200,000 tonnes from M. Wild, Principal, Wild and Partners, LLC, Vienna, personal communication with REN21, spring 2014. Torrefaction is a thermal pre-treatment process in air applicable to all solid biomass to give pellets with lower volatiles and higher heat values than wood pellets. Hydrothermal carbonisation uses water as the medium to produce "bio-coal" pellets as processed by SunCoal and AVA-CO2; see "SunCoal Industries," https://www.facebook.com/SunCoalIndustries, viewed May 2014, and "AVA-CO2, pioneer of hydrothermal carbonisation (HTC), is today putting the first industrial-size HTC plant in the world into operation in Karlsruhe, Germany," *Business Wire*, 26 October 2010, http://www.businesswire.com/news/home/20101026006679/en/AVA-CO2-Introduces-Industrial-Size-Hydrothermal-Carbonisation-HTC-Plant.

100 Biomass Pellets Trade & Power, "CMT's Biomass Pellets Trade & Power Taps into Growing Biomass Demand in North Asia," http://www.cmtevents.com/aboutevent.aspx?ev=130929, viewed 15 May 2014; Keeley Downey, "Looking to the future," *Bioenergy Insight*, January-February 2014, p. 55, http://issuu.com/horseshoemedialtd/docs/bioenergy_jan-feb_2014.

101 Ibid.

102 Ibid.

103 Proceedings of the 4th Biomass Pellets Trade and Power Conference, op. cit. note 58.

104 Biogas production rates continually vary with temperature and feedstock, so measuring the plant capacity, the electricity generated, and/or the useful heat produced are the common indicators used. However, the biogas industry can now benefit from development of a new Siemens continuous automatic monitoring technology, per Andrea Hoferichter, "Maximum Methane," *Pictures of the Future*, Spring 2011, http://www.siemens.com/innovation/apps/pof_microsite/_pof-spring-2011/_html_en/biogas-plants.html.

105 David Collins, "DEFRA AD Strategy Annual Report – 2012/2013," 23 July 2013, http://www.biogas.org.uk/news/defra-ad-strategy-annual-report-2012-13.

106 These sites offer the potential to produce sufficient biogas to generate 1 TWh per year of electricity, per Philip Simpson, "More uses for food wastes," *Bioenergy Insight*, January/February 2014, p. 37, http://issuu.com/horseshoemedialtd/docs/bioenergy_jan-feb_2014. See also DEFRA, "Landfill Directive,", http://archive.

defra.gov.uk/environment/waste/strategy/legislation/landfill/documents/landfilldir.pdf, viewed 15 May 2014.

107 Based on information from EBA, op. cit. note 27.

108 Ibid. The Italian feed-in tariff was revised to focus support on small-scale plants that use organic residues as their main feedstock and that incorporate nitrogen recovery.

109 Ibid.; Sherrard, op. cit. note 46.

110 Based on data for 2010 or 2011 from Patrick Serfass, American Biogas Council, "State of the U.S. Biogas Industry," presentation, http://americanbiogascouncil.org/pdf/ABC-StateoftheInd-BiocyclePolicyPres.pdf, and from American Biogas Council, "Operational Biogas Systems in the U.S.," http://www.americanbiogascouncil.org/biogas_maps.asp, viewed 10 May 2014.

111 ANEEL, "Combustível Biomassa," http://www.aneel.gov.br/aplicacoes/capacidadebrasil/CombustivelPorClasse.cfm?Classe=Biomassa, viewed 15 May 2014.

112 See, for example, "Biogas Plants to Convert Residues from Farmed Pigs," The Pig Site, 13 November 2013, http://www.thepigsite.com/swinenews/34878/biogas-plants-to-convert-residues-from-farmed-pigs, and "Waste not, want not," *Bioenergy Insight*, January-February 2014, p. 74, http://issuu.com/horseshoemedialtd/docs/bioenergy_jan-feb_2014.

113 Ibid.

114 This technology was recently employed in the 2,300 m3 digester on the University of Wisconsin campus, which is fuelled by high dry matter gardening and food wastes. The biogas produced powers a CHP unit that provides 8% of the campus power demand. M. Cocchi, "Biogas-2," *BE Sustainable*, January 2014, p. 21, http://issuu.com/besustainablemagazine/docs/be-sustainable-january_2014-single.

115 Gobigas meets the growing need for biogas; see http://gobigas.goteborgenergi.se/En/About_us, viewed May 2014.

116 Ibid.

117 Frankfurt School–UNEP Collaborating Centre for Climate & Sustainable Energy Finance and Bloomberg New Energy Finance, *Global Trends in Renewable Energy Investment 2014* (Frankfurt: 2014).

118 IEA, *Tracking Clean Energy Progress*, Annual Report to Clean Energy Ministerial (Paris: 2013).

119 RFA, *Falling Walls & Rising Tides – 2014 Ethanol Industry Outlook* (Washington, DC: 2014), http://ethanolrfa.org/page/-/rfa-association-site/Resource%20Center/2014%20RFA%20Outlook%20Presentation.pdf?nocdn=1.

120 A U.S. EPA proposal under consideration would reduce mandates on biofuel production and blending under the Renewables Fuel Standard 2 and remove incentives for the uptake of advanced biofuels, per NACS, op. cit. note 68. The National Biodiesel Board (NBB) sought extension of tax incentives in March 2014, per NBB, "Advanced biofuel trade groups ask for extension of tax incentives," *Biodiesel Magazine*, 24 March 2014, http://biodieselmagazine.com/articles/33863/advanced-biofuel-trade-groups-ask-for-extension-of-tax-incentives.

121 Brazilian Sugarcane Industry Association (UNICA), "Producer prices report," http://www.unicadata.com.br/preco-ao-produtor.php?idMn=42&tipoHistorico=7, viewed January 2014.

122 Reference Table R4 shows updated production volumes for 2012 and estimates of volumes produced in 2013 for the top 15 countries based on F.O. Licht 2014 data; see Endnote 4 in Reference Tables section. The increase in Brazilian ethanol production could have been due to the continuing low sugar commodity price. Data from F.O. Licht, op. cit. note 69, both sources. Brazil plant data from Ministry of Agriculture, Livestock, and Supply, op. cit. note 69.

123 "POET to build corn ethanol plant in Brazil," Global BioBusiness, 11 February 2014, http://www.globalbiobusiness.com/nav.asp?l=36&cmd=view&wr=20208&articleid=150.

124 "Animal feed industry in Brazil concerned with increasing corn use for ethanol," Global BioBusiness, 3 March 2014, http://www.globalbiobusiness.com/nav.asp?l=36&cmd=view&wr=20208&articleid=165.

125 "Largest plant in Argentina commissioned," *Bioenergy International*, vol. 70, no. 1 (2014), p. 25, http://www.exakta.se/x-online/bioenergi/2014/1401/#/24/.

126 R. Wagner, "Biodiesel margins down but not out," *Seeking Alpha*, 14 January 2014, http://seekingalpha.com/article/1945231-biodiesel-margins-down-but-not-out.

127 Brazilian Association of Vegetable Oil Industries (ABIOVE), "Preço médio do biodiesel recua 12,7% em 2013, Segundo Abiove" (São Paolo: 4 November 2013), http://www.abiove.org.br/site/_FILES/Portugues/04112013-184803-agencia_estado_4_nov_2013.pdf.

128 Since all three plants are currently under-utilised, an assessment is questioning whether the cost for support under the Australian government's Ethanol Production Grants Programme remains justified. See Bureau of Resources and Energy Economics Australia, "An assessment of key costs and benefits associated with the Ethanol Production Grants program" (Canberra: February 2014), http://www.bree.gov.au/sites/default/files/files//publications/other/asssessment-ethanol-production-grants-program.pdf.

129 K. Ugolik, "China New Energy to Build Cassava Biorefinery in Nigeria," 29 October 2013, http://www.law360.com/articles/484248/china-new-energy-to-build-cassava-biorefinery-in-nigeria.

130 "Biofuel Companies Reach Important Milestones: Gevo (GEVO) and KiOR (KIOR Start First Commercial Plants, Solazyme (SZYM) Set to Begin Operations in First Major Plant in the Fourth Quarter," Wall Street Transcript, 22 August 2013, http://finance.yahoo.com/news/biofuel-companies-reach-important-milestones-151900486.html. Advanced biofuel production capacity in North America increased from 1.8 billion litres in 2012 to around 4 billion litres in 2013, from Environmental Entrepreneurs (E2), cited in Erin Voegele, "Report: 160 Commercial Advanced Biofuel Plants Under Development," *Ethanol Producer Magazine*, 4 September 2013, http://ethanolproducer.com/articles/10206/report-160-commercial-advanced-biofuel-plants-under-development; this follows on from Neste Oil's "renewable diesel" entry into the U.S. market in 2012, from "Neste Oil Sold its First Batch of NExBTL Renewable Diesel to the US Market," Marketwired, 26 April 2012, http://www.sys-con.com/node/2263874. See also Bryan Walsh, "Next-Generation Biofuels Are Inching Towards Reality, Gallon by Gallon," *TIME*, 11 October 2013, http://nation.time.com/2013/10/11/next-generation-biofuels-are-inching-towards-reality-gallon-by-gallon/.

131 Keeley Downey, "Making waves," *Bioenergy Insight*, January-February 2014, pp. 76–77, http://issuu.com/horseshoemedialtd/docs/bioenergy_jan-feb_2014.

132 RFA, op. cit. note 66.

133 Novozymes, "Commercial-Scale Cellulosic Ethanol Refinery Opens in Italy," *Ethanol Producer*, 9 October 2013, http://ethanolproducer.com/articles/10332/commercial-scale-cellulosic-ethanol-refinery-opens-in-italy.

134 AgroChart, "China. Biofuels Annual. Sep 2013 ," 8 November 2013, http://www.agrochart.com/en/news/news/081113/china-biofuels-annual-sep-2013/.

135 "Iogen signs biomass contract in Brazil after a decade of waiting," *Bioenergy Insight*, January-February 2014, p. 8, http://issuu.com/horseshoemedialtd/docs/bioenergy_jan-feb_2014.

136 "Concorde Blue and Lanzatech sign agreement for renewable fuels," *Bioenergy Insight,* January-February 2014, p. 25, http://issuu.com/horseshoemedialtd/docs/bioenergy_jan-feb_2014.

137 "Empyro BV breaks ground of its biomass to liquid pyrolysis plant," *BE Sustainable,* 11 February 2014, http://www.besustainablemagazine.com/cms2/empyro-bv-breaks-ground-of-its-biomass-to-liquid-pyrolysis-plant/. Approximately 6,000 tonnes of wood chips is the feedstock, with electricity also being generated for use on site and excess steam sold. "Mercedes-Benz will run fleet tests with Clariant's Sunliquid 20 cellulosic ethanol," *BE Sustainable,* 30 January 2014, http://www.besustainablemagazine.com/cms2/mercedes-benz-will-run-test-fleets-with-clariants-sunliquid-20-cellulosic-ethanol/.

138 "Chapter 8: Transport," in IPCC, op. cit. note 3.

139 "Boeing sees a great future in what is called 'green diesel'," Global BioBusiness, 19 January 2014, http://www.globalbiobusiness.com/nav.asp?l=36&cmd=view&wr=20208&articleid=126.

140 The biofuel based on palm oil and used cooking oil feedstocks presently costs around 2–3 times more to produce than jet fuel, due in part to the high cost of cooking oil collection. Chris Luo, "Aviation biofuel project could kill two birds with one stone - if Sinopec brings cost down," *South China Morning Post*, 13 February 2014, http://www.scmp.com/news/china-insider/article/1427123/aviation-authority-gives-go-ahead-commercial-use-sinopec-biofuel.

GEOTHERMAL POWER AND HEAT

1 Based on electricity generation of 76 TWh (273 PJ) and heat output of 91 TWh (328 PJ). Electricity estimate based on global capacity of 12 GW and average capacity factor of 72%, which is based on 2012 global capacity of 11.4 GW and 2012 global generation of 72 TWh, from International Energy Agency (IEA), *Medium-Term Renewable Energy Market Report 2013* (Paris: Organisation for Economic Co-operation and Development (OECD)/IEA, 2013), p. 173. **Heat estimate** derived from the average of two estimated values. The first (376 PJ) was derived from global annual direct use in 2011 of 335 PJ, from IEA,"World Energy Statistics," (Paris: OECD/IEA, 2013), and escalated at the observed two-year average growth rate (2009–2011) to 2012 and 2013; the second (281 TJ) was derived from global direct use in 2009 of 223 PJ, from John W. Lund, Derek H. Freeston, and Tonya L. Boyd, "Direct Utilization of Geothermal Energy 2010 Worldwide Review," *Proceedings World Geothermal Congress 2010, Bali, Indonesia: 25–29 April 2010*, which was escalated first at the annual growth rate from IEA data ("World Energy Statistics," op. cit. this note) to 2011 and then by the two-year average growth rate (2009–2011) to 2012 and 2013, as above. The average of these two values is the estimated global direct use of 328 PJ (91 TWh). **Capacity estimate** derived from the average of two estimated values. The first (25.8 GW_{th}) was derived from global annual direct use in 2009–2011, from IEA,"World Energy Statistics," op. cit. this note, and capacity factor of about 46% for 2009, calculated from Lund, Freeston, and Boyd, op. cit. this note, and escalated at the observed two-year average growth rate (2009–2011) to 2012 and 2013; the second (19.3 GW_{th}) was derived from global capacity of 15,346 MW_{th} in 2009, from Lund, Freeston, and Boyd, op. cit. this note, which was escalated first at the annual growth rate from IEA data ("World Energy Statistics," op. cit. this note) to 2011 and then by the two-year average growth rate (2009–2011) to 2012 and 2013, as above. The average of these two values is the estimated global heat capacity at 22.6 GW_{th}, with estimated increase of 1.3 GW_{th} during 2013. The divergence between the two sources for geothermal heat output, and the need to extrapolate over 2–4 years, makes these estimates of output and capacity subject to great uncertainty. The difference between the two datasets is due largely to different heat output data for China, diverging by a factor of three (difference of about 100 PJ). The IEA reports direct use in China being 150.7 PJ (41.9 TWh) in 2010, while Lund, Freeston, and Boyd report direct use in China in 2009 being 46.3 PJ (12.9 TWh).

2 Total global installed capacity in 2013 of 12 GW is based on inventory of existing capacity and installed capacity in 2013, from Geothermal Energy Association (GEA), per Benjamin Matek, GEA, personal communication with REN21, March 2014; and from additional sources for capacity additions by country provided throughout this section. The total difference between newly installed capacity and net additions (net of replacements) in 2013 is estimated to be 65 MW. Capacity additions for Turkey in 2013, according to latest government sources (149 MW), are higher than those represented here (112 MW), per Energy Market Regulatory Authority of the Turkish Republic, provided by Mustafa Sezgin, Secretary General and Member of the Board, Turkish Energy Foundation (TENVA), personal communication with REN21, May 2014. Estimated annual generation is based on global capacity of 12 GW and average capacity factor of 72%, which is based on 2012 global capacity of 11.4 GW and 2012 global generation of 72 TWh, from IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1, p. 173.

3 Capacity values from current Inventory of existing capacity and additions from GEA, op. cit. note 2.

4 **Figure 8** and country installed capacity in 2013 based on inventory of existing capacity and installed capacity in 2013, from ibid. and from additional sources for capacity additions by country provided throughout this section.

5 **Figure 9** and country installed capacity in 2013 based on inventory of existing capacity and installed capacity in 2013, from ibid.

6 Contact Energy, "Continued performance improvement," press release (Wellington, New Zealand: 18 February 2014), http://www.contactenergy.co.nz/web/pdf/financial/cen-hy14-media-release.pdf.

7 Robert Peltier, "Contact Energy Ltd.'s Te Mihi Power Station Harnesses Sustainable Geothermal Energy," *Power Magazine*, 1 August 2013, http://www.powermag.com/contact-energy-ltd-s-te-mihi-power-station-harnesses-sustainable-geothermal-energy/.

8 Contact Energy, "The Te Mihi Project," http://www.contactenergy.co.nz/web/ourprojects/temihi.

9 Mighty River Power, "PM opens showcase Geothermal plant: boost for MRP, benefits for NZ," press release (Auckland, New Zealand: 3 October 2013), http://www.mightyriver.co.nz/PDFs/PDFs/New-Geothermal-plant-boosts-MRP-and-benefits-NZ.aspx.

10 Ormat, "Ormat Successfully Completed The Ngatamariki Geothermal Plant," press release (Reno, NV: 3 September 2013), http://www.ormat.com/news/latest-items/ormat-successfully-completed-ngatamariki-geothermal-plant.

11 Inventory of existing capacity and installed capacity in 2013 from GEA, op. cit. note 2. Higher value for capacity addition of 149 MW and a total capacity of 311 MW from Energy Market Regulatory Authority of the Turkish Republic, op. cit. note 1. Additional information from the following: Phillip Dumas, European Geothermal Energy Council, personal communication with REN21, February 2014; Özgür Çağlan Kuyumcu, "Middle East Geothermal Potential," presentation at the Geothermal Resources Council Annual Meeting 2013, Las Vegas, NV, 29 September–2 October 2013, http://www.geothermal.org; Mahmut Parlaktuna et al., "Geothermal Country Update report of Turkey (2012-2013),"prepared for the European Geothermal Congress 2013, Pisa, Italy, 3–7 June 2013, http://www.geothermal-energy.org/pdf/IGAstandard/EGC/2013/EGC2013_CUR-32.pdf.

12 Fuji Electric, "Introduction to Fuji Electric's Recent Experiences in Geothermal Power Plant Business," presentation, October 2013, http://www.jica.go.jp/information/seminar/2013/ku57pq00001ktre1-att/20131101_01_06.pdf; "Zorlu's geothermal power plant opened," *Hurriyet Daily News*, 30 September 2013, http://www.hurriyetdailynews.com/zorlus-geothermal-power-plant-opened.aspx?pageID=238&nID=55378&NewsCatID=345.

13 MB Holding [Menderes Geothermal Elektrik Üretim (MEGE)], "Dora-3 Produces, Turkey Wins," 17 September 2013, http://www.mb.com.tr/en/basinda-mb-holding; Kuyumcu, op. cit. note 11; BM Holding, "Gümüşköy GEPP Project," http://www.bmholding.com.tr/group_companies/geothermal.asp?show=gumuskoy_gepp_project&menu=power_generation.

14 Dumas, op. cit. note 11; Parlaktuna et al., op. cit. note 11.

15 Enel Green Power, "Enel Green Power: The Cove Fort Geothermal Power Plant Starts Operations in Utah," press release (Rome and Boston: 27 November 2013), http://www.enelgreenpower.com/en-GB/ena/events_news/press_releases/release.aspx?iddoc=1661220.

16 U.S. Department of Energy (DOE), "Nevada Deploys First U.S. Commercial, Grid-Connected Enhanced Geothermal System," 12 April 2013, http://energy.gov/articles/nevada-deploys-first-us-commercial-grid-connected-enhanced-geothermal-system.

17 In-field and near-field EGS are located within or near existing conventional geothermal installations, while greenfield projects would be located on previously undeveloped sites, per GEA, 2013 *Geothermal Power: International Market Overview* (Washington, DC: September 2013).

18 Ormat, "Ormat Completes the Don A. Campbell Geothermal Power Plant with Full 16 Megawatt (net) Output," press release (Reno, NV: 6 January 2014), http://www.ormat.com/news/latest-items/ormat-completes-don-campbell-geothermal-power-plant-full-16-megawatt-net-output; Alexander Richter, "Gradient Resources starts operation of Patua plant in Nevada," Think Geoenergy, 15 January 2014, http://thinkgeoenergy.com/archives/17677; Gradient Resources Web site, www.gradient.com.

19 Ormat, "Ormat Becomes Sole Owner of the Mammoth Complex in Mammoth Lakes, California," press release (Reno, NV: 2 August 2010), http://www.ormat.com/news/acquisitions/ormat-becomes-sole-owner-mammoth-complex-mammoth-lakes-california; Ormat, "Ormat Reaches Commercial Operation of the Newly Refurbished Mammoth G1 Power Plant," press release (Reno, NV: 23 January 2014), http://www.ormat.com/news/latest-items/ormat-reaches-commercial-operation-newly-refurbished-mammoth-g1-power-plant.

20 Ormat, "Ormat Technologies Commences Operation of 36 MW Geothermal Power Plant In Kenya," press release (Reno, NV: 2 May 2013), http://www.ormat.com/news/latest-items/ormat-technologies-commences-operation-36-mw-geothermal-power-plant-kenya; Ormat "Olkaria III Geothermal Complex in Kenya Reaches 110 MW with Commercial Operation of Plant 3," press release (Reno, NV: 4 February 2014), http://www.ormat.com/

news/latest-items/olkaria-iii-geothermal-complex-kenya-reaches-110-mw-commercial-operation-plant-3.

21 GEA, op. cit. note 17; global inventory of geothermal power plants from GEA, op. cit. note 2.

22 Alstom, "Los Humeros II, Units 9 & 10," http://www.alstom.com/Global/Power/Resources/Documents/Brochures/los-humeros-II-mexico-geothermal-power-plant-datasheet.pdf; Alstom, "Alstom to build "Los Humeros III" geothermal project in Mexico," 19 December 2013, http://www.alstom.com/press-centre/2013/11/alstom-to-build-los-humeros-iii-geothermal-project-in-mexico/; United Nations Framework Convention on Climate Change (UNFCCC), "Project 8861: Los Humeros II Phase A+B Geothermal Project," http://cdm.unfccc.int/Projects/DB/DNV-CUK1355831407.2/view.

23 Luis Gutierrez-Negrin, Mexican Geothermal Association, personal communication with REN21, April 2014.

24 Maibarara Geothermal Inc., "20 MW Maibarara Geothermal Power Project Starts Commercial Operations," 9 February 2014, http://maibarara.com.ph/news/20-mw-maibarara-geothermal-power-project-starts-commercial-operations; Maibarara Geothermal Inc., "Maibarara Geothermal Power Project Gets CDM Approval," 15 May 2013, http://maibarara.com.ph/uncategorized/maibarara-geothermal-power-project-gets-cdm-approval.

25 Manuel S. Ogena and Ariel Fronda, Philippines Department of Energy, "Prolonged Geothermal Generation and Opportunity in the Philippines," presentation at the Geothermal Resources Council Annual Meeting 2013, Las Vegas, NV, 30 September 2013, http://www.geothermal.org.

26 Jørgen Fenhann, United Nations Environment Programme Risø Center, "CDM project pipeline," 1 April 2014, http://cdmpipeline.org/publications/CDMPipeline.xlsx.

27 The plants are in the localities of Kirchstochach and Dürrnhaar at the outskirts of Munich. Turboden, "References: 277," http://www.turboden.eu/en/references/references.php; Süddeutsche Geothermie-Projekte Gesellschaft, "Projekte," http://www.sgg-bayern.de/pro_1.shtml; capacity rating from Bundesverband Geothermie,"Tiefe Geothermieprojekte in Deutschland," http://www.geothermie.de/fileadmin/useruploads/aktuelles/projekte/tiefe/deutschland/Projektliste_Tiefe_Geothermie_alphabetisch.pdf; new installed capacity of 19 MW in 2013, from Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), *Erneuerbare Energien im Jahr 2013* (Berlin: Bundesministerium für Wirtschaft und Energie (BMWi), Berlin, 2014), p. 3 and Table 5, http://www.bmwi.de/BMWi/Redaktion/PDF/A/agee-stat-bericht-ee-2013.

28 Stadtwerke München, "Geothermie-Heizkraftwerk Sauerlach geht offiziell in Betrieb," press release (Munich: 30 January 2014), http://www.swm.de/dms/swm/pressemitteilungen/2014/01/versorgung20140130/Pressemitteilung%20vom%2030.01.2.014.pdf; "SWM Geothermie-Kraftwerk in Sauerlach eröffnet," Muenchen.de, 31 January 2014, http://www.muenchen.de/themen/aktuell/swm-geothermie-kraftwerk.html.

29 Exergy, "Exergy Brings Geothermal Energy into the Future for Enel Green Power," translated by Exergy from article in *La Stampa*, 10 June 2013, http://www.exergy-orc.com/newspressred/2013/exergy-brings-geothermal-energy-into-the-future-for-enel-green-power; Exergy, "Radial Outflow Turbine," http://exergy-orc.com/radial-outflow-turbine.

30 Dumas, op. cit. note 11.

31 Benjamin Matek and Karl Gawell, "Report on the State of Geothermal Energy in California" (Washington, DC: GEA, February 2014).

32 **Sidebar 4** from the following sources: Miklos Antics, Ruggero Bertani, and Burkhard Sanner, "Summary of EGC 2013 Country Update Reports on Geothermal Energy in Europe," presented at European Geothermal Congress, Pisa, Italy, 3–7 June 2013; use of waste heat from Burkhard Sanner et al., *Strategic Research and Innovation Agenda for Renewable Heating and Cooling* (Luxembourg: European Commission, European Technology Platform – Renewable Heating and Cooling, March 2013), Figure 17, http://www.rhc-platform.org/fileadmin/user_upload/members/Downloads/RHC_SRA_epo_final_lowres.pdf; heat pump efficiency from idem; overall energy efficiency dependence on efficiency of electricity consumption from idem, Section 3.5; 2010 survey data from Lund, Freeston, and Boyd, op. cit. note 1; 2013 update from Antics, Bertani, and Sanner, op. cit. this note; European market figures from Thomas Nowak, European Heat Pump Association, personal communication with REN21, April 2014, and from EurObserv'ER, *Heat Pumps Barometer* (Paris: October 2013); 2012 sales from Nowak, op. cit. this note. EurObserv'ER, which may have greater geographic coverage, indicates significantly larger market size, at 1.65 million units, but similar overall market decline from 2011 to 2012; Heinz Kopetz, World Bioenergy Association, personal communication with REN21, 13 February 2014; attractive for large buildings from Nowak, op. cit. this note, January 2014; 15% share from Nowak, op. cit. this note, April 2014; use of hybrid systems from Sanner et al., op. cit. this note, p. 30. For hybrid systems, see, for example, Stephanie Banse, "Thailand: Government Continues Subsidy Programme in 2013," Solar Thermal World, 15 February 2013, http://solarthermalworld.org/content/thailand-government-continues-subsidy-programme-2013, and "Solar + Heat Pump Systems," *Solar Update* (IEA Solar Heating and Cooling Programme), January 2013; interest in larger-scale pumps from Nowak, op. cit. this note, 16 April 2014; Denmark from Søren Berg Lorenzen, Danish Geothermal District Heating, "Deep Geothermal projects in Jutland," presentation at the FURGY Congress 2014, Husum, Denmark, 21 March 2014, http://www.furgy.eu/fileadmin/downloads/veranstaltungen/FURGY_Kongress_2014/Pres._Lorenzen.pdf; Norway from Star Refrigeration, "World's Largest Zero Carbon 90°C District Heat Pump Opens Its Doors 25th Feb," http://www.star-ref.co.uk/star/worlds-largest.html; EU standardisation from "Directive 2009/28/EC of the European Parliament and the Council of 23 April 2009," (Article 5(4)), *Official Journal of the European Union*, 5 June 2009; Commission Decision of 1 March 2013 (2013/114/EU), *Official Journal of the European Union*, 6 March 2013. According to the Commission Rules, the renewable share of heat pump energy output would be: $[E_{RES} = Q_{usable} * (1-1/SPF)]$, Where Q_{usable} is the usable heat delivered and defined as the product of equivalent full-load hours of operation and the capacity of the heat pump; and where the SPF of any electrically driven heat pump considered shall always be greater than $[1.15 * 1/\eta]$, where η is the ratio of gross production of electricity to primary energy used in electricity generation across the EU. With the EU power system efficiency (η) established at 45.5% in March 2013, the minimum SPF for electrically driven heat pumps ($sCOP_{net}$) was thereby set at the value of 2.5 to qualify as being considered renewable energy under the Directive.

33 See, for example, Lund, Freeston, and Boyd, op. cit. note 1.

34 See sources in Endnote 1.

35 Ibid.

36 Dumas, op. cit. note 11.

37 See, for example, Lund, Freeston, and Boyd, op. cit. note 1, and Antics, Bertani, and Sanner, op. cit. note 32.

38 Country data from the following sources: **China**: capacity of 3,688 MW from Lund, Freeston, and Boyd, op. cit. note 1; output of 156.2 PJ in 2010 and 162 PJ in 2011 from IEA, *World Energy Statistics for 2011* (Paris: OECD/IEA, 2013); output of 46.3 PJ in 2010, excluding heat pumps, from Lund, Freeston, and Boyd, op. cit. note 1; **Turkey**: capacity of 2,667 MWt across three categories of space heating, greenhouses, and baths, from Parlaktuna et al., op. cit. note 11; geothermal direct use output of 16.3 TWh based on 2012 capacity for each use category (per idem) and 2010 capacity factors for each category, as implied by reported 2010 capacity and output values (per Lund, Freeston, and Boyd, op. cit. note 1); according to capacity and output figures for 2010 (per Lund, Freeston, and Boyd, op. cit. note 1), Turkish direct use for "bathing and swimming" in 2010 suggests a 100% capacity factor of associated thermal capacity, which is much higher than the average across other countries in the same source. Alternatively, the capacity value may be understated; additional sources include Antics, Bertani, and Sanner, op. cit. note 32, and Dumas, op. cit. note 11; **Iceland**: capacity of 2,155 MW from Antics, Bertani, and Sanner, op. cit. note 32; 7.8 TWh based on direct use being 60% of total final energy use for heat and power of 46.7 PJ, or 28 PJ, from Orkutölur 2013, Orkustofnun (Energy Statistics in Iceland 2013) (Reykjavik: April 2014), http://www.os.is/gogn/os-onnur-rit/orkutolur_2013-islenska.pdf; Conversely, another source suggests 8.2 TWh for 2012 (Antics, Bertani, and Sanner, op. cit. note 32); **Japan**: capacity of 2,086 MW from Lund, Freeston, and Boyd, op. cit. note 1; output of 7.2 TWh from Institute for Sustainable Energy Policies (ISEP), *Renewables Japan Status Report 2014* (Toyko: 2014), http://www.isep.or.jp/jsr2014, via Hironao Matsubara, ISEP, personal communication with REN21, April 2014; **Hungary:** capacity of 695 MW and output of 2.8 TWh from Antics, Bertani, and Sanner, op. cit. note 32; **Italy:** capacity of 779 MW and output of 2.4 TWh from idem.

39 See sources in Endnote 1.

40 The IEA ("World Energy Statistics," op. cit. note 1) reports direct use in China being 162 PJ (45 TWh) in 2011 and global direct use being 335 PJ (93 TWh), while Lund, Freeston, and Boyd (op. cit. note 1) report direct use in China in 2009 being 46.3 PJ (12.9 TWh) and global use 223 PJ (62 TWh).

41 See all sources in Endnote 38.

42 PannErgy, "Projekt bemutatása," http://pannergy.com/projektek/#miskolc.

43 Mannvit, "Geothermal Energy Development in Hungary," http://www.mannvit.com/GeothermalEnergy/ProjectExampleinfo/geothermal-energy-development-in-hungary.

44 Enel, "Monteverdi M.Mo (PI): Inaugurato L'Impianto di Teleriscaldamento. Collaborazione Tra Comune, Regione ed Enel Green Power," 4 April 2013, http://www.enel.it/it-IT/media_investor/comunicati/comunicati_regione/toscana/release.aspx?iddoc=1658368.

45 Stadtwerke München, op. cit. note 28; "SWM Geothermie-Kraftwerk in Sauerlach eröffnet," op. cit. note 28.

46 Antics, Bertani, and Sanner, op. cit. note 32.

47 Ibid.

48 Geodynamics, "Completion of 1 MWe Habanero Pilot Plant demonstration," press release (Milton, Australia: 8 October 2013), http://www.geodynamics.com.au/getattachment/75e9468a-0e17-4e2f-8501-839968abd7e0/Completion-of-1-MWe-Habanero-Pilot-Plant-demonstra.aspx; Geodynamics, "Innamincka (EGS) Project," http://www.geodynamics.com.au/Our-Projects/Innamincka-Deeps.aspx.

49 The turbine is referred to as "radial outflow turbine" and is said to excel at several operational parameters, including generating efficiency. Exergy, "Exergy Brings Geothermal Energy into the Future for Enel Green Power," op. cit. note 29; Exergy, "Radial Outflow Turbine," op. cit. note 29.

50 Ormat, "Ormat Reaches Commercial Operation of the Newly Refurbished Mammoth G1 Power Plant," op. cit. note 19.

51 See for example, Magnus Gehringer and Victor Loksha, World Bank Energy Sector Management Assistance Program (ESMAP), *Geothermal Handbook: Planning and Financing Power Generation* (Washington, DC: June 2012), Figure 1.11, p. 28.

52 Chevron, "Geothermal – Harnessing Renewable Energy for Power Generation," http://www.chevron.com/deliveringenergy/geothermal; Ormat, "Company Profile," http://www.ormat.com/company-profile; Enel Green Power, "Geothermal Energy," http://www.enelgreenpower.com/en-GB/doc/plants/geotermia.pdf.

53 Ormat, op. cit. note 52; Ormat, "Ormat Successfully Completed the Ngatamariki Geothermal Plant," press release (Reno, NV: 3 September 2013), http://www.ormat.com/news/latest-items/ormat-successfully-completed-ngatamariki-geothermal-plant; Turboden, "Company," http://www.turboden.eu/en/about/about-company.php; Turboden, op. cit. note 27; Exergy, "Exergy Brings Geothermal Energy into the Future for Enel Green Power," op. cit. note 29.

54 Japan based on data compiled by Bloomberg New Energy Finance, provided by Dumas, op. cit. note 11; see, for example, Gehringer and Loksha, op. cit. note 51, Figure 1.11, p. 28; Siemens, "Steam Turbines for Geothermal Power Plants," http://www.energy.siemens.com/hq/pool/hq/power-generation/steam-turbines/downloads/Geothermal_Steam_Turbines.pdf; Ansaldo Energia, "Ansaldo Energia," http://ansaldoenergia.it/easyNews/NewsLeggi.asp?NewsID=1.

55 Doug Hollett, Geothermal Technologies Office, DOE, "Hot Rock and Hard Places," presentation for the Geothermal Resources Council Annual Meeting 2013, Reno, NV, 30 September 2013, http://www.geothermal.org.

56 Ibid.; DOE, "Geothermal Technologies Program Coproduction Factsheet" (Washington, DC: February 2012), http://www1.eere.energy.gov/geothermal/pdfs/gtp_coproduction_factsheet.pdf.

57 Another example of this is the 1 MWe/12.4 MW_{th} ORC plant in Altheim, Austria, which supplies the town of 5,000 people with district heat but engages power generation during peak load periods for additional revenue and improved plant economics. Bundesverband Geothermie, "The Altheim Rankine Cycle Turbogenerator," http://www.geothermie.de/wissenswelt/archiv/englisch/the-altheim-rankine-cycle-turbogenerator.html.

58 Géothermie Perspectives, "Central EGS Soultz-sous-Forêts, Alsace," 16 January 2014, http://www.geothermie-perspectives.fr/article/centrale-egs-soultz-forets-alsace.

59 DOE, "How an Enhanced Geothermal System Works," http://www1.eere.energy.gov/geothermal/egs_animation.html.

60 Adam H. Goldstein and Ralph Braccio, *2013 Market Trends Report*, prepared by Booz Allen Hamilton (Washington, DC: DOE, Office of Energy Efficiency and Renewable Energy (EERE), Geothermal Technologies Office, January 2014), p. vi.

61 Ibid., p. 39; Philippe Dumas, European Geothermal Energy Council, personal communication with REN21, May 2014.

62 The hydro-shearing used to enhance permeability of the rock is different from shale gas fracturing in that it uses only water at lower pressure and no chemicals, but instances of small fracture-induced seismic activity have still raised public concern. Burkhard Sanner, President, European Geothermal Energy Council, personal communication with REN21, 14 January 2013.

63 Gehringer and Loksha, op. cit. note 51, Figure 2.1, p. 52.

64 Ibid.

65 Dumas, op. cit. note 61.

66 S. Fraser et al., *European Geothermal Risk Insurance Fund EGRIF*, June 2013, http://www.geoelec.eu/wp-content/uploads/2011/09/D-3.2-GEOELEC-report-on-risk-insurance.pdf.

67 Japan Oil, Gas and Metals National Corporation (JOGMEC), "Geothermal," http://www.jogmec.go.jp/english/geothermal/; DOE, EERE, Geothermal Technologies Office, "Financial Opportunities," http://www1.eere.energy.gov/geothermal/current_opportunities.html.

68 World Bank, "Full Steam Ahead: World Bank Seeks 'Global Push' for Geothermal Energy Revolution," 6 March 2013, http://www.worldbank.org/en/news/feature/2013/03/06/full-steam-ahead-world-bank-seeks-global-push-for-geothermal-energy-revolution; Pierre Audinet, World Bank ESMAP, "Global Geothermal Development Plan," presentation for Knowledge Exchange Forum, Paris, 27–28 November 2013, http://www.esmap.org/sites/esmap.org/files/ESMAP_Paris_Geothermal_Energy_KEF_Optimized.pdf.

HYDROPOWER

1 Last year's GSR reported a total of 990 GW, but that figure has been revised downward by 30 GW based on input from the International Hydropower Association (IHA) Hydropower Database, personal communication with REN21, March 2014; from preliminary estimates in International Energy Agency (IEA), *Medium-Term Renewable Energy Market Report 2014* (Paris: Organisation for Economic Co-operation and Development (OECD)/IEA, forthcoming 2014); and from Hydropower Equipment Association (HEA) Database, based on its members' aggregated input, personal communication with REN21, April 2014.

2 Based on input from IHA, personal communication with REN21, April 2014; from IEA, op. cit. note 1; and from a projection based on 2012 hydropower output of 3,673 TWh from BP, *Statistical Review of World Energy 2013* (London: June 2013), as well as observed average year-on-year change in output (+2.8%) for top producing countries (China, Brazil, Canada, the United States, the European Union-27, Russia, India, and Norway), which together accounted for over 70% of global hydropower output.

3 Country data from the following sources: **China**: China Electricity Council (CEC), summary of electricity supply and demand from CEC's 2014 Annual Report, http://www.cec.org.cn/guihuayutongji/gongxufenxi/dianligongxufenxi/2014-02-25/117272.html; Shi Pengfei, China Wind Energy Association, personal communication with REN21, 12 March 2014; **Brazil**: 1,533 MW (264 MW small hydro and 1,264 MW large hydro) added in 2013, per National Agency for Electrical Energy (ANEEL), "Fiscalização dos serviços de geração," February 2013, http://www.aneel.gov.br/area.cfm?idArea=37; large hydro capacity is listed as 81.093 GW at end-2013 and small hydro at 4.656 GW, for a total of 85,749 MW; generation from National Electrical System Operator of Brazil (ONS), "Geração de Energia," http://www.ons.org.br/historico/geracao_energia.aspx; **United States**: 2012 capacity from U.S. Energy Information Administration (EIA), *Electric Power Annual*, Table 4.3 Existing Capacity by Energy Source, http://www.eia.gov/electricity/annual/html/epa_04_03.html; projected net additions in 2013 of 201 MW from idem, Table 4.5 Planned Generating Capacity Changes by Energy Source, 2013-2017, http://www.eia.gov/electricity/annual/html/epa_04_05.html; generation from EIA, *Electric Power Monthly*, February 2014, Table 1.1, http://www.eia.gov/electricity/monthly; **Canada**: Canadian Hydropower Association, communication with REN21, February 2014; HEA Database, op. cit. note 1; generation from Statistics Canada, "Table 127-0002 Electric Power Generation, by class of electricity producer," http://www5.statcan.gc.ca/cansim; **Russia**: capacity and generation from System Operator of the Unified Energy System of Russia, *Report on the Unified Energy System in 2013* (Moscow: undated), http://www.so-ups.ru/fileadmin/files/company/reports/disclosure/2014/ups_rep2013.pdf; **India**: installed capacity in 2013 (units larger than 25 MW) of 39,893.4 MW from Government of India, Ministry of Power, Central Electricity Authority (CEA), "Installed capacity as of 31 December 2013," http://www.cea.nic.in/reports/monthly/inst_capacity/dec13.pdf, and idem, "List of H.E. Stations in the Country with Station Capacity Above 25 MW," http://www.cea.nic.in/reports/hydro/list_he__stations.pdf; capacity additions in 2013 (>25 MW) of 554 MW from CEA, "Executive Summary of the Power Sector (monthly)," http://www.cea.nic.in/exesum_cood.html; installed capacity in 2013 (<25 MW) of 3,763.15 MW from Government of India, Ministry of New and Renewable Energy (MNRE), "Physical Progress (Achievements)," http://www.mnre.gov.in/mission-and-vision-2/achievements/, viewed 18 January 2014; capacity additions in 2013 (<25 MW) of 267 MW based on difference of year-end 2013 figure (above) and year-end 2012 figure (3,496.15 MW) from MNRE, *Annual Report 2012-2013* (New Delhi: undated), Table 3.7, http://www.mnre.gov.in/mission-and-vision-2/publications/annual-report-2; generation for plants larger than 25 MW from CEA, "Executive Summary of the Power Sector (monthly)," op. cit. this note, and output from hydropower plants smaller than 25 MW estimated, based on capacity from MNRE, *Annual Report 2012-2013*, op. cit. this note and on average capacity factor for large hydropower facilities in India; **Norway**: capacity of 29.3 GW from Seming Skau, Senior Engineer, Section for Resources, Energy Department, Norwegian Water Resources and Energy Directorate, via IHA Hydropower Database, personal communication with REN21, February 2014; generation from Statistics Norway, http://www.ssb.no/en. **Figure 10** based on capacity and generation sources provided in this note.

4 Sources indicate total global pumped storage capacity in the range of 135–140 GW. In addition to government sources noted elsewhere, global and national capacity values based on input from IHA Hydropower Database, op. cit. note 2; from IEA, op. cit. note 1; and from HEA Database, op. cit. note 1.

5 **China, Brazil, India,** and **Russia** from relevant sources in Endnote 3. Other countries from the following sources: **Turkey**: capacity was 19,609.4 MW at the end of 2012 and 22,493.6 MW by 31 January 2014, from Dr. Öztürk Selvitop, Ministry of Energy and Natural Resources, Republic of Turkey, "Hydropower in Turkish Energy Sector," presentation, Ankara, 4 March 2014, http://suyonetimi.ormansu.gov.tr/Libraries/su/Hydropower_in_Turkish_Energy_Sector.sflb.ashx. See also Turkish Electricity Transmission Company, capacity projections, http://www.teias.gov.tr/YayinRapor/APK/projeksiyon/KapasiteProjeksiyonu2013.docx; **Vietnam**: late 2013 capacity from Do Duc Quan, director, Hydropower Department, General Department of Energy, "Policies on Sustainable Hydropower Development in Vietnam, presentation, Second Mekong River Commission Summit and International Conference, Ho Chi Minh City, 2–5 April 2014, http://www.mrcsummit.org/presentations/track2/1.2-d-policy-for-sustainable-dev-ofhydro-QuanDoDuc.pdf; 2012 year-end capacity of 12.95 GW from National Electricity Center of Vietnam, http://www.nldc.evn.vn/News/7/661/Bao-cao-tong-ket-nam-2012.aspx. **Figure 11** based on capacity sources provided in this endnote and in Endnote 3.

6 China Three Gorges Corporation, "The Twelfth Generating Unit was Installed in the Xiluodu Hydropower Station with the Total Installed Capacity Reaching 9240 MW," http://www.ctgpc.com/news/news1.php?NewsId=80194; "China's 13.86-GW Xiluodu hydropower plant begins commercial operation, Hydro World, 17 July 2013, http://www.hydroworld.com/articles/2013/07/china-s-13-86-gw-xiluodu-hydrpower-plant-begins-commercial-operation.html.

7 Alstom, "Alstom commissions world's most powerful hydroelectric units at Xiangjiaba hydro power plant, in China," press release (Levallois-Perret Cedex: 21 July 2013), http://www.alstom.com/press-centre/2013/7/alstom-commissions-worlds-most-powerful-hydroelectric-units-at-xiangjiaba-hydro-power-plant-in-china/.

8 China Electricity Council, Planning and Statistics Department, "2013 National Electricity Industry Statistics," 26 January 2014, http://www.cec.org.cn/guihuayutongji/tongjxinxi/yuedushuju/2014-01-26/116224.html (using Google Translate). This figure may include investment in pumped storage.

9 Recent examples include China Exim financing the expansion by Sinohydro of Zimbabwe's Kariba plant, Sinohydro and Chinese National Electric Engineering contract for Nigeria's Zungeru station, and Dongfang recently delivering the Allai Khwar project in Pakistan with more projects pending. "China lends Zimbabwe $319 million for Kariba hydropower upgrade," Times Live, 11 November 2013, http://www.timeslive.co.za/africa/2013/11/11/china-lends-zimbabwe-319-million-for-kariba-hydropower-upgrade; "Sinohydro Corp and CNEEC commence construction on 700MW hydro plant," *Power Insider*, 29 May 2013, http://www.pimagazine-asia.com/news/other-news/sinohydro-corp-and-cneec-commence-construction-on-700mw-hydro-plant; "Sino Hydro and ZPC sign on for Kariba hydroelectric power project upgrade," Hydro World, 27 December 2012, http://www.hydroworld.com/articles/2012/12/sino-hydro-and-zpc-sign-on-for-kariba-hydroelectric-power-project-upgrade.html; "Chinese company hands over Allai Khwar power project to WAPDA," *Pak Tribune*, 8 October 2013, http://paktribune.com/business/news/Chinese-company-hands-over-Allai-Khwar-power-project-to-WAPDA-11655.html; "Fourth Tarbela Extension Hydropower Project: Wapda, Sinohydro ink agreement," *Business Reporter*, 10 September 2013, http://www.brecorder.com/fuel-a-energy/193/1229536.

10 Capacity was 19,609.4 MW at the end of 2012 and 22,493.6 MW by 31 January 2014, from Selvitop, op. cit. note 5; installed capacity in 2012 was 19,609.4 MW, from Turkish Electricity Transmission Company, op. cit. note 5, Table 12.

11 Ibid.

12 The lower added-capacity figure of 1.53 GW and total capacity from ANEEL, "Fiscalização dos serviços de geração," updated February 2014, http://www.aneel.gov.br/arquivos/zip/Resumo_Geral_das_Usinas_fev_2014.zip. The larger added-capacity figure of 2 GW, which may account for additional turbine-generators that were installed in 2014 but not fully commissioned or grid-connected, from HEA Database, op. cit. note 1. The HEA

database indicates that 90 GW of capacity was installed in Brazil by the end of 2014, which is about 4 GW more than government figures cited here.

13 "Reservoir filling begins at Brazil's Simplicio hydroelectric complex," Hydro World, 26 February 2013, http://www.hydroworld.com/articles/2013/02/reservoir-filling-begins-at-brazil-s-simplicio-hydroelectric-com.html; "Simplicio plant notable for its single drop of 115 m," PINI Web, 10 July 2013, http://piniweb.pini.com.br/construcao/infra-estrutura/obra-da-usina-de-simplicio-se-destaca-por-queda-unica-292341-1.aspx (in Portuguese).

14 "First Hydro Turbine at 3,750-MW Jirau now in operation," Hydro World, 11 September 2013, http://www.hydroworld.com/articles/2013/09/first-hydro-turbine-at-3-750-mw-jirau-now-in-operation.html; "Interview: Eduardo de Melo Pinto, CEO, Santo Antonio Energia, Brazil," Energyboardroom.com, 21 December 2013, http://www.energyboardroom.com/interviews/interview-eduardo-de-melo-pinto-ceo-santo-antonio-energia-brazil.

15 Richard Taylor, IHA, personal communication with REN21, 15 January 2014. Both are registered Clean Development Mechanism (CDM) projects and credited for significant carbon dioxide reductions beginning in 2013, per United Nations Framework Convention on Climate Change, CDM, "Project Search," http://cdm.unfccc.int/Projects/projsearch.html.

16 Taylor, op. cit. note 15; Simon Smith, IHA, personal communication with REN21, 12 March 2014.

17 "Work OK to resume at Brazil's 1.8-GW Teles Pires, court rules," Hydro World, 1 October 2013, http://www.hydroworld.com/articles/2013/09/work-ok-to-resume-at-brazil-s-1-8-gw-teles-pires-court-rules.html; other notable projects under way include: Colíder (300 MW by 2015), and Ferreira Gomes (252 MW by 2015), which saw its first of three Kaplan turbines installed in early 2014. ANEEL, "Construction schedule for large hydropower facilities as of February 2014," http://www.aneel.gov.br/arquivos/pdf/Cronograma_de_Eventos_UHE_fev_2014.pdf; "Voith Installs First Turbine Unit at Ferreira Gomes Hydropower Project," Hydro World, 16 January 2014, http://www.hydroworld.com/articles/2014/01/voith-installs-first-turbine-unit-at-ferreira-gomes-hydropower-project.html.

18 Late 2013 capacity of 14.24 GW and 2012 capacity of 11.67 GW (increase of 2.57 GW) from Do Duc Quan, op. cit. note 5; "Hydropower potential almost fully tapped: National Assembly," Vietnamnet, 5 November 2013, http://english.vietnamnet.vn/fms/government/88389/hydropower-potential-almost-fully-tapped--national-assembly.html; addition of 1.3 GW based on 2012 year-end capacity of 12.95 GW from National Electricity Center of Vietnam, op. cit. note 5.

19 "Vietnamese prime minister calls for improvements to country's dam safety evaluations," Hydro World, 17 January 2013, http://www.hydroworld.com/articles/2013/01/vietnamese-prime-minister-calls-for-improvements-to-countrys-dam.html; "Vietnam halts 18 hydropower plant projects," *Than Nien News*, 8 July 2013, http://www.thanhniennews.com/society/vietnam-halts-18-hydropower-plant-projects-1930.html.

20 Installed (>25 MW) capacity of 39,893.4 MW in 2013 from CEA, "List of H.E. Stations in the Country with Station Capacity Above 25 MW," op. cit. note 3; 2013 capacity additions (>25 MW) of 554 MW from CEA, "Executive Summary of the Power Sector (monthly)," op. cit. note 3; 2013 capacity of small hydropower facilities of 3,763.15 MW from MNRE, "Physical Progress (Achievements)," op. cit. note 3; 2013 capacity additions (<25 MW) of 267 MW based on difference of year-end 2013 figure (above) and year-end 2012 figure (3,496.15 MW) from MNRE, *Annual Report 2013–2013*, op. cit. note 3, Table 3.7.

21 Permanent Court of Arbitration, "Court of Arbitration Renders Its Final Award in the First Arbitration under the Indus Waters Treaty 1960," press release (The Hague: 21 December 2013), http://www.pca-cpa.org/showpage.asp?pag_id=1392.

22 Net capacity additions based on increased year-end figures from System Operator of the Unified Energy System of Russia, op. cit. note 3; see also relevant sources in note 3; gross capacity installations of 3.2 GW from HEA Database, op. cit. note 1.

23 Bui Power Authority, "President John Dramani Mahama commissions Bui Generating Station – adds 400MW to Ghana's installed capacity," http://www.buipowerauthority.com/node/154; "Gabon's 160-MW Grand Poubara hydroelectric plant enters full operation," Hydro World, 5 September 2013, http://www.hydroworld.com/articles/2013/09/gabon-s-160-mw-grand-poubara-enters-full-operation.html.

24 Sinohydro, "Business Portfolio," http://eng.sinohydro.com/index.php?m=content&c=index&a=lists&catid=42.

25 Voith Hydro, "Voith Modernizes Generators and Turbines at Inga I Hydropower Station in the Democratic Republic of Congo," press release (Heidenheim, Germany: 4 June 2013), http://voith.com/en/pm_newrev-2013-05-28_inga-i_en.pdf; International Water Power and Dam Construction, "Andritz works on Inga 2 rehab," 19 March 2012, http://www.waterpowermagazine.com/news/newsandritz-works-on-inga-2-rehab.

26 Alex Abutu, "Nigeria: Kainji, Jebba Dams To Be Rehabilitated," *Daily Trust*, 31 January 2013, http://allafrica.com/stories/201301310431.html.

27 Alstom, "Alstom to supply hydroelectric equipment for the Grand Renaissance dam in Ethiopia," press release (Levallois-Perret Cedex: 7 January 2013), http://www.alstom.com/press-centre/2013/1/alstom-to-supply-hydroelectric-equipment-for-the-grand-renaissance-dam-in-ethiopia; "The Grand Renaissance Hydroelectric Project, Ethiopia," Power Technology, www.power-technology.com/projects/the-grand-renaissance-hydroelectric-project.

28 World Bank, "World Bank Approves Rusumo Falls Hydropower Plant," press release (Washington, DC: 6 August 2013), http://www.worldbank.org/en/news/press-release/2013/08/06/world-bank-approves-rusumo-falls-hydropower-plant.

29 "Congo to commence construction of 40,000MW Inga hydro project," renewable-technology.com, 20 May 2013, http://www.renewable-technology.com/news/newscongo-to-commence-construction-of-40000mw-inga-hydro-project.

30 Sonal Patel, "Headway for Congo's Long-Delayed 40-GW Inga Hydro Project," *Power Magazine*, 1 December 2013, http://www.powermag.com/headway-for-congos-long-delayed-40-gw-inga-hydro-project/.

31 Installed capacity for 2013 was 28.73 GW and pumped storage addition was 1.2 GW, from CEC, op. cit. note 3.

32 Iberdrola, "HRH The Prince of Asturias and Iberdrola Chairman Dedicate Cortes-La Muela Pumped-Storage Scheme in Valencia (Spain)," press release (Bilbao, Spain: 14 October 2013), http://www.iberdrola.es/press-room/press-releases/national-international/2013/detail/press-release/131014_NP_01_LaMuela.html.

33 Fernando Perán Montero and Juan J. Pérez, "Wind-Hydro Integration: Pumped Storage to Support Wind," Hydro World, 1 June 2009, http://www.hydroworld.com/articles/print/volume-17/issue-3/Articles/wind-hydro-integration-pumped-storage-to-support-wind.html.

34 European Commission, Directorate-General for Energy, "The future role and challenges of Energy Storage," DG ENER Working Paper, undated, http://ec.europa.eu/energy/infrastructure/doc/energy-storage/2013/energy_storage.pdf.

35 Voith Hydro, *Annual Report 2013* (Heidenheim, Germany: undated), p. 79; Ray Smith, "German Sun Beats Swiss Water," *Inter Press Service*, 28 August 2013, http://www.ipsnews.net/2013/08/german-sun-beats-swiss-water/.

36 Eurelectric, *Europe Needs Hydro Pumped Storage: Five Recommendations* (Brussels: May 2012), http://www.eurelectric.org/media/27210/eurelectric_5_recomm-pumped_storage-final_draft_clean-for_upload-2012-160-0002-01-e.pdf.

37 "Bundestag Approves 3rd Amendment of German Energy Act – Offshore Liability, Shutdown Restrictions for Conventional Power Plants, and More," German Energy Blog, 30 November 2012, http://www.germanenergyblog.de/?p=11581; stoRE, "Current situation in Germany," http://www.store-project.eu/en_GB/current-situation-in-the-target-countries-germany.

38 Hironao Matsubara, Institute for Sustainable Energy Policies, Tokyo, personal communication with REN21, April 2014.

39 European Commission, op. cit. note 34.

40 "African Development Bank launches $1.26bn Kenya-Ethiopia transmission line," Power Technology, 8 May 2013, http://www.power-technology.com/news/newsafrican-development-bank-launches-126bn-kenya-ethiopia-transmission-line-project; World Bank, "The Eastern Electricity Highway Project under the First Phase of the Eastern Africa Power Integration Program," http://www.worldbank.org/projects/P126579/regional-eastern-africa-power-pool-project-apl1?lang=en.

41 Jay Zarnikau et al., "Will the SIEPAC Transmission Project Lead

to a Vibrant Electricity Market in Central America?" *IAEE Energy Forum* (International Association for Energy Economics), Fourth Quarter 2013, http://www.iaee.org/en/publications/newsletterdl.aspx?id=211.

42 Michael Harris, "Northern Exposure: Canadian Hydro in the Spotlight," *Hydro Review*, December 2013.

43 World Bank, *Toward a Sustainable Energy Future for All: Directions for the World Bank Group's Energy Sector* (Washington, DC: 9 July 2013), http://documents.worldbank.org/curated/en/2013/07/18016002/toward-sustainable-energy-future-all-directions-world-bank-group%C2%92s-energy-sector.

44 International Water Power and Dam Construction, "Statkraft starts new R&D programme on climate change," 21 November 2013, http://www.waterpowermagazine.com/news/newsstatkraft-starts-new-rd-programme-on-climate-change.

45 Taylor, op. cit. note 15.

46 Andritz, *Annual Report 2013* (Graz, Austria: 2013), p. 5.

47 Voith Hydro, op. cit. note 35, p. 79.

48 Ibid., p. 82.

49 Alstom, *Annual Results – Fiscal Year 2012/13* (Levallois-Perret Cedex: 7 May 2013), http://www.alstom.com/Global/Group/Resources/Documents/Investors%20document/Financial%20results/2012-2013/Annual%20results/analyst%20presen%20FY%20may%2013_final-%20screen.pdf.

50 Alstom, "Alstom inaugurates its largest hydropower industrial site in Tianjin, China," press release (Levallois-Perret Cedex: 11 October 2013), http://www.alstom.com/press-centre/2013/9/alstom-inaugurates-its-largest-hydropower-industrial-site-in-tianjin-china/.

51 Alstom, "Alstom inaugurates its new global hydropower technology centre in Grenoble," press release (Levallois-Perret Cedex: 1 February 2013), http://www.alstom.com/press-centre/2013/2/alstom-inaugurates-its-new-global-hydropower-technology-centre-in-grenoble.

52 Harbin Electric Company Limited, *Interim Report 2013* (Harbin, China: August 2013).

53 Taylor, op. cit. note 15.

54 Ibid.

OCEAN ENERGY

1 Ocean Energy Systems (OES), also known as the Ocean Energy Systems Implementing Agreement, is an inter-governmental collaboration among countries that operates under a framework established by the International Energy Agency (IEA) in Paris, at http://www.ocean-energy-systems.org/ocean_energy/. The definition of ocean energy used in this report does not include offshore wind power or marine biomass energy.

2 Global installed capacity based on OES, Annual Report 2012 (Lisbon: 2012), Table 6.1, http://www.ocean-energy-systems.org/oes_reports/annual_reports/2012_annual_report/; OES, *Annual Report 2013* (Lisbon: 2013), Table 6.2, http://www.ocean-energy-systems.org/documents/82577_oes_annual_report_2013.pdf/; IEA, *Medium-Term Renewable Energy Market Report 2013* (Paris: Organisation for Economic Co-operation and Development (OECD)/IEA, 2013), p. 179; and sources for 2013 capacity installations as noted elsewhere in this section.

3 Capacity values from OES, "Ocean Energy in the World," http://www.ocean-energy-systems.org/ocean_energy_in_the_world/; OES, *Annual Report 2012*, op. cit. note 1; Électricité de France (EDF), "Usine marémotrice de La Rance," http://energie.edf.com/hydraulique/energies-marines/carte-des-implantations-marines/usine-maremotrice-de-la-rance/presentation-51516.html.

4 Alstom, "Alstom's tidal turbine reaches 1MW in offshore conditions," press release (Levallois-Perret, France: 31 July 2013), http://www.alstom.com/press-centre/2013/7/alstoms-tidal-turbine-reaches-1mw-in-offshore-conditions.

5 Voith Hydro Ocean Current Technologies is a joint venture of Voith Hydro and RWE Innogy. Voith, "Tidal Current Power Stations," http://voith.com/en/products-services/hydro-power/ocean-energies/tidal-current-power-stations--591.html; SAL Heavy Lift GmbH, "MV Lone installed Tidal Turbine," September 2013, http://sal-heavylift.com/news-press/latest-news.

6 MeyGen Ltd, "MeyGen secures consent for 86MW tidal energy project," 16 September 2013, http://www.meygen.com/the-project/meygen-news

7 Aquamarine Power, "Aquamarine Power secures full consent for 40MW Lewis wave energy farm," press release (Edinburgh: 22 May 2013), http://www.aquamarinepower.com/news/aquamarine-power-secures-full-consent-for-40mw-lewis-wave-energy-farm.

8 U.K. Planning Inspectorate, "Swansea Tidal Lagoon application accepted for examination," press release (Bristol, U.K.: 7 March 2014), http://www.gov.uk/government/news/swansea-tidal-lagoon-application-accepted-for-examination.

9 Tidal Lagoon Swansea Bay, "Timeline," http://www.tidallagoonswanseabay.com/timeline.aspx, viewed April 2014.

10 "Severn Barrage: Environment and economy benefits 'unproven'," *BBC News*, 10 June 2013, http://www.bbc.com/news/uk-wales-politics-22812911.

11 K. Steiner-Dicks, "FERC approves Turnagain Arm permit," Tidal Today, 26 February 2014, http://social.tidaltoday.com/environmental-permitting/ferc-approves-turnagain-arm-permit.

12 European Marine Energy Centre (EMEC), "EMEC to support development of marine energy test site in Singapore," press release (Orkney, Scotland: 7 November 2013), http://www.emec.org.uk/press-release-emec-to-support-development-of-marine-energy-test-site-in-singapore/.

13 OES, "Ireland's 1 Million Square Kilometers of Potential Ocean Energy," press release (Lisbon: February 2014), http://www.ocean-energy-systems.org/documents/70749_press_release_february_2014.pdf. The plan commits USD 35.8 million (EUR 26 million) for the period 2013–2016 to develop test facilities, as well as USD 26.2 million (EUR 19 million) for R&D, and a FIT tariff of USD 358/MWh (EUR 260/MWh) for the first 30 MW of ocean energy capacity.

14 Alstom, "Alstom completes the acquisition of Tidal Generation Limited (TGL) from Rolls-Royce plc," press release (Levallois-Perret, France: 30 January 2013), http://www.alstom.com/press-centre/2013/1/alstom-completes-the-acquisition-of-tidal-generation-limited-tgl-from-rolls-royce-plc.

15 Alstom, "Memorandum of Understanding signed between Alstom and Scottish Power Renewables for tidal power devices," press release (Levallois-Perret, France: 17 September 2013), http://www.alstom.com/press-centre/2013/9/memorandum-of-understanding-signed-between-alstom-and-scottish-power-renewables-for-tidal-power-devices.

16 Innogy Venture Capital, "Innogy Venture Capital sells its stake in Voith Hydro Ocean Current Technologies," press release (Essen, Germany: 29 November 2013), http://www.innogy-ventures.com/web/cms/mediablob/en/2260764/data/477104/2/innogy-venture-capital-gmbh/Innogy-Venture-Capital-sells-its-stake-in-Voith-Hydro-Ocean-Current-Technologies.pdf.

17 Voith, "Electricity from ocean energies," http://voith.com/en/insights/energy-transition-22419.html.

18 Alstom, op. cit. note 4.

19 Atlantis Resources, "First Day of Dealings and Admission to Trading on AIM," 20 February 2014, http://atlantisresourcesltd.com/medianews/news/288-first-day-of-dealings-and-admission-to-trading-on-aim.html.

20 Atlantis Resources, "Atlantis Resources Secures €7.7 Million from European Commission," 20 February 2014, http://atlantisresourcesltd.com/medianews/news/287-atlantis-resources-secures-7-7-million-from-european-commision.html.

21 OpenHydro, "DCNS takes control of OpenHydro," press release (Paris: 14 March 2013), http://www.openhydro.com/news/OpenHydroPR-140313.pdf; EMEC, "Open Hydro," http://www.emec.org.uk/about-us/our-tidal-clients/open-hydro/.

22 DCNS, "Fortum, DCNS, AW-Energy and Bretagne Region cooperate on wave power demonstration project in France," press release (Paris: 19 September 2013), http://en.dcnsgroup.com/2013/09/19/fortum-dcns-et-aw-energy-soutenus-par-la-region-bretagne-unissent-leurs-forces-dans-un-projet-de-developpement-de-l%e2%80%99energie-des-vagues-en-france/.

23 "UPDATE 1-Hollande mobilises French industry for tidal energy push," *Reuters*, 30 September 2013, http://www.reuters.com/article/2013/09/30/france-marine-energy-idUSL6N0HQ2DT20130930.

24 Andrew Williams, "GDF Suez: Tapping into 80% of French tidal power potential," Tidal Today, 6 November 2013, http://social.tidaltoday.com/technology-engineering/gdf-suez-tapping-80-french-tidal-power-potential; DCNS, "Tidal Energy – From Marine currents to electrical current," http://en.dcnsgroup.com/energy/marine-renewable-energy/marine-turbine/.

25 Aquamarine Power, "Aquamarine Power secures full consent for 40MW Lewis wave energy farm," press release (Edinburgh: 22 May 2013), http://www.aquamarinepower.com/news/aquamarine-power-secures-full-consent-for-40mw-lewis-wave-energy-farm.

26 Pelamis Wave Power, "ETI project boosts power capture of Pelamis wave device," 23 September 2013, http://www.pelamiswave.com/news/news/145/ETI-project-boosts-power-capture-of-Pelamis-wave-device.

27 Pelamis Wave Power, "Knowledge Transfer Partnership with the University of Dundee," 12 July 2013, http://www.pelamiswave.com/news/news/139/Knowledge-Transfer-Partnership-with-the-University-of-Dundee.

28 EMEC, "Vattenfall," http://www.emec.org.uk/about-us/wave-clients/vattenfall/.

29 Wello Ltd, "Wello's Wave Energy Converter Producing Clean Energy," 10 September 2013, http://www.wello.eu/news.php.

30 Wave Hub, "Seatricity secures berth at Wave Hub," 10 December 2013, http://www.wavehub.co.uk/news/seatricity-secures-berth-at-wave-hub/.

31 Minesto, "Minesto's step-change marine power plant now producing electricity in Northern Ireland proving viability for huge ocean current power market," press release (Gothenburg, Germany: 12 November 2013), http://minesto.com/Resources/minesto-pm-in-operation-engfinal.pdf; Minesto, "Deep Green Technology," http://minesto.com/deepgreentechnology/index.html.

32 OES, "China Turns to the Ocean in a New Quest for Power," press release (Lisbon: May 2013), http://www.ocean-energy-systems.org/news/china_turns_to_the_ocean_in_a_new_quest_for_power/.

33 Ibid.

34 European Commission, "Commission sets out an action plan to support the development of blue energy," press release (Brussels: 20 January 2014), http://europa.eu/rapid/press-release_IP-14-36_en.htm.

35 European Commission, Maritime Affairs, "Ocean energy forum workshop – Brussels," 4 April 2014, http://ec.europa.eu/maritimeaffairs/policy/ocean_energy/forum/workshop-brussels/index_en.htm.

SOLAR PHOTOVOLTAICS (PV)

1 Figures of at least 39 GW and 139 GW based on the following: at least 36.9 GW was added for a total of more than 136 GW from International Energy Agency-Photovoltaic Power Systems Programme (IEA-PVPS), *PVPS Report – Snapshot of Global PV 1992–2013: Preliminary Trends Information from the IEA PVPS Programme* (Brussels: March 2014), http://www.iea-pvps.org/fileadmin/dam/public/report/statistics/PVPS_report_-_A_Snapshot_of_Global_PV_-_1992-2013_-_final_3.pdf; 39–40 GW installed for a total of 138–140 GW, from Gaëtan Masson, IEA PVPS, and iCARES Consulting, personal communication with REN21, February–May 2014; preliminary estimates of around 38.5 GW added for a total of 138–139 GW (calculated using low early estimate for China), from European Photovoltaic Industry Association (EPIA), *Global Market Outlook for Photovoltaics 2014-2018* (Brussels: forthcoming June 2014); some 39 GW added from Frankfurt School–UNEP Collaborating Centre for Climate & Sustainable Energy Finance (FS-UNEP) and Bloomberg New Energy Finance (BNEF), *Global Trends in Renewable Energy Investment 2014* (Frankfurt: 2014).

2 Based on 2013 year-end capacity, 2.6 GW was in operation at the beginning of 2004 and 70.2 GW at the end of 2011, from EPIA, *Market Report 2013* (Brussels: March 2014), http://www.epia.org/uploads/tx_epiapublications/Market_Report_2013_02.pdf; **Figure 12** from idem, p. 4; from EPIA, op. cit. note 1; and from Masson, op. cit. note 1.

3 EPIA, op. cit. note 2, p. 4.

4 Ibid.; other promising markets included South Africa and Chile, from Masson, op. cit. note 1.

5 The nine countries in 2013 were China, Germany, Greece, India, Italy, Japan, Romania, the United Kingdom, and the United States, from IEA-PVPS, op. cit. note 1; this was up from seven countries in 2012, including Australia, China, France, Germany, Italy, Japan, and the United States, from IEA-PVPS, *Trends 2013 in Photovoltaic Applications: Survey Report of Selected IEA Countries Between 1992 and 2012* (Brussels: 2013), http://iea-pvps.org/fileadmin/dam/public/report/statistics/FINAL_TRENDS_v1.02.pdf.

6 IEA-PVPS, op. cit. note 1.

7 Germany had 436 Watts per inhabitant, Italy 294 W, Belgium 268 W, Greece 229 W, the Czech Republic 206.8 W, and Australia 144 W, per EPIA, op. cit. note 1.

8 Ibid., and from China National Energy Administration, provided by Masson, op. cit. note 1.

9 China added 12.92 GW of solar PV capacity in 2013 per China National Energy Administration, provided by Masson, op. cit. note 1. This brings the year-end total to 19.9 GW based on 7 GW in place at end-2012, from Masson, op. cit. note 1. Other estimates include: China added 11,300 MW to the grid in 2013, from IEA-PVPS, op. cit. note 1, and from China Electricity Council (CEC), *2014 National Power Sector Report*, viewed 2 March 2014, and provided by Frank Haugwitz, Asia Europe Clean Energy (Solar) Advisory Co. Ltd. (AECEA), personal communication with REN21, March 2014. Data of 11.3 GW are unverifiable and likely cover only grid-connected capacity that was commissioned in 2013, per Masson, op. cit. note 1. For year-end total, other estimates include: about 18 GW total based on data from CEC, op. cit. this note; an estimated 18.1 GW from EPIA, op. cit. note 2, p. 4, and 18.3 GW from IEA-PVPS, op. cit. note 1. Note that the CEC seems to be omitting data below a certain kW level, which implies that they underestimate the total added and cumulative capacity, from Haugwitz, op. cit. this note. **Figure 13** from data and sources provided throughout this section.

10 Frank Haugwitz, *China's Continuing Grid Curtailment Requires NEA to Strengthen its Supervision*, Briefing Paper—China Solar PV Development (Beijing: AECEA, January 2014). Curtailment arose as an issue as early as 2012, per IEA-PVPS, op. cit. note 5, p. 21.

11 Very large projects from Chinese Renewable Energy Industries Association (CREIA), "In 2013 the World's Leading Solar PV Installed Da Qidi Countries," January 2014, http://www.creia.net/news/headline/1529.html (using Google Translate); utilities are China Power Investment, China Three Gorges, and China Huadian, per James Montgomery, "China's Dragon Awakens," Renewable Energy World, 27 January 2014, http://www.renewableenergyworld.com/rea/news/article/2014/01/asia-report-the-solar-dragon-awakens; provinces are Gansu (with 24% of all 2013 installations), Xinjiang (18%), and Qinghai

(17%), per BNEF, "China's 12GW Solar Market Outstripped All Expectations in 2013," press release (Beijing and Zurich: 23 January 2014), http://about.bnef.com/press-releases/chinas-12gw-solar-market-outstripped-all-expectations-in-2013/.

12 Smaller-scale and distributed from CREIA, op. cit. note 11, and from IEA-PVPS, op. cit. note 5, p. 21; shift to rooftop from Giles Parkinson, "China Switches Solar PV Focus from Utility-Scale to Rooftop Market," Renew Economy, 10 December 2013, http://reneweconomy.com.au/2013/china-switches-solar-pv-focus-from-utility-scale-to-rooftop-market-36069; Frank Haugwitz, *Will China Exceed 10 GW of New Solar PV Installations in 2014?* Briefing Paper-China Solar PV Development (Beijing: AECEA, November 2013).

13 Japan added 6,900 MW for a total of 13,643 MW (recalculated from data reported in DC (direct current)), from IEA-PVPS, op. cit. note 1; 6,900 MW added also from EPIA, op. cit. note 2. p. 4. Note that Japan reports official figures in AC (alternating current), and these are converted to DC (direct current). Solar PV installation under Japan's FIT, from January through December 2013, was reported to be 6,028 MW, from Ministry of Energy, Economy and Industry Japan, Agency of Natural Resource and Energy, "Renewable Energy Installation Under FIT (as of the end of Dec 2013) MW" (Tokyo: 20 March 2014), modified and translated by Japan Renewable Energy Foundation.

14 At the end of August 2013, rooftop installations accounted for 89% of Japan's market by capacity, per Finlay Colville, "Recharged Japan Solar PV Industry its 10 GW of Installed Capacity," Solar Buzz, 11 September 2013, http://www.solarbuzz.com/resources/articles-and-presentations/recharged-japan-solar-pv-industry-hits-10-gw-of-installed-capacity; PV homes accounted for about 30% of Japan's total residential PV market in 2012, per Junko Movellan, "New Solar Homes: Japanese Homebuilders Helping the Fight for Energy Independence," Renewable Energy World, 29 July 2013, http://www.renewableenergyworld.com/rea/news/article/2013/07/new-solar-homes-japanese-homebuilders-helping-the-fight-for-energy-independence; Sekisui House Ltd., Japan's largest builder of single-family homes, says more than 80% of the homes it builds have solar power, per Peter Landers and Mayumi Negishi, "In Post-Tsunami Japan, Homeowners Pull Away from Grid," *Wall Street Journal*, 17 September 2013, http://online.wsj.com/article/SB10001424127887323838204579001290288855268.html#articleTabs%3Dvideo.

15 Junko Movellan, "Recovery Report: Japan PV Manufacturers Find Their Domestic Sweet Spot," Renewable Energy World, 12 June 2013, http://www.renewableenergyworld.com/rea/news/article/2013/06/recovery-report-japan-pv-manufacturers-find-their-domestic-sweet-spot.

16 Herman K. Trabish, "Japan's Solar Market Surge Blows Away Earlier Forecasts," Green Tech Media, 7 November 2013, http://www.greentechmedia.com/articles/read/Japans-Solar-Market-Surge-Blows-Away-Earlier-Forecasts; Elisa Wood, "Japan: Solar's Real Deal? Nation's Large-scale Solar Market Is Booming—But Is It Sustainable?" Large Scale Solar, supplement to *Renewable Energy World*, May–June 2013, pp. 5–7; Japanese brand equipment from James Topham and Aaron Sheldrick, "Japan's Solar Dream Shatters as Projects Fail," *Reuters*, 19 November 2013, http://planetark.org/wen/70431. A study by the Japanese Ministry of Economy, Trade, and Industry determined that almost 800 approved solar PV projects had failed to obtain necessary equipment and land to begin construction, per "METI Investigations Find 784 Projects Stalled," *PV News*, March 2014, p. 3.

17 EPIA, op. cit. note 2. p. 4; IEA-PVPS, op. cit. note 1; India added 1,115 MW for a total of 2,319 MW, South Korea added 442 MW for a total of 1,467 MW, and Thailand added 317 MW for a total of 704 MW, per idem. India added 1,041.8 MW for a total of 2,323.38 MW at the end of 2013, per Akshay Urja, Bi-monthly magazine published by Ministry of New and Renewable Energy, Government of India, November-December 2012 and September-December 2013, provided by Shirish Garud, The Energy and Resources Institute (TERI), personal communication with REN21, December 2013.

18 EPIA, op. cit. note 1. North America includes the United States and Canada. Canada added 444 MW for a total of 1,210 MW at end 2013, from IEA-PVPS, op. cit. note 1.

19 GTM Research and U.S. Solar Energy Industries Association (SEIA), *U.S. Solar Market Insight Report: 2013 Year-in Review* (Washington, DC: 2014), Executive Summary, http://www.seia.org/research-resources/solar-market-insight-report-2013-year-review. The United States added 4,751 MW in 2013 for a total of 12.1 GW, from idem, and added 4,750 MW for a total of 12,020 MW, from IEA-PVPS, op. cit. note 1.

20 Innovative financing options include third-party ownership, pay-as-you-go solar leasing, home equity loans, and mortgages, per James Montgomery, "US Joins 10-GW Solar PV Club, Prepares for Liftoff," Renewable Energy World, 10 July 2013, http://www.renewableenergyworld.com/rea/news/article/2013/07/us-joins-10-gw-solar-pv-club-prepares-for-liftoff; impacts of third-party leasing and pay-as-you-go from Davide Savenije and Bill Opalka, "Four Solar Trends to Watch in 2014," Utility Dive, 17 January 2014, http://www.utilitydive.com/news/four-solar-trends-to-watch-in-2014/; home equity loans and mortgages from "U.S. Solar Market Surpasses 10 GW Mark," *PV News*, February 2014, p. 8; changing the game for all consumers, from small-scale homeowner level to commercial and industrial level, from Shawn W. Kravetz, Esplanade Capital, quoted in Jamie Smith Hopkins, "Solar Projects 'More Mainstream' As Costs Fall," *Baltimore Sun*, 20 October 2013, http://www.baltimoresun.com/business/bs-bz-businesses-going-solar-20131020,0,955547.story; Christine Beadle, "Mid-Size Solar PV Installations Accounting for Over 60% of US Project Pipeline," Solar Buzz, 24 May 2013, http://www.solarbuzz.com/resources/blog/2013/05/mid-size-solar-pv-installations-accounting-for-over-60-of-us-project-pipeline. See also Andreas Karelas, "Fostering Community Power: A New Pay It Forward Model for Solar," Renewable Energy World, 12 March 2014, http://www.renewableenergyworld.com/rea/blog/post/2014/03/a-new-way-to-foster-community-power-a-first-of-its-kind-pay-it-forward-model-for-solar.

21 The total market was up 41%, with the residential sector up 60%, non-residential sector up 37%, and utility sector up 58%, per GTM Research and SEIA, op. cit. note 19. Large ground-mounted systems from NPD Solarbuzz, North America PV Markets Quarterly, December 2013, cited in "Record 2013 Solar PV Installations Promotes U.S. to Strongest Market Outside Asia-Pacific, According to NDP Solarbuzz," Solar Buzz, 8 January 2014, http://www.solarbuzz.com/news/recent-findings/record-2013-solar-pv-installations-promotes-us-strongest-market-outside-asia-pa.

22 Businesses from SEIA and the Vote Solar Initiative, *Solar Means Business 2013: Top U.S. Commercial Solar Users* (Washington, DC: 2013). Colorado utility Xcel Energy in October chose large-scale solar PV and wind over other options based on price alone (without considering RPS or carbon costs), from Dave Levitan, "For Utility-Scale Solar Industry, Key Questions About the Future," *YaleEnvironment360*, 21 November 2013, http://e360.yale.edu/feature/for_utility-scale_solar_industry_key_questions_about_the_future/2713/, and from David Eves, CEO of Public Service Company of Colorado, an Xcel subsidiary, cited in Cathy Proctor, "Xcel Energy Hopes to Triple Colorado Solar, Add Wind Power," *Denver Business Journal*, 9 September 2013, http://www.bizjournals.com/denver/blog/earth_to_power/2013/09/xcel-energy-proposes-to-triple-solar.html?page=all.

23 Ethan Howland, "Large Utility-Scale Solar Development Slows to a Crawl," Utility Dive, 14 January 2014, http://www.utilitydive.com/news/large-utility-scale-solar-development-slows-to-a-crawl/; Levitan, op. cit. note 22.

24 California added 2,621 MW of the total 4,751 MW installed during 2013, from GTM Research and SEIA, op. cit. note 19; successfully transition from "US Solar Market on the Path to Mainstream with 4.8 GW Installed in 2013," *PV News*, April 2014, p. 8.

25 The EU had more than 80 GW and wider Europe had 81.5 GW by the end of 2013, from EPIA, op. cit. note 1.

26 Capacities added in 2013 from EPIA, op. cit. note 1; shares of global market based on IEA-PVPS, op. cit. note 1 and additional data for China from Masson, op. cit. note 1. Note that Europe added 22.4 GW in 2011 and 17.6 GW in 2012, from EPIA, op. cit. note 2, p. 2, and added 22 GW in 2011 and 17 GW in 2012, from IEA-PVPS, op. cit. note 1.

27 EPIA, op. cit. note 2, p. 2. For more regarding taxes on solar PV, see Ben Willis, "Bulgarian President Steps in Over Solar Levy Dispute," PV-tech, 14 January 2014, http://www.pv-tech.org/news/bulgarian_president_steps_in_over_solar_levy_dispute; Cristiano Dell'Oste and Michela Finizio, "Fotovoltaico sul tetto? Per il Fisco vale come una stanza in più e va accatastato," ilsole24ore.com, 18 February 2014, http://www.ilsole24ore.com/art/tecnologie/2014-02-17/fotovoltaico-tetto-il-fisco-vale-come-stanza-piu-e-va-accatastato-175132.shtml (using Google Translate); Sophie Vorrath, "Czech Follows Spain in Deciding

to Tax Output from Solar Power," reneweconomy.com.au, 18 September 2013, http://reneweconomy.com.au/2013/czech-follows-spain-in-deciding-to-tax-output-from-solar-power-49694; John Parnell, "Spanish Solar Cuts Force IKEA to Hand PV Plant Back to the Bank," PV-tech, 6 February 2014, http://www.pv-tech.org/news/spanish_solar_cuts_force_ikea_to_hand_pv_plant_back_to_the_bank.

28 Tim Murphy, "Addressing PV Grid-Access Barriers Across Europe," NPD Solarbuzz, 7 February 2013, http://www.renewableenergyworld.com/rea/news/article/2013/02/addressing-pv-grid-access-barriers-across-europe.

29 Figure of 3,305 MW added from Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), *Erneuerbare Energien im Jahr 2013* (Berlin: Bundesministerium für Wirtschaft und Energie, 2014), p. 2, http://www.bmwi.de/BMWi/Redaktion/PDF/A/agee-stat-bericht-ee-2013,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf; 3,304 MW added for a total of 35,500 MW, and 7.6 GW for three years from IEA-PVPS, op. cit. note 1.

30 The year-end total was 35,948 from AGEE-Stat, op. cit. note 29, p. 2; and 35,500 MW, from IEA-PVPS, op. cit. note 1.

31 BSW-Solar survey, cited in Ben Willis, "Survey Reveals Shift to PV Self-Consumption in Germany," PV-tech, 26 July 2013, http://www.pv-tech.org/news/survey_reveals_shift_to_pv_self_consumption_in_germany. Self-generation introduces new complexities for solar PV installers, who must determine appropriate system size. These complexities also result in higher costs for system owners, per Masson, op. cit. note 1.

32 More than 1.5 GW from EPIA, op. cit. note 1; 1,000 MW added for a total of 2,900 MW, from IEA-PVPS, op. cit. note 1; region's strongest from Marc Rosa, "England's Clouds Part for Solar as Panels Carpet Fields," *Bloomberg*, 14 January 2014, http://www.renewableenergyworld.com/rea/news/article/2014/01/englands-clouds-part-for-solar-as-panels-carpet-fields. The market for smaller systems was also healthy, driven by the FIT for systems under 50 kW capacity, and more than 500,000 rooftop systems were operating in the country by year's end, per "More than 500,000 Rooftop PV Systems Installed in the UK," *PV News*, February 2014, p. 3.

33 Italy added 1,461 MW for a total of 17,600 MW, Romania added 1,100 MW for a total of 1,150 MW, and Greece added 1,041 MW for a total of 2,579 MW, all from IEA-PVPS, op. cit. note 1, and from EPIA, op. cit. note 2, p. 4.

34 Italy added 1,461 MW in 2013, down from 9.3 GW in 2011, 3.6 GW in 2012; Belgium added 215 MW, down from 600 MW, for a total of 2,983 MW; Denmark added 153 MW, down from 300 MW in 2012, for a total of 532 MW; and France added 613 MW in 2013 for a total of 4,632 MW, all from IEA-PVPS, op. cit. note 1. Italy's "Quinto Conto Energia" (grant for PV) ended on July 2013, but a 50% tax credit for small-scale rooftop systems is ongoing. The tax credit is expected support the growth of small residential PV plants, per Alessandro Marangoni, Althesys Strategic Consultants, personal communication with REN21, 16 April 2014.

35 Tim Flannery and Veena Sahajwalla, *The Critical Decade: Australia's Future—Solar Energy* (Climate Commission Secretariat, 2013), http://apo.org.au/files/Resource/climatecommission_australias-future-solar-energy_2013.pdf; Clean Energy Council, "Rooftop Solar Powers Past New Milestone," press release (Melbourne: 5 December 2013).

36 An estimated 848 MW was added for a total of 3,255 MW at year's end, from IEA-PVPS, op. cit. note 1; to reduce electricity bills from Jonathan Gifford, "Australia Hits 3 GW Installed Capacity Milestone," *PV Magazine*, 4 December 2013, http://www.pv-magazine.com/news/details/beitrag/australia-hits-3-gw-installed-capacity-milestone_100013649.

37 Penn Energy, "Australia Reaches 3 GW Solar Renewable Energy Milestone," 9 December 2013, http://www.pennenergy.com/articles/pennenergy/2013/12/australia-reaches-solar-power-capacity-milestone-of-3-gw.html.

38 Promising markets in the region include Chile, the Dominican Republic, Ecuador, French Guyana, Guadeloupe, Guatemala, Martinique, Mexico, Peru, and Uruguay. In Peru, a "double 20 MW" plant was inaugurated in early 2013, per IEA-PVPS, op. cit. note 5, p. 20; Ecuador from Maria Gabriela da Rocha, BNEF, cited in Marc Roca, "Mexican Sun Lures Cash to Solar as Panel Prices Plunge," *Bloomberg*, 4 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/mexican-sun-lures-cash-to-solar-as-panel-prices-plunge; Guatemala began construction of Central America's largest solar park (50 MW), due to be completed August 2014, per Gustavo E. Méndez, "Pioneered Solar Guatemala in Central America," Agencia Guatemalteca de Noticias, 14 February 2013, http://www.agn.com.gt/index.php/world/business/item/2629-guatemala-pionera-en-energ%C3%ADa-solar-en-centroamérica (using Google Translate); "Sky Solar and Tecnova Renovables to Build 8 MW Solar Park in Western Uruguay," Photon.info, 14 November 2013, http://www.photon.info/photon_news_detail_en.photon?id=82287; Edgar Meza, "Uruguay Receives 11 Bids for PV Projects Totaling 27 MW," *PV Magazine*, 28 October 2013, http://www.pv-magazine.com/news/details/beitrag/uruguay-receives-11-bids-for-pv-projects-totaling-27-mw_100013250/z; Blanca Diaz and Edgar Meza, "Net Metering in Dominican Republic Shows Results," *PV Magazine*, 4 July 2013, http://www.pv-magazine.com/news/details/beitrag/net-metering-in-dominican-republic-shows-results-_100011922/#axzz2z8EuzWQa. For more on Latin America, see Vince Font, "Solar in 2014 Finally Gets Some Respect," *Renewable Energy World*, January–February 2014, p. 24.

39 Slower than expected from EPIA, op. cit. note 2, p. 5; Chile has seen several project announcements, but little capacity added as of 2013, from IEA-PVPS, op. cit. note 5, p. 19. Hurdles to deployment in Chile include transmission constraints and permitting and siting delays. By September 2013, Chile had a pipeline backlog greater than 3 GW of solar PV capacity, but only 70 MW was under development, and only 3.5 MW of grid-connected capacity was operating, per James Montgomery, "Latin America Report: Chile's Road to Solar Grid Parity," Renewable Energy World, 11 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/latin-america-report-chiles-road-to-solar-grid-parity; Peter Carvill, "Mexican President Inaugurates One of Latin America's Largest Solar Farms," *PV Magazine*, 3 April 2014, http://www.pv-magazine.com/news/details/beitrag/mexican-president-inaugurates-one-of-latin-americas-largest-solar-farms_100014731/; Christian Roselund, "Land of the Sun: Solar PV in Latin America," Solar Server, 18 March 2014, http://www.solarserver.com/solar-magazine/solar-report/solar-report/land-of-the-sun-solar-pv-in-latin-america.html.

40 Martifer Solar, "Martifer Solar and Gauss Energía Inaugurate Aura Solar, Latin America's Largest Connected PV Plant," press release (Oliveira de Frades, Portugal: 26 March 2014), http://www.martifersolar.com/fr/PressReleases01_14.php; Blanca Diaz-Lopez, "Chile Reaches 150 MW of Installed Solar with Further 225 MW Under Construction," *PV Magazine*, 20 March 2014, http://www.pv-magazine.com/news/details/beitrag/chile-reaches-150-mw-of-installed-solar-with-further-225-mw-under-construction_100014563/; Roselund, op. cit. note 39. In Mexico, large-scale solar PV projects are not subsidised but development is driven by good solar resources, falling solar PV costs, and foreign developers and manufacturers in search of new markets, per Maria Gabriela da Rocha, BNEF, cited in Roca, op. cit. note 38. Mexico added 45 MW in 2013 for a total of 100 MW, from IEA-PVPS, op. cit. note 1.

41 Included in energy plans from IEA-PVPS, op. cit. note 5, p. 37; interest increasing from Heba Hashem, "What's in Store for the MENA's PV Market?" PV Insider, 4 February 2014, http://news.pv-insider.com/photovoltaics/what%E2%80%99s-store-mena%E2%80%99s-pv-market; Scott Burger, "Turkey Solar Market Outlook, 2013-2017," *PV News*, February 2013, p. 1; Matt Carr, "Photovoltaic Opportunities in Saudi Arabia Growing," Renewable Energy World, 5 February 2013, http://www.renewableenergyworld.com/rea/companies/first-conferences/news/article/2013/02/photovoltaic-opportunities-in-saudi-arabia-growing; Vesela Todorova, "Dubai's First Solar Plant on Schedule," *The National*, 4 July 2013, http://www.thenational.ae/news/uae-news/environment/dubais-first-solar-power-plant-on-schedule.

42 Jordan, Kuwait, and United Arab Emirates (UAE) from David Renné, International Solar Energy Society (ISES), personal communication with REN21, 10 April 2014; a 13 MW plant was commissioned in Dubai, UAE in late 2013, making it the largest PV installation in the region at the time, and Dubai put out a tender for another 100 MW, per D. McQueen, Ministry of Foreign Affairs, UAE, personal communication with REN21, 14 April 2014; "First Solar Secures 20-Year PPA for Solar Project in Jordan," Solar Novus, 20 March 2014, http://www.solarnovus.com/first-solar-secures-20-year-ppa-for-solar-project-in-jordan_N7577.html; SMA Solar Technology AG, "Parking Lot Saudi Aramco," http://www.sma.de/fileadmin/content/global/Products/Documents/Referenzanlagen/EN_ARAMCO.pdf,

viewed 19 March 2014; Dagmar Buth-Parvaresh, "Saudi Arabia: The Largest PV Module-Covered Parking Lot in the World," Sunny: The SMA Corporate Blog, 6 September 2013, http://en.sma-sunny.com/2013/09/06/saudi-arabia-the-largest-pv-module-covered-parking-lot-in-the-world/.

43 Markets include Angola, Cameroon, Ethiopia, Ghana, Senegal, and Zimbabwe, from IEA-PVPS, op. cit. note 5, p. 38; Egypt from Steve Sawyer, Global Wind Energy Council (GWEC), personal communication with REN21, 18 September 2013.

44 W. Jonker Klunne, Council for Scientific and Industrial Research, Pretoria, South Africa, personal communication with REN21, 12 April 2014; Renewable Energy Independent Power Producer Procurement programme also from "South Africa's Renewable Energy Programme Announces Successful Bidders for Round Three," Energyblog, 14 November 2013, http://www.energy.org.za/news/14-the-energy-blog/78-reippp-window-three; "South Africa's First Solar Plant Goes Online," SouthAfrica.info, 14 November 2013, http://www.southafrica.info/business/investing/solar-141113.htm; Terence Creamer, "Two N Cape Solar Farms to Be Inaugurated in May as Operations Begin," Engineeringnews.co.za, 17 April 2014, http://www.engineeringnews.co.za/article/two-n-cape-solar-farms-to-be-inaugurated-in-may-as-operations-begin-2014-04-17.

45 At least 13 countries and 49 plants based on the following sources: Denis Lenardic, "Large-scale Photovoltaic Power Plants Ranking 1-50," updated 22 February 2014, http://www.pvresources.com/PVPowerPlants/Top50.aspx; at least another four plants based on idem, updated 15 March 2014, 143 MW Catalina Solar Project in California, from "Catalina Solar Reaches Commercial Operation," *PV News*, October 2013, p. 6; EDF Renewable Energy, "Project Detail: Catalina Project," http://www.edf-re.com/projects/detail/catalina_solar_project/, viewed 13 March 2014; 320 MW solar PV plant co-located with an existing 1.28 GW hydropower dam in Qinghai Province, Northwestern China, per "CPI Completes Massive Hybrid Solar PV/Hydro Plant in Western China," Solar Server, 12 December 2013, http://www.solarserver.com/solar-magazine/solar-news/current/2013/kw50/cpi-completes-massive-hybrid-solar-pvhydro-plant-in-western-china.html; 200 MW Chinese PV plant in Gonghe Industrial Park, from China Power Investment Corporation (CPIC), "200 MW Gonghe PV Station of Huanghe Company Synchronized," press release (Beijing: 16 December 2013), http://eng.cpicorp.com.cn/e_corporateNews/201312/t20131218_227495.htm; 100 MW Chinese plant in Chengde, from CPIC, "100 MW Chengde PV Station Put into Operation," press release, 13 December 2013, http://eng.cpicorp.com.cn/NewsCenter/CorporateNews/201401/t20140114_228662.htm. The countries are Bulgaria, Canada, China, France, Germany, India, Italy, Japan, South Africa, Spain, Thailand, Ukraine, and the United States, per Lenardic, op. cit. this note, updated 15 March 2014. Note that reportedly a 100 MW solar PV plant was completed and commissioned by SunEdison (United States) in Chile during January 2014, per "Chile Reports that the 100 MW Amanecer Solar PV Plant is Online," Solar Server, 21 February 2014, http://www.solarserver.com/solar-magazine/solar-news/current/2014/kw08/chile-reports-that-the-100-mw-amanecer-solar-pv-plant-is-online.html.

46 Based on data from Lenardic, op. cit. note 45, updated 15 March 2014.

47 Estimate of at least 14 in 2013 includes extensions of existing PV power projects as well as single stages completed in 2013, and based on data from Lenardic, op. cit. note 45, updated 15 March 2014; Japan plant is 70 MW Kagoshima Nanatsujima Mega Solar Power Plant, per Kyocera, "KYOCERA Starts Operation of 70 MW Solar Power Plant, the Largest in Japan," press release (Tokyo: 5 November 2013), http://global.kyocera.com/news/2013/1101_nnms.html; South Africa plant is 75 MW Kalkbult plant, per Scatec Solar, "Inauguration of the 75 MW PV Plant Kalkbult," press release (Oslo: 11 December 2013), http://www.scatecsolar.com/page_3_1.php?cms_beg=0&pg=&kat1=&kat2=&kat3=&cmsshowfull=2_0_1001&dummy=0#cmsjumpto1. Note that tied for second largest at year's end was the California Valley Solar Ranch, which expanded to its final capacity of 250 MW in operation in late 2013 (the first 22 MW began delivering power in October 2012), per "CVSR Reaches Full Commercial Operation," *PV News*, December 2013, pp. 6–7.

48 "CPI Completes Massive Hybrid Solar PV/Hydro Plant in Western China," Solar Server, 12 December 2013, http://www.solarserver.com/solar-magazine/solar-news/archive-2013/2013/kw50/cpi-completes-massive-hybrid-solar-pvhydro-plant-in-western-china.html.

49 United States and other leaders based on data from Lenardic, op. cit. note 45, updated 22 February 2014 and 15 March 2014. Note that the United States had more than 1,430 MW of capacity in plants larger than 50 MW, followed by Germany (more than 1,200 MW), China (11,200 MW), India (almost 330 MW), and Ukraine (more than 310 MW), per idem, updated 22 February and 15 March 2014.

50 For example: the Sterling Project (1,200 MW) and McCoy Solar Energy Center (750 MW) in California were in early development stages in California by late 2013, per SEIA, cited in Levitan, op. cit. note 22; the first 57 MW of the planned 579 MW Solar Star project was connected to the U.S. grid in late 2013 or early 2014, with full construction due to be completed by end-2015, from Scott DiSavino, "Giant California Solar Star Power Plant Enters Service," *Reuters*, 13 January 2014, http://planetark.org/wen/70837, and from "First Phase of Solar Star Connected to the Grid," *PV News*, February 2014, p. 6; the 96 MW Jasper Solar Project, financed in part by Google, is under way in South Africa, and two projects of over 100 MW received approval in Chile in 2013, per J. Matthew Roney, "Solar Power: World Solar power topped 100,000 Megawatts in 2012" (Washington, DC: Earth Policy Institute, 31 July 2013), http://www.earth-policy.org/indicators/C47/solar_power_2013; in Australia, construction began in early 2014 on a 102 MW plant, per "Construction Begins on 102 MW Nyngan Plant, Australia's Largest Solar PV Plant," Solar Plaza, 28 January 2014, http://www.solarplaza.com/news/construction-begins-on-102mw-nyngan-plant-australi; construction of the largest solar project (64 MW) in the Caribbean region began in the Dominican Republic in late 2013, per "Caribbean's Largest Solar Plant Under Construction," *PV News*, October 2013, p. 7; in China, there were announcements of plans to construct several projects of 1 GW or larger, from Shunfeng Photovoltaic International Limited, "Announcement: Cooperation Agreements," September 2013, http://www.hkexnews.hk/listedco/listconews/SEHK/2013/0901/LTN20130901053.pdf, and from Louise Downing, "Trina to Build 1-Gigawatt Solar Farm in Western China," *Bloomberg*, 30 December 2013, http://www.bloomberg.com/news/2013-12-30/trina-to-build-1-gigawatt-solar-project-in-western-china.html.

51 Paula Mints, "And the Future of Residential Solar Is… Up for Grabs," Renewable Energy World, 14 March 2014, http://www.renewableenergyworld.com/rea/news/article/2014/03/and-the-future-of-residential-solar-isup-for-grabs. The commercial- and utility-owned share of the on-grid global market has been larger than the residential share since 2006, per idem.

52 Mints, op. cit. note 51. Self-consumption is expected to reach competitiveness later than net metering for solar PV, but many countries are considering policies (payment for grid costs, taxes, etc.) that would make self-consumption less competitive, therefore slowing markets, per Masson, op. cit. note 1; in Italy there is a strong debate about net metering, from Marangoni, op. cit. note 34; debate over net metering in the United States from, for example, Mark Chediak, Christopher Martin, and Ken Wells, "Utilities Feeling Rooftop Solar Heat Start Fighting Back," *Bloomberg*, 31 December 2013, http://www.renewableenergyworld.com/rea/news/article/2013/12/utilities-feeling-rooftop-solar-heat-start-fighting-back, and from Marc Gunther, "With Rooftop Solar on the Rise, U.S. Utilities are Striking Back," *YaleEnvironment360*, 3 September 2013, http://e360.yale.edu/feature/with_rooftop_solar_on_rise_us_utilities_are_striking_back/2687/; James Montgomery, "More Insights into Solar and Utilities: Large-Scale Integration, Self-Ownership, and Net Metering," Renewable Energy World, 5 June 2013, http://www.renewableenergyworld.com/rea/news/article/2013/06/more-insights-into-solar-and-utilities-large-scale-integration-self-ownership-and-net-metering; Giles Parkinson, "Australian Utilities Erect Barricades in Bid to Halt Solar Storm," Reneweconomy.com.au, 23 October 2013, http://reneweconomy.com.au/2013/australian-utilities-erect-barricades-in-bid-to-halt-solar-storm-91715.

53 "Australian Community Solar Project Begins Operation," *PV News*, January 2013, p. 11; Japan from Hironao Matsubara, ISEP, Tokyo, personal communication with REN21, 16 April 2014; United Kingdom from Andrew Williams, "Sharing Renewable Energy: Solar Power Co-operatives in the UK," Renewable Energy World, 8 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/sharing-renewable-energy-solar-power-co-operatives-in-the-uk; Thailand from IEA-PVPS, op. cit. note 5, p. 25.

54 Bryan Lewis, "'Solar Gardens: Clean Energy Within Reach of Low-Income Families," Climate Progress, 28 August 2013,

http://thinkprogress.org/climate/2013/08/28/2546291/community-solar-income/; David Shaffer, "First Community Solar Projects Getting Launched," *Star Tribune*, 19 July 2013, http://www.startribune.com/business/216093571.html; Chris Meehan, "Clean Energy Collective Digs into Solar Gardens in Massachusetts," Renewable Energy World, 16 January 2014, http://www.renewableenergyworld.com/rea/blog/post/2014/01/clean-energy-collective-digs-into-solar-gardens-in-massachusetts; Christine Beadle, "Mid-Size Solar PV Installations Accounting for Over 60% of US Project Pipeline," Solar Buzz, 24 May 2013, http://www.solarbuzz.com/resources/blog/2013/05/mid-size-solar-pv-installations-accounting-for-over-60-of-us-project-pipeline. Carve-outs for solar gardens from Lewis, op. cit. this note, and from Shaffer, op. cit. this note.

55 Alasdair Cameron, "Tracking the Market: focus on the concentrating photovoltaic sector," *Renewable Energy World*, July–August 2011, pp. 71–75; locations from Travis Bradford, Prometheus Institute, personal communication with REN21, 21 March 2012.

56 A 1.5 MW CPV plant began feeding power into Victoria, Australia's grid in mid-2013, per "Australia Completes its Largest CPV Power Station," *CPV Intelligence Brief*, 13–25 June 2013, http://news.pv-insider.com/users/ksdicks; Jason Deign, "Italy: Worth a Second Look for CPV," PV Insider, 7 January 2013, http://news.pv-insider.com/concentrated-pv/italy-worth-second-look-cpv; California's largest CPV plant (1.5 MW) was completed, per "Soitec Completes California's Largest CPV Plant," *PV News*, August 2013, p. 7; Chile from Soitec, "Minera El Tesoro Mining Group and Soitec Establish CPV Solar-Energy Pilot Plant for Mining Operation in Chile," press release (Bernin, France and Santiago, Chile: 27 May 2013), http://www.soitec.com/en/news/press-releases/minera-el-tesoro-mining-group-and-soitec-establish-cpv-solar-energy-pilot-plant-for-mining-operation-in-chile-1304/; Namibia from Soitec, "Soitec Connects Solar-Power Demonstration Plant in Namibia," press release (Bernin, France: 10 June 2013), http://www.soitec.com/en/news/press-releases/soitec-connects-solar-power-demonstration-plant-in-namibia-1317/; Portugal from Soitec, "Soitec Announces Financing and Construction Start of Solar Power Plant in Portugal," press release (Bernin, France: 2 December 2013), http://www.soitec.com/en/news/press-releases/soitec-announces-financing-and-construction-start-of-solar-power-plant-in-portugal-1391/; Saudi Arabia from Soitec, "Khaled Juffali Company and Soitec Announce Saudi Aramco Chooses Soitec's Solar-Energy Technology," press release (Jeddah, Saudi Arabia and Bernin, France: 12 June 2013, http://www.soitec.com/en/news/press-releases/khaled-juffali-company-and-soitec-announce-saudi-aramco-chooses-soitec-s-solar-energy-technology-1320/. See also "Signs of Progress for CPV, But Momentum Needs to be Sustained," PV Insider, 17 September 2013, http://news.pv-insider.com/users/ritesh-gupta.

57 Suncore Photovoltaic Technology Co., Ltd., "50 MW CPV Power Plant in Golmud, Qinghai, China," 2013, http://www.suncorepv.com/index.php?m=content&c=index&a=lists&catid=107; "Research and Markets: Global Concentrated Photovoltaic Cumulative Installations to Achieve More than 1 Gigawatt Capacity, by 2020," *Business Wire*, 25 March 2014, http://www.businesswire.com/news/home/20140325005716/en/Research-Markets-Global-Concentrated-Photovoltaic-Cumulative-Installations.

58 Based on mid-2012 data from PV Insider, "CPV World Map 2012, June Update," prepared for CPV USA 2012, 4th Concentrated Photovoltaic Summit USA, San Jose, CA, October 2012, http://www.pv-insider.com/cpv/documents/CPVWorldMap2012.PDF; and on capacity added in 2013. The United States added 10 MW of CPV in 2013 for a total of at least 48 MW in operation, based on data (including only projects 1 MW and larger) from SEIA, "Major Solar Projects in the United States, Operating, Under Construction, or Under Development," updated 6 March 2014, http://www.seia.org/sites/default/files/resources/Major%20Solar%20Projects%20List%203.6.14.pdf; China added 60 MW for a year-end 2013 total of 70 MW, per Haugwitz, op. cit. note 9. Nearly 154 MW was in operation by early 2014 according to GlobalData, cited in James Montgomery, "CPV Update: SunPower Ramps Up in China, Soitec Achieves South Africa Milestone," Renewable Energy World, 28 March 2014, http://www.renewableenergyworld.com/rea/news/article/2014/03/cpv-update-sunpower-ramps-up-in-china-soitec-achieves-south-africa-milestone?cmpid=SolarNL-Saturday-March29-2014; 357.9 MW was in operation in 2014, per "Research and Markets…," op. cit. note 57.

59 Italy and Greece (about 5.8%), from IEA-PVPS, op. cit. note 1; Germany from AGEE-Stat, op. cit. note 29, p. 2. Examples of daily peaks include: in the U.S. state of California, for example, solar power (both solar PV and concentrating solar thermal) met 18% of the state's 22,700 MW demand on 8 March 2014, per "California Electric Grid Sets Solar Generation Record," *Reuters*, 10 March 2014, http://www.reuters.com/article/2014/03/10/utilities-california-solar-idUSL2N0M724F20140310; Thomas Gerke, "Sunday, Solar Sunday—Germany's July 7 Solar Power Record In-Depth," Clean Technica, 12 July 2013, http://cleantechnica.com/2013/07/12/sunday-solar-sunday-germany-solar-power-record-in-depth/; Ian Clover, "Solar Power Saves the Day During Australia's Record Heatwave," *PV Magazine*, 17 January 2014, http://www.pv-magazine.com/news/details/beitrag/solar-power-saves-the-day-during-australias-record-heatwave_100013970/.

60 Figure of 3% of total consumption and 6% of peak demand, from EPIA, op. cit. note 2, p. 5, and from IEA-PVPS, op. cit. note 1; 0.3% in 2008 from Gaëtan Masson, "Editorial: 2013, A Qualified Record-year for Photovoltaics," EPIA, March 2014, http://www.epia.org/news/news/?page=1#news-278. At least 160 TWh is based on capacity in operation at the end of 2013, from IEA-PVPS, op. cit. note 1; this is up from an estimated 110 TWh with capacity installed at the end of 2012, from EPIA, op. cit. note 1, pp. 13, 44. At least 15 countries had enough PV to produce at least 1% of their electricity demand by year's end, from IEA-PVPS, op. cit. note 1.

61 Ehren Goossens, "Solar Rebound Beating Dot-Com Recovery as Demand Surges," *Bloomberg*, 31 October 2013, http://www.bloomberg.com/news/2013-10-31/solar-rebound-beating-dot-com-recovery-as-demand-surges.html.

62 Paula Mints, "Object Lesson: Europe's Solar Energy Market," *Renewable Energy World*, 16 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/object-lesson-europes-solar-energy-market.

63 Goossens, "Solar Rebound Beating . . .," op. cit. note 61.

64 BNEF, "US Unlocks USD 15BN Financing Door for Alternative Vehicles," *Energy: Week in Review*, 27 August–2 September 2013.

65 Paula Mints, "The Aggressive Solar Pricing U-Turn That Was Impossible to Make," *Renewable Energy World*, 14 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/the-aggressive-solar-pricing-u-turn-that-was-impossible-to-make; Masson, op. cit. note 1.

66 See, for example: Doug Young, "New Litigation Trips Up Suntech, Trina, Yingli," Young's China Business Blog, 14 October 2013, http://www.youngchinabiz.com/en/new-litigation-trips-up-suntech-trina-yingli/; James Montgomery, "Update: EU-China Solar Trade War Entering Endgame?" Renewable Energy World, 9 May 2013, http://www.renewableenergyworld.com/rea/news/article/2013/05/eu-china-solar-trade-war-entering-endgame?cmpid=WNL-Friday-May10-2013; Xiaolu Wang and Marlies Huijbers, "Is a Chinese Sun Powering Western Solar Energy Economies?" Renewable Energy World, 28 February 2014, http://www.renewableenergyworld.com/rea/news/article/2014/02/is-a-chinese-sun-powering-western-solar-energy-economies.

67 Module prices and robust demand from GTM Research, PV Pulse, April 2014. Module prices stabilised per Masson, op. cit. note 1. Note that module prices fell 70% in two years, from "PV Technology and Cost Outlook, 2013-2017," *PV News*, August 2013, p. 16.

68 Rapid learning and low materials costs from Paula Mints, "The Return of the Badly Rhyming 12 Days of Solar Christmas," Renewable Energy World, 24 December 2013, http://www.renewableenergyworld.com/rea/news/article/2013/12/the-return-of-the-badly-rhyming-12-days-of-solar-christmas; manufacturing cost reductions and improved manufacturing processes from Giles Parkinson, "SunPower Continues to Drive Down the Cost Curve," Green Tech Media, 21 February 2014, http://www.greentechmedia.com/articles/read/SunPower-Continues-To-Drive-Down-the-Cost-Curve; faster than targeted and Chinese producers from "PV Technology and Cost Outlook, 2013-2017," *PV News*, August 2013, p. 16. However, the rate of decline in cost per watt for traditional module manufacturers has slowed, per Deutsche Bank Markets Research, "2014 Outlook: Let the Second Gold Rush Begin," Industry Update, 6 January 2014, p. 25.

69 Masson, op. cit. note 1. In the United States, the price of rooftop systems 10 kW or smaller fell 37%, but over 80% of the cost reduction was attributable to falling module costs, per Galen Barbose et al., *Tracking the Sun VI, An Historical Summary of the*

Installed Price of Photovoltaics in the United States from 1998 to 2012 (Berkeley, CA: Lawrence Berkeley National Laboratory, July 2013), pp. 14–15, http://emp.lbl.gov/sites/all/files/lbnl-6350e.pdf.

70 FS–UNEP Centre and BNEF, op. cit. note 1. **Figure 14** sources: global capacity added during 2004–2012 from EPIA, op. cit. note 2, and preliminary estimates for capacity added during 2013 from Masson, op. cit. note 1; investment data from BNEF, provided by Angus McCrone, BNEF, personal communication with REN21, 26 March 2014.

71 FS–UNEP Centre and BNEF, op. cit. note 1, p. 43. Levelised costs of generation for crystalline silicon PV systems fell 53% between 2009 and early 2014, per idem, p. 36.

72 Deutsche Bank Markets Research, op. cit. note 68, p. 2. Markets include several countries in Latin America, Europe, Asia, and some U.S. states, per idem, pp. 2, 4, 17. In Germany and Italy, the retail price of electricity for some consumer segments is higher than solar PV generation costs, from IEA-PVPS, op. cit. note 5, p. 73. Note that soft costs vary greatly according to system size, customer type, location, and other factors, per idem, p. 63.

73 During 2013, for example, SunPower (United States) announced an agreement between Total (France) and Etrion Partners (Switzerland) to build a 70 MW project in Chile that initially will sell all electricity on the spot market and will be the world's largest unsubsidised solar PV project, from Sanjay Shrestha, Lazard Capital, 26 September 2013, cited in *PV News*, November 2013, p. 2, and from Javier Vergara and Raul Sandoval, "Renewable Year-end Focus: Chile," Renewable Energy World, 25 December 2013, http://www.renewableenergyworld.com/rea/news/article/2013/12/renewable-year-end-focus-chile; Conergy (Germany) installed projects in Spain that were generating at grid-competitive rates, without subsidies, starting in late 2012, and reaching 1 GW by mid-2013, and developed business models for competitive markets in Australia, South Africa and the United States (not carried out due to subsequent insolvency), per Chris Meehan, "Conergy Installing Solar at Cost of Conventional Electricity in Spain," Clean Energy Authority, 5 June 2013, http://www.cleanenergyauthority.com/solar-energy-news/conergy-installing-solar-at-grid-in-spain-060513; FS–UNEP Centre and BNEF, op. cit. note 1, Chapter 3.

74 GTM Research, op. cit. note 67. Note that there are a number of differing estimates for module production and production capacity. Information is highly sensitive and no one knows exactly what the amounts are, per Masson, op. cit. note 1.

75 GTM Research, op. cit. note 67.

76 Paula Mints, "Reality Check: The Changing World of PV Manufacturing," *Renewable Energy World*, 5 October 2011, http://www.renewableenergyworld.com/rea/news/article/2011/10/reality-check-the-changing-world-of-pv-manufacturing; Paula Mints, "The Solar Pricing Struggle," Renewable Energy World, 28 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/the-solar-pricing-struggle.

77 GTM Research, op. cit. note 67. China's share was up slightly from almost two-thirds in 2012, from GTM Research Competitive Intelligence Tracker, April 2013.

78 GTM Research, op. cit. note 67.

79 Ibid.

80 Bridge to India, "The Real Problem Facing Domestic Manufacturing Is the Lack of Scale," *India Solar Weekly Market Update*, 6 September 2013; World Bank, "Transforming India's Future With Solar Power," 12 December 2013, http://www.worldbank.org/en/news/feature/2013/12/12/transforming-indias-future-with-solar-power; Finlay Colville, "Indian Solar Cell Capacity at Five-year Low," Ciol.com, 6 September 2013, http://www.ciol.com/ciol/features/195014/indian-solar-cell-capacity-low.

81 GTM Research, op. cit. note 67. Other rankings of suppliers differ according to what is counted and when. The top five module suppliers were Yingli, Trina Solar, Sharp (Japan), which stepped up three, Canadian Solar (Canada), down two steps, and Jinko (China), up from eighth to fifth, per GlobalData, "Sun Continues to Shine on Yingli Green Energy as It Retains First Position in GlobalData's Top Five Crystalline Module Manufacturers, 2013," press release, 25 March 2014, http://energy.globaldata.com/media-center/press-releases/power-and-resources/sun-continues-to-shine-on-yingli-green-energy-as-it-retains-first-position-in-globaldatas-top-five-crystalline-module-manufacturers-2013; the top 10 cell and thin film manufacturers in 2013, by shipment, were Yingli, Trina Solar, JA Solar, Canadian Solar, First Solar, Hareon, Motech, NeoSolar, Jinko Solar, and Sunpower, per Paula Mints, "April Fools, Magical Thinking, and PV Manufacturer Shipment Announcements," Renewable Energy World, 7 April 2014, http://www.renewableenergyworld.com/rea/news/article/2014/04/april-fools-magical-thinking-and-pv-manufacturer-shipment-announcements.

82 Record levels from Mercom Capital Group, cited in James Montgomery, "Solar VC Funding: 'The Fear Is Gone' for Investors," *Renewable Energy World*, 9 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/solar-vc-funding-the-fear-is-gone-for-investors; mergers and acquisitions also from Althesys Strategic Consultants, "The Strategies of the 50 Leading Companies in the Global Renewable Energy Industry," II Edition (Milan: 2014), Summary, http://www.althesys.com/wp-content/uploads/2014/03/Althesys-IREX-International-2014-.pdf. Examples of mergers and acquisitions, bankruptcies, and restructuring include: JinkoSolar (China) acquired the manufacturing assets of Topoint (China), per John Parnell, "China Cuts Cord on Struggling Solar Manufacturers," *PV-tech*, 2 January 2014, http://www.pv-tech.org/news/china_cuts_the_cord_on_struggling_solar_manufacturers; Aleo Solar (Germany) announced its withdrawal from the U.S. market and expected loss for 2013, and its parent company, Bosch (Germany) announced plans to exit the crystalline PV sector, from "Aleo to Shut Down US Operations," *PV News*, October 2013, p. 4, and from Max Hall, "More Grim News for Aleo Solar," *PV Magazine*, 10 January 2014, http://www.pv-magazine.com/news/details/beitrag/more-grim-news-for-aleo-solar_100013907/; SolarWorld AG (Germany) took over much of Bosch Solar Energy (Germany), per "SolarWorld Acquires Bosch Solar Assets," *PV News*, January 2014, p. 4; private equity firm Kawa Capital Management Inc. (USA) took over Conergy AG (Germany) after it filed for bankruptcy, from Nicholas Brautlecht, "U.S. Investor Kawa to Buy Insolvent German Solar Company Conergy," *Bloomberg*, 24 July 2013, http://www.renewableenergyworld.com/rea/news/article/2013/07/u-s-investor-kawa-to-buy-insolvent-german-solar-company-conergy; panel manufacturer Helios USA stopped operations, per Meg Cichon, "US Solar Manufacturing Woes: Helios Shutters Plant, 1SolTech Slapped with State Lawsuit," *Renewable Energy World*, 24 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/us-solar-manufacturing-woes-helios-shutters-plant-1soltech-slapped-with-state-lawsuit; Siliken (Spain) from Mercom Capital Group, "Siliken Files for Insolvency," *Market Intelligence Report – Solar*, 4 February 2013; Alicante (IATSO, Spain) from Mercom Capital Group, "Spanish Module Producer Iatso Files for Insolvency," *Market Intelligence Report – Solar*, 25 February 2013; First Solar (USA) restructured its global operations and announced plans for layoffs in the United States, from "First Solar to Lay Off 150 Employees in North America," Power Engineering, 7 May 2013, http://www.power-eng.com/articles/2013/05/first-solar-to-lay-off-150-north-american-employees.html; Honda (Japan) announced plans to withdraw from the production and sale of PV products as of spring 2014, per "Honda to Discontinue Operations of PV Subsidiary," *PV News*, December 2013, p. 4; Sharp (Japan) announced in early 2014 that it would stop manufacturing panels in the United States and previously announced plans to close manufacturing facility in Wales, per "Sharp Says to End Solar Panel Production in U.S. by end-March," *Reuters*, 22 January 2014, http://www.reuters.com/article/2014/01/23/us-sharp-solar-idUSBREA0M05I20140123.

83 For example, Nanosolar (United States) closed in July, and the German arm relaunched in November, per Andy Colthorpe, "Nanosolar Germany Relaunched as Smartenergy Renewables Deutschland," PV-tech, 15 November 2013, http://www.pv-tech.org/news/nanosolar_germany_relaunched_as_smartenergy_renewables_deutschland; SoloPower (United States) suspended operations in Oregon and laid off workers and sold equipment at its San Jose, California, facility, all from James Montgomery, "CIGS Solar PV Roundup: Fundings, Expansions, and Cutbacks," Renewable Energy World, 12 July 2013, http://www.renewableenergyworld.com/rea/news/article/2013/07/cigs-solar-pv-roundup-fundings-expansions-and-cutbacks; Solarion (Germany) entered insolvency proceedings in early 2013 and exited in mid-year, from "Solarion Exits Bankruptcy," Thin Film Intelligence Brief, 26 June – 9 July 2013, http://news.pv-insider.com/thin-film-pv/thin-film-intelligence-brief-26-june-%E2%80%93-9-july-2013; CIGS startup NuvoSun (United States) was purchased by Dow Chemical, per "Dow Purchases CIGS Startup NuvoSun," *PV News*, April 2013, p. 7.

84 During the height of the boom, some 400 companies were involved in PV panel production; by late 2013, China had an estimated 150, per Doug Young, "China Boosts Solar with New

Construction Ban," Young's China Business Blog, 23 September 2013, http://www.youngchinabiz.com/en/china-boosts-solar-with-new-construction-ban/; at one point there were approximately 650 module manufacturers in China, and it is believed that 300–400 remain, per Haugwitz, op. cit. note 9.

85 Capacity shut down from Doug Young, "China Solar Heats Up with Trina, Renesola Mega Deals," Young's China Business Blog, 31 December 2013, http://www.youngchinabiz.com/en/china-solar-heats-up-with-trina-renesola-mega-deals/; government encouraging from John Parnell, "JinkoSolar adds 500 MW of Cell and Wafer Capacity with Topoint Acquisition," PV-tech, 10 January 2014, http://www.pv-tech.org/news/jinkosolar_adds_500mw_of_cell_and_wafer_capacity_with_topoint_acquisition; curb oversupply and improve quality from John Parnell, "China Cuts Cord on Struggling Solar Manufacturers," PV-tech, 2 January 2014, http://www.pv-tech.org/news/china_cuts_the_cord_on_struggling_solar_manufacturers. The Chinese government ordered that no new construction be based on current technologies, per Doug Young, "China Boosts Solar with New Construction Ban," Young's China Business Blog, 23 September 2013, http://www.youngchinabiz.com/en/china-boosts-solar-with-new-construction-ban/; quality issues from, for example: Jennifer Runyon, "Solar PV Module Quality Concerns Still Exist for Developing World," Renewable Energy World, 8 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/solar-pv-module-quality-concerns-still-exist-for-developing-word; "Dupont: PV Module Quality Is Improving but More Must Be Done," *Renewable Energy World*, 9 August 2013, video/interview with Conrad Burke, Dupont, http://www.renewableenergyworld.com/rea/video/view/dupont-pv-module-quality-is-improving-but-more-must-be-done; "Solar Champion Paula Mints on Solar Manufacturing Quality," Renewable Energy World, 12 July 2013, video/interview with Paula Mints, http://www.renewableenergyworld.com/rea/video/view/solar-champion-paula-mints-on-solar-manufacturing-quality; Todd Woody, "Solar Industry Anxious Over Defective Panels," *New York Times*, 28 May 2013, http://www.nytimes.com/2013/05/29/business/energy-environment/solar-powers-dark-side.html.

86 Debt is according to Chinese Ministry of Industry and Information Technology, 15 August 2013, cited in Feifei Shen, "Massive China Solar Debts, Deadlines Rattling Investors," *Bloomberg*, 3 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/china-solar-defaults-shock-holders-as-8-4-billion-due; "Suntech First Chinese Company to Enter Insolvency," *PV News*, April 2013, p. 7; Fiona Harvey, "Suntech's Troubles Cast a Shadow Over the Green Tech Industry," *The Guardian*, 20 March 2013, http://www.theguardian.com/environment/2013/mar/20/suntech-troubles-shadow-green-tech-industry. Suntech also announced the closure of its U.S. factory in Arizona in early 2013, per "Chinese Solar Power Firm Defaults on Debts," *The Guardian*, 19 March 2013, http://www.theguardian.com/world/2013/mar/19/suntech-china-solar-power-default. LDK has also faced challenges, per Justina Lee, "Survival of the Fittest in China's Renewable Energy Market," *Bloomberg*, 25 February 2014, http://www.renewableenergyworld.com/rea/news/article/2014/02/survival-of-the-fittest-in-chinas-renewable-energy-market?cmpid=SolarNL-Tuesday-February25-2014; see also Doug Young, "LDK Melts Down, Solar Default Signs Grow," YoungChinaBiz.com, 2 April 2014, http://www.youngchinabiz.com/en/ldk-melts-down-solar-default-signs-grow/.

87 Production ramped up in general from James Montgomery, "New Crop of Reports Indicate Solar Outlook is Brightening," Renewable Energy World, 12 November 2013, http://www.renewableenergyworld.com/rea/news/article/2013/11/new-crop-of-outlooks-see-solar-outlook-brightening, and from Masson, op. cit. note 1; Argentina from "El Primer Panel Solar Hecho en San Juan Estará para Junio de 2015," Tiempo de San Juan, 3 October 2013, http://www.tiempodesanjuan.com/notas/2013/10/3/primer-panel-solar-hecho-juan-estara-para-junio-2015-40810.asp (using Google Translate); Brazil from Roselund, op. cit. note 39; Canadian Solar formed a partnership with Samsung Renewable Energy to make modules for Samsung's Ontario solar projects, per "Samsung to Open New Facility in Canada," PV Intelligence Brief, 26 June–9 July 2013, http://news.pv-insider.com; "Wafer Factory Opens in Massachusetts," *PV News*, March 2013, p. 10; Europe from "European Firms Ramp Up Module Production," PV News, May 2013, p. 5; Calyxo (Germany) CdTe thin film manufacturer opened a new fully automated production line of 60 MW in Germany, per Katherine Steiner Dicks, "Calyxo Starts Up New Production Line," Thin Film Intelligence Brief, 27 November–10 December 2013, http://news.pv-insider.com/thin-film-pv/thin-film-intelligence-brief-27-november-%E2%80%93-10-december-2013; Canadian Solar, "Samsung and Canadian Solar Open Solar Manufacturing Facility in London," press release (London and Ontario: 6 March 2014), http://investors.canadiansolar.com/phoenix.zhtml?c=196781&p=irol-newsArticle&ID=1906933&highlight=; Samer A. Zawaydeh, Association of Energy Engineers, Jordan Energy Chapter, personal communication with REN21, 13 April 2014; Turkish Investment Support and Promotion Agency, "Turkey's Largest PV Module Manufacturing Plant Commissioned," 24 May 2013, http://www.invest.gov.tr/en-US/infocenter/news/Pages/240513-csun-turkey-solar-module-plant-opened.aspx; Astana Solar opened a new wafer and module manufacturing plant in Kazakhstan, per "Kazakhstan PV Manufacturing Industry Poised for Growth," PV News, February 2013, p. 5; "Panasonic Begins Full-Scale Production in Malaysia," *PV News*, October 2013, p. 3; "Hanwha Q-Cells Expands Malaysia Cell Production," *PV News*, February 2014, p. 4.

88 "First PV Module Factory Opens in Ethiopia," *PV News*, March 2013, p. 10.

89 Doug Young, "China Solar Heats Up with Trina, Renesola Mega Deals," Young's China Business Blog, 31 December 2013, http://www.youngchinabiz.com/en/china-solar-heats-up-with-trina-renesola-mega-deals/; Charlie Zhu, "China's Solar Industry Rebounds, But Will Boom-Bust Cycle Repeat?" *Reuters*, 24 January 2014, http://planetark.org/wen/70925; Hanergy acquired MiaSolé (United States), Silibro (Germany), and Global Solar Energy (United States), from James Montgomery, "CIGS Solar PV Roundup: Fundings, Expansions, and Cutbacks," *Renewable Energy World*, 12 July 2013, http://www.renewableenergyworld.com/rea/news/article/2013/07/cigs-solar-pv-roundup-fundings-expansions-and-cutbacks, and from "Hanergy Makes Third CIGS Acquisition," *PV News*, September 2013, p. 5; Mark Osborne, "Hanergy Solar to Start Building 3 GW CIGS Thin-film Manufacturing Complex in China," PV-tech, 27 January 2014, http://www.pv-tech.org/news/hanergy_solar_to_start_building_3gw_cigs_thin_film_manufacturing_complex_in.

90 Japan's manufacturers are increasing capacity and the technology mix is shifting away from poly-crystalline toward high-efficiency mono-crystalline silicon modules, which can maximise production on residential rooftops, and thin films, from Junko Movellan, "Recovery Report: Japan PV Manufacturers Find Their Domestic Sweet Spot," Renewable Energy World, 12 June 2013, http://www.renewableenergyworld.com/rea/news/article/2013/06/recovery-report-japan-pv-manufacturers-find-their-domestic-sweet-spot.

91 Innovation and product differentiation from IEA-PVPS, op. cit. note 5, p. 55. One example is the PV Heater, which uses PV electricity directly to heat water in a storage tank. This system can increase a household's level of self-consumption, and the system is not connected to the grid, so that output is not taxable. See, for example, REFUsol, "Photovoltaic Inverter Product Line," p. 28, http://europe.refusol.com/fileadmin/user_upload/pdf/brochures/Produktprogramm_REFUsol_EN.pdf; and Nigel Morris, "Game Changer for PV and SHW?" 19 June 2013, http://solarbusiness.com.au/game-changer-for-pv-and-shw/.

92 Jeremy Bowden, "PV Policy and Markets – Impact of US Tariffs on LCOE," *Renewable Energy World*, November–December 2012, p. 7; Cedric Brehaut and M.J. Shiao, "Megawatt-Scale PV Operations and Maintenance," *PV News*, January 2014, pp. 9–10; EurObserv'ER, *Photovolatic Barometer* (Paris: April 2013), p. 65, http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro-jdp9.pdf. Examples of diversification and strategic partnerships include: several Chinese manufacturers moved into project development, spurred by government incentives and continued low prices, per Charlie Zhu, "China's Ailing Solar Panel Makers See the Light, On a Farm," *Reuters*, 8 November 2013, http://planetark.org/wen/70300; panel manufacturer Kyocera (Japan) has become a solar PV project developer in Japan and announced plans in 2013 to develop plants for institutional clients in the United States, per Morgan Lee, "Kyocera to Develop Solar Projects in U.S.," utsandiego.com, 10 September 2013, http://www.utsandiego.com/news/2013/sep/10/kyocera-develops-solar-farms/; Hanwha Q Cells USA Began offering a "one-stop solutions for bankable" commercial rooftop systems, per "Hanwha Q Cells Expands Commercial Rooftop Solar Services," *PV News*, December 2013, p. 6; in Japan, manufacturers Kyocera, Sharp, and Solar Frontier began expanding into project development and becoming independent power producers, per Movellan, op. cit. note 90.

93 "First Solar Announces Partnership with GE, c-Si Production," *PV News*, September 2013, p. 3; "SolarCity Brings Solar to Honda Customers," *PV News*, April 2013, p. 8; "BMW's Solar Partnership Helps Give EV Industry a Jolt," Greenbiz.com, 2 December 2013, http://www.greenbiz.com/blog/2013/12/02/bmw-solar-partnership-e-series-solarcity; "IKEA to Offer Solar Installations in the UK," *PV News*, November 2013, p. 6. Other examples: SunPower (United States) partnered with U.S. home builders—including KB Home, Richmond American Homes, Lennar, and Pulte, to construct solar homes—from Chris Meehan, "Solar Likely on 20% of New Homes in California in 2013," *Renewable Energy World*, 17 June 2013, http://www.renewableenergyworld.com/rea/blog/post/2013/06/solar-likely-on-20-of-new-homes-in-california-in-2013; "Solarcentury, Momentous Energy Form JV in Africa," *PV News*, September 2013, p. 5.

94 For example, Yingli Green Energy (China) formed a joint venture with Datong Coal Mine Group, China's third largest state-owned coal mining company, to develop and build solar PV plants, per Andy Colthorpe, "Yingli forms JV with Chinese state-owned coal mining company," PV-tech, 2 January 2014, http://www.pv-tech.org/news/yingli_green_forms_jv_with_chinese_state_owned_coal_mining_company; Yingli also entered into an investment agreement with China Rich Energy Corporation (a subsidiary of China National Nuclear Corporation) to develop and construct distributed solar projects across China, per "Yingli Forms JV in China, Signs Distribution Agreement in Japan," *PV News*, February 2014, p. 4; while traditional Chinese energy investors, such as China Power Investment Corp., are racing to develop large projects in western China, so are non-energy companies like Huabei Express (toll road operator) and Jiangsu Kuangda Auto Textile Group, per Charlie Zhu, "China's Solar Industry Rebounds, But Will Boom-Bust Cycle Repeat?" *Reuters*, 24 January 2014, http://planetark.org/wen/70925; in India, Coal India Limited and Neyveli Lignite Corporation, both large mining companies, and Oil India Limited are also moving into solar, from Sumit Moitra, "Coal India Gets into Solar Power," *DNA India*, 27 May 2013, http://www.dnaindia.com/money/report-coal-india-gets-into-solar-power-1839903, and from Bridge to India, "Our Market View," *India Solar Weekly Market Update*, 24 May 2013; Google partnered with Silver Ridge Power (formerly AES Solar) in the 265.7 MW Mount Signal Solar project in California, per "Google Invests in Mount Signal Solar," *PV News*, November 2013, p. 7.

95 Mergers and acquisitions included, for example, Mitsubishi Corp (Japan) acquired stakes in solar plants in France, per Chisaki Watanabe, "Mitsubishi Buys Stakes in France from Energies Nouvelles," *Bloomberg*, 19 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/mitsubishi-buys-solar-stakes-in-france-from-energies-nouvelles; in the United States, Real Goods (United States) expanded through the purchase of other installers, Mercury Solar Systems and Syndicated Solar, from "Real Goods Solar Expands with Multiple Acquisitions," *PV News*, September 2013, p. 5; SolarCity (United States) acquired at least two companies, from "SolarCity Acquires Paramount Solar," *PV News*, September 2013, p. 5, and from "SolarCity Acquires Zep Solar for $158 Million," *PV News*, November 2013, p. 4; project purchases from Mercom Capital Group, cited in Montgomery, op. cit. note 82.

96 S.A.G Solarstrom and Gehrlicher filed for insolvency, from "S.A.G. Solarstrom Files for Insolvency," *PV News*, January 2014, p. 5; and from "Gehrlicher Files for Insolvency, Blames EU Tariffs," PV News, August 2013, p. 5; Gehrlicher's U.S. division, Gehrlicher Solar America Corporation was acquired by the U.S. division of M+W Group (Germany), per Edgar Meza, "M+W Americas Acquires Gerlicher Solar America," *PV Magazine*, 22 August 2013, http://www.pv-magazine.com/news/details/beitrag/mw-americas-acquires-gehrlicher-solar-america-_100012474/; "Juwi Opens Subsidiary in Dubai," *PV News*, November 2013, p. 5.

97 "SunEdison Buys Khosla-Funded EchoFirst," *PV News*, September 2013, p. 5.

98 Ucilia Wang, "SunPower to Launch Solar Leases Overseas," *Renewable Energy World*, 16 May 2013, http://www.renewableenergyworld.com/rea/news/article/2013/05/sunpower; Deutsche Bank Markets Research, op. cit. note 68, p. 19; "SunPower Introduces Residential Solar Loan in Australia," "SolarWorld Launches Financing Plan in Hawaii," and "HelioPower Buys Financial Solutions Company Greenzu," all from PV News, October 2013, pp. 5–6; "SunPower, Canadian Solar Announce Loan Programs," *PV News*, November 2013, p. 5; James Montgomery, "Why the Money's Flowing into US Residential Solar Markets," Renewable Energy World, 18 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/why-the-moneys-flowing-into-us-residential-solar-models; "Upsolar to Offer Solar Leasing France," *PV News*, January 2014, pp. 5–6; in Fiji, a private company Sunergise has introduced SunLease scheme in which they provide the capital costs for PV installations to commercial entities and charge a fixed rate for electricity produced, from Atul Raturi, University of the South Pacific, personal communication with REN21, 13 April 2014, and from http://www.sunergisegroup.com/.

99 Toshiba will install systems in apartments and operate and manage them, selling power at below rate charged by utilities, per "Toshiba to Launch Innovative Photovoltaic Power Business for Apartment Buildings in Germany," press release (Tokyo: 4 December 2013), http://www.toshiba.co.jp/about/press/2013_12/pr0401.htm; "Toshiba steigt in deutschen Photovoltaikmarkt ein," Photovoltaik.eu, 12 April 2013, http://www.photovoltaik.eu/Toshiba-steigt-in-deutschen-Photovoltaikmarkt-ein,QUIEPTU2NTI4OCZNSUQ9MzAwMjE.html.

100 Martin LaMonica, "Solar Crowdfunding Trend Is Heating Up," Green Biz, 17 January 2014, http://www.greenbiz.com/blog/2014/01/17/new-product-solarcity-crowdsourcing; Davide Savenije and Bill Opalka, "Four Solar Trends to Watch in 2014," Utility Dive, 17 January 2014, http://www.utilitydive.com/news/four-solar-trends-to-watch-in-2014/. For other examples of innovative financing developments, see "Mosaic Awarded $1 Million, Plans International Expansion," and "Conergy Launches Commercial Financing Program," both in *PV News*, February 2014, p. 5.

101 Roselund, op. cit. note 39.

102 U.S. National Renewable Energy Laboratory (NREL), "Best Research-Cell Efficiencies," http://www.nrel.gov/ncpv/images/efficiency_chart.jpg.

103 For more on perovskite-based solar cells see, for example, Mitch Jacoby, "Tapping Solar Power with Perovskites: Low cost and impressive performance thrust new solar-cell technology into spotlight," *Chemical and Engineering News*, 24 February 2014, pp. 10–16, http://cen.acs.org/articles/92/i8/Tapping-Solar-Power-Perovskites.html; Kevin Bullis, "A New Solar Material Shows Its Potential," *MIT Technology Review*, 10 November 2013, http://www.technologyreview.com/news/521491/a-new-solar-material-shows-its-potential/; Gary Hodes, "Perovskite-Based Solar Cells," *Science*, October 2013, pp. 317–18, http://www.sciencemag.org/content/342/6156/317.summary; Robert Coontz, "Science's Top 10 Breakthroughs of 2013," *Science*, 19 December 2013, http://news.sciencemag.org/2013/12/sciences-top-10-breakthroughs-2013; Bernie Bulkin, "Perovskites: The Future of Solar Power?" *The Guardian*, 7 March 2014, http://www.theguardian.com/sustainable-business/perovskites-future-solar-power.

104 SolFocus (United States) failed to find a buyer and shut down in late 2013, from "SolFocus Ceases Trading," *CPV Intelligence Brief*, 5-17 September 2013, http://news.pv-insider.com/users/ksdicks, and from James Montgomery, "CPV Outlook: Demand Doubling, Costs Halved by 2017," *Renewable Energy World*, 12 December 2013, http://www.renewableenergyworld.com/rea/news/article/2013/12/cpv-outlook-demand-doubling-costs-halved-by-2017; Amonix closed its plant in Las Vegas, Nevada, Zenith Solar (Israel) was acquired by Suncore (China), and consolidation and new partnerships all from "Signs of Progress for CPV, But Momentum Needs to be Sustained," *PV Insider*, 17 September 2013, http://news.pv-insider.com/users/ritesh-gupta.

105 Meg Cichon, "Soitec to Shutter German CPV Manufacturing, 'Regroup' at its San Diego Facility," *Renewable Energy World*, 2 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/soitec-to-shutter-germany-cpv-manufacturing-regroup-its-san-diego-facility; Soitec, "Soitec Completes Its First Solar Power Plant in California with Modules from its New San Diego Manufacturing Facility," press release (San Francisco: 10 July 2013), http://www.soitec.com/en/news/press-releases/soitec-completes-its-first-solar-power-plant-in-california-with-modules-from-its-new-san-diego-manufacturing-facility-1341/; "Alsom and Soitec Create CPV Alliance," *PV News*, September 2013, p. 6.

106 "Solar Junction Partners with Amonix to Improve CPV Efficiency," *PV News*, April 2013, p. 6.

107 Beyond niche and South Africa from "Signs of Progress for CPV, but Momentum Needs to Be Sustained," *PV Insider*, 17 September 2013, http://news.pv-insider.com/users/ritesh-gupta; China from Frank Haugwitz, *CPV Developments—More Production Capacities*

and More Projects Coming Online, Briefing Paper—China Solar PV Development (Beijing: AECEA, July 2013).

108 "New CPV Record Set," and "Semprius Hits 35.5% Record," both from *CPV Intelligence Brief*, 18 September–1 October 2013, http://news.pv-insider.com/users/ksdicks; "Sharp Sets CPV Cell Record of 44.4%," *CPV Intelligence Brief*, 13–25 June 2013, http://news.pv-insider.com/users/ksdicks; Montgomery, op. cit. note 104.

109 More sophisticated from IEA-PVPS, op. cit. note 5, p. 56; fastest developing from ABB, "ABB Complete Acquisition of Power-One," press release (Zurich: 25 July 2013), http://www.abb.com/cawp/seitp202/bf86c5972758ad3ec1257bb300773351.aspx.

110 ABB, op. cit. note 109; second largest from Power-One, "Why Choose Power-One Renewable Energy Solutions?" http://www.power-one.com/renewable-energy, viewed 20 April 2014; Silke Koltrowitz, "ABB Bets on Solar Power with $1 Billion Takeover," *Reuters*, 22 April 2013, http://www.reuters.com/article/2013/04/22/us-abb-power-one-idUSBRE93L04U20130422.

111 James Montgomery, "Solar PV Inverter Market Shakeout Continues with ABB and Power-One Deal," Renewable Energy World, 22 April 2013, http://www.renewableenergyworld.com/rea/news/article/2013/04/solar-pv-inverter-market-shakeout-continues-with-abb-and-power-one-deal; SMA (Germany) acquired a majority stake in Jiangsu Zeversolar New Energy (China), per "SMA Acquires Majority Stake in Zeversolar," *PV News*, April 2013, p. 7; but, in late 2013, it announced plans to downsize in response to changing market conditions, from "SMA to Complete Downsizing in 2014," *PV News*, November 2013, p. 4, and from Christoph Steitz, "Update 2-Solar Crisis Drags Germany's SMA into Loss," *Reuters*, 8 August 2013, http://www.reuters.com/article/2013/08/08/smasolar-results-idUSL6N0G90BC20130808; Satcon Technology Corp. (United States) announced plans to liquidate, per "Satcon Unable to Find Buyer, Moves to Liquidate," *PV News*, April 2013, p. 6.

112 James Montgomery, "Price Pressures Squeeze Solar Inverter Shipment Outlook," *Renewable Energy World*, 16 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/price-pressures-squeeze-solar-inverter-shipment-outlook.

CONCENTRATING SOLAR THERMAL POWER (CSP)

1 Global CSP capacity and capacity additions, and **Figure 15**, derived from the following sources: REN21, *Renewables 2013 Global Status Report* (Paris: REN21 Secretariat, June 2013), http://www.ren21.net/Portals/0/documents/Resources/GSR/2013/GSR2013_lowres.pdf; Luis Crespo, European Solar Thermal Electricity Association (ESTELA), personal communication with REN21, February 2014; Fred Morse, Morse Associates, Inc., personal communication with REN21, February–May 2014; 2014; "CSP World Map," CSP World, http://www.csp-world.com/cspworldmap; "CSP Today Global Tracker," CSP Today, http://social.csptoday.com/tracker/projects; U.S. Solar Energy Industries Association (SEIA), "Solar Energy Facts: 2013 Year in Review," 5 March 2014, http://www.seia.org/sites/default/files/YIR%202013%20SMI%20Fact%20Sheet.pdf; SEIA, "Major Solar Projects in the United States: Operating, Under Construction, or Under Development," 6 March 2014, http://www.seia.org/sites/default/files/resources/Major%20Solar%20Projects%20List%203.6.14.pdf; "NextEra dedicates 250 MW Genesis CSP Plant," Solar Server, 25 April 2014, http://www.solarserver.com/solar-magazine/solar-news/current/2014/kw17/nextera-dedicates-250-mw-genesis-csp-plant.html; Abengoa Solar, "Mojave Solar Project," http://www.abengoasolar.com/web/en/nuestras_plantas/plantas_en_construccion/estados_unidos/. To the extent possible, the GSR uses net capacity CSP data. The net capacity is the peak generating capacity of the plant after subtracting internal power requirements from gross capacity (i.e., the peak generating capacity of its turbine unit).

2 Crespo, op. cit. note 1.

3 Heba Hashem, "Emerging CSP markets: More than meets the eye," CSP Today, 22 November 2013, http://social.csptoday.com/markets/emerging-csp-markets-more-meets-eye.

4 Global CSP growth rates derived from the following: REN21, op. cit. note 1; Crespo, op. cit. note 1; Morse, op. cit. note 1; "CSP World Map," op. cit. note 1; "CSP Today Global Tracker," op. cit. note 1.

5 Crespo, op. cit. note 1.

6 U.S. capacity added during 2013 includes the 250 MW Solana plant and the 125 MW first phase of the 250 MW Genesis plant, which was commissioned in late 2013. All capacities reported are net. Added capacities, from Fred Morse, Morse Associates, Inc., personal communication with REN21, April 2014; Bureau of Land Management, U.S. Department of the Interior, "Genesis Solar Power Project (CACA 48880)," 7 March 2012, http://www.blm.gov/ca/st/en/fo/palmsprings/Solar_Projects/Genesis_Ford_Dry_Lake.html; "NextEra dedicates 250 MW Genesis CSP plant," SolarServer, http://www.solarserver.com/solar-magazine/solar-news/current/2014/kw17/nextera-dedicates-250-mw-genesis-csp-plant.html; U.S. National Renewable Energy Laboratory (NREL), "Concentrating Solar Power Projects: Solana Generating Station," 17 March 2014, http://www.nrel.gov/csp/solarpaces/project_detail.cfm/projectID=23; capacity under construction from idem; James Montgomery, "Go-Time for Solar CSP: Ivanpah, Crescent Dunes Switch On," Renewable Energy World, 12 February 2014, http://www.renewableenergyworld.com/rea/news/article/2014/02/go-time-for-solar-csp-ivanpah-; "NextEra dedicates 250 MW Genesis CSP Plant," op. cit. note 1; Abengoa Solar, op. cit. note 1; HeliosCSP, "Ivanpah: World's Biggest Concentrated Solar Power Tower Project Goes On-Line," 19 February 2013, http://www.helioscsp.com/noticia.php?id_not=2332.

7 Abengoa Solar, "Solana, the largest parabolic trough plant in the world," http://www.abengoasolar.com/web/en/nuestras_plantas/plantas_en_operacion/estados_unidos/; "Abengoa's Solana Begins Commercial Operation and Marks Major CSP Milestone," Solar International, 10 October 2013, http://www.solar-international.net/article/78480-Abengoa-acirc-s-Solana-begins-commercial-operation-and-marks-major-CSP-milestone.php.

8 HeliosCSP, op. cit. note 6.

9 Jason Kastrenakes, "This is what the world's largest solar plant looks like when it's catching rays," The Verge, 13 February 2013, http://www.theverge.com/2014/2/13/5408686/ivanpah-solar-plant-begins-commercial-operation.

10 Crespo, op. cit. note 1.

11 EurObservER, *Solar Thermal and Concentrated Solar Power Barometer* (Paris: May 2013), http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro215.pdf.

12 Crespo, op. cit. note 1.

13 United Arab Emirates from EurObservER, op. cit. note 11; India from Jenny Muirhead, "MENA Shows Patience Towards Delay in CSP Projects," *Weekly Intelligence Brief: July 15–July 22*, CSP Today, 22 July 2013, http://social.csptoday.com/markets/weekly-intelligence-brief-july-15-%E2%80%93-july-22; China from Crespo, op. cit. note 1.

14 Crespo, op. cit. note 1.

15 "CSP World Map," op. cit. note 1; "CSP Today Global Tracker," op. cit. note 1.

16 Hashem, op. cit. note 3.

17 Crespo, op. cit. note 1.

18 Rochelle Gayle, "Namibia evaluating concentrated solar power potential in feasibility study," CSP Today, 3 February 2014, http://social.csptoday.com/emerging-markets/namibia-evaluating-concentrated-solar-power-potential-feasibility-study.

19 "More than 1GW of CSP Headed for MENA," Renewable Energy World, 5 July 2013, http://www.renewableenergyworld.com/rea/news/article/2013/07/more-than-1-gw-of-csp-headed-for-mena.

20 Morocco from Crespo, op. cit. note 1; Egypt from "Kom Ombo CSP Project," CSP World, http://www.csp-world.com/cspworldmap/kom-ombo-csp-project.

21 Jenny Muirhead, "CSP makes a grand entry into Kuwait," CSP Today, 1 July 2013, http://social.csptoday.com/emerging-markets/csp-makes-grand-entry-kuwait.

22 Bill Scanlon, "Saudi Arabia Looks to NREL for Solar Monitoring Expertise," Renewable Energy World, 22 April 2013, http://www.renewableenergyworld.com/rea/news/article/2013/04/saudi-arabia-looks-to-nrel-for-solar-monitoring-expertise.

23 SustainableBusiness, "Israel Gets Its First Big Solar Project: 5th Largest in the World," 31 October 2013, http://www.sustainablebusiness.com/index.cfm/go/news.display/id/25325; "Ashalim CSP plant 2," CSP World, http://www.csp-world.com/cspworldmap/ashalim-csp-plant-2, viewed 24 April 2014.

24 Crespo, op. cit. note 1.

25 CleanBiz Asia, "India's plans for world's largest CSP need honest soul-searching," 22 August 2013, http://www.cleanbiz.asia/news/indias-plans-worlds-largest-csp-need-honest-soul-searching; CleanBiz Asia, "India continues solar thermal push despite lackluster success," 29 May 2013, http://www.cleanbiz.asia/news/india-continues-solar-thermal-push-despite-lackluster-success.

26 Regulatory hindrances in Italy from HeliosCSP, "Go-ahead needed for Concentrated Solar Power (CSP) in Italy for the domestic industry to be competitive on foreign markets," 3 April 2014, http://www.helioscsp.com/noticia.php?id_not=2417; introduction of feed-in tariff from EurObservER, op. cit. note 11.

27 Coal hybrid application from NREL, "First Hybrid CSP-Coal Power Plant Is Fired Up in Colorado," 23 July 2010, http://www.nrel.gov/solar/news/2010/870.html; geothermal hybrid application from Jenny Muirhead, "CSP-Geothermal Hybrid Plant Projects Spring to Life," CSP Today, 22 July 2013, http://social.csptoday.com/technology/csp-geothermal-hybrid-plant-projects-spring-life; natural gas hybrid application from "New hybrid CSP-natural gas plant announced in Sacramento, US," CSP World, 31 October 2013, http://www.csp-world.com/news/20131031/001242/new-hybrid-csp-natural-gas-plant-announced-sacramento-us.

28 CS Energy, "Kogan Creek Solar Boost Project. The largest project of its kind in the world," http://kogansolarboost.com.au/about/.

29 Examples include a CSP project that was rejected in California, from John Parnel, "California rejects another Brightsource CSP project," PV Tech, 17 December 2013, http://www.pv-tech.org/news/california_rejects_another_brightsource_csp_project, and another project in California that was abandoned, from James Montgomery, "K Road Gives Up on Calico Solar Project," Renewable Energy World, 1 July 2013, http://www.renewableenergyworld.com/rea/news/article/2013/07/k-road-gives-up-on-calico-solar-project.

30 Global growth expectations from Jason Deign, "Consolidation's effect on CSP's supply chain," CSP Today, 2 August 2013, http://social.csptoday.com/markets/consolidation%E2%80%99s-effect-csp%E2%80%99s-supply-chain; interest in TES from Jason Deign, "Tracking new directions in CSP thermal energy storage," CSP Today, 26 July 2013, http://social.csptoday.com/technology/tracking-new-directions-csp-thermal-energy-storage.

31 Deign, "Tracking new directions in CSP thermal energy storage," op. cit. note 30.

32 Crespo, op. cit. note 1.

33 Deign, "Consolidation's effect on CSP's supply chain," op. cit. note 30.

34 Siemens from Beatriz Gonzalez, "Siemens to Shut its CSP Business," *Weekly Intelligence Brief: June 17–24*, CSP Today, 24 June 2013, http://social.csptoday.com/markets/weekly-intelligence-brief-june-17-24; Schott Solar from Tildy Bayar, "European CSP, Solar Water Heating Face Difficulties," Renewable Energy World, 11 June 2013, http://www.renewableenergyworld.com/rea/news/article/2013/06/european-csp-solar-thermal-face-difficulties-after-spains-fall.

35 Abengoa portfolio from EurObservER, op. cit. note 11; leadership of Spanish companies from HeliosCSP, "Current Status of CSP in the World," 21 June 2013, http://www.helioscsp.com/noticia.php?id_not=1853.

36 Bayar, op. cit. note 34.

37 Range of alternatives, and graphite, ceramic, rock pebble, and slag storage from Deign, "Tracking new directions in CSP thermal energy storage," op. cit. note 30; superheated steam, as at the PS-10 and PS-20 plants in Spain, and the Khi Solar One facility currently under construction in South Africa, from Jason Deign, "Baring the secrets of Khi Solar One," CSP Today, 13 September 2013, http://social.csptoday.com/markets/baring-secrets-khi-solar-one; ternary salts from Crespo, op. cit. note 1.

38 "The Andalusian solar plant Gemasolar as the stage of Gran Turismo 6 PlayStation video game," Energy News, 17 December 2013, http://www.energynews.es/english/the-andalusian-solar-plant-gemasolar-as-the-stage-of-gran-turismo-6-playstation-video-game/.

39 HeliosCSP, op. cit. note 6; Jenny Muirhead, *Weekly Intelligence Brief: October 7–14*, CSP Today, 14 October 2014, http://social.csptoday.com/markets/weekly-intelligence-brief-october-7-14; EurObservER, op. cit. note 11; Alison Ebbage, "Large-scale plants: the future for CSP?" CSP Today, 31 January 2014, http://social.csptoday.com/technology/large-scale-plants-future-csp; growing evidence of potential cost reductions derived from an analysis conducted by CSP Today, which showed that the EUR/Watt capital expenditure of a 50 MW plant is around 25% higher than that of a 200 MW plant, as a result of economies of scale in the development of the plant. Similar work by the International Renewable Energy Agency (IRENA) and the International Energy Agency (IEA) determined that the specific cost of parabolic trough plant with thermal storage decreases by approximately 12% if the plant size is increased from 50 MW to 100 MW, and by 20% if size is increased from 50 MW to 200 MW; see Groupe Reaction, "Making cents of CSP economies of scale," CSP Today, 22 July 2013, http://social.csptoday.com/markets/making-cents-csp-economies-scale.

40 Other cost-reduction interventions under investigation include standardisation of central receivers on power towers; increased aperture size on linear Fresnel plants; use of supercritical turbines; and application of new tracking mechanisms for heliostats using hydraulics, from Crespo, op. cit. note 1. Researchers in Spain are developing engineering tools to enable the thermo-economic design and optimisation of CSP plants, and the reduction of TES costs; see Jenny Muirhead, "New initiatives to reduce the cost of CSP," CSP Today, 11 October 2013, http://social.csptoday.com/technology/new-initiatives-reduce-cost-csp.

41 Research on geothermal augmentation from Dan Wendt, "Hybrid Geothermal-Solar" (Washington, DC: U.S. Department of Energy (DOE), 22 April 2013), http://www1.eere.energy.gov/geothermal/pdfs/hybrid_geo_solar_peer2013.pdf; integration of CSP and natural gas from DOE, "Sacramento Utility to Launch Concentrating Solar Power-Natural Gas Project," press release (Washington, DC: 31 October 2013), http://www.energy.gov/articles/sacramento-utility-launch-concentrating-solar-power-natural-gas-project.

SOLAR THERMAL HEATING AND COOLING

1 Total additions and capacity based on Franz Mauthner, AEE – Institute for Sustainable Technologies (AEE-INTEC), Gleisdorf, Austria, personal communication with REN21, March-May 2014, and on Franz Mauthner and Werner Weiss, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2012* (Gleisdorf, Austria: International Energy Agency (IEA) Solar Heating and Cooling Programme (SHC), forthcoming May 2014). The Mauthner and Weiss report covers 58 countries and is assumed to represent 95% of the global market. Data provided were 52.7 GW_{th} added (75.3 million m^2) for a total of 269 GW_{th}, which were adjusted upwards to 100% for the GSR to reach 55.4 GW_{th} added (79.2 million m^2) and 283.4 GW_{th} total. Note that collector area (and respective capacity) in operation were estimated by Mauthner and Weiss based on official country reports regarding the lifetime basis used; where such reports were not available, a 25-year lifetime was assumed except in the case of China, where the Chinese Solar Thermal Industry Federation (CSTIF) considers lifetime to be below 10 years. Also, note that in 2004 the represented associations from Austria, Canada, Germany, the Netherlands, Sweden, and the United States, as well as the European Solar Thermal Industry Federation (ESTIF) and the IEA-SHC agreed to use a factor of 0.7 kW_{th}/m^2 to derive the nominal capacity from the area of installed collectors; this conversion rate is also used in the GSR.

2 Glazed water collectors accounted for a 96.8% share of the global market in 2012 (unglazed water systems accounted for about 3.0% of the global market in 2012, and glazed and unglazed air systems for less than 0.2%), and global capacity of glazed collectors added in 2012 was 51 GW_{th}, per Mauthner, op. cit. note 1, and Mauthner and Weiss, op. cit. note 1. The 51 GW_{th} was adjusted upwards by REN21 from an estimated 95% of the global market to 100%, to reach 53.7 GW_{th}.

3 Preliminary estimate from Mauthner, op. cit. note 1. Note that the estimate does not consider air collectors.

4 Mauthner and Weiss, op. cit. note 1. **Figure 16** based on data from Mauthner and Weiss, op. cit. note 1, and from Mauthner, op. cit. note 1. Global total was adjusted upwards by REN21 from an estimated 95% of the global market to 100%, and this is reflected in shares data.

5 Mauthner and Weiss, op. cit. note 1. **Figure 17** from idem and from Mauthner, op. cit. note 1.

6 Mauthner, op. cit. note 1.

7 Ibid.; Mauthner and Weiss, op. cit. note 1. Estimates for 2013 are based on available data from Austria, China, Germany, Japan, Mexico, Portugal, Spain, and the United States; data for remaining countries were estimated by Mauthner and Weiss according to their trends for the previous two years; these estimates assume 100% of the global market. **Figure 18** based on data from Mauthner and Weiss, op. cit. note 1, and from Mauthner, op. cit. note 1. Data were adjusted upwards by REN21 from an estimated 95% of the global market to 100%.

8 Ibid.

9 Based on installations of an estimated 66 million m^2, from Hu Runquing, CSTIF, data provided by Mauthner, op. cit. note 1.

10 An estimated 21% of newly installed capacity replaced existing collectors, and net additions were 52.3 million m^2; the estimated cumulative capacity at end-2013 was based on 310 million m^2, per Runquing, op. cit. note 9.

11 Solar heaters cost an estimated 3.5 times less than electric water heaters and 2.6 less than gas heaters over the system lifetime, from CSTIF, cited in Bärbel Epp, "Solar Thermal Competition Heats Up in China," Renewable Energy World, 10 September 2012, http://www.renewableenergyworld.com/rea/news/article/2012/09/solar-thermal-competition-heats-up-in-china, and from Bärbel Epp, "Solar Thermal Shake-Out: Competition Heats Up in the Chinese Market," *Renewable Energy World*, July–August 2012, pp. 47–49; annual market growth has increased fairly steadily year-by-year, up from 4,480 MW_{th} in 2000, per Franz Mauthner and Werner Weiss, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2011* (Gleisdorf, Austria: IEA-SHC, May 2013), http://www.iea-shc.org/data/sites/1/publications/Solar-Heat-Worldwide-2013.pdf.

12 Epp, op. cit. note 11.

13 European Commission, European Technology Platform Renewable Heating & Cooling, *Common Vision for the Renewable Heating & Cooling Sector in Europe* (Brussels: European Union, 2011), ftp://ftp.cordis.europa.eu/pub/etp/docs/rhc-vision_en.pdf.

14 Mauthner, op. cit. note 1.

15 Contraction has occurred since the peak in 2008, per EurObserv'ER, *Solar Thermal and Concentrated Solar Power Barometer* (Brussels: 2013), http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro215.pdf; lower construction rates and pressure from idem; pressure particularly in Germany, according to Harald Drück, University of Stuttgart, cited in Bärbel Epp and Jan Gesthuizen, "Germany: A Standstill Is Not the Answer, a System Solution Is," Solar Thermal World, 26 May 2013, http://solarthermalworld.org/content/germany-standstill-not-answer-system-solution; France from Bärbel Epp, personal communication with REN21, 26 March 2014; see also Robin Welling, ESTIF, interview with Bärbel Epp, "It is a groundbreaking fact that solar thermal is the only technology to be enabled to obtain the A+++ label," Solar Thermal World, 4 December 2013, http://solarthermalworld.org/content/it-groundbreaking-fact-solar-thermal-only-technology-be-enabled-obtain-label; solar PV had greater appeal for investors in Austria, and reduction of support policies, from Pedro Dias, ESTIF, Brussels, personal communication with REN21, 4 May 2013.

16 Based on 1.02 million m^2 of added collector area during 2013 for a total of 17.5 million m^2 installed in Germany by year's end, with all data from Bundesverband Solarwirtschaft e.V., "Statistiche Zahlen der deutschen Solarwärmebranche (Solarthermie), March 2014, http://www.solarwirtschaft.de/fileadmin/media/pdf/2014_03_BSW_Solar_Faktenblatt_Solarwaerme.pdf; decline in 2011 from ESTIF, *Trends and Market Statistics 2012* (Brussels: June 2013), p. 5, http://www.estif.org/fileadmin/estif/content/market_data/downloads/Solar_Thermal_M%20arkets%202012.pdf.

17 Figure of 14% market decline in 2013, -15.9% in 2012, -12.8% in 2011, and -21.7% in 2010, from AEE-INTEC, provided by Mauthner, op. cit. note 1.

18 More than doubled based on 671,156 m^2 in 2008, from Solar Heating Department (DASOL), Brazilian Association of Refrigeration, Air Conditioning, Ventilation and Heating (ABRAVA), cited in Filipa Cardoso, "Brazil: Residential Demand Drives Market," Solar Thermal World, 24 July 2013, http://solarthermalworld.org/content/brazil-residential-demand-drives-market; 2013 additions and year-end total based on 1,378.8 thousand m^2 of newly installed glazed and unglazed collector area and 9.8 million m^2 of accumulated area, from DASOL, ABRAVA, 2014, and provided by Renata Grisoli, MGM Innova, personal communication with REN21, 29 March 2014. Note that additions were up from 1,151.3 thousand m^2 in 2012, and 1,029.6 thousand m^2 in 2011, from idem.

19 Drivers also include a growing awareness of sustainability issues, and are all from Cardoso, op. cit. note 18. Solar thermal is competitive in Brazil due to good solar resources/weather conditions and high electricity prices—systems can pay off in two years. See also Alejandro Diego Rosell, "Brazil: Rising Electricity Prices Put Spotlight on Solar Thermal," Solar Thermal World, http://solarthermalworld.org/content/brazil-rising-electricity-prices-put-spotlight-solar-thermal. Note that Minha Casa, Minha Vida has resulted in installation of only 260,000 systems since 2009.

20 Mexico added an estimated 200 MW_{th} (285,000 m^2) in 2013, although down from 210 MW_{th} (300,000 m^2) in 2012 due mainly to a crisis in the construction sector, from Daniel García, Mexican renewable energy industry association FAMERAC, cited in Alejandro Diego Rosell, "Mexico: ANES to Provide National Solar Market Statistics," Solar Thermal World, 24 February 2014, http://solarthermalworld.org/content/mexico-anes-provide-national-solar-market-statistics, and from Alejandro Diego Rosell, "Mexico: Fight for New Incentives," Solar Thermal World, 13 September 2013, http://solarthermalworld.org/content/mexico-fight-new-incentives; Argentina from Eva Augsten, "Argentina: Solar Water Heaters for Rural Schools," Solar Thermal World, 29 October 2011, http://solarthermalworld.org/content/argentina-solar-water-heaters-rural-schools, and from Eva Augsten, "Argentina: ASADES' Network for Solar Energy," Solar Thermal World, 6 April 2012, http://solarthermalworld.org/content/argentina-asades-network-solar-energy; Chile has seen great success from a tax rebate scheme, approved in 2009, with 20,000 systems installed under the programme as of mid-2013, but uncertainty about its extension beyond the end of 2013 caused much uncertainty in Chile's industry, per Alejandro Diego Rosell, "Chile: So Far

No Government Compromise on Extending Tax Credits," Solar Thermal World, 8 July 2013, http://solarthermalworld.org/content/chile-so-far-no-government-compromise-extending-tax-credits; most of Chile's systems have been installed in new social housing projects, per Alejandro Diego Rosell, "Chile: New Government to Extend Tax Credits," Solar Thermal World, 23 January 2014, http://solarthermalworld.org/content/chile-new-government-extend-tax-credits; Eva Augsten, "Chile: Mining Sector May Be Solar Thermal's Future," Solar Thermal World, 24 January 2013, http://solarthermalworld.org/content/chile-mining-sector-may-be-solar-thermals-future; Costa Rica has an annual market volume estimated at 5,000–6,000 m² of glazed collectors, of which 30% are vacuum tubes with most imported from China, based on estimate by Stefan Frey, Swissol, cited in Bärbel Epp, "Costa Rica: Small Market but Prestigious Large-Scale Projects," Solar Thermal World, 23 July 2013, http://solarthermalworld.org/content/costa-rica-small-market-prestigious-large-scale-projects; Uruguay has seen slow growth despite government incentives due to the lack of a financing culture and inability of most people to afford high upfront costs, plus low-quality imported systems have made people wary of investing in them, per Alejandro Diego Rosell, "Uruguay: Growing at Its Own Pace," Solar Thermal World, 15 July 2013, http://solarthermalworld.org/content/uruguay-growing-its-own-pace.

21 Based on 1.3 million m² added (6.17 million m² at end-2012) for a total of 7.47 million m² in operation on 31 December 2013, from Government of India, Ministry of New and Renewable Energy (MNRE), "Physical Progress (Achievements)," http://www.mnre.gov.in/mission-and-vision-2/achievements/, viewed 18 January 2014. India's market picked up in Maharashtra and Karnataka, but not in other states despite subsidies, per V. Rishi Kumar, "Implementation of Solar Projects Likely to Gather Paces, Says MNRE Secretary," *Hindu Business Line*, 7 November 2013, http://www.thehindubusinessline.com/industry-and-economy/implementation-of-solar-projects-likely-to-gather-pace-says-mnre-secretary/article5325617.ece. Note that India added 1.1 GW_{th} for a total of 5.6 GW_{th}, according to data from Malaviya Solar Energy Consultancy, provided by Mauthner, op. cit. note 1.

22 Japan added approximately 140 MW_{th} in 2012 and about the same in 2013. Additions and total capacity data estimated by Institute for Sustainable Energy Policies (ISEP) based on data from Solar System Development Association, cited in ISEP, *Renewables Japan Status Report 2014* (Toyko: 2014) (in Japanese) and provided by Hironao Matsubara, ISEP, personal communication with REN21, 23 April 2014.

23 Steady growth and drivers from Yongyuth Sawatdisawanee, Thailand's Department of Alternative Energy Development and Efficiency, Ministry of Energy, interview by Stephanie Banse, "Thailand: Many Enterprises Have Become Interested in the Technology," Solar Thermal World, 6 March 2013, http://solarthermalworld.org/content/thailand-many-enterprises-have-become-interested-technology; Thailand added 8,000 m² of subsidised systems in 2013, down from 11,155 m² in 2012, from Kulwaree Buranasajjawaraporn, Thai Department of Alternative Energy Development and Efficiency (DEDE), presentation at Thai-Germany Technology Conference, Bangkok, October 2013, cited in Stephanie Banse, "Thailand: Ministry of Energy Extends Incentive Programme until 2021," Solar Thermal World, 2 February 2014, http://solarthermalworld.org/content/thailand-ministry-energy-extends-incentive-programme-until-2021.

24 Buranasajjawaraporn, cited in Banse, op. cit. note 23.

25 Mauthner and Weiss, op. cit. note 1.

26 The market was down about 10% (to 1,624,298 m²) in 2012 relative to 2011 (1,805,675 m²), but the 2011 market was considered unusually high, and demand moves up and down from year to year, based on information from A. Hakan Alaş, ezinc, provided by Mauthner, op. cit. note 1. There are still no subsidies in Turkey per Bärbel Epp, personal communication with REN21, 26 March 2014.

27 About 60% based on an estimated 14,311.4 MW_{th} of unglazed water collectors in operation in 2012, from Weiss and Mauthner, op. cit. note 1; 30,000 annually from Beam Engineering, *Solar Heating & Cooling: Energy for a Secure Future*, prepared for U.S. Solar Energy Industries Association (SEIA) (Washington, DC: 2013), http://www.seia.org/research-resources/solar-heating-cooling-energy-secure-future.

28 Ranking and capacity data from Mauthner and Weiss, op. cit. note 1. The United States added 530.2 MW_{th} of unglazed systems and 169.2 MW_{th} of glazed systems in 2012, for a year-end total of 14,311.4 MW_{th} of unglazed systems and 1,935.4 MW_{th} of glazed systems, from idem. Note that U.S. data are uncertain because the U.S. Energy Information Administration no longer tracks solar thermal and SEIA has not finalised a planned survey, from Bärbel Epp, "USA: GoSolar at SEIA's Birthday," Solar Thermal World, 27 January 2014, http://solarthermalworld.org/content/usa-gosolar-seias-birthday.

29 See, for example, Jennifer Runyon, "New Hampshire Sets Thermal Renewable Energy Carve Out," Renewable Energy World, 26 June 2012, http://www.renewableenergyworld.com/rea/news/article/2012/06/hew-hampshire-sets-thermal-renewable-energy-carve-out; SEIA, "RPS Solar Carve Out Arizona," 12 February 2013, http://www.seia.org/sites/default/files/resources/RPS%20Solar%20Fact%20Sheet%20AZ.pdf; SEIA, "RPS Solar Carve Out Pennsylvania," 12 February 2013, http://www.seia.org/sites/default/files/resources/RPS%20Solar%20Fact%20Sheet%20PA.pdf; Jennifer Runyon, "Trend: U.S. States Adding Thermal Energy to Their RPS (Part 1)," District Energy, 15 August 2012, http://www.districtenergy.org/blog/2012/08/10/trend-u-s-states-adding-thermal-energy-to-their-rps-part-1/; "Small-scale Renewables: Big Problem, Small Solution," in REW Guide to North American Renewable Energy Companies 2013, special supplement in *Renewable Energy World*, March–April 2013, pp. 18–24. A few states also allow utilities to meet requirements under RPS laws by buying Solar Renewable Energy Emission Certificates produced by solar water heaters. See, for example, Bärbel Epp, "USA: Solar Thermal SRECs Traded in Washington, D.C. and North Carolina," Solar Thermal World, 27 February 2011, http://solarthermalworld.org/content/usa-solar-thermal-srecs-traded-washington-dc-and-north-carolina, and Bärbel Epp, "Maryland/USA: Solar Water Heaters Eligible for Solar Renewable Energy Credits," Solar Thermal World, 27 April 2011, http://solarthermalworld.org/content/marylandusa-solar-water-heaters-eligible-solar-renewable-energy-credits.

30 Based on 643.9 MW_{th} of capacity added during 2012, of which 455 MW_{th} was unglazed, and 5,128.2 MW_{th} of cumulative capacity at year's end, of which 3,045 MW_{th} was unglazed, from Mauthner and Weiss, op. cit. note 1.

31 Tim Flannery and Veena Sahajwalla, *The Critical Decade: Australia's Future—Solar Energy* (Climate Commission Secretariat, Australian Department of Industry, Innovation, Climate Change, Science Research and Tertiary Education, 2013), http://climatecommission.files.wordpress.com/2013/09/australias-future-solar-energy-report.pdf.

32 Israel, Jordan, and Lebanon rankings from Mauthner and Weiss, op. cit. note 10; 85% of households from Observatoire Méditerranéen de l'Energie (OME), *Solar Thermal in the Mediterranean Region: Market Assessment Report* (Nanterre, France: September 2012), p. 37, http://www.b2match.eu/system/stworkshop2013/files/Market_Assessment_Report_II.pdf?1357834276; Lebanon experienced market growth averaging over 17% during 2008–2012, from Wilson Rickerson et al., *Solar Water Heating Techscope Market Readiness Assessment* (Paris: United Nations Environment Programme (UNEP), 2014), prepared for UNEP, Division of Technology, Industry and Economics, Global Solar Water Heating Initiative, p. 67, http://www.al.undp.org/content/dam/india/docs/EnE/solar-water-heating-techscope-market-readiness-assessment.pdf.

33 Mauthner and Weiss, op. cit. note 10. Egypt has a small market but has seen a rapid increase, particularly in the hotel sector, as solar thermal is a readily available option for reducing costly diesel consumption, from Bärbel Epp, "Egypt: Green Star Hotels 'Download' the Sun," Solar Thermal World, 9 January 2013, http://solarthermalworld.org/content/egypt-green-star-hotels-download-sun; thanks to a support scheme that was introduced in 2009, Tunisia had 14,000 m² by the end of 2012, mostly in hotels, public baths, hospitals, and 30 hotels had installed systems by late 2013, from Bärbel Epp, "Tunisia Funds Solar Process Heat," Solar Thermal World, 7 October 2013, http://solarthermalworld.org/content/tunisia-funds-solar-process-heat; South Africa has seen success driven greatly by rising electricity prices, fear of electricity shortages, and a national rebate programme from utility Eskom, from Frank Stier, "South Africa: High Demand from Tourism Sector," Solar Thermal World, 1 July 2013, http://solarthermalworld.org/content/south-africa-high-demand-tourism-sector.

34 Anton Schwarzlmüller, Domestic Solar Heating, Zimbabwe, cited in "Zimbabwe: Installing 100 Locally Produced Storage Tanks in 2013 Would Be a Big Success," Solar Thermal World, 1 May 2013, http://solarthermalworld.org/content/

zimbabwe-installing-100-locally-produced-storage-tanks-2013-would-be-big-success; Stier, op. cit. note 33; Yaping Zhang, "Thailand: Prefabricated Container Solution Improves Quality in Tannery," Solar Thermal World, 9 April 2013, http://solarthermalworld.org/content/thailand-prefabricated-container-solution-improves-quality-tannery; Alejandro Diego Rosell, "Uruguay: Growing at Its Own Pace," op. cit. note 21.

35 Mauthner and Weiss, op. cit. note 1. Also among the top 10 in 2012 were Australia, Germany, Turkey, China, and Jordan.

36 European Commission, op. cit. note 13.

37 Mauthner, op. cit. note 1.

38 European Commission, op. cit. note 13.

39 Mauthner and Weiss, op. cit. note 1; Mauthner, op. cit. note 1.

40 Mauthner and Weiss, op. cit. note 1; Mauthner, op. cit. note 1; approximately two out of five systems in Germany are combi-systems, from Bundesindustrieverband Deutschland Haus-, Energie- und Umwelttechnik e.V. (BDH) and Bundesverband Solarwirtschaft (BSW), "Solarkollektorabsatz 2013 rückläufig – Solar- und Heizungsbranche fordern: Wärmewende jetzt einläuten," press release (Berlin and Cologne: 17 February 2014), http://www.solarwirtschaft.de/fileadmin/media/pdf/pm_kollektorabsatz2013.pdf; Poland also from Marcin Czekanski, "Poland: Market in Transition," Solar Thermal World, 30 May 2013, http://solarthermalworld.org/content/poland-market-transition; France and Switzerland also have a growing share of combi-systems, from European Commission, European Technology Platform on Renewable Heating and Cooling, *Strategic Research and Innovation Agenda for Renewable Heating & Cooling* (Brussels: European Union, 2013), p. 14, http://www.rhc-platform.org/fileadmin/user_upload/members/Downloads/RHC_SRA_epo_final_lowres.pdf; and markets are growing in Russia, particularly in areas with cold climates, per interviews with manufacturers in Russia, New Polus, Inten, and Kassol, cited in Vladislava Adamenkova, "Russia: 2014 – Year of Change and Growth," Solar Thermal World, 22 January 2014, http://solarthermalworld.org/content/russia-2014-year-change-and-growth.

41 European Commission, op. cit. note 13. The trend towards hybrid systems including heat pumps is seen particularly in Austria, Germany, and Switzerland, where policies and high electricity prices create favourable conditions, per "Solar + Heat Pump Systems," *Solar Update* (IEA-SHC), January 2013, p. 14, http://www.iea-shc.org/data/sites/1/publications/2013-01-SolarUpdate.pdf.

42 Mauthner, op. cit. note 1.

43 Cooling systems include one-stage absorption chillers, adsorption chillers, and desiccant cooling systems (DEC) systems for thermal cooling, from ibid.

44 With such systems, pressurised water, steam or thermo-oil can be used as heat transfer medium, from ibid.

45 Other heat sources from Jan-Olof Dalenbäck and Sven Werner, CIT Energy Management AB, *Market for Solar District Heating*, supported by Intelligent Energy Europe (Gothenburg, Sweden: revised July 2012), http://solarthermalworld.org/sites/gstec/files/story/2013-05-21/sw_solar_markets.pdf.

46 Solar District Heating, Intelligent Energy Europe Programme of the European Union, "Solar District Heating," viewed 6 March 2014, http://www.solar-district-heating.eu/SDH.aspx.

47 Jan-Olof Dalenbäck, "An Emerging Option: Solar District Heating and Cooling," Euro Heat & Power, vol. 10, no. (2013), pp. 26–29; Jan-Olof Dalenbäck, Chalmers University of Technology and Solar District Heating (SDH), personal communication with REN21, 12 April 2014; cost competitive in Denmark only, from Bärbel Epp, solrico, personal communication with REN21, 29 April 2014; Rachana Raizada, "Renewables and District Heating: Eastern Europe Keeps It Warm," Renewable Energy World, 13 September 2012, http://www.renewableenergyworld.com/rea/news/article/2012/09/renewables-and-district-heating. Costs have come down considerably in the past five years and, in Denmark, the heat price from solar thermal is as low as USD 42.7/MWh (EUR 31/MWh), below that of gas-fired district heating, due to the large size of fields and low interest rates over expected lifetime of at least 20 years, from Søren Elisiussen, Arcon, cited in Bärbel Epp, "Denmark: 'We have improved the cost/performance ratio by around 50 % over the last 5 years'," Solar Thermal World, 4 March 2014, http://solarthermalworld.org/content/denmark-we-have-improved-costperformance-ratio-around-50-over-last-5-years. See also Bärbel Epp, "Germany/Denmark: Solar District Heating Prices between 37 and 88 EUR/MWh," Solar Thermal World, 24 March 2014, http://solarthermalworld.org/content/germanydenmark-solar-district-heating-prices-between-37-and-88-eurmwh.

48 Natural Resources Canada, "Canadian Solar Community Sets New World Record for Energy Efficiency and Innovation," press release (Okotoks, Alberta: 5 October 2012), http://www.nrcan.gc.ca/media-room/news-release/2012/2143; Canada also from "Solar Community Tops World Record," *Solar Update* (IEA-SHC), January 2013, p. 16, https://www.iea-shc.org/data/sites/1/publications/2013-01-SolarUpdate.pdf; Government of Canada, "Drake Landing Solar Community," brochure, www.dlsc.ca/DLSC_Brochure_e.pdf, viewed 29 April 2014; China's "Utopia Garden" project in Dezhou covers 10 blocks of apartment buildings with 5.025 m^2 combined with seasonal storage beneath the complex, per Bärbel Epp, "China: Utopia Garden Sets New Standard for Architectural Integration," Solar Thermal World, 10 April 2012, http://solarthermalworld.org/content/china-utopia-garden-sets-new-standard-architectural-integration; the University of Pretoria's 672 m^2 solar thermal system provides warm water for apartments for 550 students, per Stephanie Banse, "South Africa: University of Pretoria's 672 m^2 Solar Thermal System," Solar Thermal World, 12 April 2012, http://solarthermalworld.org/content/china-utopia-garden-sets-new-standard-architectural-integration.

49 Constructed in 2013 from Dalenbäck, "Emerging Options…," op. cit. note 47. Dalenbäck, personal communication, op. cit. note 47. Most plants were in Denmark, but there were two in Austria, two in Germany, one in France, and one in Norway. See also "Büsingen: First German ground-mounted solar district heating plant in operation," Newsletter of the Solar District Heating, Intelligent Energy Europe Programme of the European Union, 16 September 2013, http://www.solar-district-heating.eu/NewsEvents/News/tabid/68/ArticleId/299/Busingen-First-German-groundmounted-solar-district-heating-plant-in-operation.aspx; Jan Erik Nielsen, "Large Solar Heating and Cooling Systems," IEA-SHC Task 45, 2014, provided by Mauthner, op. cit. note 1. Denmark's Dronninglund Solar District Heating Plant is 26 MW_{th} (37,000 m^2 of collectors) with 60,000 m^3 seasonal storage. It is expected that the field together with storage will cover about 50% of annual heat load for 1,400 connected customers, from Nielsen, op. cit. this note.

50 Uli Jakob, "Technologies and Perspectives of Solar Cooling Systems," presentation for AHK Conference, Sydney Australia, 24 March 2014, slide 29, http://australien.ahk.de/fileadmin/ahk_australien/Dokumente/Delegations/Energieeffizienz_2014/Presentations/DrJakob_Green_Chiller_Assoc.pdf; data from Solem Consulting/TECSOL/Green Chiller, provided by Uli Jakob, Green Chiller Verband für Sorptionskälte e.V., personal communication with REN21, 22 April 2014. Note that roughly 600 solar cooling systems were installed worldwide in 2010, per Hans-Martin Henning, "Solar Air-conditioning and Refrigeration—Achievements and Challenges," Conference Proceedings of International Conference on Solar Heating, Cooling and Buildings—EuroSun 2010, Graz, Austria, 2010, http://solarthermalworld.org/sites/gstec/files/EuroSun2010_Keynote-Henning.pdf.

51 Europe accounted for about 81% of installed systems worldwide as of 2013, based on data from Jakob, op. cit. note 50; Australia, Mediterranean islands, and Middle East from IEA, *Technology Roadmap, Solar Heating and Cooling* (Paris: OECD/IEA, 2012), p. 11, http://www.iea.org/publications/freepublications/publication/Solar_Heating_Cooling_Roadmap_2012_WEB.pdf. Several hundred small cooling kits were sold in these countries in 2011. The Australian market has grown 30% annually over the past eight years, from Uli Jakob, Green Chiller and Solem Consulting, cited in Eva Augsten, "Australia: Country to Publish First Solar Air Conditioning Standard," Solar Thermal World, 17 June 2013, http://solarthermalworld.org/content/australia-country-publish-first-solar-air-conditioning-standard; in India, for example, solar thermal is used for cooling at a hospital and at Muni Seva Ashram in Gujarat state, where 100 parabolic dishes (Scheffler type) supply a 100-tonne air conditioning system, from Eva Augsten, "India: Quarterly Sun Focus Magazine Presents Concentrating Solar Heat," Solar Thermal World, 19 September 2013, http://solarthermalworld.org/content/india-quarterly-sun-focus-magazine-presents-concentrating-solar-heat; Jamaica's first solar cooling system was commissioned in an office tower in Kingston, from SOLID, "Commissioning of S.O.L.I.D.'s First Solar Cooling Plant in Jamaica," press release (Graz, Austria: 2013), http://www.solid.

at/en/news-archive/2013/152-commissioning-of-s-o-l-i-d-s-first-solar-cooling-plant-in-jamaica.

52 IEA, op. cit. note 51, p. 11. Several hundred small cooling kits were sold in Australia, Mediterranean islands, and the Middle East in 2011.

53 Daniel Rowe, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia, personal communication with REN21, 29 April 2013.

54 Mauthner, op. cit. note 1. See also, for example, Uli Jacob, Green Chiller, "Status and Perspective of Solar Cooling in Europe," Australian Solar Cooling 2013 Conference, Sydney, Australia, April 2013.

55 Eva Augsten, "The world of solar process heat," *Sun & Wind Energy*, March 2014, pp. 36–45.

56 The 27.5 MW_{th} (39,300 m^2 of collector area) system is combined with 4,000 m^3 of heat storage to provide heat for the remote Gaby mine of the state-owned company Codelco, per Bärbel Epp, "Chile: President Inaugurates World's Largest Solar Field with 27.5 MW_{th}," Solar Thermal World, 13 November 2013, http://solarthermalworld.org/content/chile-president-inaugurates-worlds-largest-solar-field-275-mwth. This field is 8% larger than the Saudi Arabian plant inaugurated at the end of 2011 to supply heat to a women's university, per Eva Augsten, "Saudi Arabia: World's Biggest Solar Thermal Plant in Operation," Solar Thermal World, 26 January 2012, http://solarthermalworld.org/content/saudi-arabia-worlds-biggest-solar-thermal-plant-operation.

57 Solar Heat for Industrial Processes—SHIP Database, IEA-SHC Task 49/IV, http://ship-plants.info/projects, viewed 10 April 2014.

58 Jaideep Malaviya, "India: Pilgrim Sites Use Solar Energy," Solar Thermal World, 31 May 2013, http://solarthermalworld.org/content/india-pilgrim-sites-use-solar-energy. At least a dozen large religious sites in India use concentrating solar thermal for community cooking; the largest (Saibaba Ashram in Shirdi, Maharashtra State) uses solar thermal concentrators (parabolic dishes) to cook for 50,000 people per day, saving 100,000 kilograms of LPG annually, from idem. By late 2013, at least 23 additional systems were under development in India, primarily to replace conventional boilers and generate steam for cooking, per Eva Augsten, "India: Quarterly Sun Focus Magazine Presents Concentrating Solar Heat," Solar Thermal World, 19 September 2013, http://solarthermalworld.org/content/india-quarterly-sun-focus-magazine-presents-concentrating-solar-heat.

59 Rapid expansion and fuel prices, and an estimated 11,600 m^2 of solar concentrators installed during 2012, with a cumulative area of 28,000 m^2 by year's end, all from Jaideep Malaviya, Malaviya Solar Energy Consultancy, interview with Franz Mauthner, information provided by Mauthner, op. cit. note 1. The figure of 40 MW_{th} is based on a collector area of 28,000 m^2 and the conversion factor of 0.7 kW_{th}/m^2. Note that there is no agreed-upon standard conversion factor for solar concentrators, and an expert group of the IEA-SHC Task 49 is currently dealing with this topic. However, for now the conversion with 0.7 is considered acceptable, per Mauthner, op. cit. note 1. Note that India has 7,967 m^2 of solar concentrator systems for solar cooling, and a total of 27,972 m^2 of solar concentrator-based systems for industrial applications, from Shirish Garud, The Energy and Resources Institute, personal communication with REN21, 16 April 2014.

60 See, for example, Eva Augsten, "Germany: Solar Process Heat Support Shows First Results," Solar Thermal World, 22 January 2013, http://solarthermalworld.org/content/germany-solar-process-heat-support-shows-first-results; Eva Augsten, "Germany: Solar Process Heat Cheaper than Fossil-Fuel Heat, but Outperformed by CHP," Solar Thermal World, 4 December 2013, http://solarthermalworld.org/content/germany-solar-process-heat-cheaper-fossil-fuel-heat-outperformed-chp; Stephanie Banse, "Austria: Large-Scale Solar Plants Subsidy Scheme Shows Increase in Average System Sizes," Solar Thermal World, 3 January 2014, http://solarthermalworld.org/content/austria-large-scale-solar-plants-subsidy-scheme-shows-increase-average-system-sizes; Frank Stier, "Denmark: Launch of Subsidy Scheme for the Industrial Sector," Solar Thermal World, 26 September 2013, http://solarthermalworld.org/content/denmark-launch-subsidy-scheme-industrial-sector; Jaideep Malaviya, "India: 90 Process Heat Projects with Concentrating Collectors in Five Years," Solar Thermal World, 11 June 2012, http://solarthermalworld.org/content/india-90-process-heat-projects-concentrating-collectors-five-years.

61 Interest growing from, for example, Vladislava Adamenkova, "Russia: 2014 – Year of Change and Growth," Solar Thermal World, 22 January 2014, http://solarthermalworld.org/content/russia-2014-year-change-and-growth; Observatoire Méditerranéen de l'Energie (OME), *Solar Thermal in the Mediterranean Region: Market Assessment Report* (Nanterre, France: September 2012), pp. 40–41, 74–75, http://www.b2match.eu/system/stworkshop2013/files/Market_Assessment_Report_II.pdf; Bärbel Epp, "Tunisia Funds Solar Process Heat," Solar Thermal World, 7 October 2013, http://solarthermalworld.org/content/tunisia-funds-solar-process-heat; Emily Hois, "US Ranchers Roundup the Power of the Sun," Renewable Energy World, 16 July 2013, http://www.renewableenergyworld.com/rea/blog/post/2013/07/ranchers-roundup-the-power-of-the-sun; 1% from Mauthner and Weiss, op. cit. note 10, p. 3.

62 European Commission, op. cit. note 13. Note that the Hyatt Regency in Aruba uses solar thermal to provide its guests with pure drinking water, from SOLID, "S.O.L.I.D. Installed a Large Solar Plant at the Hyatt Regency in Aruba," press release (Graz, Austria: 2013), http://www.solid.at/en/news-archive/2013/169-s-o-l-i-d-installed-a-large-solar-plant-at-the-hyatt-regency-in-aruba; and solar thermal is being used in Oman, where it is cheaper than natural gas for powering oil recovery projects, from Wael Mahdi, "Solar Beats Natural Gas to Unlock Middle East's Heavy Oil, Says GlassPoint Solar," *Bloomberg*, 20 January 2014, http://www.renewableenergyworld.com/rea/news/article/2014/01/solar-beats-natural-gas-to-unlock-middle-easts-heavy-oil-says-glassdoor-solar; a pilot "tri-generation" project in Jordan, operational since 2011, uses a parabolic trough system for electricity generation, industrial steam generation, and water desalination and chilling, per Rayer Ltd., "State of the Art Tri-Generation Project," http://www.rayer.co.uk/tri-generation-project, viewed 3 May 2014.

63 Production data from Solar Alliance Network, http://www.21tyn.com/news/echo.php?id=31269.htm (in Chinese), cited in Bärbel Epp, "China: Flat Plate Collector Share is Growing," Solar Thermal World, 1 July 2013, http://solarthermalworld.org/content/china-flat-plate-collector-share-growing.

64 Epp, op. cit. note 8. China's exports were up 20% between 2010 and 2012.

65 Poland from Czekanski, op. cit. note 40; Turkey from A. Hakan Alaş, ezinc, interview with Bärbel Epp, "Turkey: Vacuum Tubes on the Rise," Solar Thermal World, 23 April 2012, http://solarthermalworld.org/content/turkey-vacuum-tubes-rise; India from Jaideep Malaviya, "India: Flat Plate vs Vacuum Tube Technology," Solar Thermal World, 19 November 2012, http://solarthermalworld.org/content/india-flat-plate-vs-vacuum-tube-technology.

66 For example, the Austrian Greiner Group announced in mid-June 2013 the closure of the former Sun Master collector production plant, and the Danish Velux Group announced the phase out of its production and sale of solar collector systems in September 2013, per Bärbel Epp and Eva Augsten, "The seven year itch," *Sun & Wind Energy,* November–December 2013, pp. 32–45.

67 Bärbel Epp, "Germany: Management Buyout of Schüco's Collector Production," Solar Thermal World, 14 March 2013, http://solarthermalworld.org/content/germany-management-buyout-schucos-collector-production; Bärbel Epp, "Austria/Europe: General Solar Systems and Sonnenkraft Management Buyout," Solar Thermal World, 27 February 2014, http://solarthermalworld.org/content/austriaeurope-general-solar-systems-and-sonnenkraft-management-buyout.

68 From the 12 collector manufacturers in the Czech Republic in 2007, seven have since left the solar thermal sector or plan to close in the coming months, per Bärbel Epp, personal communication with REN21, 4 March 2014.

69 Foreign markets from Alejandro Diego Rosell, "Spain: 'Most of these companies will survive thanks to internationalisation'," Solar Thermal World, 16 December 2013, http://solarthermalworld.org/content/spain-most-these-companies-will-survive-thanks-internationalisation; local partnerships and investments from Welling, op. cit. note 15. For example, boiler manufacturer Bosch Thermotechnik (Germany) operated solar production facilities in five locations on four continents by late 2012, from Epp and Augsten, op. cit. note 66.

70 Greencape, Green Cape Sector Development, Market Intelligence Report: Energy Efficiency & Embedded Generation, Cape Town, South Africa, January 2014, pp. 7–8.

71 Carlos Alencar, DASOL, ABRAVA, cited in Cardoso, op. cit. note 18.

72 Ibid.

73 Based on the ISOL Index, an international business climate index developed and surveyed by solrico since the beginning of 2010. This point-based indicator (ranging from 0 to 100 points) shows the satisfaction of solar thermal manufacturers and system suppliers with current and expected market development, and company values are averaged to obtain country and regional indices, per http://www.solrico.com. The average long-term current business ISOL Index 2012/2013 for Greece was 58 points, the highest score together with India, per Bärbel Epp, solrico, personal communication with REN21, February 2014.

74 Jaideep Malaviya, "India: Industry Shifts to Vacuum Tube Collectors," Solar Thermal World, 1 May 2013, http://solarthermalworld.org/content/india-industry-shifts-vacuum-tube-collectors.

75 European Technology Platform on Renewable Heating and Cooling, *Strategic Research Priorities for Solar Thermal Technologies* (Brussels: December 2012), p. 22, http://www.rhc-platform.org/fileadmin/Publications/Solar_thermal_SRP.pdf.

76 Werner Weiss and Pam Murphy, IEA-SHC, personal communication with REN21, March 2014.

77 Most PVT manufacturers are based in Europe, but there are also companies in China, Israel, Turkey, and the United States, from Irina Mitina, Fachhochschule Düsseldorf, Arbeitsgruppe E^2 – Erneuerbare Energien und Energieeffizienz, "Technology Survey: Pros and Cons of Different PVT Collectors," SMEThermal 2014, Berlin, 18 February 2014. See also Lydie Bahjejian, "France: Third Player to Launch PVT Panel on Market," Solar Thermal World, 7 May 2013, http://solarthermalworld.org/content/france-third-player-launch-pvt-panel-market.

78 See, for example, Stephanie Banse and Joachim Berner, "Lowering Costs, Maintaining Efficiency," *Sun & Wind Energy*, December 2012, pp. 62–65; Epp, op. cit. note 20; Rosell, "Mexico: Fight for New Incentives," op. cit. note 20.

79 The test standard EN ISO 9806, by ISO committees CEN/TC 312 and ISO TC180, includes testing methodology for a number of new solar thermal technologies, such as solar air heating collectors and concentrating medium-temperature collectors, from Bärbel Epp, "Global Collector Test Standard Incorporates New Technologies," Solar Thermal World, 24 October 2013, http://solarthermalworld.org/content/global-collector-test-standard-incorporates-new-technologies.

80 For example, review of a technical quality standard in Mexico during 2012 reduced the approved system models from 250 to 40, and there are still efforts under way to create a national standard, from Rosell, "Mexico: Fight for New Incentives," op. cit. note 20; Costa Rica's Institute of Technical Standards began working on a standardisation process for solar thermal systems, from Epp, op. cit. note 20.

81 The first World Map of the Solar Process Heat Collector Industry includes 36 companies from 10 countries including 18 parabolic trough collector manufacturers, four Fresnel collector manufacturers, 1 evacuated flat-plate collector manufacturer, 8 scheffler/paraboloid dish collector manufacturers, and 4 receiver (tube) manufacturers, per Eva Augsten, "The world of solar process heat," *Sun & Wind Energy*, March 2014. Only a small portion (perhaps one-third) of manufacturers is also active in the CSP field, per Bärbel Epp, solrico, personal communication with REN21, 26 March 2014.

82 Based on survey with manufacturers of process heat systems, from Augsten, op. cit. note 81, pp. 36–45.

83 Jakob, op. cit. note 50, slide 26.

84 Eva Augsten, "Australia: Country to Publish First Solar Air Conditioning Standard," Solar Thermal World, 17 June 2013, http://solarthermalworld.org/content/australia-country-publish-first-solar-air-conditioning-standard.

85 Makatec (Germany) and Solabcool (Netherlands) released new chillers; Solabcool, Mitsubishi Plastics (Japan), and Jiangsu Huineng (China) put out new cooling kits, from Augsten, op. cit. note 84.

86 Eva Augsten, "Germany: Additional Support for Small Solar Cooling Systems," Solar Thermal World, 3 February 2014, http://solarthermalworld.org/content/germany-additional-support-small-solar-cooling-systems.

87 Daniel Mugnier, TECSOL SA, personal communication with REN21, 11 April 2014. See, for example, http://en.helioclim.fr/.

WIND POWER

1 A total of 35,289 MW was added during the year, bringing the total to 318,105 MW, according to Global Wind Energy Council (GWEC), *Global Wind Report—Annual Market Update 2013* (Brussels: April 2014), p. 17, http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf, and Steve Sawyer, GWEC, personal communication with REN21, 10 April 2014; 35,550 MW added for an increase of 12.8%, to a total of 318,529 MW, from World Wind Energy Association (WWEA), *World Wind Energy Report 2013* (Bonn: 2014); and 36,134 MW added for a total of 321,559 MW, from Navigant Research, *World Market Update 2013: International Wind Energy Development. Forecast 2014-2018* (Copenhagen: March 2014), Executive Summary; 35,572 MW was installed for a total of 318,576 MW, per EurObserv'ER, *Wind Energy Barometer* (Paris: February 2014), p. 2, http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro-jde14-gb.pdf. **Figure 19** based on historical data from GWEC, op. cit. this note, and data for 2013 from sources in this note.

2 Down 10 GW after several record years from GWEC, op. cit. note 1; drop in United States from Steve Sawyer, GWEC, personal communication with REN21, 18 December 2013.

3 GWEC, "Global Wind Statistics 2013" (Brussels: 5 February 2014); Sawyer, op. cit. note 2.

4 At least 85 countries from Shruti Shukla, GWEC, personal communication with REN21, 13 April 2014; figures of 71 and 24 countries from Shruti Shukla, GWEC, personal communication with REN21, 26 March 2014. Note that there was wind-related activity in at least 46 countries during 2013 and, as of end-2013, 75 countries had 10 MW or more capacity, and 24 had more than 1 GW in operation, from WWEA, op. cit. note 1. During 2013, 19,028 new turbines were erected in 54 countries, from Navigant Research, op. cit. note 1.

5 Based on 120,624 MW at end of 2008, and 39,431 MW at end of 2003, from GWEC, op. cit. note 1, p. 21.

6 Sixth consecutive year and shares based on data for China, the European Union, the United States, Canada, and the world, from GWEC, op. cit. note 1, pp. 17, 18. Note that Europe accounted for 32% of all new installations in 2013, up from 28.5% in 2012 and 24.5% in 2011, from Navigant Research, op. cit. note 1; and the EU accounted for 32.3% of 2013 installations from WWEA, op. cit. note 1.

7 Latin America (including Mexico) accounted for 1,615 MW in 2013, or nearly 4.6% of capacity additions based on data from GWEC, op. cit. note 1; Latin America accounted for 5.1% of the global market, from WWEA, op. cit. note 1.

8 GWEC, op. cit. note 1.

9 WWEA, op. cit. note 1. The top five are followed by Germany (372.1 W/capita), Canada (209.7), Estonia (191.2), Austria (182.2), and the United States (167.7).

10 Based on the following: 16,088 MW added for a total of 91,412 MW installed by the end of 2013, from Chinese Wind Energy Association (CWEA), provided by Shi Pengfei, CWEA, personal communication with REN21, 14 March 2014; 16,000 MW added for a total of 91,324 MW, from WWEA, op. cit. note 1; and 16,088 MW added for a total of 91,412 MW, from GWEC, op. cit. note 1, p. 17. For more on China-related developments, see also "Statistics of Wind Power Development in China 2013," *WWEA Quarterly Bulletin*, March 2014, pp. 22–33, http://www.wwindea.org/webimages/WWEA_Bulletin-ISSUE_1_2014_reduced.pdf. **Figure 20** based on country-specific data and sources provided throughout this section.

11 Figure of 14.1 GW added to the grid for a year-end total of 75,480 MW from China Electricity Council (CEC), provided by Shi Pengfei, CWEA, personal communication with REN21, 15 April 2014. Note that 77,160 MW was available for grid connection, from China Renewable Energy Engineering Institute (CREEI), provided by Shi, op. cit. note 10. Most of the capacity added in 2013 was feeding the grid by year's end, per Sawyer, op. cit. note 1. Note that the process of finalising the test phase and getting a commercial contract with the system operator takes time, as does getting paid, all of which account for delays in reporting. The difference in statistics among Chinese organisations and agencies is explained by the fact that they count different things—there are three prevailing statistics in China: installed capacity (turbines installed according to commercial contracts); construction

capacity (constructed and connected to grid for testing); and operational capacity (connected, tested, and receiving tariff for electricity produced). The lowest number (operational) only registers once the feed-in tariff has been paid, which can take weeks or even months.

12 An estimated 16.2 TWh was curtailed in 2013, from Shi, op. cit. note 10.

13 China National Energy Administration, provided by Liu Minghui, CWEA, personal communication with REN21, February 2014; "China Wind Farm Idling Improves with Better Planning," *Bloomberg*, 9 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/china-wind-farm-idling-improves-with-better-planning. Note that a ±800 kV DC transmission line over 2,200 kilometres, from Hami in Xinjiang province to Zhengzhou in Henan, came into operation in January 2014, with 8 GW capacity for wind and coal power. In addition, several ultra-high transmission lines are planned to carry electricity from Inner Mongolia and Gansu to eastern China. In 2012, 20.8 TWh of wind power could be generated but were lost due to dispatching requirements, and unable to be consumed; this number declined to 16.2 TWh in 2013, all from Shi, op. cit. note 10.

14 Figure of 140.1 TWh and exceeding nuclear from CEC, provided by Shi Pengfei, CWEA, personal communication with REN21, 12 March 2014; and up 40% based on 100.4 TWh generated in 2012, from CEC, provided by Shi, op. cit. note 10.

15 CREEI, provided by Shi, op. cit. note 10.

16 Based on data from European Wind Energy Association (EWEA), *Wind in Power: 2013 European Statistics* (Brussels: February 2014), p. 3, http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA_Annual_Statistics_2013.pdf; from GWEC, op. cit. note 3; and from WWEA, op. cit. note 1.

17 EWEA, op. cit. note 16. The EU added 11,264 MW to the grid in 2013 for a total of 117,289 MW.

18 Ibid., p. 5.

19 Market decline from ibid., p. 6; financing is becoming more challenging particularly for offshore projects, according to Shruti Shukla, GWEC, personal communication with REN21, 19 March 2014; policy uncertainty also from Sarah Azau, "Wind Energy Sector Faces Uncertainty Crisis," *Wind Directions*, April 2013, p. 19. Note that 2013 additions in Europe reflect orders that were made before political uncertainty began to sweep across Europe in 2011, per GWEC, op. cit. note 1, p. 22.

20 EWEA, op. cit. note 16, p. 3.

21 Germany's strong year was driven largely by developers' efforts to install projects and acquire the best wind power purchasing terms possible before pending reform of the EEG in 2014, from EurObserv'ER, op. cit. note 1, p. 5; and from C. Ender, "Wind Energy Use in Germany—Status 31.12.2013," *DEWI Magazin*, February 2014, http://www.dewi.de/dewi/fileadmin/pdf/publications/Magazin_44/07.pdf; the previous German record was set in 2002, per EurObserv'ER, op. cit. note 1, pp. 3, 5.

22 Germany added 3,591.71 MW of capacity in 2013, but only 3,237 MW of that was grid-connected by year's end (not all new offshore capacity was connected), and 236 MW was removed for repowering, from Ender, op. cit. note 21. From other sources: In 2013, Germany added 3,238 MW (of which 240 MW was grid-connected offshore) for a total of 33,730 MW, per EWEA, op. cit. note 16, pp. 4–5; 3,238 MW was added for a total of 34,250 MW grid-connected, from GWEC, op. cit. note 1, p. 48; 3,237 MW was added, from Navigant Research, op. cit. note 1; 3,345 MW was added for a total of 34,660 MW (including installed capacity that was not grid-connected), from WWEA, op. cit. note 1; Germany's gross additions were 3,592 MW, with net additions of 3,356 MW (accounting for repowering), including 2,761 MW onshore, for a year-end total of 34,660 MW (including about 355 MW of offshore capacity that was not grid-connected by year's end), per Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), *Erneuerbare Energien im Jahr 2013* (Berlin: Bundesministerium für Wirtschaft und Energie (BMWi), Berlin, 2014), http://www.bmwi.de/BMWi/Redaktion/PDF/A/agee-stat-bericht-ee-2013.

23 AGEE-Stat, op. cit. note 22.

24 The United Kingdom installed 1,883 MW for a year-end total of 10,531 MW, per EWEA, op. cit. note 16, pp. 4–5; the same numbers are used by GWEC and Navigant Research. The U.K. added 2,088 MW for a total of 10,976 MW, from U.K. Department of Energy and Climate Change (DECC), Section 6 – Renewables, in *Energy Trends* (London: March 2014), https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295362/ET_March_2014.PDF.

25 Poland added 894 MW for a total of 3,390 MW; Sweden added 724 MW for a total of 4,470 MW; Romania added 695 MW for a total of 2,600 MW; Denmark added 657 MW for a total of 4,772 MW, from EWEA, op. cit. note 16, pp. 3–5. Note that Denmark added net 626 MW for total of 4,792 MW at year's end, per Carsten Vittrup, "2013 Was a Record-Setting Year for Danish Wind Power," Energinet.DK, 15 January 2014, http://www.energinet.dk/EN/El/Nyheder/Sider/2013-var-et-rekordaar-for-dansk-vindkraft.aspx. At the end of 2013, wind power accounted for 7% of Sweden's electricity consumption, from GWEC, op. cit. note 1, p. 23.

26 France added 631 MW for a total of 8,254 MW, and Italy added 444 MW for a total of 8,551 MW, from EWEA, op. cit. note 16, pp. 3–5. Note that France added 535 MW of wind capacity in 2013, down from 815 MW in 2012, for a total of 8,163 MW, per Commissariat Général au Développement Durable, Ministère de l'Écologie du Développement durable et de l'Énergie, "Observation et Statistiques," Chiffres & Statistiques, no. 498, February 2014, http://www.developpement-durable.gouv.fr/IMG/pdf/CS498.pdf.

27 Spain added 175 MW for a total of 22,959 MW from EWEA, op. cit. note 16, p. 4; 173 MW net additions for total of 22,746 MW from Red Eléctrica de España, "Potencia Instalada Peninsular (MW)," http://www.ree.es, updated March 2014; policy changes from Chris Rose, "A Closer Look at Spain," *Wind Directions*, November 2013, p. 30; lowest in 16 years from EurObserv'ER, op. cit. note 1, p. 9.

28 EWEA, op. cit. note 16, p. 4.

29 Ibid., p. 4. Iceland also added capacity (1.8 MW) for the first time in 2013, from idem. In addition, Bolivia added wind capacity (3 MW) for the first time in 2013, from Shukla, op. cit. note 4, 26 March 2014; and Mongolia added its first commercial wind capacity (50 MW) for a total of 50 MW from GWEC, op. cit. note 1, p. 17. Note, however, that Bolivia and Iceland added capacity prior to, but not during, 2013; and Mongolia added 46.9 MW in 2013 for a total of 50.9 MW, from WWEA, op. cit. note 1.

30 Market contraction based on 1,729 MW added in 2013 and 2,336 MW installed in 2012, with 2012 data from GWEC, op. cit. note 1, p. 9.

31 Figure of 1,729 MW added in 2013 for a year-end total of 20,150 MW, from GWEC, op. cit. note 1, p. 17; and from EurObserv'ER, op. cit. note 1, p. 2; added 1,987 MW per Navigant Research, op. cit. note 1; added 1,829 MW for a total of 20,150 MW, from WWEA, op. cit. note 1.

32 "Asia Report: What's Driving, And Hampering, India's Wind Market Momentum," Renewable Energy World, 5 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/asia-report-whats-driving-and-hampering-indias-wind-market-momentum-1; Natalie Obiko Pearson, "India's Currency Plunge Derailing its $1.6 Billion Wind Industry," *Bloomberg*, 3 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/rupee-derailing-1-6-billion-india-wind-farm-revival; GWEC, op. cit. note 1, pp. 28, 58; Navigant Research, op. cit. note 1.

33 The GBI was reinstated in August 2013, retroactively from April 2012, from Shukla, op. cit. note 4, 26 March 2014. Accelerated depreciation (of 80%), a key support policy for privately-owned projects, was not yet reinstated as of year's end, from Navigant Research, op. cit. note 1.

34 Japan added 50 MW in 2013 for a total of 2,661 MW, from GWEC, op. cit. note 1, p. 17, and from WWEA, op. cit. note 1. Japan's guidelines for wind power projects are stricter than those for new skyscrapers, per Steve Sawyer, GWEC, personal communication with REN21, 15 January 2014; environmental assessments for construction of large-scale wind farms in Japan take about three years, from Kazuaki Nagata, "Wind Power on Verge of Taking Off," *Japan Times*, 26 February 2014, http://www.japantimes.co.jp/news/2014/02/26/business/wind-power-on-verge-of-taking-off/#.Uw-8m_I5Np8; Thailand added 111 MW for a total of 223 MW, and Pakistan added 50 MW for a total of 106 MW, from GWEC, op. cit. note 1, p. 17. Note that Thailand added 81 MW for a total of 193 MW, and Pakistan added no capacity for a total of 106 MW, from WWEA, op. cit. note 1. Vietnam's first commercial project came on line in 2012, and the second in 2013, from "Bac Lieu Wind-Power Project Comes on Line," Vietnamnet.vn, 31 May 2013, http://english.vietnamnet.vn/fms/environment/75604/

bac-lieu-wind-power-project-comes-on-line.html; total of 52 MW from Sawyer, op. cit. note 1. Note that Vietnam added 0 MW in 2013 for a total of 31 MW, from WWEA, op. cit. note 1.

35 Canada added 1,599 MW for a total of 7,803 MW, of which 2,470 MW was in Ontario and 2,398.3 MW in Quebec, from GWEC, op. cit. note 1, pp. 17, 22. Canada added nearly 1,600 MW for a total of 7,802.72 MW from Canadian Wind Energy Association (CanWEA), "Installed Capacity," http://canwea.ca/wind-energy/installed-capacity/, viewed 11 April 2014; 1,699 MW was added per Navigant Research, op. cit. note 1; and 1,497 MW was added for a total of 7,698 MW, from WWEA, op. cit. note 1. Market increase of more than 70% based on 2013 additions and added capacity of 935 MW in 2012, from GWEC, *Global Wind Report: Annual Market Update 2012* (Brussels: 2013), p. 9.

36 The United States added 1,087 MW in 2013 for a total of 61,110 MW, from American Wind Energy Association (AWEA), "U.S. Capacity & Generation," in *U.S. Wind Industry Annual Market Report 2013* (Washington, DC: 10 April 2014), http://www.awea.org/AnnualMarketReport.aspx?ItemNumber=6305&RDtoken=35392&userID=.

37 Figure of 13,131 MW was added during 2012, from AWEA, *AWEA U.S. Wind Industry Annual Market Report, Year Ending 2012* (Washington, DC: 2013), Executive Summary, http://www.awea.org/annualmarketreport2012.

38 James Montgomery, "Updated: Massachusetts Utilities Sign PPA for Wind Energy That Is Cheaper Than Coal," Renewable Energy World, 24 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/massachusetts-utilities-pool-for-cheaper-wind-energy-supply; utilities included American Electric Power's Public Service Company of Oklahoma, Xcel Energy, Detroit Edison, Austin Energy, Omaha Public Power District, from AWEA, "Wind Power's Growth Continues to Attract Investment, Benefit Consumers and Local Economies," press release (Washington, DC: 31 October 2013), http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=5775; corporate purchasers included Google and Microsoft, which signed long-term PPAs to power data centres in Texas, from AWEA, *AWEA U.S. Wind Industry Fourth Quarter 2013 Market Report* (Washington, DC: 30 January 2014), Executive Summary, p. 4, http://www.awea.org/4Q2013; in response to low power prices from Christopher Martin, "US Wind Power Slumps in 2013 After Tax Credit Drives 2012 Boom," *Bloomberg*, 1 November 2013, http://www.renewableenergyworld.com/rea/news/article/2013/11/u-s-wind-power-slumps-in-2013-after-tax-credit-drives-2012-boom; more than 12 GW from AWEA, "Largest-ever Crop of Wind Farms Under Construction, Building U.S. Industry's Momentum," press release (Washington, DC: 30 January 2014), http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=6044. Note that the U.S. market was still busy after expiration of the PTC because a change in the law, made in early 2013, provides support to all projects that were started before 31 December 2013.

39 Texas had 12,355 MW at year's end, California 5,830 MW, Iowa 5,178 MW, Illinois 3,568 MW, and Oregon 3,153 MW, per AWEA, *AWEA U.S. Wind Industry Fourth Quarter 2013 Market Report*, op. cit. note 38, p. 6, http://www.awea.org/4Q2013.

40 In 2013, Brazil added 948.2 MW of capacity, which was considered by ABEEólica to be grid-connected; a further 304.2 MW was installed and not yet grid-connected at year's end, for a total of 3.46 GW, from Francine Martins Pisni, Associação Brasileira de Energia Eólica (ABEEólica), communication with REN21 via Suani Coelho, CENBIO, 29 April 2014. For comparison, in 2012, Brazil added an estimated 1,077 MW for a total of 2,508 MW, from GWEC, *Global Wind Report – Annual Market Update 2012* (Brussels: April 2013), and from ABEEólica, "Boletim Mensal de Dados do Setor Eólico – Publico," January 2013, p. 2, http://www.abeeolica.org.br. Ranked seventh based on data from GWEC, op. cit. note 1. Note that ABEEólica deems capacity to be installed and grid-connected once it has achieved the status "Able to Operate," meaning that the wind farm operator receives monthly payment for power sales, according to the accounting system of the Chamber of Electric Energy Commercialisation (CCEE), which considers the energy to be delivered under the contract at the contracted price. This status was created due to delays in completion of some transmission lines.

41 Figure of 3.5 GW based on 3.46 GW installed and with status "Able to Operate" (see previous endnote), from Pisni, op. cit. note 40; Brazil had about 2.2 GW in commercial operation by the end of 2013, from National Electricity Agency of Brazil (ANEEL), cited in "Capacidade instalada para energia eólica cresce 20% no Brasil," *Jornal da Energia*, 1 April 2014, http://www.portalabeeolica.org.br/index.php/noticias/1739-capacidade-instalada-para-energia-eólica-cresce-20-no-brasil.html (using Google Translate). Brazil added 953 MW in 2013, all of which was fully commissioned but not all grid-connected, for a total of 3,461 MW, from GWEC, op. cit. note 1, p. 24; added 892 MW for a total of 3,399 MW, from WWEA, op. cit. note 1.

42 Specifically, utilities such as CPFL Energia and Tractebel Energia are seeking to increase their focus on wind power, per Bloomberg New Energy Finance (BNEF), "Marubeni Is the Main Attraction in Stream of August Renewable Energy Deals," *Energy: Week in Review*, 6-12 August 2013; 4.7 GW of new capacity was contracted in 2013 alone, in three auctions, and a total of 10 GW was under contract by the end of the year, from Sawyer, op. cit. note 1.

43 Argentina added 76 MW for a total of 218 MW; Chile added 130 MW for a total of 335 MW; Mexico added 380 MW for a total of 1,917 MW, all from GWEC, op. cit. note 1, p. 17. Data from WWEA were similar, with Argentina adding 76.2 MW for a total of 217.1 MW, Chile adding 145 MW for a total of 335 MW, from WWEA, op. cit. note 1. The exception is Mexico, with 644 MW added for a total of 1,992 MW, from idem. Others in the region that also added capacity were Ecuador (16.5 MW), Nicaragua (39.6 MW), and Uruguay adding 3.6 MW for a total of 59.3 MW, from idem.

44 Australia added 655 MW for a total of 3,239 MW, from GWEC, op. cit. note 1, p. 17. It added 465 MW for a total of 3,049 MW, from WWEA, op. cit. note 1.

45 Reliance on Russian gas from Sarah Azau and Zoë Casey, "Europe's Emerging Markets Take Flight," *Wind Directions*, February 2013, p. 37; Turkey added 646 MW for a total of 2,959 MW, from GWEC, op. cit. note 1, p. 17, and from WWEA, op. cit. note 1. An additional 11 GW of capacity was planned or under construction in Turkey by year's end, from Sarah Azau, "The Powerhouse Bridging East and West," *Wind Directions*, September 2013, p. 30.

46 Morocco added a total of 200 MW in three wind projects, from Philippe Lempp, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, personal communication with REN21, 24 April 2014; 204 MW added from WWEA, op. cit. note 1; 120 MW and mitigating impacts in Ethiopia from Aaron Maasho, "Ethiopia Opens Africa's Largest Wind Farm to Boost Power Production," *Reuters*, 28 October 2013, http://planetark.org/wen/70186. The Ashegoda Wind Farm was scheduled for completion in 2011, but delayed due to logistical constraints, and it is the country's second commercial wind project, from idem. Ethiopia added 90 MW during 2013 for year-end total of 171 MW, from GWEC, op. cit. note 1, p. 17; and 120 MW were added for a total of 171 MW, from WWEA, op. cit. note 1.

47 For example, South Africa expects 700–1,000 MW to come on line in 2014; at the end of 2013, Jordan signed a PPA with Jordan Wind Power Company for a 117 MW wind farm, per Samer Zawaydeh, Association of Energy Engineers, Jordan Energy Chapter, personal communication with REN21, 12 April 2014. Long-term plans from GWEC, op. cit. note 1, p. 24.

48 Figures of 14 countries, 1,625.9 MW added for a total of 7,040.9 MW, from Shukla, op. cit. note 4, 26 March 2014. In 14 countries also from WWEA, op. cit. note 1. In 2013, 13 new projects were installed with 1,720 MW of capacity, from Navigant Research, op. cit. note 1; 1,902.1 MW was added offshore eight countries for a global total of 7,357.8 MW, with 6,935.9 MW of this capacity in Europe, from WWEA, op. cit. note 1. Offshore capacities by country were: the United Kingdom added 733 MW added for a total of 3,680.9 MW; Denmark added 349.5 MW for 1,270.6 MW; China added 39 MW for 428.6 MW; Belgium added 192 MW for 571.5 MW; Germany added 240 MW to the grid for 520.3 MW of grid-connected capacity; Netherlands added 0 MW for 246.8 MW; Sweden added 48 MW for 211.7 MW; Finland added 0 MW for 26.3 MW; Ireland added 0 MW for 25.2 MW; Japan added 24.4 MW for 49.7 MW; South Korea added 0 MW for 5.0 MW; Spain added 5 MW for 5 MW; Norway added 0 MW for 2.3 MW; Portugal added 0 MW for 2.0 MW; and United States added 0 MW for 0.02 MW (pilot), all from GWEC, op. cit. note 1, p. 55. Data from WWEA were similar with the following exceptions: United Kingdom added 705.1 MW for total of 3,653 MW; Germany added 595 MW for 914.9 MW (including capacity that was not grid-connected at year's end); Finland added 0 MW for 30 MW; China added 0 MW for 389.6 MW; Japan added 2 MW for 27.3 MW; South Korea added 5 MW for 5 MW, all from WWEA, op. cit. note 1.

49 Europe added 1,567 MW offshore capacity to the grid for a total

of 6,562 MW in 11 countries, from EWEA, *The European Offshore Wind Industry – Key Trends and Statistics 2013* (Brussels: January 2014), p. 5, and from GWEC, op. cit. note 1, p. 55. Of the 1,567 MW added, 72% were in the North Sea, 22% in the Baltic Sea, and 6% in the Atlantic Ocean, from EWEA, op. cit. this note. Europe added 1,772.9 MW offshore for a total of 6,949.2 MW, from EurObserv'ER, op. cit. note 1, p. 4. The difference in year-end data is explained by how sources count newly installed capacity that was not grid-connected at year's end.

50 EWEA, op. cit. note 49, p. 5, and from GWEC, op. cit. note 1, p. 55. Note that Denmark's largest offshore wind farm, the 400 MW Anholt wind farm was completed by Dong Energy, from "Denmark: All Turbines at Anholt Offshore Wind Farm Now Operational," *Wind Directions*, September 2013, p. 19. Germany had 394.6 MW of offshore capacity awaiting grid connection at year's end (not included in the 240 MW figure), from B. Neddermann, "German Offshore Market Growing Despite Problems with Grid Connection," *DEWI Magazin,* February 2014, p. 55, http://www.dewi.de/dewi/fileadmin/pdf/publications/Magazin_44/09.pdf.

51 Slowdown due to policy uncertainty from EWEA, op. cit. note 49, p. 19; and from Sarah Azau, "Record Offshore Wind Figures Conceal Slow-down in New Projects," Renewable Energy World, 29 January 2014, http://www.renewableenergyworld.com/rea/blog/post/2014/01/record-offshore-figures-conceal-slow-down-in-new-projects; Justin Wilkes, EWEA, cited in Tildy Bayar, "Europe Doubles Its Offshore Wind Capacity, but Policy Uncertainty Still a Challenge," Renewable Energy World, 16 July 2013, http://www.renewableenergyworld.com/rea/news/article/2013/07/europe-doubles-its-offshore-wind-capacity-but-policy-uncertainty-still-a-challenge. Several projects were cancelled due to concerns about challenging offshore conditions and/or projects were deemed to be uneconomic with existing technology, from Karolin Schaps, "Scottish Power Becomes Third Firm to Scrap UK Offshore Wind Farm," *Reuters*, 16 December 2013, http://planetark.org/wen/70684; Kelvin Ross, "RWE Scraps Atlantic Array Offshore Wind Farm in UK," Power Engineering International, 26 November 2013, http://www.renewableenergyworld.com/rea/news/article/2013/11/rwe-scraps-atlantic-array-offshore-wind-farm-in-uk; "RWE Cuts UK Offshore Wind Farm Capacity by Up to Half," *Reuters*, 6 January 2014, http://uk.reuters.com/article/2014/01/06/uk-britain-rwe-tritonknoll-idUKBREA050EC20140106; Alex Morales, "Birds, Bombs, Sharks Slow Offshore Wind from UK to Germany," *Bloomberg*, 20 February 2014, http://www.renewableenergyworld.com/rea/news/article/2014/02/birds-bombs-sharks-slow-offshore-wind-from-uk-to-germany.

52 China added 39 MW for a year-end total of 428.6 MW, of which 300.5 MW is inter-tidal, from CWEA, provided by Shi Pengfei, CWEA, personal communication with REN21, 24 March 2014. No capacity was added in 2013, and China ended the year with 389.6 MW of offshore wind, from WWEA, op. cit. note 1. Japan added 24 MW for a total of 49.7 MW, and South Korea added no capacity and ended the year with 5 MW, from GWEC, op. cit. note 1, pp. 55, 56. Japan added a 16 MW near-shore project and South Korea added no new capacity, from Navigant Research, op. cit. note 1; Japan added 2 MW for a total of 27.3 MW, and South Korea added 5 MW for a total of 5 MW, from WWEA, op. cit. note 1; and Japan added 8 MW for a total of 34 MW, from Hironao Matsubara, Institute for Sustainable Energy Policies (ISEP), Tokyo, personal communication with REN21, 16 April 2014. Note that several Chinese projects have been delayed over the use of sea areas, from Mao Pengfei, "Analysis: China Approves First Commercial Offshore Projects," Wind Power Offshore, 4 December 2013, http://www.windpoweroffshore.com/article/1223773/analysis-china-approves-first-commercial-offshore-projects; but almost 5 GW of Chinese projects were approved in 2013, from Sawyer, op. cit. note 2; and more than 1,000 MW of offshore capacity was under construction in China by early 2014, from GWEC, op. cit. note 1, p. 56.

53 Cape Wind (Massachusetts) and Deepwater Block Island (Rhode Island) both qualified, from James Montgomery, "Wind Energy 2014 Outlook: Major Markets Recover, Battling Policy and Grid Concerns," *Renewable Energy World*, January-February 2014, p. 35; competing to be first in operation, by 2015, from James Montgomery, "First US Offshore Leases Go to Deepwater," Renewable Energy World, 1 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/first-us-offshore-wind-leases-go-to-deepwater. In addition, there is a 20 kW machine in U.S. waters, from Shukla, op. cit. note 4, 26 March 2014.

54 See, for example, Honda, "Honda Begins Construction of the First Wind Farm by an Automaker in Brazil," press release (São Paulo: 29 October 2013), http://world.honda.com/news/2013/c131029First-Wind-Farm-Brazil/index.html; Louise Downing, "Ikea to Buy Wind Farm in Ireland from Mainstream Renewable," *Bloomberg*, 12 August 2013, http://www.bloomberg.com/news/2013-08-12/ikea-to-buy-wind-farm-in-ireland-from-mainstream-renewable.html; Jeff Anthony, "Utilities' Appetite for Wind Energy Continues to Grow," Renew-grid.com, 10 June 2013, http://www.renew-grid.com/e107_plugins/content/content.php?content.9985.

55 For Australia, see, for example, "Australia's First Community-Owned Wind Farm in Daylesford," Castlemaine Independent, 18 October 2013, http://www.castlemaineindependent.org/2013/10/australias-community-owned-wind-farm-daylesford/; and The Greens, "Unleashing Community-Owned Energy," http://greens.org.au/community-energy, viewed 3 March 2014; in Canada, for example, the country's first union-owned and -operated wind turbine came on line, in Ontario (Port Elgin), per Ken Lewenza, President of Canadian Auto Workers (CAW), cited in "CAW Owned and Operated Wind Turbine Begins Operation in Port Elgin, Ontario," 25 March 2013, http://www.caw.ca/en/12003.htm; Japan from Tetsu Iida, ISEP, Tokyo, personal communication with REN21, 14 January 2014; United States from A.C. Orrell et al., *2012 Market Report on Wind Technologies in Distributed Applications* (Richland, WA: Pacific Northwest Laboratory, August 2013), p. 59; and from Windustry, "Community Wind," http://www.windustry.org/community-wind, viewed 3 March 2014. A community project came on line in South Dakota with 600 investors, but it is increasingly difficult to make investment open for "normal investors" in the United States now that the federal cash grant programme has expired, per Brian Minish in interview with John Farrell, "600 Investors in South Dakota's Premier Community Wind Project," (podcast) Renewable Energy World, 13 August 2013, http://www.renewableenergyworld.com/rea/blog/post/2013/08/600-investors-in-south-dakotas-premier-community-wind-project; Europe from, for example, Energy4All Limited, "Delivering Community-Owned Green Power," http://www.energy4all.co.uk/, viewed 3 March 2014, from Richard Cowell, "Community Wind in Europe – Strength in Diversity?" *WWEA Quarterly Bulletin*, December 2012, pp. 10–15, and from Tildy Bayar, "Community Wind Arrives Stateside," Renewable Energy World, 5 July 2012, http://www.renewableenergyworld.com/rea/news/article/2012/07/community-wind-arrives-stateside. See also "Community Wind Energy," http://en.wikipedia.org/wiki/Community_wind_energy, viewed 3 March 2014.

56 Stefan Gsänger, WWEA, Bonn, personal communication with REN21, 1 April 2013.

57 For example, over a 13-hour period, 1,700 Dutch households bought shares in a wind turbine, to be located in Culemborg, raising USD 1.8 million (EUR 1.3 million) through crowd funding, from Tildy Bayar, "Dutch Wind Turbine Purchase Sets World Crowdfunding Record," Renewable Energy World, 24 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/dutch-wind-turbine-purchase-sets-world-crowdfunding-record.

58 Pike Research, "Small Wind Power," www.pikeresearch.com/research/small-wind-power, viewed March 2013; WWEA, *Small World Wind Power Report 2013* (Bonn: March 2013), Summary, http://www.wwindea.org/webimages/SWWR_summary.pdf; RenewableUK, *Small and Medium Wind UK Market Report* (London: October 2013), http://www.renewableuk.com/en/publications/index.cfm/Small-and-Medium-Wind-UK-Market-Report-2013.

59 Off-grid from WWEA, op. cit. note 58.

60 Stefan Gsänger and Jean Pitteloud, *Small Wind World Report 2014 Update* (Bonn: WWEA, March 2014), Summary, http://small-wind.org/wp-content/uploads/2014/03/2014_SWWR_summary_web.pdf. Note that these numbers are based on available data, and the total excludes data for Italy and India, both of which are important markets. WWEA estimates that the actual total is closer to 1 million units worldwide.

61 All information except U.S. capacity data is from Gsänger and Pitteloud, op. cit. note 60; the United States added about 18.4 MW in 2012 (nearly 3,700 turbines) for an estimated 216 MW cumulative installed since 1980, with 131 MW added during 2003–2012, mostly by homeowners, farmers, and other individuals, per Orrell et al., op. cit. note 55, pp. 11, 18, 62.

62 RenewableUK, op. cit. note 58. Note that a tariff degression in late

2012 led to a rush of installations at year's end. The U.K. installed 37 MW during 2012 and ended the year with 87.3 MW, per Gsänger and Pitteloud, op. cit. note 60. Several other countries also have small-scale wind specific tariff pricing under FITs, including Cyprus, Greece, Italy, Israel, Japan, Lithuania, Portugal, Slovenia, and Switzerland, as well as Ontario and Nova Scotia in Canada, and the U.S. states of Indiana, Hawaii and Vermont, per idem.

63 Gsänger and Pitteloud, op. cit. note 60.

64 International Energy Agency (IEA), *Technology Roadmap – Wind Energy, 2013 Edition* (Paris: OECD/IEA, 2013), p. 10; James Lawson, "Repowering Gives New Life to Old Wind Sites," Renewable Energy World, 17 June 2013, http://www.renewableenergyworld.com/rea/news/article/2013/06/repowering-gives-new-life-to-old-wind-sites; B. Neddermann, "Status of Repowering in 2013," *DEWI Magazin*, February 2014, p. 47, http://www.dewi.de/dewi/fileadmin/pdf/publications/Magazin_44/08.pdf. **Sidebar 5** from the following sources: lifecycle carbon dioxide emissions from Union of Concerned Scientists, "Environmental Impacts of Wind Power," 3 May 2013, www.ucsusa.org; offshore marine impacts from U.K. Maritime and Coastguard Agency, "Offshore Renewable Energy Installations: Impact on Shipping," http://www.gov.uk, and from M.L. Johnson and D.P. Rodmell, "Fisheries, the Environment and Offshore Wind Farms: Location, Location, Location," *Food Ethics*, vol. 4, no. 1 (2009), pp. 23–24; public health effects from Australian National Health and Medical Research Council (NHMRC), "NHMRC Public Statement: Wind Turbines & Health," July 2010, http://www.nhmrc.gov.au; claims unsupported from Emma Fitzpatrick, "Acoustics Group Says Wind Turbine Infrasound Less than a Heart-beat," 16 September 2013, http://reneweconomy.com.au, and from NHMRC, op. cit. this note; innovation in turbine blades and reduced noise generation from Z. Casey, "Wind Farms: A Noisy Neighbour?" *Wind Directions* (EWIA), February 2013, and from T. Evans, "Macarthur Wind Farm, Infrasound & Low Frequency Noise, Operational Monitoring Results," 18 July 2013, http://www.agl.com.au; offshore noise reduction from German Federal Agency for Nature Conservation (BFN), *Development of Noise Mitigation Measures in Offshore Wind Farm Construction 2013* (Bonn: February 2013), and from German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), *Innovation Through Research: 2012 Annual Report on Research Funding in the Renewable Energies Sector* (Bonn: July 2013); radar or GPS systems from M. Chediak, "Texas Gulf Coast Beckons Wind Farms," *Bloomberg*, 11 October 2013, http://www.bloomberg.com/news/2013-10-10/gulf-coast-beckons-wind-farms-when-west-texas-gusts-fade.html, and from R. Drouin, "8 Ways Wind Power Companies Are Trying to Stop Killing Birds and Bats," 6 January 2014, http://www.motherjones.com/environment/2014/01/birds-bats-wind-turbines-deadly-collisions; ultrasonic noise from idem; idling and bat fatalities from American Wind Wildlife Institute, "Wind Turbine Interactions with Wildlife and their Habitats: A Summary of Research Results and Priority Questions," fact sheet (Washington, DC: January 2014); other areas under investigation from Drouin, op. cit. this note; land use impacts from P. Denholm et al., *Land-use Requirements of Modern Wind Power Plants in the United States* (Golden, CO: National Renewable Energy Laboratory, 2009); rare earths from REN21, *Renewables 2011 Global Status Report* (Paris: 2011); best practice guidelines from, for example, Canadian Wind Energy Association, *Wind Energy Development Best Practices for Community Engagement and Public Consultation* (Ottawa: undated), and from WindProtocol, *The Protocol for Public Engagement with Proposed Wind Energy Developments in England* (London: Department of Trade and Industry, May 2007); impact assessments, mitigation, or compensation measures from the following: Martha Ekkert, BMU, personal communication with REN21, 27 January 2014; Victoria Department of Transport, Planning and Local Infrastructure, "Wind Energy Facilities," 18 October 2013, http://www.dpcd.vic.gov.au; Irish Wind Energy Association, "Planning Regulations and Administration," 2 September 2008, http://www.iwea.com; A. Campbell, Standard Bank, "Funding Projects in REIPP – lessons learned from BD1," presentation at PV Project Development Summit South Africa, September 2012; U.K. Department of Energy & Climate Change, "Offshore Wind: Part of the UK's Energy Mix," 1 August 2013, https://www.gov.uk/offshore-wind-part-of-the-uks-energy-mix.

65 Other countries include India, Italy, Portugal, Spain, the United Kingdom, and the United States, from IEA, op. cit. note 64, p. 10; and from Lawson, op. cit. note 64.

66 Denmark replaced 39 units (47 MW), Finland (2 units/2.3 MW), Japan (4 units/2.1 MW), from Navigant Research, op. cit. note 1; Germany replaced 339 turbines (226 MW) with 256 turbines (726 MW), plus removed 34 turbines (10 MW) from single sites, which also qualified for the "repowering bonus", from Neddermann, op. cit. note 64, p. 47.

67 Key markets include Bulgaria, Poland, Romania, Turkey, Vietnam, and several countries in South America, from Lawson, op. cit. note 64.

68 Based on estimated 257 TWh of electricity production in a normal wind year, calculated using average capacity factors on- and offshore, and using Eurostat electricity consumption data for 2011, from EWEA, op. cit. note 16, p. 3. Note that wind power accounted for about 7.2% of Europe's electricity output (of 3,270 TWh) in 2013, up from 6.2% in 2012 and 1.8% in 2004, per EurObserv'ER, op. cit. note 1, p. 4. Wind's contribution to EU electricity demand is up from 6.3% at the end of 2011, and 4.8% at the end of 2009, from GWEC, op. cit. note 1, p. 22. Note that Portugal met more than 20% of its electricity demand with wind, and Ireland more than 16%, from WWEA, op. cit. note 1; Ireland's share was up from 12.7% in 2012, from EWEA, *Wind in Power: 2012 European Statistics* (Brussels: February 2013).

69 In Spain, wind generated 20.9% versus nuclear's 20.8%, according to an advance report from the system operator Red Eléctrica de España (REE), per Asociación Empresarial Eólica (AEE), "Spain Was in 2013 the First Country Where Wind Energy Was the First Source of Electricity for an Entire Year," press release (Madrid: 15 January 2014), http://www.aeeolica.org/en/new/spain-was-in-2013-the-first-country-where-wind-energy-was-the-first-source-of-electricity-for-an-entire-year/; this was up from 16.3% in 2012, per EWEA, op. cit. note 68. Denmark met 33.2% of electricity demand with wind power, based on 11.1 billion kWh of wind power generation in 2013 and 33.5 billion kWh of total electricity consumption, from Vittrup, op. cit. note 25; this was up from 30% in 2012, per GWEC, *Global Wind Report – Annual Market Update 2012* (Brussels: April 2013), p. 34.

70 Mecklenburg-Vorpommern had enough wind to meet 65.5% of its electricity demand, followed by Schleswig-Hostein (53%), Sachsen-Anhalt (51.2%), and Brandenburg (50.9%); the next state was Niedersachsen (26.2%), all from Ender, op. cit. note 21, p. 42. Note that wind power supplied about 8% of Germany's net electricity consumption in 2013, from GWEC, op. cit. note 1, p. 52.

71 Figure of 3.5% of U.S. generation in 2012 from U.S. Energy Information Administration (EIA), "Wind Industry Brings Almost 5,400 MW of Capacity Online in December 2012," www.eia.gov/electricity/monthly/update/?scr=email, viewed 25 April 2013; 2013 shares from AWEA, "American Wind Power Reaches Major Power Generation Milestones in 2013," press release (Washington, DC: 5 March 2014), http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=6184. States generating over 12% of their electricity from wind were Colorado (13.8%), Idaho (16.2%), Iowa (27.4%), Kansas (19.4%), Minnesota (15.7%), North Dakota (15.6%), Oklahoma (14.8%), Oregon (12.4%), and South Dakota (26%), from AWEA, "Wind Energy Generation Records," http://www.awea.org/generationrecords, viewed 6 March 2014. Wind generated 167,776 MWh of U.S. electricity during 2013, per AWEA, op. cit. note 36.

72 CEC, provided by Shi, op. cit. note 14.

73 The figure 2.9% is an estimate derived for Figure 3 in this report, and is based on end-2013 capacity. See Endnote 39 in Global Market and Industry Overview section for sources and details. In addition, note that the figure of "at least 2.87%", or 662 TWh is considered a conservative estimate for 2014 based on existing wind capacity at end-2013, from Navigant Research, op. cit. note 1, and is up from at least 2.6% in 2012, from Navigant's BTM Consult, *World Market Update 2012* (Copenhagen: March 2013); wind power generated about 527 TWh in the end of 2012, up from 254 TWh in end of 2008, per IEA, op. cit. note 64, pp. 9–10. Wind power was enough to meet an estimated 4% of world demand, or 640 TWh, from WWEA, op. cit. note 1. Estimated wind shares depend on assumptions about global electricity demand.

74 Sawyer, op. cit. note 1.

75 Sawyer, op. cit. note 34; Australia, Brazil, Chile, Mexico, New Zealand, Turkey, and South Africa also from IEA, op. cit. note 64, p. 14. Also, in Australia, unsubsidised renewable energy is now cheaper than electricity from new-build coal- and gas-fired power stations (including cost of emissions under new carbon pricing scheme), per BNEF, "Renewable energy now cheaper than new fossil fuels in Australia," 7 February 2013, http://about.

bnef.com/2013/02/07/renewable-energy-now-cheaper-than-new-fossil-fuels-in-australia/; the best wind projects in India can generate power and the same costs as coal-fired power plants and cheaper in some locations, per Ravi Kailas, CEO of India's third-largest wind farm developer, cited in Natalie Obiko Pearson, "Wind Installations 'Falling Off a Cliff' in India," Bloomberg, 26 November 2012, http://www.renewableenergyworld.com/rea/news/article/2012/11/wind-installations-falling-off-a-cliff-in-india; cheaper in some locations from Greenko Group Plc, cited in Natalie Obiko Pearson, "In Parts of India, Wind Energy Proving Cheaper Than Coal," *Bloomberg*, 18 July 2012, http://www.renewableenergyworld.com/rea/news/article/2012/07/in-parts-of-india-wind-energy-proving-cheaper-than-coal; a 2012 study concluded that, although wind power has higher upfront costs in EUR/MWh than natural gas, the net cost of wind is lower than that of combined-cycle gas turbines, per Ernst & Young, "Analysis of the value creation potential of wind energy policies," July 2012, http://www.ey.com; in Brazil, wind was excluded from the A-5 auction because it was too cheap; in the wind-only auction, the average contract price was USD 45/MWh, from Steve Sawyer, GWEC, personal communication with REN21, 28 August 2013; bid prices in South Africa's national tender in late 2013 were around USD 70/MWh, or about 30% below that of new coal plants under construction there with World Bank support, from Steve Sawyer, GWEC, personal communication with REN21, 13 November 2013 and 15 January 2014; many countries in the European Union from Stefan Gsänger, WWEA, personal communication with REN21, 16 April 2014; United States from Michael Taylor, International Renewable Energy Agency (IRENA), personal communication with REN21, April 2013; several U.S. utilities signed contracts for more wind capacity than previously planned because of low prices (as low as USD 25/MWh in some locations), from Christopher Martin, "US Wind Power Slumps in 2013 After Tax Credit Drives 2012 Boom," *Bloomberg*, 1 November 2013, http://www.renewableenergyworld.com/rea/news/article/2013/11/u-s-wind-power-slumps-in-2013-after-tax-credit-drives-2012-boom; James Montgomery, "Updated: Massachusetts Utilities Sign PPA for Wind Energy that is Cheaper than Coal," *Renewable Energy World*, 24 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/massachusetts-utilities-pool-for-cheaper-wind-energy-supply; utilities included American Electric Power's Public Service Company of Oklahoma, Xcel Energy, Detroit Edison, Austin Energy, Omaha Public Power District, from AWEA, "Wind Power's Growth Continues to Attract Investment, Benefit Consumers and Local Economies," press release (Washington, DC: 31 October 2013), http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=5775. See also Ryan Wiser et al., *2012 Wind Technologies Market Report* (Washington, DC: U.S. Department of Energy, August 2013), Executive Summary, http://www.windpoweringamerica.gov/pdfs/2012_annual_wind_market_report.pdf. Investment costs for offshore wind remain two to three times higher than those for onshore wind, from IEA, op. cit. note 64, p. 15.

76 Over the five-year period from Q2 2009 to Q1 2014, from Frankfurt School–UNEP Collaborating Centre for Climate & Sustainable Energy Finance (FS-UNEP Centre) and BNEF, *Global Trends in Renewable Energy Investment 2014* (Frankfurt: 2014), pp. 36–37. Offshore costs have risen 41%/MWh over this period as projects have moved to deeper water farther from shore, and pressure has increased on supply of installation vessels, cables, and other items. Note that, in the United States, onshore generating costs declined 43% between 2009 and 2012, per AWEA, *AWEA U.S. Wind Industry Fourth Quarter 2013 Market Report*, op. cit. note 38, p. 4.

77 Li Yan, "China Wind Power 2013: Market Growth Stable, Faces Grid Shortage," ecns.cn, 18 October 2013, http://www.ecns.cn/2013/10-18/84917.shtml; EurObserv'ER, *Wind Power Barometer* (Paris: February 2013), p. 61, http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro-jde12.pdf; James Lawson, "Keeping Wind Competitive: Manufacturing Ups its Game," *Renewable Energy World*, March-April 2013, p. 19; Christopher Martin, "Shale Gas Boom Leaves Wind Companies Seeking More Subsidy," Bloomberg.com, 7 April 2014, http://www.bloomberg.com/news/2014-04-06/shale-gas-boom-leaves-wind-companies-seeking-more-subsidy.html.

78 Bard from EurObserv'ER, op. cit. note 1, pp. 9, 11; Fuhrländer from Gsänger, op. cit. note 75; Vestas from BNEF, "Vestas Sees Winds of Change, as UK Aims for Greener Biomass and California CO2 Sells Out," *Energy: Week in Review*, 20–26 August 2013.

79 Navigant Research, op. cit. note 1.

80 Factory closures and layoffs from Wiser et al., op. cit. note 75; from Sawyer, op. cit. note 2; and from Jennifer Runyon, "Nordex Announces Closure of US Wind Power Manufacturing Plant," Renewable Energy World, 28 June 2013, http://www.renewableenergyworld.com/rea/news/article/2013/06/nordex-announces-closure-of-us-wind-power-manufacturing-plant; ramped up from AWEA, "American Wind Power See Unprecedented Growth Entering 2014," press release (Washington, DC: 30 January 2014), http://www.awea.org/MediaCenter/pressrelease.aspx?ItemNumber=6044; manufacturing from Elizabeth Salerno, AWEA, "Fact Check: IER Finds it Hard to Kick Habit of Attacking Wind Power," Renewable Energy World, 9 December 2013, http://www.renewableenergyworld.com/rea/news/article/2013/12/fact-check-ier-finds-it-hard-to-kick-habit-of-attacking-wind-power.

81 Natalie Obiko Pearson, "India's Currency Plunge Derailing its $1.6 Billion Wind Industry," *Bloomberg*, 3 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/rupee-derailing-1-6-billion-india-wind-farm-revival; BNEF, "Europe Skirmishes With America on Airline Emissions, and With China on Solar," *Energy: Week in Review*, 18–24 September 2012; Natalie Obiko Pearson and Anurag Joshi, "Wind Turbine Manufacturer Suzlon to Default on Bond Debt," *Bloomberg*, 11 October 2012, http://www.renewableenergyworld.com/rea/news/article/2012/10/wind-turbine-manufacturer-suzlon-set-to-default-on-bond-debt.

82 In Latin America, for example, wind power projects are being delayed due to lack of grid infrastructure, from Gonzalo Bravo, Fundación Bariloche, personal communication with REN21, 14 January 2014; grid connection remains a major challenge for offshore wind, particularly off Germany's coast, where 43% of the turbines installed in 2013 (or nearly 395 MW) lacked grid connection by year's end, from B. Neddermann, "German Offshore Market Growing Despite Problems with Grid Connection," *DEWI Magazin*, February 2014, p. 55, http://www.dewi.de/dewi/fileadmin/pdf/publications/Magazin_44/09.pdf, and from Ender, op. cit. note 21, p. 42; an issue formerly seen in the developing world/emerging markets of Latin America and China, is now seen in the established market of Germany, where electricity is re-routed through Poland and the Czech Republic, from Aris Karcanias, FTI Consulting, personal communication with REN21, 14 April 2014; curtailment and inability to integrate in several countries, including China and India, from Shukla, op. cit. note 19, and from Klaus Rave, GWEC Chairman, "Get Connected!" Editorial, in GWEC Newsletter, 12 November 2013, http://www.gwec.net/get-connected/.

83 Oscar Fitch-Roy et al., *Workers Wanted: The EU Wind Energy Sector Skills Gap* (Brussels: European Wind Energy Technology Platform, August 2013), http://www.ewea.org/fileadmin/files/library/publications/reports/Workers_Wanted_TPwind.pdf; Electricity Human Resources Canada, *Renewing Futures: Powerful HR Solutions for the Renewable Energy Workforce*, cited in Michael Copley, "Canada Faces Labor Shortfall for Renewable Energy Expansion, Report Finds," SNL Financial, 5 March 2014, http://www.snl.com/Interactivex/article.aspx?CdId=A-27145217-13868; Shukla, op. cit. note 19; Navigant Research, op. cit. note 1. **Sidebar 6** and **Table 1** based on the following sources: from IRENA, *Renewable Energy and Jobs – Annual Review 2014* (Abu Dhabi: 2014), http://www.irena.org/Publications/rejobs-annual-review-2014.pdf; IRENA, *Renewable Energy and Jobs* (Abu Dhabi: 2013), http://www.irena.org/rejobs.pdf; Brazil from MTE/RAIS (Ministry of Labor and Employment/ Annual Report of Social Information), "Annual List of Social Information Database: including active and inactive employments for sugarcane cultivation and alcohol manufacture," http://portal.mte.gov.br/rais/estatisticas.htm, viewed March 2014; U.K. from renewableUK, *Working for a Green Britain and Northern Ireland 2013-23. Employment in the UK Wind & Marine Energy Industries* (Solihull, U.K.: September, 2013), http://www.renewableuk.com/download.cfm/docid/82BF89A1-9EA2-4D77-8E9B1B986BE8B727; India from K. Ganesan et al., "IISD GSI Project: Assessing Green Industrial Policy – India Case Studies" (New Delhi: CEEW, forthcoming 2014).

84 IEA, op. cit. note 64, p. 10; Japan from Navigant Research, op. cit. note 1. China was home to 8 of the top 15 manufacturers, from idem.

85 IEA, op. cit. note 64, p. 11. See also GWEC, op. cit. note 1, p. 40. Turbine manufacturers are located in many other countries as well. For example, in 2013 Argentinean firm IMPSA sold 574MW to the Brazilian market, from Gonzalo Bravo, Fundación Bariloche,

personal communication with REN21, 16 April 2014.

86 Figure of 70% from Navigant Research, op. cit. note 1; 77% in 2012 from Navigant's BTM Consult, op. cit. note 73.

87 Navigant Research, op. cit. note 1. Other sources also put Vestas in the lead, but rank other companies differently. Make Consulting estimated the top 10 captured 68.4% of the market and puts Suzlon ahead of GE Wind and Gamesa, from Make Consulting, cited in North American Windpower, "Top 15 Wind Turbine Suppliers of 2013 Revealed," 11 March 2014, http://www.nawindpower.com/e107_plugins/content/content.php?content.12710. GlobalData ranks Enercon ahead of Goldwind, followed by Siemens and Suzlon to round out the top five, from "Vestas Wind Systems Blows into World-Leading Position for 2013 Wind Turbine Installations, says GlobalData," GlobalData.com, 12 March 2014, http://energy.globaldata.com/media-center/press-releases/power-and-resources/vestas-wind-systems-blows-into-worldleading-position-for-2013-wind-turbine-installations-says-globaldata. **Figure 21** based on data from Navigant Research, op. cit. note 1.

88 James Lawson, "Keeping Wind Competitive: Manufacturing Ups Its Game," *Renewable Energy World*, March–April 2013, p. 19.

89 Aris Karcanias, BTM Consult, cited in James Lawson, "Keeping Wind Competitive: Manufacturing Ups its Game," *Renewable Energy World*, March–April 2013, p. 19.

90 Jennifer Runyon, "Servicing the Wind Energy Sector is Big Business for Siemens," Renewable Energy World, 19 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/servicing-the-wind-energy-sector-is-big-business-for-siemens; Navigant Research, op. cit. note 1. See also, for example, GE, "Wind Services," http://www.ge-energy.com/products_and_services/services/wind_services/, viewed 3 March 2014; Gamesa, "Operation and Maintenance Services," http://www.gamesacorp.com/en/gamesaen/lines-of-business/operation-and-maintenance-services/, viewed 3 March 2014; Vestas, "Active Output Management," http://www.vestas.com/en/products_and_services/operation_and_maintenance#!, viewed 3 March 2014; increase value from Shukla, op. cit. note 19.

91 Mitsubishi, "MHI and Vestas Agree to Form Joint-Venture Company Dedicated to Offshore Wind Turbine Business," press release (Tokyo: 27 September 2013), http://www.mhi.co.jp/en/news/story/1309271718.html; Areva, "Offshore Wind: Areva Accelerates its Development by Creating a European Champion with Gamesa to Become a Leading Global Player," press release (Paris: 20 January 2014), http://www.areva.com/EN/news-10115/offshore-wind-areva-accelerates-its-development-by-creating-a-european-champion-with-gamesa-to-become-a-leading-global-player.html; Toray acquired Zolteck, a producer of carbon fibre for wind turbine blades, per GWEC, op. cit. note 1, p. 61.

92 Shukla, op. cit. note 19.

93 Lawson, op. cit. note 89.

94 David Appleyard, "New Turbine Technology: Key Players On- and Offshore," Renewable Energy World, 1 May 2013, http://www.renewableenergyworld.com/rea/news/article/2013/05/new-turbine-technology-the-future-is-larger-offshore; Siemens in the United States from Feng Zhao, Navigant Research-BTM, personal communication with REN21, 2 April 2014.

95 Appleyard, op. cit. note 94; James Montgomery, "Wind Energy 2014 Outlook: Major Markets Recover, Battling Policy and Grid Concerns," *Renewable Energy World*, January–February 2014, p. 29; IEA, op. cit. note 64; Jeff Anthony, "Utilities' Appetite for Wind Energy Continues to Grow," Renew-grid.com, 10 June 2013, http://www.renew-grid.com/e107_plugins/content/content.php?content.9985; Navigant Research, op. cit. note 1.

96 IEA, op. cit. note 64, p. 5; Wiser et al., op. cit. note 75; Valerie A. Hines, Alistair B. Ogilvie, and Cody R. Bond, *Continuous Reliability Enhancement for Wind (CREW) Database: Wind Plant Reliability Benchmark* (Albuquerque, NM and Livermore, CA: Sandia National Laboratories, September 2013), p. 12, http://energy.sandia.gov/wp/wp-content/gallery/uploads/CREW2013Benchmark-Report-SAND2013-72881.pdf.

97 James Montgomery, "GE Wants to 'Power Up' Older Wind Turbines," Renewable Energy World, 11 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/ge-wants-to-power-up-older-wind-turbines; Appleyard, op. cit. note 94. GE launched its services packages called PowerUp Software, similar to an earlier package named WindBoost, to improve the power output of each unit and the overall wind farm while introducing a 2.5 MW "brilliant" model to incorporate short-term battery storage as part of the complete turbine package, from Navigant Research, op. cit. note 1.

98 The share of direct turbines rose from 12% in 2008 to 20% in 2012/13, per IEA, op. cit. note 64, p. 12; their share was 28.1% of the global market in 2013, per Navigant Research, op. cit. note 1. For example, two-bladed turbines are new to the offshore market, with Aerodyn (Germany) introducing an innovative two-bladed down-wind machine and Envision (China) testing its two-bladed (3.6 MW) prototype in Denmark in 2013. Aerodyn from Eize de Vries, "Offshore Wind Turbine Vendors Unveil Next-Generation Wind Power Machines," Renewable Energy World, 10 December 2013, http://www.renewableenergyworld.com/rea/news/article/2013/12/offshore-wind-turbines-are-getting-bigger-all-the-time; Envision from Navigant Research, op. cit. note 1.

99 Average size delivered to market (based on measured rated capacity) was 1,926 kW in 2012, up an average 79 kW over 2011, from Navigant Research, op. cit. note 1.

100 Average sizes were 2.7 MW in Germany; 1,841 kW in the United States, 1,719 kW in China, and 1,336 kW in India, from Navigant Research, op. cit. note 1; 2.6 MW in Germany from Ender, op. cit. note 21, p. 43, http://www.dewi.de/dewi/fileadmin/pdf/publications/Magazin_44/07.pdf; and from GWEC, op. cit. note 1, p. 52. 1,720 kW in China also from "Statistics of Wind Power Development in China 2013," op. cit. note 10, p. 24.

101 Gsänger, op. cit. note 75.

102 The average size was about 4 MW, due to the dominance of Siemens' 3.6 MW machine, although larger turbines have been commercialised, from EWEA, op. cit. note 49, p. 9. Note that the average size installed offshore fell from 3,793 kW in 2012 to 3,613 kW in 2013, per Navigant Research, op. cit. note 1. Samsung installed its 7 MW machine, the largest operating offshore by late 2013, near Fife, Scotland, from Jim Bell, "Securing the World's Largest Turbine," Renewable Energy World, 1 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/securing-the-worlds-largest-wind-turbine. The average size of turbines installed in Germany's offshore wind farms during 2013 was 4.2 MW (4,158 kW), per Ender, op. cit. note 21, p. 43; and it was 5 MW, from GWEC, op. cit. note 1, p. 56.

103 European manufacturers testing new turbines include Areva (France), Vestas (Denmark), and Siemens (Germany), from David Appleyard, "A Window on the Future of Offshore Wind Turbines," Renewable Energy World, 21 June 2013, http://www.renewableenergyworld.com/rea/news/article/2013/06/a-window-on-the-future-of-offshore-wind-turbines; Eize de Vries, "Offshore Wind Turbine Vendors Unveil Next-Generation Wind Power Machines," Renewable Energy World, 10 December 2013, http://www.renewableenergyworld.com/rea/news/article/2013/12/offshore-wind-turbines-are-getting-bigger-all-the-time; Vestas began testing the world's most powerful wind turbine (V164-8.0 MW) at the Østerild Test Centre in Denmark, from GWEC, op. cit. note 1, p. 46; China's Sinovel received a grant of USD 6.6 million (RMB 42 million) from China's National Development and Reform Commission to develop a 10 MW turbine, and Goldwind and Guodian United Power are also competing to develop a 10 MW machine, from Appleyard, op. cit. note 94; China also from James Quilter, "Ming Yang Working on 12 MW Offshore Turbine," *Wind Power Monthly,* 11 July 2013, http://www.windpowermonthly.com/article/1190352/ming-yang-working-12mw-offshore-turbine.

104 EWEA, op. cit. note 49, p. 9.

105 Foundation types include Spar Buoy, Tension Leg Platform, and Semi-submersible, from David Appleyard, "Floating Offshore Wind Power Taking Hold," Renewable Energy World, 7 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/floating-offshore-wind-power-taking-hold.

106 Japan launched a 2 MW turbine in October, and another off the coast of Fukushima in November 2013, goal from Nobuteru Ishihara, Japan's Minister of Environment, cited in "Another Floating Offshore Wind Project Online in Japan This Week," GWEC Newsletter, 12 November 2013, http://www.gwec.net/japans-floating-wind-turbines/; Hiroko Tabuchi, "To Expand Offshore Power, Japan Builds Floating Windmills," *New York Times*, 24 October 2013, http://www.nytimes.com/2013/10/25/business/international/to-expand-offshore-power-japan-builds-floating-windmills.html?_r=0; leasing in the United Kingdom from Appleyard, op. cit. note 105. Other countries experimenting with floating turbines include Norway and Portugal, from idem. In addition, the first offshore wind turbine deployed off the U.S. coast, was a 20 kW floating turbine anchored off the coast of Maine in mid-2013, from James

Montgomery, "First US Offshore Wind Turbine Launches in Maine," Renewable Energy World, 31 May 2013, http://www.renewableenergyworld.com/rea/news/article/2013/05/first-us-offshore-wind-turbine-launches-in-maine.

107 Tabuchi, op. cit. note 106; Kari Lundgren, "Britain's Forgotten Ports Put Wind in Goldman's Sails: Freight," *Bloomberg*, 2 May 2013, http://www.bloomberg.com/news/2013-05-01/britain-s-forgotten-ports-put-wind-in-goldman-s-sails-freight.html.

108 UK's Seajacks International joined with Samsung Heavy Industries (Korea) to the build world's largest jack-up barge, from "Largest Offshore Wind Barge Under Construction," Renewables International, 12 June 2013, http://www.renewablesinternational.net/largest-offshore-wind-barge-under-construction/150/505/63296/; Tildy Bayar, "A Bigger Boat: Offshore Wind Service Vessels Grow Up," Renewable Energy World, 5 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/a-bigger-boat-offshore-wind-service-vessels-grow-up; David Appleyard, "New Offshore Jack-up Vessel Commissioned by Hochtief," Renewable Energy World, 13 December 2013, http://www.renewableenergyworld.com/rea/news/article/2013/12/new-offshore-jack-up-vessel-commissioned-by-hochtief; Philippa Jones, "Booming Boats," *Wind Directions*, September 2013, p. 48; Chinese from Navigant Research, op. cit. note 1.

109 Tildy Bayar, "Subsea Cables Bring Offshore Wind Power to the People," Renewable Energy World, 19 December 2013, http://www.renewableenergyworld.com/rea/news/article/2013/12/subsea-cables-bring-offshore-wind-power-to-the-people.

110 Offshore wind power costs rose 41%/MWh from the second quarter of 2009 till the first quarter of 2014, as projects moved to deeper water farther from shore, from FS-UNEP Centre and BNEF, op. cit. note 76, p. 37.

111 Based on USD 4.7 million/MW (EUR 3.4 million/MW) of installed capacity and operational costs of USD 259 million/kW (EUR 187/kW), from Aris Karcanias and Athanasia Arapogianni, *Innovative Financing of Offshore Wind* (London: FTI Consulting, April 2014).

112 Pike Research, "Small Wind Power," http://www.pikeresearch.com/research/small-wind-power, viewed March 2013. By the end of 2011, more than 330 manufacturers around the world offered commercial systems, and more than 300 companies supplied parts and services, per Gsänger and Pitteloud, op. cit. note 60.

113 Gsänger and Pitteloud, op. cit. note 60. In 2013, for example, the United Kingdom had more than 10 manufacturers of wind turbines ranging in size from several hundred watts to 60 kW, from RenewableUK, op. cit. note 58.

114 As of 2011, 74% of commercialised one-piece small-scale wind manufacturers produced horizontal axis machines, 18% focused on vertical, and 6% on both, from Gsänger and Pitteloud, op. cit. note 60.

115 **Table 2** derived from the sources outlined in this endnote. Note that all IRENA data are exclusive of subsidies, based on an assumed 7% weighted average cost of capital, derived from actual project data, with O&M costs sourced from International Renewable Energy Agency (IRENA), *Renewable Power Generation Costs in 2012: An Overview* (Abu Dhabi: 2013), http://costing.irena.org/media/2769/Overview_Renewable-Power-Generation-Costs-in-2012.pdf.

POWER SECTOR

Biomass power: Bioenergy levelised costs of energy for power generation vary widely with costs of biomass feedstock (typically USD 0.50–9/GJ), complexity of technologies, plant capacity factor, size of plant, co-production of useful heat (CHP), regional differences for labour costs, life of plant (typically 30 years), discount rate (typically 7%), etc. In some non-OECD countries, lack of air emission regulations for boilers means capital costs are lower due to lack of control equipment. So before developing a new bioenergy plant, individual cost analysis is essential. Bio-power plants that rely on seasonal crops, such as sugar cane in Latin America, may have average capacity factors below 50%. Sources: IRENA Renewable Cost Database 2014; IRENA, *Renewable Power Generation Costs in 2012...*, op. cit. this note; Frankfurt School–UNEP Collaborating Centre for Climate & Sustainable Energy Finance (FS–UNEP Centre) and Bloomberg New Energy Finance (BNEF), *Global Trends in Renewable Energy Investment 2012* (Frankfurt: 2012), http://fs-unep-centre.org/publications/gtr-2014; O. Edenhofer et al., eds., *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* (Cambridge, U.K. and New York: Cambridge University Press, 2011), http://srren.ipcc-wg3.de/report; Joint Research Centre of the European Commission (JRC), *2011 Technology Roadmap of the European Strategic Energy Technology Plan* (Petten, The Netherlands: 2011). **Geothermal power:** Capacity factor and from Edenhofer et al., op. cit. this note, pp. 425–26 and 1,004–06. Michael Taylor, IRENA, personal communication with REN 21, March–May 2014, input based on the "IRENA Renewable Costs Database" and analysis thereof; IRENA estimates the LCOE of a typical project to be USD 0.05–0.14/kWh for greenfield and brownfield projects. In 2010, the International Energy Agency (IEA) estimated the LCOE of a binary plant to be USD 0.08–0.11/kWh, per IEA, *Energy Technology Systems Analysis Programme, Geothermal Heat and Power*, Technology Brief E07 (Paris: May 2010), Table 5, http://www.iea-etsap.org/web/E-TechDS/PDF/E06-geoth_energy-GS-gct.pdf. **Hydropower:** Characteristics based on Edenhofer et al., op. cit. this note, and on Arun Kumar, Alternate Hydro Energy Centre, Indian Institute of Technology Roorkee, personal communication with REN21, March 2012. For grid-based projects, capital cost ranges and LCOE for new plants of any size provided in table are from Taylor, op. cit. this note. Off-grid capital costs and LCOE from REN21, *Renewables 2011 Global Status Report* (Paris: 2011), http://www.ren21.net/Portals/0/documents/Resources/GSR2011_FINAL.pdf. Note that the cost for hydropower plants is site specific and may have large variations. Small capacity plants in some areas even may exceed these limits. The cost is dependent on several factors especially plant load factor, discount rate, and life of the project. Normally, small-scale hydro projects last 20–50 years compared to large-scale hydro plants, which may last 30–80 years. Hydro facilities that are designed to provide system balancing (rather than baseload) have lower capacity factors and therefore higher generation costs per kWh, on average, but provide additional value. **Ocean Energy:** All data are from Edenhofer et al., op. cit. this note. Note that this is based on a very small number of pilot and demonstration installations to date; LCOE range assumes a 7% discount rate. Electricity generation costs are in the range of USD 0.31–0.39/kWh (EUR 0.24–0.30/kWh), from Sarasin, *Working Towards a Cleaner and Smarter Power Supply: Prospects for Renewables in the Energy Revolution* (Basel, Switzerland: December 2012), p. 11. **Solar PV:** *Rooftop solar systems:* peak capacities are based on Europe and drawn from European Photovoltaic Industry Association (EPIA), *Market Report 2011* (Brussels: January 2012), http://www.epia.org/uploads/tx_epiapublications/Annual_Report_2011.pdf, and from EPIA, personal communication with REN21, 3 April 2012. Capacity factor from IRENA, *Renewable Power Generation Costs in 2012...*, op. cit. this note, p. 56. Note that values outside of this range are possible for exceptional sites (higher) or where siting is suboptimal (lower); adding tracking systems can raise these capacity factors significantly, from IRENA, idem. Capital costs based on: average of EUR 1,640/kW in Q1 2014 (using exchange rate of EUR 1 = USD 1.37) for residential systems from German Solar Industry Association (BSW-Solar), "Statistic Data on the German Solar Power (Photovoltaic) Industry," 2014, at www.solarwirtschaft.de; U.S. range of 3,500 to 7,000 based on data from IRENA and CSI, (excludes top and bottom 5% of projects) and U.S. Solar Energy Industries Association (SEIA) and GTM Research, *U.S. Solar Market Insight* (Washington, DC and Boston: 2014); Japan from Hironao Matsubara, Institute for Sustainable Energy Policies (ISEP), personal communication with REN21, April 2014; Germany, United States, China, and Italy from Gestore Servizi Energetici (GSE) and provided by Taylor, op. cit. this note; Australia from Taylor, op. cit. this note; typical global range for industrial systems based on EUR 1,150–2,000/kW (converted using EUR 1 = USD 1.3), from Gaëtan Masson, EPIA and IEA Photovoltaic Power Systems Programme (IEA-PVPS), personal communication with REN21, April 2013. LCOE costs for OECD and non-OECD are real 2013 USD values, from lowest to highest, and based on 7% cost of capital, from IRENA, *Renewable Power Generation Costs in 2012...*, op. cit. this note, from IRENA Renewable Cost Database, 2013, and from Michael Taylor, IRENA, personal communication with REN21, May 2013; Europe based on costs in the range of EUR 0.12–0.29/kWh (converted using EUR 1 = USD 1.3) for residential, commercial, and industrial projects in the south and north of France, Germany, Italy, Spain, and the United Kingdom, from EPIA database, provided by Masson, op. cit. this note. *Ground-mounted utility-scale systems:* peak capacity from EPIA, *Market Report 2011*, op. cit. this note, from David Renne, International Solar Energy Society (ISES), personal communication with REN21, April 2013, and from Denis Lenardic, pvresources.com, personal communication with REN21, April 2013; also see relevant section and endnotes in Market and Industry Trends section. Capital costs based on the following: typical global costs based on EUR 1,000–1,500 per kW (converted using EUR 1 = USD 1.3) from Masson, April 2013, op. cit. this note; United States, China, Germany, Japan, and India from Taylor, op. cit. this note, March-May 2014; LCOE based on the following: OECD and non-OECD cost ranges are 2013 USD, with 7% discount rate, from IRENA Renewable Cost Database, op. cit. this note and from Taylor, op. cit. this note, March-May 2014; Europe based on LCOE in the range of EUR 0.11–0.26/kWh (using exchange rate of EUR 1 = USD 1.3) for ground-mounted systems in the south and north of France, Germany, Italy, Spain, and the United Kingdom, from EPIA database, provided by Masson, op. cit. this note. Note that the LCOE in Thailand is estimated to be in the range of USD 0.15–0.18/kWh, based on input from project developers and from former Thai Minister of Energy Piyasvasti Amranand, per Chris Greacen, Palang Thai, personal communication with REN21, April 2013. While PV module prices are global, balance of system costs are much more local. Also, note that prices have been changing rapidly. **CSP:** Characteristics including plant sizes from European Solar Thermal Electricity Association (ESTELA), personal communication with REN21, 22 March 2012 and 24 January 2013; from Protermosolar, the Spanish Solar Thermal Electricity Industry Association, April 2012; and based on parabolic trough plants that are typically in the range of 50–200 MW; tower 20–70 MW; and Linear Fresnel in the range of 1–50 MW, per Bank Sarasin, *Solar Industry: Survival of the Fittest in the Fiercely Competitive Marketplace* (Basel, Switzerland: November 2011). Note that multiple systems can be combined for higher-capacity plants. Capacity factors based on ESTELA, op. cit. this note, and on Michael Mendelsohn, Travis Lowder, and Brendan Canavan, *Utility-Scale Concentrating Solar Power and Photovoltaics Projects: A Technology and Market Overview* (Golden, CO: U.S. National Renewable Energy Laboratory (NREL), April 2012), http://www.nrel.gov/docs/fy12osti/51137.pdf; on 20–28% capacity factor for plants without storage and 40–50% for plants with 6–7.5 hours storage, from U.S. Department of Energy, *SunShot Vision Study*, prepared by NREL (Golden, CO: February 2012), p. 105, http://energy.gov/sites/prod/files/2014/01/f7/47927.pdf; on 20–30% for parabolic trough plants without storage and 40% to as high as 80% for tower plants with 6–15 hours of storage, from IRENA, *Renewable Power Generation Costs in 2012…*, op. cit. this note, p. 19; and on the capacity factor of parabolic trough plants with six hours of storage, in conditions typical of the U.S. Southwest estimated to be 35–42%, per Edenhofer et al., op. cit. this note, pp. 1,004, 1,006. Note that the Gemasolar plant, which began operation in Spain in 2011, has storage for up to 15 hours, per Torresol Energy, “Gemasol,” www.torresolenergy.com/TORRESOL/gemasolar-plant/en. Capital costs based on: U.S. parabolic trough and tower plants without storage in the range of USD 4,000–6,000/kW, and trough and towers with storage in the range of USD 7,000–10,000/kW, from U.S. Department of Energy, Loans Programs Office, www.lgprogram.energy.gov, provided by Fred Morse, Abengoa Solar, personal communication with REN21, April 2013; U.S. tower plants at USD 5,600/kW without storage and USD 9,000/kW with storage from Lazard, “Lazard’s Levelized Cost of Energy Analysis – Version 7.0,” (New Orleans, LA: August 2013); and on parabolic trough plants with storage capital costs of USD 4,700–7,300/kW in OECD countries, and 3,100–4,050/kW in non-OECD (based on costs of five projects), and costs with storage all from IRENA, Renewable Power Generation Costs in 2012…, op. cit. this note, pp. 19, 59–60; and on range of about 3,900–8,000/kW from IEA, *Tracking Clean Energy Progress 2013* (Paris: OECD/IEA, 2013), http://www.iea.org/publications/tcep_web.pdf. LCOE estimates for trough and fresnel plants come from IRENA, *Renewable Power Generation Costs in 2012…*, op. cit. this note, p. 65. LCOE for tower plants from Lazard, op. cit. this note. **Wind power:** Characteristics based on the following: turbine sizes from JRC, *2011 Technology Map…*, op. cit. this note; on- and offshore capacity factors from Edenhofer et al., op. cit. this note, p. 1005; and from IRENA, *Renewable Power Generation Costs in 2012…*, op. cit. this note, p. 36. Note that weighted average capacity factors range from around 25% for China to an average 33% in the United States (with a range of 18–53%); ranges in Africa and Latin America are similar to the United States, whereas ranges in Europe are closer to China. Curtailments in China due to grid constraints put the average capacity factor for dispatched generation closer to 20%, all from IRENA, *Renewable Power Generation Costs in 2012…*, op. cit. this note, p. 36. Capital costs for onshore wind from Taylor, op. cit. this note, March-May 2014; from IRENA, *Renewable Power Generation Costs in 2012…*, op. cit. this note, pp. 18, 32–37; from Navigant’s BTM Consult, *International Wind Energy Development: World Market Update 2012* (Copenhagen: 2013); and on a range of about USD 1,250–2,300/kW from IEA, Tracking Clean Energy…, op. cit. this note. LCOE for onshore wind assume 7% discount rate and are from IRENA Renewable Cost Database, 2014, and from Taylor, op. cit. this note, March-May 2014; also based on range of USD 0.04–0.16 U.S. cents/kWh from IEA, *Deploying Renewables: Best and Future Policy Practice* (Paris: 2011), http://www.iea.org/publications/freepublications/publication/Deploying_Renewables2011.pdf; additional input from Steve Sawyer, Global Wind Energy Council, personal communication with REN21, April 2014. Note that the lowest-capital cost onshore wind projects have been installed in China; higher costs have been experienced in Europe and the United States. Offshore capital from Taylor, op. cit. this note, 2014; on Navigant’s BTM Consult, op. cit. this note; and on range of USD 3,000–6,000/kW from IEA, *Tracking Clean Energy…*, op. cit. this note. Offshore LCOE based on USD 0.15–0.17 assuming a 45% capacity factor, USD 0.035/kWh operations and maintenance cost, and 10% cost of capital, and on USD 0.14-0.15/kWh assuming a 50% capacity factor, from IRENA, *Renewable Power Generation Costs in 2012…*, op. cit. this note, p. 38; also from the low LCOE for offshore wind in the OECD is about USD 0.15/kWh and the high is USD 0.23/kWh, assuming a 7% discount rate, per idem, p. 37; IRENA Renewable Cost Database, 2013, and from Taylor, op. cit. this note, May 2013. Small-scale wind capital costs ranged from USD 2,300–10,000/kW in the United States in 2011, with an average installed cost of USD 6,040/kW; this represented an increase of 11% over 2010. All capital cost data from Stefan Gsänger and Jean Pitteloud, *Small Wind World Report 2014* (Bonn: World Wind Energy Association (WWEA) and New Energy Husum, March 2014), Executive Summary, http://small-wind.org/wp-content/uploads/2014/03/2014_SWWR_summary_web.pdf. All small-scale LCOE wind data from WWEA, *2012 Small Wind World Report* (Bonn: March 2012), http://www.wwindea.org/webimages/WWEA%20Small%20Wind%20World%20Report%20Summary%202012.pdf. Note that in 2011, installed costs of the top 10 small wind turbine models in the United States were in the range of USD 2,300–10,000/kW in 2011, and the average installed cost of all small-scale wind turbines was USD 6,040/kW; in China, the average was USD 1,900/kW, per WWEA, *Small Wind World Report 2013* (Bonn: March 2013), http://www.wwindea.org/webimages/SWWR_summary.pdf]].

HEAT AND COOLING SECTOR

Biomass heat: Cost variations between heat plants are wide for reasons similar to those listed above for bio-power. Further details can be found at: Fachagentur Nachwachsende Rohstoff e.V. (FNR), “Faustzahlen Biogas,” www.biogasportal.info/daten-und-fakten/faustzahlen/, viewed May 2013; and Pellet Fuels Institute, “Compare Fuel Costs,” http://pelletheat.org/pellets/compare-fuel-costs/, viewed May 2013. Bioenergy CHP includes small-scale biogas engine generating sets and biomass medium-scale steam turbines. Data converted using USD 1 GJ = 0.36 U.S. cents/kWh. Top of range for capital cost of USD 1,500 from Taylor, op. cit. this note, March-May 2014. **Geothermal heat:** Geothermal space heating from Edenhofer et al., op. cit. this note, pp. 427 and 1,010–11 (converted from USD 2005 to 2012), assuming 7% discount rate, and using USD 1 GJ = 0.36 U.S. cents/kWh. Also, for building heating, assumptions included a load factor of 25–30%, and a lifetime of 20 years; and for district heating, the same load factor, a lifetime of 25 years, and transmission and distribution costs are not included. For ground-source heat pumps, IPCC shows capital costs of USD (2012) 1,095–4,370/kW, and USD 20–65/GJ assuming 25–30% as the load factor and 20 years as the operational lifetime. In 2011, IEA indicated a range of USD 439–4,000/kW based on 2007 data and operating efficiency of 250–500% (COP of 2.5–5.0), from IEA, *Technology Roadmap Energy – Efficient Buildings: Heating and Cooling Equipment* (Paris: OECD/IEA, 2011), Table 5, http://www.iea.org/publications/freepublications/publication/buildings_roadmap.pdf. For 2013, the upper end of the range for capital cost has been reduced to USD 2,250 and the LCOE has been adjusted accordingly, based on input from Taylor, op. cit. this note, March-May 2014; It is worth taking into account that actual LCOH are influenced by electricity market prices. Drilling costs are included for commercial and institutional installations, but not for residential installations. **Solar thermal heating:** Solar heating plant sizes and efficiency rates for hot water systems and combi systems, based on 2007 data, from IEA, *Technology Roadmap…*, op. cit. this note, pp. 12–13, and district heat plant sizes from Werner Weiss, AEE – Institute for Sustainable Technologies (AEE-INTEC), Gleisdorf, Austria, personal communication with REN21, April 2012. Capital costs for

OECD new-build and for OECD retrofit (for year 2007) from IEA, *Technology Roadmap…*, op. cit. this note; LCOH for domestic hot water (low end), and capital costs and LCOH for China (all converted from USD 2005 to USD 2012; and LCOH assuming 7% discount rate, and converted using USD 1/GJ = 0.36 U.S. cents/kWh) from Edenhofer et al., op. cit. this note, p. 1,010; and LCOH for domestic hot water (high end) from Andreas Häberle, PSE AG, Freiburg, personal communication with REN21, 29 May 2013. European district heat capital costs from Weiss, op. cit. this note, and from Häberle, op. cit. this note, 25 April 2013. Note that the low of USD 470/kW is for district heat systems in Denmark, where costs start at about USD 370/kW (EUR 200/m^2) and storage costs a minimum of USD 100/kW. LCOH for district heat in Denmark based on low of EUR 0.03/kWh (converted using EUR 1 = USD 1.3), from Häberle, op. cit. this note. According to the IEA, the most cost effective solar district heating systems in Denmark have had investment costs in the USD 350–400/kW range, resulting in heat prices of USD 35–40/MWh_{th}, from IEA, *Technology Roadmap – Solar Heating and Cooling* (Paris: OECD/IEA, 2012), p. 21, http://www.iea.org/publications/freepublications/publication/2012_SolarHeatingCooling_Roadmap_FINAL_WEB.pdf. Industrial process heat data all from Häberle, op. cit. this note, 25 April 2013. LCOH of USD/GJ based on USD 0.4-016/kWh, from idem. **Solar cooling:** capacity data, efficiency, and capital cost in the range of USD 2,925–5,850/kW from Uli Jakob, "Status and Perspective of Solar Cooling Outside Australia," in *Proceedings of the Australian Solar Cooling 2013 Conference* (Sydney: 12 April 2013). Efficiency based on coefficient of performance (COP) ranging from 0.50 to 0.70, depending on the system used and on driving, heat rejection, and cold water temperatures. Capital cost ranges based on EUR 2,250/kW for large-scale kits to EUR 4,500/kW for small-scale kits. Low-end of capital costs based on range of USD 1,600–3,200/kW for medium- to large-scale systems from IEA, *Technology Roadmap – Solar Heating and Cooling*, op. cit. this note, p. 21.

TRANSPORT SECTOR

Biofuel costs vary widely due to fluctuating feedstock prices (see, for example, Agriculture Marketing Resource Center (AgMRC), "Tracking Ethanol Profitability," www.agmrc.org/renewable_energy/ethanol/tracking_ethanol_profitability.cfm. Costs quoted exclude value of any co-products. Sources: Taylor, op. cit. this note, March-May 2014; IRENA, *Road Transport: The Cost of Renewable Solutions* (Abu Dhabi: June 2013), http://www.irena.org/DocumentDownloads/Publications/Road_Transport.pdf; Gonzalo Bravo, Fundación Bariloche, personal communication with REN21, April 2014; Ernst and Young, *Renewable Energy Attractiveness Indices* (London: November 2012), http://emergingmarkets.ey.com/wp-content/uploads/downloads/2012/11/EY-Cleantech-CAI-Issue-35-FINAL-1112.pdf; JRC, *2011 Technology Roadmap* ..., op. cit. this note; USDA Foreign Agricultural Service, "Indonesia – Biofuels Annual – 2012," 14 August 2012, http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Jakarta_Indonesia_8-14-2012.pdf.

RURAL ENERGY

Biogas digesters, average cost for Asia and Africa (weighted average across countries based on number of installations) from SNV, *Domestic Biogas Newsletter*, September 2011, http://www.snvworld.org/en/download/publications/snv_domestic_biogas_newsletter_issue_5_September_2011.pdf; wind capital cost data based on what is representative for Africa, from B. Klimbie, "Small and Medium Wind for Off-Grid Electrification," presentation at International Off-Grid Renewable Energy Conference and Exhibition (IOREC), 2 November 2012, cited in IRENA, *Renewable Power Generation Costs in 2012…*, op. cit. this note, p. 34; LCOE from Alliance for Rural Electrification, cited in Simon Rolland, "Campaigning for Small Wind: Facilitating Off-Grid Uptake," *Renewable Energy World*, March–April 2013, pp. 47–49. David Lecoque, Alliance for Rural Electrification; Paul Bertheau, Reiner Lemoine Institut; Nico Peterschmidt, INSENSUS—all personal communications with REN21, May 2014. All other data from past editions of REN21, *Renewables Global Status Report* (Paris: REN21 Secretariat, various years).

INVESTMENT FLOWS

1 China Electricity Council, provided by Shi Pengfei, China Wind Energy Association, personal communication with REN21, 12 March 2014; China Electricity Council, Planning and Statistics Department, "2013 National Electricity Industry Statistics," 26 January 2014, http://www.cec.org.cn/guihuayutongji/tongjxinxi/yuedushuju/2014-01-26/116224.html (using Google Translate).

2 The BNEF estimate for investment in large hydropower (>50 MW) is based on at least 20 GW of capacity commissioned during 2013 and a capital cost per MW of USD 1.75 million, bringing the total investment in large hydropower to USD 35 billion. The figure USD 1.75 billion per GW is the average value based on numbers provided by developers of large hydro projects in applications for the Clean Development Mechanism. Estimates are approximate only, due greatly to the fact that timing of the investment decision on a project may be about four years on aver¬age away from the moment of commissioning. As a result, a large share of the investment total for the projects commissioned in 2013 was actually invested in prior years; in addition, there was investment during 2013 for projects that are currently under construction and are not included in the BNEF estimates. Note that data for hydropower projects larger than 50 MW differ somewhat between this GSR and the *Global Trends in Renewable Energy Investment 2014* due to different methodologies and data sources. This *GSR* estimates that about 40 GW of total hydropower capacity was commissioned worldwide during 2013, and a significant portion of this was projects larger than 50 MW (see Hydropower section in this report), whereas BNEF estimates that at least 24 GW of hydro capacity was commissioned in 2013, including more than 20 GW of large projects (>50 MW). Taking the BNEF estimate that 4 GW hydropower capacity <50 MW was added, that means as much as 36 GW of capacity >50 MW was added during 2013.

3 Note that these dollar amounts for capacity investment are based on BNEF estimates that some 81 GW of new capacity (not including hydropower >50 MW) was added in 2013, down from an estimated 88 GW in 2012. These numbers are not necessarily consistent with capacity data provided elsewhere in the GSR.

4 For more information, see "Green Bond Principles 2014: Voluntary Process Guidelines for Issuing Green Bonds," http://www.ceres.org/resources/reports/green-bond-principles-2014-voluntary-process-guidelines-for-issuing-green-bonds/view.

03

POLICY LANDSCAPE

1 This section is intended to be only indicative of the overall landscape of policy activity and is not a definitive reference. Policies listed are generally those that have been enacted by legislative bodies. Some of the policies listed may not yet be implemented, or are awaiting detailed implementing regulations. It is obviously difficult to capture every policy, so some policies may be unintentionally omitted or incorrectly listed. Some policies also may be discontinued or very recently enacted. This report does not cover policies and activities related to technology transfer, capacity building, carbon finance, and Clean Development Mechanism projects, nor does it highlight broader framework and strategic policies—all of which are still important to renewable energy progress. For the most part, this report also does not cover policies that are still under discussion or formulation, except to highlight overall trends. Information on policies comes from a wide variety of sources, including the International Energy Agency (IEA) and International Renewable Energy Agency (IRENA) Global Renewable Energy Policies and Measures Database, the U.S. Database of State Incentives for Renewables & Efficiency (DSIRE), RenewableEnergyWorld.com, press reports, submissions from REN21 regional- and country-specific contributors, and a wide range of unpublished data. Much of the information presented here and further details on specific countries appear on the "Renewables Interactive Map" at www.ren21.net. It is unrealistic to be able to provide detailed references to all sources here. **Table 3** is based on idem and numerous sources cited throughout this section. **Figures 26** and **27** are from idem and from Renewable Energy Policy Network for the 21st Century (REN21), *Renewables 2005 Global Status Report* (Washington, DC: Worldwatch Institute, 2005), and *REN21, Renewables Global Status Report 2006 Update* (Paris: REN21 Secretariat and Washington, DC: Worldwatch Institute, 2006).

2 REN21, *Renewables 2005…*, op. cit. note 1. **Figures 29** and **30** based on past editions of the GSR and all sources listed in Endnote 1.

3 World Wind Energy Association (WWEA), *World Wind Energy Report 2013* (Bonn: 2014); Algerian Ministry of Energy and Mines, *Renewable Energy and Energy Efficiency Program* (Algiers: March 2011), http://www.mem-algeria.org/francais/uploads/enr/Programme_ENR_et_efficacite_energetique_en.pdf; China's 49 GW target includes installations of a number of different renewable energy sources (final installed capacity by technology can be found in the corresponding technology sections of the report), per "Asia Report: Reacting to China's Goal of 49 GW of Renewables in 2013," *Renewable Energy World*, 22 January 2013, http://www.renewableenergyworld.com/rea/news/article/2013/01/asia-report-reacting-to-chinas-goal-of-49-gw-of-renewables-in-2013; Jennifer Dugan, "China Sets New World Record for Solar Installations," The Guardian, 30 January 2014, http://www.theguardian.com/environment/chinas-choice/2014/jan/30/china-record-solar-energy.

4 India had installed only 2,110 MW as of January 2014, per Government of India, Ministry of New and Renewable Energy (MNRE), "Physical Progress (Achievements)," http://www.mnre.gov.in/mission-and-vision-2/achievements/.

5 Economic Consultant Associates, *Review of the Fiji National Energy Policy*, July 2013, http://www.fdoe.gov.fj/images/NEP2013/draft%20national%20energy%20policy%202013.pdf.

6 France installed 613 MW of solar PV and no CSP in 2013, per IEA Photovoltaic Power Systems Programme (IEA-PVPS), *PVPS Report—Snapshot of Global PV 1992-2013: Preliminary Trends Information from the IEA PVPS Programme* (Brussels: March 2014); Nepal from WWEA, op cit. note 3; South Africa from Wim Jonker Klunne, Council for Scientific and Industrial Research (CSIR), personal communication with REN21, 26 January 2014; South Korea installed 79 MW of wind power in 2013, per Global Wind Energy Council (GWEC), *Global Wind Statistics 2013* (Brussels: 5 February 2014).

7 REN21, *Renewables 2013 Global Status Report* (Paris: REN21 Secretariat, 2013), http://www.renewableenergyworld.com/rea/news/article/2013/01/france-doubles-solar-energy-target-seeks-to-promote-european-equipment.

8 Vladislav Vorotnikov, "Azerbaijan Aims to Boost Output of Renewable Energy," *Renewable Energy World*, 1 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/azerbaijan-aims-to-boost-output-of-renewable-energy?cmpid=WNL-Friday-August2-2013; Royal Government of Bhutan, *Alternative Renewable Energy Policy 2013* (Thimpu, Bhutan: 2013), http://www.moea.gov.bt/documents/files/pub0ip10496bv.pdf; Kazakhstan from Bloomberg New Energy Finance (BNEF), *Energy Week in Review*, 23–¬29 July 2013.

9 Kenya Ministry of Energy and Petroleum, *National Energy Policy: November 2013 Draft* (Nairobi: November 2013), http://www.kengen.co.ke/documents/National%20Energy%20Policy%20-%20Final%20Draft%20-%2014%20Nov%202013.pdf; Dennis Kibira, African Solar Designs, personal communication with REN21, 4 December 2013.

10 Qatar Ministry of Energy & Industry, "Qatar Launches Project to Produce Electricity from Solar in Parallel with the COP18" (Doha: 2012), http://www.mei.gov.qa/search-results-en/?Search=renewable#news-en/Qatar-launches-project-to-produce-electricity-from-solar-in-parallel-with-the-COP18/67/; Russia from BNEF, *Energy Week in Review*, 1–6 May 2013.

11 Michelle Yun, "GCL-Poly Drops After China Sets Solar Target: Hong Kong Mover," *Bloomberg*, 27 January 2014, http://www.bloomberg.com/news/2014-01-27/gcl-poly-drops-after-china-sets-solar-target-hong-kong-mover.html; "China to Boost Renewable Energy to Curb Air Pollution, CCTV Says," *Bloomberg*, 15 January 2014, http://www.bloomberg.com/news/2014-01-15/china-to-boost-renewable-energy-to-curb-air-pollution-cctv-says.html; Frank Haugwitz and Rolf Hug, "China became the world's largest solar PV market in Q3; nation is poised to additional multi-GW deployment," SolarServer, undated, http://www.solarserver.com/solar-magazine/solar-report/solar-report/china-became-the-worlds-largest-solar-pv-market-in-q3-nation-is-poised-to-additional-multi-gw-deployment.html; Feifei Shen, "China Confirms Goal for 35 GW of Solar Capacity by 2015," *Renewable Energy World*, 15 July 2013, http://www.renewableenergyworld.com/rea/news/article/2013/07/china-confirms-goal-for-35-gw-of-solar-capacity-by-2015?cmpid=SolarNL-Tuesday-July16-2013; John Parnell, "China Extends Distributed Solar Target to 2015," PV Tech, 21 October 2013, http://www.pv-tech.org/news/china_extends_distributed_solar_target_to_20gw_by_2015.

12 GWEC, *Global Wind Report: Annual Market Update 2013* (Brussels: 2014).

13 Jeff Postelwait, "India's Prime Minister Vows to Double Renewable Energy Capacity," *Renewable Energy World,* 18 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/04/indias-pm-vows-to-double-renewable-energy-capacity?cmpid=WNL-Friday-April19-2013.

14 BNEF, *Energy Week in Review*, 23¬–29 July 2013; Paul Gipe, "Thailand Adding 1,000 MW of Solar with New Feed-in Tariffs," Wind Works, 18 July 2013, http://www.wind-works.org/cms/index.php?id=39&tx_ttnews%5Btt_news%5D=2534&cHash=d5ffa689d1bd548eb94f81d3838843a7.

15 Max Hall, "Thai FITs for further 1 GW of solar," *PV Magazine,* 19 July 2013, http://www.pv-magazine.com/news/details/beitrag/thai-fits-for-further-1-gw-of-solar_100012097/#axzz2rDDAHCB5.

16 Vanuata National Energy Roadmap 2013-2020, March 2013, http://www.kuthenergy.com/assets/Vanuatu_National_Energy_Roadmap.pdf.

17 Lara Ferreira, Portuguese Renewable Energy Association (ARPEN), personal communication with REN21, 2 December 2013.

18 David Appleyard, "UK Confirms Plans for 39 GW of Offshore Wind by 2030," *Renewable Energy World,* 8 November 2013, http://www.renewableenergyworld.com/rea/news/article/2013/11/uk-confirms-plans-for-39-gw-of-offshore-wind-by-2030?cmpid=WNL-Wednesday-November13-2013.

19 Martha Ekkert, Federal Ministry for the Environment, Nature Protection and Nuclear Safety (BMU), personal communication with REN21, 27 January 2014; "Germans Cut Offshore Wind Goal," reNews.com, 11 November 2013, http://renews.biz/53795/germans-cut-offshore-wind-goal/; Steve Sawyer, GWEC, cited in James Montgomery, "Wind Energy 2014 Outlook: Major Markets Recover, Battling Policy and Grid Concerns," *Renewable Energy World Magazine*, January–February 2014, p. 30.

20 Egypt from GTM Research, *PV News*, November 2013; Barbara Lewis, "Libya aims to get about fifth of power from solar by 2020," *Reuters*, 11 April 2013, http://www.reuters.com/article/2013/04/11/eu-libya-idUSL5N0CY2MZ20130411; Ian Clover, "Desert Solar conference instills Saudi confidence," *PV Magazine*, 15 November 2013, http://www.pv-magazine.com/news/details/beitrag/desert-solar-conference-instills-saudi-confid

ence_100013454/#axzz2nN7pXCI9.

21 Chile from Jenny Muirhead, "Weekly Intelligence Brief: October 14-21," CSP Today, 21 October 2013, http://social.csptoday.com/print/29790?utm_source=http%3A%2F%2Fuk.csptoday.com%2Ffc_csp_pvlz%2F&utm_medium=email&utm_campaign=CSP%20ebrief%2021-10-13%20en&utm_term=Who%20are%20the%20leading%20CSP%20companies%20in%202013%3F&utm_content=125566; Clean Technica, "90% Renewable Electricity by 2015 Is Uruguay's Goal," http://cleantechnica.com/2013/01/08/90-renewable-electricity-by-2015-is-uruguays-goal/.

22 CARICOM, "Targets approved for renewable energy development and energy efficiency improvement in CARICOM," press release (Georgetown, Guyana: 6 March 2013), http://www.caricom.org/jsp/pressreleases/press_releases_2013/pres50_13.jsp.

23 Michael Puttre, "California's New 600 MW Renewables Law Targets Distributed Solar, Low-Income Areas," *Solar Industry*, 10 October 2013, http://www.solarindustrymag.com/e107_plugins/content/content.php?content.13321; Jeff Postelwait, "California Energy Bill Passes, Awaits Gov. Brown's Signature," *Renewable Energy World*, 12 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/california-energy-bill-passes-awaits-gov-browns-signature?cmpid=WNL-Friday-September13-2013; California Senate, "Groundbreaking New California Law Will Provide Renewable Energy to Renters, Small Business," 30 September 2013, http://sd03.senate.ca.gov/news/2013-09-30-groundbreaking-new-california-law-will-provide-renewable-energy-renters-small-busine.

24 Governor of Massachusetts, "Patrick-Murphy Administration Reaches 2017 Solar Energy Targets, Sets New Goal," press release (Boston: 1 May 2013), http://www.mass.gov/governor/pressoffice/pressreleases/2013/0501-solar-power-goal-reached.html; C2ES, "Minnesota Passes 'Omnibus Energy Bill' Including 1.5 Percent Solar Requirement," 2013, http://www.c2es.org/us-states-regions/news/2013/minnesota-passes-omnibus-energy-bill-including-15-percent-solar-requirem.

25 **Figure 28** based on past editions of the GSR and all sources listed in Endnote 1.

26 Enerdata, "Kazakhstan Adopts Energy Efficiency 2020 Programme and Feed-in Tariffs," 2 September 2013, http://www.enerdata.net/enerdatauk/press-and-publication/energy-news-001/kazakhstan-adopts-energy-efficiency-2020-programme-and-feed-tariffs_21910.html; in Ecuador, rates for biomass (11 U.S. cents/kWh) and geothermal (13.81 U.S. cents/kWh) were unchanged, wind tariffs were raised from 9.13 to 11.74 U.S. cents/kWh, CSP rates were lowered to 25 U.S. cents/kWh from 31 U.S. cents/kWh, and tidal energy rates were lowered to 32 U.S. cents/kWh (down from 44 U.S. cents/kWh), per BNEF and Multilateral Investment Fund (MIF), *Climatescope 2013* (Washington, DC: 2013), http://idbdocs.iadb.org/wsdocs/getDocument.aspx?DOCNUM=38168432; Government of Ecuador, National Electricity Council, "Treatment for energy produced from non-conventional renewable energy resources (Regulation No. 004 CONELEC/11)," April 2011, http://www.conelec.gob.ec/normativa_detalle.php?cd_norm=361.

27 CITI FM Online, "PURC to introduce special tariffs," 5 April 2013, http://www.citifmonline.com/index.php?id=1.1326767.

28 GTM Research, *PV News*, June 2013; Government of Germany, Federal Network Agency, "EEG tariffs for PV systems," http://www.bundesnetzagentur.de/DE/Sachgebiete/ElektrizitaetundGas/Unternehmen_Institutionen/ErneuerbareEnergien/Photovoltaik/DatenMeldgn_EEG-VergSaetze/DatenMeldgn_EEG-VergSaetze_node.html. Reduction rates were 1.8% per month between May and October 2013, 1.4% monthly between November 2013 and January 2014, and 1% monthly from February to April 2014, per Markus Wacket and Madeline Chambers, "Germany Ushers in Renewable Energy Reform," *Reuters*, 8 April 2014, http://www.reuters.com/article/2014/04/08/us-germany-energy-idUSBREA3716I20140408.

29 GTM Research, op. cit. note 28.

30 BNEF, *Energy Week in Review*, 11–17 June 2013; Sinead Orlandi, "Italy: Rearrangement of the Conto Energia Scheme," Energy Observer, 15 March 2014, http://www.energyobserver.com/tekst.php?lang=2&ID=1978.

31 The Netherlands SDE+ feed-in premium support scheme provides technology-differentiated payments over a maximum contract length of 15 years. RES Legal, RAC 2013, 12 November 2013, http://www.res-legal.eu/search-by-country/netherlands/sources/t/source/src/rac-2012/; Rijksdienst voor Ondernemend Nederland, "Solar Subsidy Scheme Closed," 8 August 2013, http://www.agentschapnl.nl/subsidies-regelingen/subsidieregeling-zonnepanelen-gesloten.

32 "Feed-in Tariff table," *PV Magazine*, 12 December 2013; Ilias Tsagas, "Czech Republic Ends FIT Program, Extends Solar Trax," *PV Magazine*, 16 September 2013, http://www.pv-magazine.com/news/details/beitrag/czech-republic-ends-fit-program--extends-solar-tax-_100012748/#axzz2nwMg7Z3c; Greece from GTM Research, op. cit. note 28; Renewable Energy World Editors, "Greek Government Proposes More Cuts to Renewable Energy Feed-in Tariff," *Renewable Energy World*, 25 March 2014, http://www.renewableenergyworld.com/rea/news/article/2014/03/greek-government-proposes-more-cuts-to-renewable-energy-feed-in-tariff?cmpid=WNL-Wednesday-March26-2014; Lins Jegelevicius, "Lithuanian FIT Cuts Dampen Solar Development, But Net Metering May Rekindle Industry," *Renewable Energy World*, 18 November 2013, http://www.renewableenergyworld.com/rea/news/article/2013/11/lithuanian-fit-cuts-dampen-development-but-net-metering-may-rekindle-industry.

33 Ferreira, op. cit. note 17.

34 Marie Latour, "Portugal: Drastic cuts to the feed-in tariff scheme," European Photovoltaic Industry Association, January 2014, http://www.photon.info/photon_news_detail_en.photon?id=83685; RES Legal, *Electricity Promotion in Portugal*, 6 November 2013, http://www.res-legal.eu/search-by-country/portugal/tools-list/c/portugal/s/res-e/t/promotion/sum/180/lpid/179/page.pdf?out=pdf.

35 In addition to wind power, the full FIT remained in place for large-scale CHP plants. Eclareon, *Monthly Progress Update: Part of the project "Assessment of climate change policies in the context of the EU Semester"* (Brussels: European Commission, 5 November 2013), http://ec.europa.eu/clima/policies/g-gas/progress/docs/progress_201310_en.pdf.

36 Frankfurt School–UNEP Collaborating Centre for Climate & Sustainable Energy Finance and BNEF, *Global Trends in Renewable Energy Investment 2013* (Frankfurt: 2013).

37 "Feed-in Tariff table," op. cit. note 32.

38 Regionally differentiated rates for ground-mounted solar in China have been set at either CNY 1/kWh (USD 0.163/kWh), CNY 0.9/kWh (USD 0.147/kWh), or CNY 0.95/kWh (USD 0.155/kWh), per Solar Server, "China approves regional variations to feed-in tariff for solar PV," 3 November 2013, http://www.solarserver.com/solar-magazine/solar-news/current/2013/kw36/china-approves-regional-variations-to-feed-in-tariff-for-solar-pv-updated.html.

39 Chisake Watanabe, "Japan Gives Final Approval to 10% Tariff Cut for Solar Power," *Bloomberg*, 28 March 2013, http://www.bloomberg.com/news/2013-03-29/japan-gives-final-approval-to-10-tariff-cut-for-solar-power.html; Yuka Obayashi and James Topham, "Japan Lifts Offshore Wind Tariff, Cuts Solar Prices, " *Reuters*, 25 March 2014, http://www.reuters.com/article/2014/03/25/japan-renewables-subsidies-idUSL4N0MM23520140325.

40 "Feed-in Tariff table," op. cit. note 32.

41 GWEC, op. cit. note 12.

42 Legifrance, "Arrêté du 7 janvier 2013 portant majoration des tarifs de l'électricité produite par certaines installations utilisant l'énergie radiative du soleil telles que visées au 3° de l'article 2 du décret n° 2000-1196 du 6 décembre 2000," 1 February 2013, http://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000027008908; Craig Morris, "EU Rules Against French FITs for Wind," Renewables International, 16 January 2014, http://www.renewablesinternational.net/eu-rules-against-french-fits-for-wind/150/537/75762/; Paul Gipe, "EU Concludes French Feed-in Tariffs for Wind Energy Permissable," Wind-Works, 28 March 2014, http://www.wind-works.org/cms/index.php?id=39&tx_ttnews%5Btt_news%5D=3037&cHash=8bc2af003adf136ba300d53af143dacc.

43 Ocean Energy Systems, "Ireland's 1 Million Square Kilometers of Potential Ocean Energy," press release (Lisbon: February 2014), at http://www.ocean-energy-systems.org/news/irish_offshore_renewable_energy_development_plan/.

44 Peter Bennett, "DECC extends FiT funding for community projects up to 10 MW," Solar Power Portal, 3 July 2013, http://www.solarpowerportal.co.uk/news/decc_extends_fit_funding_for_community_projects_up_to_10mw_2356.

45 Xie Yu, "New policy boosts construction of solar plants," *China Daily*, 13 November 2013, http://www.chinadaily.com.cn/

business/2013-09/13/content_16968866.htm.

46 Christopher Dent, University of Leeds, personal communication with REN21, 2 April 2014.

47 Yuka Obayashi and James Topham, "Japan Lifts Offshore Wind Tariff, Cuts Solar Prices," *Reuters*, 25 March 2014, http://www.reuters.com/article/2014/03/25/japan-renewables-subsidies-idUSL4N0MM23520140325.

48 Thailand's new rooftop solar PV FIT set rates at USD 0.21/kWh (THB 6.96/kWh) for systems under 10kW, USD 0.20/kWh (THB 6.56/kWh) for systems of 10–450 kW, and USD 0.19/kWh (THB 6.16/kWh) for systems of 450 kW¬–1 MW, per Thailand Energy Regulatory Commission, "The purchase of electricity from solar power installed on the roof," http://www.erc.or.th/ERCWeb2/Front/StaticPage/StaticPage.aspx?p=200&Tag=SolarRooftop; Government of Spain, "Boletin Oficial Del Estado," December 2012, http://www.boe.es/boe/dias/2012/12/28/pdfs/BOE-A-2012-15649.pdf; Thailand's revised community solar FIT scheme set rates at THB 9.75/kWh for years 1–3, THB 6.5/kWh for years 4–10, and THB 4.5/kWh for years 11–25, per Government of Thailand, *Joint Committee on the National Energy Policy: No. 2/2556*, 16 July 2013, http://www.eppo.go.th/nepc/kpc/kpc-145.html#7.

49 Algeria's FIT provides payment only for a set number of hours per year. After the cap is reached, electricity can be sold at market rates. Minister de l'Energie et des Mines, *Journal Officiel de la Republique Algerienne N23*, 23 April 2014, http://www.joradp.dz/FTP/jo-francais/2014/F2014023.pdf; new rates in South Africa are set at USD 0.16/kWh (ZAR 1.65/kWh) off-peak with peak rates of USD 0.38/kWh (ZAR 3.96/kWh), per Max Crompton, CSP Today, personal communication with REN21, 1 August 2013.

50 Uganda's FIT programme includes the introduction of a Premium Payment Mechanism, a Guarantee Facility, and a Private Finance Mechanism, per Tildy Bayar, "Uganda Launches Innovative Feed-in Tariff Program," *Renewable Energy World,* 2 July 2013, http://www.renewableenergyworld.com/rea/news/article/2013/07/uganda-launches-innovative-feed-in-tariff-programme?cmpid=WNL-Wednesday-July3-2013; Get FiT Uganda, "About GET FiT," http://www.getfit-uganda.org/information-for-developers/get-fit-solar-pv-component/.

51 FIT support is now guaranteed at a base rate of USD 0.133/kWh, ranging up to USD 0.20/kWh for solar PV and USD 0.225/kWh for CSP, per David Appleyard, "Solar Power Surges on Turkish Policy Backing," *Renewable Energy World*, 18 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/solar-power-surges-on-turkish-policy-backing?cmpid=SolarNL-Thursday-September19-2013.

52 Graham Armstrong, *Renewable Energy in Australia: The Renewable Energy Target (RET), Feed-in-Tariffs (FITs), Green Power, Solar Hot Water-Heat Pumps and Some International Trends*, Saturn Corporate Resources Pty Ltd., 26 June 2013.

53 Tildy Bayar, "Western Australia Backs Down on Solar Feed-in Tariff Cut," *Renewable Energy World*, 12 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/western-australia-backs-down-on-solar-feed-in-tariff-cut; "Feed-in Tariff table," op. cit. note 32.

54 Nova Scotia Department of Energy, *Developmental Tidal Feed-in Tariff Program*, 21 August 2013, http://www.novascotia.ca/energy/publications/Developmental-Tidal-Feed-in-Tariff-Program-Discussion-Paper.pdf; Ontario Power Authority, "Changes to Domestic Content and New FIT/microFIT Price Schedule," 16 August 2013, http://fit.powerauthority.on.ca/newsroom/august-16-2013-program-update; GTM Research, *PV News*, January 2014; Lucy Woods, "Ontario eliminates renewables' domestic content requirement," PV Tech, 13 December 2013, http://www.pv-tech.org/news/ontario_eliminates_renewables_domestic_content_requirement.

55 Ontario Power Authority, "FIT/microFIT Schedule Changes," http://fit.powerauthority.on.ca/sites/default/files/news/2013-FIT-Price-Comparison-Table.pdf.

56 Paul Gipe, "Two Steps Forward, One Back: Ontario Cancels Feed-in Tariffs for Large Projects," *Renewable Energy World*, 10 June 2013, http://www.renewableenergyworld.com/rea/news/article/2013/06/two-steps-forward-one-back-ontario-cancels-feed-in-tariffs-for-large-projects.

57 Natalie Obiko Pearson, "India Rejects Petition for Retroactive Solar Tariff Cut," *Renewable Energy World*, 19 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/india-rejects-petition-for-retroactive-solar-tariff-cut.

58 Small-scale distributed generation is differentiated by technology: solar, 50–500 kW; wind, 50 kW–1.5 MW; other technologies may not exceed 1 MW, per State of Rhode Island, "2013-H 5803 Substitute A: An Act Relating to Public Utilities and Carriers-Distributed Generation Standard Contracts," 28 February 2013, http://webserver.rilin.state.ri.us/BillText/BillText13/HouseText13/H5803A.pdf.

59 BNEF, *Energy Week in Review*, 23–29 April 2013; DSIRE USA Database. *Renewable Portfolio Standard Policies*. March 2013, http://www.dsireusa.org/documents/summarymaps/RPS_map.pdf.

60 BNEF, op. cit. note 59; DSIRE USA, op. cit. note 59.

61 Michael Puttre, "California's New 600 MW Renewables Law Targets Distributed Solar, Low-Income Areas," *Solar Industry*, 10 October 2013, http://www.solarindustrymag.com/e107_plugins/content/content.php?content.13321; Jeff Postelwait, "California Energy Bill Passes, Awaits Gov. Brown's Signature," *Renewable Energy World*, 12 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/california-energy-bill-passes-awaits-gov-browns-signature.

62 Solar PV and Solar Thermal Electric are listed as qualifying solar technologies for the RPS mandate, per DSIRE USA, "Minnesota: Renewables Portfolio Standard," 4 June 2013, http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=MN14R&re=0&ee=0.

63 DSIRE USA, "Colorado: Renewable Energy Standard," 25 June 2013, http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=CO24R&re=0&ee=0.

64 In addition to phasing out the Renewables Obligation, the Energy Act in the U.K. also revised financial incentives for renewables, changing support for a fixed certificate to rates based on a guaranteed strike price for renewables. GWEC, op. cit. note 12.

65 India Solar Market, "Is Solar in Tamil Nadu back?" Bridge to India, 11 February 2014, http://indiasolarmarket.com/2014/02/solar-tamil-nadu-back/.

66 Greece from Eclareon, "Monthly Progress Update: Part of the project "Assessment of climate change policies in the context of the EU Semester" (Brussels: European Commission, 5 November 2013), http://ec.europa.eu/clima/policies/g-gas/progress/docs/progress_201310_en.pdf; Latvia Ministry of Economics, "Households green energy production made more accessible, easier and simpler," press release (Riga: 10 October 2013), http://www.em.gov.lv/em/2nd/?lng=lv&id=33544&cat=621; Ukraine from GTM Research, *PV News*, November 2013.

67 Republic of Honduras, *Decreto No. 138-2013*, 1 August 2013, http://www.tsc.gob.hn/leyes/Ref_art_2_ley_promocion_energia_electrica_2013.pdf.

68 Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), *Net-Metering Reference Guide* (Bonn: November 2013), http://www.giz.de/fachexpertise/downloads/giz2013-en-net-metering-reference-guide-philippines.pdf.

69 Denmark from IEA Photovoltaic Power Systems Programme, *Trends in 2013 in Photovoltaic Applications* (Paris: 2013); Netherlands from Ecologic, *Assessment of climate change policies in the context of the European Semester* (Brussels: European Commission, June 2013), http://ec.europa.eu/clima/policies/g-gas/progress/docs/nl_2013_en.pdf.

70 Edgar Meza, "India: Andhra Pradesh introduces net metering for rooftop plants," *PV Magazine*, 26 August 2013, http://www.pv-magazine.com/news/details/beitrag/india--andhra-pradesh-introduces-net-metering-for-rooftop-plants_100012497/#ixzz2lPaJJ40; Avinash Nair, "New net-metering policy to power Gujarat's solar-rooftops," *Financial Express*, 25 January 2014, http://www.financialexpress.com/news/new-netmetering-policy-to-power-gujarats-solarrooftops/1220714.

71 Bridge to India, "India Solar Weekly Market Update," 30 August 2013.

72 GTM Research, op. cit. note 54.

73 New net metering provisions were adopted with the passage of AB 327. The bill also included provisions changing the state's electricity rate design system, per Jeff St. John, "AB 327: From California Solar Killer to Net Metering Savior?" GreenTech Media, 3 September 2013, http://www.greentechmedia.com/articles/read/ab-327-from-california-solar-killer-to-net-metering-savior.

74 State of New York, *Improvements Made to Renewable Energy Program*, 13 June 2013, http://www3.dps.ny.gov/pscweb/WebFileRoom.nsf/Web/

EC38C89DDE53F42085257B6D005A9133/$File/pr13029.pdf?OpenElement; Anne Galloway, "Vermont House passes net metering bill on voice vote; raises cap to 15%," *Bennington Banner*, 1 February 2014, http://www.benningtonbanner.com/localnews/ci_25039149/vermont-house-passes-net-metering-bill-voice-vote.

75 James Montgomery, "Mixed Results: Arizona Keeps Net Metering, But Levies Smaller Solar Fee," *Renewable Energy World*, 15 November 2013, http://www.renewableenergyworld.com/rea/news/article/2013/11/mixed-result-arizona-keeps-net-metering-but-levies-smaller-solar-fee?cmpid=SolarNL-Saturday-November16-2013; GTM Research, op. cit. note 66.

76 International Renewable Energy Agency (IRENA), *Renewable Energy Auctions in Developing Countries* (Abu Dhabi: 2013).

77 Mario Sergio Lima, "Brazil Energy Auction Sells 2.3 Gigawatts of Wind-Power Projects," *Bloomberg*, 13 December 2013, http://www.bloomberg.com/news/2013-12-13/brazil-energy-auction-sells-2-3-gigawatts-of-wind-power-projects.html; GTM Research, *PV News*, October 2013; Steve Sawyer, GWEC, personal communication with REN21, 28 August 2013; Adam James, "Brazilian State Auction Clears 12 Megawatts of Solar PV," GreenTech Media, 2 January 2014, http://www.greentechmedia.com/articles/read/Brazilian-State-Auction-Clears-122-Megawatts-of-Solar-PV; Stephan Nielsen, "Brazil Gives Fossil Fuels Advantage Over Wind in Power Auction," *Bloomberg*, 12 November 2013, http://www.bloomberg.com/news/2013-11-12/brazil-gives-fossil-fuels-advantage-over-wind-in-power-auction.html.

78 Chile from Jenny Muirhead, "Weekly Intelligence Brief: October 14–21," CSP Today, 21 October 2013, http://social.csptoday.com/print/29790?utm_source=http%3A%2F%2Fuk.csptoday.com%2Ffc_csp_pvlz%2F&utm_medium=email&utm_campaign=CSP%20ebrief%2021-10-13%20en&utm_term=Who%20are%20the%20leading%20CSP%20companies%20in%202013%3F&utm_content=125566; Ecuador from Alejandro Lobo-Guerrero Rodriguez, juwi Energías Renovables de Chile Ltda., personal communication with REN21, 18 October 2013; Peru from GTM Research, op. cit. note 77; BNEF, *Energy Week in Review*, 23–29 April 2013; Stephan Bielsen, "Uruguay Taking Bids on First Big Solar Farms Using Wind Development Strategy," *Renewable Energy World*, 4 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/uruguay-taking-bids-on-first-big-solar-farms-using-wind-development-strategy?cmpid=WNL-Friday-September6-2013.

79 GTM Research, *PV News*, September 2013.

80 Muriel Boselli and Marion Douet, "France to launch tender for pilot marine projects," *Reuters*, 18 September 2013, http://planetark.org/wen/69801; Tara Patel, "France Double Solar Energy Target, Seeks to Promote European Equipment," *Renewable Energy World*, 8 January 2013, http://www.renewableenergyworld.com/rea/news/article/2013/01/france-doubles-solar-energy-target-seeks-to-promote-european-equipment.

81 Heather O'Brian, "Italy assigns feed in tariff to 400MW," *Wind Power Monthly*, 2 August 2013, http://www.windpowermonthly.com/article/1193937/italy-assigns-feed-tariff-400mw; Mikael Holter, "Norway Approves $3 Billion for Wind Power Plants to Triple Capacity," *Renewable Energy World*, 26 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/norway-approves-3-billion-for-wind-power-plants-to-triple-capacity.

82 Marc Roca, "Russia Awards First Renewable Energy Tender to Boost the Industry," *Renewable Energy World*, 26 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/russia-awards-first-renewable-energy-tender-to-boost-the-industry?cmpid=WNL-Friday-September27-2013.

83 Solar Server, "Russia to introduce bidding program for 1.2 GW of PV by 2020," Solar Plaza, 10 June 2013, http://www.solarplaza.com/news/russia-to-introduce-bidding-program-for-12-gw-of-p.

84 Alex Morales, "UK Solar, Wind to Compete Head-to-Head With Solar Under Auction Plans," *Renewable Energy World*, 17 January 2014, http://www.renewableenergyworld.com/rea/news/article/2014/01/u-k-solar-wind-to-compete-head-to-head-with-solar-under-auction-plans?cmpid=SolarNL-Friday-January17-2014.

85 Egypt from GTM Research, *PV News*, June 2013; South Africa from Jenny Muirhead, "Weekly Intelligence Brief: September 20–October 7," CSP Today, 7 October 2013, http://social.csptoday.com/print/29768?utm_source=http%3A%2F%2Fuk.csptoday.com%2Ffc_csp_pvlz%2F&utm_medium=email&utm_campaign=CSP%20Ebrief%2007-10-13%20en&utm_term=Using%20CSP%20to%20purify%20water&utm_content=125566.

86 Muirhead, op. cit. note 85.

87 GTM Research, *PV News*, June 2013; Lucy Woods, "India delays solar auction for second time," PV Tech, 6 January 2014, http://www.pv-tech.org/news/india_delays_solar_tender_bid_for_second_time.

88 "Asia Report: What's Driving, and Hampering, India's Wind Market Momentum," *Renewable Energy World*, 5 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/asia-report-whats-driving-and-hampering-indias-wind-market-momentum-1.

89 Offshore wind licences were awarded in an auction held by the Department of Interior (DOI) and Bureau of Ocean Energy Management (BOEM) for USD 3.8 billion. There have since been additional licences granted. James Montgomery, "First US Offshore Wind Leases Go to Deepwater," *Renewable Energy World*, 1 August 2013, http://www.renewableenergyworld.com/rea/news/article/2013/08/first-us-offshore-wind-leases-go-to-deepwater.

90 Debjoy Sengupta, "Government extends generation based incentive scheme for wind power," *Economic Times*, 5 September 2013, http://articles.economictimes.indiatimes.com/2013-09-05/news/41802395_1_wind-power-generation-based-incentive-merchant-power-plants.

91 China from Frank Haugwitz, "Ministry of Finance announced that manufacturers are subject to 50% VAT rebate," Briefing Paper-China Solar PV Development, Asia Europe Clean Energy (Solar) Advisory Co. Ltd (ACEA), September 2013, p. 2, and from Hydroworld, "China announces new policy to encourage hydroelectric power development," 22 January 2014, www.hydroworld.com/content/hydro/en/articles/2014/01/china-announces-new-policy-to-encourage-hydroelectric-power-development.html; Iran from IEA/IRENA Policies and Measures Database, "Renewable Energy Development Fund," 12 November 2013, http://www.iea.org/policiesandmeasures/renewableenergy.

92 Danish Ministry of Energy, "How energy-intensive companies to help you go green," 1 July 2013, http://www.ens.dk/info/nyheder/nyhedsarkiv/saadan-kan-energitunge-virksomheder-faa-hjaelp-groenne.

93 Ocean Energy Systems, op. cit. note 43.

94 BNEF, *Energy: Week in Review*, 2–8 July 2013.

95 Kiley Kroh, "New York Governor Announces $1 Billion for Solar Energy," Think Progress, 9 January 2014, http://thinkprogress.org/climate/2014/01/09/3139091/cuomo-big-solar/.

96 France from TECSOL, "Fin du credit d'impot pour le photovotaique, maintien pour le chauffe-eau solaire," 22 September 2013, http://tecsol.blogs.com/mon_weblog/2013/09/fin-du-cr%C3%A9dit-dimp%C3%B4t-pour-le-photovolta%C3%AFque-maintien-pour-le-chauffe-eau-solaire.html; United States from DSIRE USA Database, "Federal Electricity Production Tax Credit (PTC)," 2 October 2013, http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F.

97 Novinte, "Bulgaria MPs OK 20% Renewable Energy Tax, Defy Protests," 5 December 2013, http://www.novinite.com/view_news.php?id=156142; Ilias Tsagas, "Czech Republic ends FIT program, extends solar tax," *PV Magazine*, 16 September 2013, http://www.pv-magazine.com/news/details/beitrag/czech-republic-ends-fit-program--extends-solar-tax-_100012748/#axzz2nwMg7Z3c; Sarah Azau, "Wind Energy Sector Faces Uncertainty Crisis," *Wind Directions*, April 2013, p. 19.

98 GTM Research, PV News, March 2014; FS-UNEP and BNEF, *Global Trends in Renewable Energy Investment 2014* (Frankfurt: 2014).

99 **Sidebar 7** from the following sources: "disruptive" technologies that are emerging and may compete with utility-provided services include solar PV, battery storage, fuel cells, geothermal energy systems, wind power, micro-turbines, and electric vehicle-enhanced storage, per Edison Electric Institute (EEI), *Disruptive Challenges: Financial Implications and Strategic Responses to a Changing Retail Electric Business* (Washington, DC: January 2013), http://www.eei.org/ourissues/finance/documents/disruptivechallenges.pdf; this is particularly true in developed countries where such business models are deeply entrenched,

per International Energy Agency (IEA) *Lessons from Liberalised Electricity Markets* (Paris: Organisation for Economic Co-operation and Development/ IEA, 2005), http://www.iea.org/publications/freepublications/publication/LessonsNet.pdf, "How to Lose Half a Trillion Euros," *The Economist*, October 2013, http://www.economist.com/news/briefing/21587782-europes-electricity-providers-face-existential-threat-how-lose-half-trillion-euros?frsc=dg%7Cb, and U.S. Electric Power Research Institute, *The Integrated Grid: Realizing the Full Value of Central and Distributed Energy Resources* (Palo Alto, CA: February 2014). http://www.eei.org/ourissues/finance/documents/disruptivechallenges.pdf; reduced load on transmission and distribution networks from Scott Sklar, Stella Group, Ltd., personal communication with REN21, 24 April 2014, and from Rocky Mountain Institute, *A Review of Solar PV Benefit and Cost Studies* (Boulder, CO: April 2013), http://www.rmi.org/Content/Files/eLab-DER_cost_value_Deck_130722.pdf; challenges facing utilities from "How to Lose Half a Trillion Euros," op. cit. this note, and from EEI, op. cit. this note; European utility losses from "How to Lose Half a Trillion Euros," op. cit. this note; Citi Research, "Rising Sun: Implications for US Utilities" (New York: August 2013); Rainer Hinrichs-Rahlwes, German Renewable Energies Federation (BEE), personal communication with REN21, 12 January 2014; Ross McCracken, "Energy Economist: Tough Times for European Utilities May Have a Lesson for the US," Platts, 22 November 2013, http://blogs.platts.com/2013/11/22/ee-nov13/?sf1076174=1; Amory Lovins, "Don't Cry for the Electric Utilities," GreenBiz.com, 12 February 2014, http://www.greenbiz.com/blog/2014/02/12/dont-lament-renewables-disruption-electric-utilities?page=full; Giles Parkinson, "Australian Utilities Erect Barricades in Bid to Halt Solar Storm," *Renew Economy*, 23 October 2013, http://reneweconomy.com.au/2013/australian-utilities-erect-barricades-in-bid-to-halt-solar-storm-91715; pushback in Europe from Hinrichs-Rahlwes, op. cit. this note; Marc Gunther, "With Rooftop Solar on Rise, U.S. Utilities Are Striking Back," *Yale Environment360*, 3 September 2013, http://e360.yale.edu/feature/with_rooftop_solar_on_rise_us_utilities_are_striking_back/2687/; shift in electricity models and 3 million households from EURELECTRIC, *Utilities: Powerhouses of Innovation* (Brussels: May 2013), p. 9, http://www.eurelectric.org/media/79178/utilties_powerhouse_of_innovation_full_report_final-2013-104-0001-01-e.pdf; Germany from German Chamber of Commerce and Industry, cited in Jan Hromadko, "German Companies Take Back the Power," *Wall Street Journal*, 2 March 2014, http://online.wsj.com/news/articles/SB10001424052702304899704579390871434033460?mg=reno64-wsj&url; Germany's RWE has begun developing utility-scale PV projects, and E.ON's subsidiaries started commercial operation for rooftop PV customers in 2013; EDF (France) is investing in solar PV, and Enel Green Power (Italy) has been developing renewable power projects internationally while cooperating with technology companies on the production of amorphous silicon PV modules, all from IEA-Photovoltaic Power Systems Programme (IEA-PVPS), *Trends in Photovoltaic Applications 2013: Survey Report of Selected IEA Countries Between 1992 and 2012* (Paris: 2013), p. 72; global survey from Katherine Tweed, "40 Percent of Utilities Predict 'Complete Transformation' by 2030," Green Tech Media, 8 October 2013, http://www.greentechmedia.com/articles/read/40-Percent-of-Utilities-Predict-Complete-Transformation-by-2030; EnBW quote from Stephen Lacey, "This Is What the Utility Death Spiral Looks Like," The Energy Collective, 6 March 2014, http://theenergycollective.com/stephenlacey/349671/what-utility-death-spiral-looks; incresed investment in renewables from "How to Lose Half a Trillion Euros," op. cit. this note, and from Gunther, op. cit. this note; share of utility investments in Europe from EURELECTRIC, op. cit. this note; Sumit Moitra, "Coal India Gets Into Solar Power," DNA India, 27 May 2013, http://www.dnaindia.com/money/report-coal-india-gets-into-solar-power-1839903; examples of downstream activities include trading, and providing energy advice, from "How to Lose Half a Trillion Euros," op. cit. this note, and from Gunther, op. cit. this note; Duke Energy and Edison International have invested in Clean Power Finance, a San Francisco-based firm that has raised half a billion dollars to finance solar projects. Also, NRG Energy (New Jersey) created a rooftop solar unit to sell systems to businesses and, eventually, homeowners, per Gunther, op. cit. this note. In addition, through its Solar Loan Programme (established in 2008), PSE&G of New Jersey has provided loans to more than 1,000 residential and commercial customers to help finance solar projects on their sites. The next phase of the programme, launched in 2013, will support the financing of 97.5 MW of distributed solar built on landfills and brownfields, and also residential and commercial buildings, per Nora Caley, "Some Utilities Embrace DG Solar," *Solar Industry Magazine*, February 2014, http://www.solarindustrymag.com/issues/SI1402/DEPT_New%20%26%20Noteworthy.html; shift to service-based model from "Electricity Utilities Must Evolve or Die: Are They Up To the Task?" 19 August 2013, http://theenergycollective.com/jessejenkins/261506/electricity-utilities-must-evolve-or-die, and from EURELECTRIC, op. cit. this note; RWE and EnBW from Lacey, op. cit. this note, from Diarmaid Williams, "Major European Utility Set for Dramatic Renewable Energy Transformation," RenewableEnergyWorld.com, 31 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/major-european-utility-set-for-dramatic-transformation?cmpid=SolarNL-Saturday-November2-2013, and from "Green Makeover Will Be Struggle for Germany's RWE," *Reuters*, 1 November 2013, http://planetark.org/wen/70238; hybrid model from Bianca Barth, Bundesverband Solarwirtschaft e.V., personal communication with REN21, 23 April 2014; need for policy framework from EURELECTRIC, op. cit. this note, p. 49; design reforms from GTM Research, *Grid Edge: Utility Modernization in the Age of Distributed Generation* (Boston: October 2013); U.K. pricing scheme from Australian Government, Department of Industry, *Energy White Paper 2014*, 7 February 2014, http://ewp.industry.gov.au/sites/ewp.industry.gov.au/files/CCCLM%20Energy%20White%20Paper%20-%20Issues%20Paper%20070214.pdf; California from Sklar, op. cit. this note; capacity markets and new market designs from Felix Matthes, et al, "Focused Capacity Markets: A New Market Design for the Transition to a New Energy System," short version of the study for the WWF Germany Environmental Foundation, 8 October 2012, http://www.wwf.de/fileadmin/fm-wwf/Publikationen-PDF/focused_capacity_market_ENG_short.pdf, from Freyr Sverrisson, Sunna Research, personal communication with REN21, 28 April 2014, from Craig Morris, "Has the Age of Capacity Markets Only Just Begun?" Energy Transition, 29 May 2013, http://energytransition.de/2013/05/the-age-of-capacity-markets/, and from EURELECTRIC, op. cit. this note.

100 Ann Koh and Winnie Zhu, "Singapore Plans to Regulate Power Futures to Prevent Speculation," *Bloomberg Businessweek*, 28 October 2013, http://www.businessweek.com/news/2013-10-28/singapore-plans-to-regulate-power-futures-to-prevent-speculation; Feng Zengkun and Grace Chua, "The Straits Times: Plan to boost solar power without destabilizing grid," Singapore National Climate Change Secretariat, 29 October 2013, http://app.nccs.gov.sg/(X(1)S(150a3o45ym3sv1n3rifuj5bi))/news_details.aspx?nid=1101&AspxAutoDetectCookieSupport=1 .

101 "China Encourages Utility Purchase of Solar to Boos Manufacturing Capacity," *Renewable Energy World*, 11 December 2013, http://www.renewableenergyworld.com/rea/news/article/2013/12/china-encourages-utility-purchase-of-solar-to-boost-manufacturing-capacity?cmpid=SolarNL-Thursday-December12-2013.

102 GWEC, op. cit. note 12.

103 Jennifer Runyon, "Spurred by Japan, Steady Growth Predicted for Energy Storage Market," *Renewable Energy World*, 19 March 2014, http://www.renewableenergyworld.com/rea/news/article/2014/03/spurred-by-japan-steady-growth-predicted-energy-storage-market.

104 James Montgomery, "Energy Storage Roundup: Ontario and California, Imergy, Stem, Hitachi," *Renewable Energy World*, 5 December 2013, http://www.renewableenergyworld.com/rea/news/article/2013/12/energy-storage-roundup-ontario-and-california-imergy-stem-hitachi.

105 Photon, "Puerto Rico's energy regulator signs final PPAs for six large-scale PV projects," 23 January 2014, http://www.photon.info/photon_news_detail_en.photon?id=83685; 25X25, "California Finalizes Major Rule to Mandate Energy Storage, Boosting Renewables," in Weekly REsource for 18 October 2013, http://www.25x25.org/index.php?option=com_content&task=view&id=1188&Itemid=246.

106 Jeff St. John, "Massachusetts Makes Smart Grid Mandatory," GreenTech Media, 31 December 2013, http://www.greentechmedia.com/articles/read/massachusetts-makes-smart-grid-mandatory.

107 Jenny Muirhead, "Weekly Intelligence Brief: October 14-21," CSP Today, 21 October 2013, http://social.csptoday.com/print/29790.

108 GWEC, op. cit. note 12.

109 "President Obama Signs Groundbreaking Legislation to Expand U.S. Hydropower Production," GreenTech Media, 12 August

2013, http://www.greentechmedia.com/industry/read/president-obama-signs-groundbreaking-legislation-to-expand-u-301773.

110 U.S. Federal Energy Regulatory Commission, *Small Generator Interconnection Agreements and Procedures* (Washington, DC: 22 November 2013), https://www.ferc.gov/whats-new/comm-meet/2013/112113/E-1.pdf.

111 Bridge to India, "India Solar Weekly Market Update," 24 March 2014.

112 IEA, "Solar energy could meet one-sixth of global demand for heating and cooling in under 40 years," 9 July 2012, http://www.iea.org/newsroomandevents/news/2012/july/name,28298,en.html.

113 Table 3 and REN21, *Renewables 2005…*, op. cit. note 1.

114 Bärbel Epp, "Albania: New Energy Law Shows Country's Strong Commitment to Solar Thermal," Solar Thermal World, 25 June 2013, http://solarthermalworld.org/content/albania-new-energy-law-shows-countrys-strong-commitment-solar-thermal.

115 Interim Standard AS 5389 (Int): *Solar heating and cooling systems-Calculation of energy consumption,* per Tildy Bayer, "Australia Leads with Solar Cooling Standard," *Renewable Energy World*, 9 September 2013, http://www.renewableenergyworld.com/rea/news/article/2013/09/australian-solar-cooling-standard-published?cmpid=SolarNL.

116 **Sidebar 8** from the following sources: USD 544 billion from IEA, *World Energy Outlook 2013* (Paris: IEA/OECD, 2013). Note that, according to the IMF, subsidies are USD 1.9 trillion if considering total post-tax subsidies, from International Monetary Fund (IMF),"Reforming Energy Subsidies Summary Note," 2013, http://www.imf.org/external/np/fad/subsidies/pdf/note.pdf.; "primary fuel" from IEA, *Energy Efficiency Market Report 2013* (Paris: IEA/OECD, 2013); co-benefits from IEA, *Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements* (Paris: 2012); global primary energy intensity saw an average annual decrease of around 1.5% between 2011 and 2012, per IEA, *World Energy Outlook 2013*, op. cit. this note, p. 234; 7% reduction in primary energy demand, or 1,260 Mtoe in absolute terms, from IEA New Policies Scenario (the business-as-usual scenario is IEA's Current Policies Scenario), per IEA, *World Energy Outlook 2013*, op. cit. this note; greatest unrealised potential from IEA, *Energy Efficiency Market Report 2013*, op. cit. this note; high rates of urbanisation and construction from McKinsey Global Institute, *Urban World: Cities and the Rise of the Consuming Class* (London: 2012); 70% of Indian building stock from S. Kumar et al., "Developing an Energy Conservation Building Code Implementation Strategy in India," 2010 ACEEE Summer Study on Energy Efficiency in Buildings, unpublished manuscript, May 2010; Chinese policies from Frank Haugwitz, "Briefing Paper – China Solar PV Development" (Beijing: Asia Europe Clean Energy (Solar) Advisory Co. Ltd., September 2013); India's Building Code is now mandatory in eight of the 28 Indian states, and indicates that solar water heating systems should be planned to meet at least 20% of expected demand, per IEA, *World Energy Outlook 2013*, op. cit. this note, and Indian Ministry of Power, "Energy Conservation Building Code 2007" (New Delhi: 2007); Australian Government Department of Industry, "Local Government Energy Efficiency Program," http://ee.ret.gov.au/node/2121, viewed 5 February 2014; REEEP and GBPN initiative from REEEP, "Interventions," www.reeep.org/interventions, viewed 17 December 2013, and from M. Hiller et al., "1 Billion m^2 of Positive Energy Buildings – A REEEP and GBPN Intervention," unpublished manuscript (Vienna: REEEP, 6 May 2013) (as an example of other ongoing initiatives, UNEP is implementing Development of Nationally Appropriate Mitigation Actions (NAMAs) for the Building Sector in Asia, a four-year project under the International Climate Initiative funded by the German Federal Ministry of Environment, Nature Conservation and Nuclear Safety (BMU). The project will help Indonesia, the Philippines, Thailand, and Vietnam identify policies or projects to increase energy efficiency and/or incorporate renewable technologies to reduce greenhouse gas emissions from the building sector, and incorporate them into NAMAs and national climate and development strategies); IPEEC, "Building Energy Rating Schemes: Assessing Issues and Impacts," forthcoming March 2014; LEED (Leadership in Energy and Environmental Design) from Marisa Long, "LEED v4, the Newest Version of LEED Green Building Program Launches at USGBC's Annual Greenbuild Conference," 20 November 2013, at www.usgbc.org; Australia's Green Star rating system, launched in 2003, from Green Building Council of Australia, "Green Star Project Directory," www.gbca.org.au/project-directory.asp, viewed 5 February 2014; Green Building Council South Africa, "Escalation of Green Star SA ratings in month of June," 3 July 2013, at www.gbcsa.org.za.

117 Robert Schachtschneider, "Heating& Cooling Promotion in Netherlands," RES Legal, 12 November 2013, http://www.res-legal.eu/search-by-country/netherlands/tools-list/c/netherlands/s/res-hc/t/promotion/sum/172/lpid/171/page.pdf?out=pdf; U.K. from Diarmaid Williams, "Amended Renewable Heat Incentive regulations published," *Cogeneration & On-Site Power Production*, 13 May 2013, http://www.cospp.com/articles/2013/05/amended-renewable-heat-incentive-regulations-published0.html.

118 EurObserv'ER, *Solar Thermal and Concentrated Solar Power Barometer* (Paris: May 2013).

119 Incentives are provided through the Fund for Renewable Energy and Energy Saving, per Bärbel Epp, "Cyprus: Grants Scheme for Solar Cooling Systems," Solar Thermal World, 27 February 2013, http://solarthermalworld.org/content/cyprus-grants-scheme-solar-cooling-systems.

120 Bärbel Epp, "Czech Republic: New Green Savings Programme Gets Off on the Wrong Foot," Solar Thermal World, 30 August 2013, http://solarthermalworld.org/content/czech-republic-new-green-savings-programme-gets-wrong-foot.

121 Frank Stier, "Germany: Additional Support for Small Solar Cooling Systems," Solar Thermal World, 3 February 2014, http://solarthermalworld.org/content/germany-additional-support-small-solar-cooling-systems.

122 GSE, "Heating and Cooling," http://www.gse.it/en/Heating_Cooling/Pages/default.aspx.

123 Portail de l'énergie en Wallonie, "Amélioration de la performance énergétique des bâtiments," 28 March 2013, http://energie.wallonie.be/nl/amelioration-de-la-performance-energetique-des-batiments.html?IDC=6431&IDD=83066.

124 Australian Government Department of Industry, "Local Government Energy Efficiency Program," http://www.ee.ret.gov.au/energy-efficiency/grants/local-government-energy-efficiency-program; Bärbel Epp, "India: Rebate Programme for 400,000m^2 in public, social and industrial sector," Solar Thermal World, 17 March 2014, http://solarthermalworld.org/content/india-rebate-programme-400000-m2-public-social-and-industrial-sector; Bärbel Epp, "Puerto Rico: New Solar Thermal Programme to Benefit Low-Income Families," Solar Thermal World, 16 April 2014, http://solarthermalworld.org/content/puerto-rico-new-solar-thermal-programme-benefit-low-income-families; Stephanie Banse, "Thailand: Ministry of Energy Extends Incentive Programme until 2021," Solar Thermal World, 2 February 2014, http://solarthermalworld.org/content/thailand-ministry-energy-extends-incentive-programme-until-2021.

125 Bärbel Epp, "South Africa: Planned Rollout with 650,000 Solar Water Heaters," Solar Thermal World, 4 September 2013, http://solarthermalworld.org/content/south-africa-planned-rollout-650000-solar-water-heaters.

126 South Africa Department of Energy, "Annual Performance Plan 2013–14," http://www.energy.gov.za/files/aboutus/DoE%20APP%202013-14.pdf.

127 U.K. from Eclareon, *Monthly Progress Update: Part of the project "Assessment of climate change policies in the context of the EU Semester"* (Brussels: European Commission, 5 November 2013), http://ec.europa.eu/clima/policies/g-gas/progress/docs/progress_201310_en.pdf; Flanders from Eclareon, *Monthly Progress Update: Part of the project "Assessment of climate change policies in the context of the EU Semester"* (Brussels: European Commission, 6 August 2013), http://ec.europa.eu/clima/policies/g-gas/progress/docs/progress_201307_en.pdf.

128 Bärbel Epp, "Spain: Most of these companies will survive thanks to internationalization," Solar Thermal World, 16 December 2013, http://solarthermalworld.org/content/spain-most-these-companies-will-survive-thanks-internationalisation.

129 Tunisia's incentives are offered under the country's PROSOL scheme, per Bärbel Epp, "Tunisia: Government Extends PROSOL Support Scheme," Solar Thermal World, 19 March 2013, http://solarthermalworld.org/content/tunisia-government-extends-prosol-support-scheme; Bärbel Epp, "Tunisia Funds Solar Process Heat," Solar Thermal World, 7 October 2013, http://solarthermalworld.org/content/tunisia-funds-solar-process-heat.

130 Bärbel Epp, "Chile: So Far No Government Compromise on Extending Tax Credits," Solar Thermal World, 8 July 2013, http://solarthermalworld.org/content/chile-so-far-no-government-compromise-extending-tax-credits; Bärbel Epp, "India: National Incentive Programme Reduces Grants," Solar Thermal

World, 30 June 2013, http://solarthermalworld.org/content/india-national-incentive-programme-reduces-grants.

131 "Ukraine aims to lift bioethanol output by 6-fold," *Xinhua*, 1 April 2013, http://news.xinhuanet.com/english/business/2013-04/01/c_132277395.htm; Meghan Sapp, "Ukraine set to supply 2014 E5 entirely from domestic production," Biofuels Digest, 30 October 2013, http://www.biofuelsdigest.com/bdigest/2013/10/30/ukraine-set-to-supply-2014-e5-entirely-from-domestic-production/; Meghan Sapp, "Ecuador to begin B5 blend in May," Biofuels Digest, 26 March 2013, http://www.biofuelsdigest.com/bdigest/2013/03/26/ecuador-to-begin-b5-blend-in-may/; Panama from Jim Lane, "Biofuels Mandates Around the World: 2014." Biofuels Digest, 31 December 2013, http://www.biofuelsdigest.com/bdigest/2013/12/31/biofuels-mandates-around-the-world-2014/.

132 Meghan Sapp, "India's ethanol mandate slowed down further by hitches at OMCs," Biofuels Digest, 3 October 2013, http://www.biofuelsdigest.com/bdigest/2013/10/03/indias-ethanol-mandate-slowed-down-further-by-hitches-at-omcs/; Esther Ng, "Analysis: Malaysia's expanded B5 biodiesel mandate too late for some producers," Platts, 21 August 2013, http://www.platts.com/latest-news/agriculture/singapore/analysis-malaysias-expanded-b5-biodiesel-mandate-26202623; Isabel Lane, "Philippines raises biofuel blend mandate to 5%," Biofuels Digest, 15 July 2013, http://www.biofuelsdigest.com/bdigest/2013/07/15/philippines-raises-biofuel-blend-mandate-to-5/; Meghan Sapp, "Philippines implementing long awaited E10 mandate on April 1," Biofuels Digest, 26 March 2013, http://www.biofuelsdigest.com/bdigest/2013/03/26/philippines-implementing-long-awaited-e10-mandate-on-april-1/.

133 Meghan Sapp, "Argentina to boost to B10 on June 1," Biofuels Digest, 17 April 2013, http://www.biofuelsdigest.com/bdigest/2013/04/17/argentina-to-boost-to-b10-on-june-1/; "Brazil to raise ethanol mix in gasoline to 25% from 20% May 1," Platts, 1 March 2013, http://www.platts.com/latest-news/oil/riodejaneiro/brazil-to-raise-ethanol-mix-in-gasoline-to-25-8194390; Stephan Nielsen and Mario Sergio Lima, "Brazil Government Weighs Mixing More Biodiesel with Diesel Fuel," *Bloomberg*, 30 October 2013, http://www.bloomberg.com/news/2013-10-30/brazil-government-weighs-mixing-more-biodiesel-with-diesel-fuel.html.

134 Meghan Sapp, "Zimbabwe heads for higher blends with E15 and sights on E20 for 2014," Biofuels Digest, 3 December 2013, http://www.biofuelsdigest.com/bdigest/2013/12/03/zimbabwe-heads-for-higher-blends-with-e15-and-sights-on-e20-for-2014/.

135 All Africa, "South Africa: Nation to Blend Biofuels From 2015," 1 October 2013, http://allafrica.com/stories/201310011284.html.

136 The reduction of the RFS comes in response to industry pressure and an Environmental Protection Agency warning over its feasibility with the current fuel mix. The EPA reported that the approaching "blend wall," the level at which the RFS could not be met by the current renewable fuel mix being used in the United States (predominantly E10), could necessitate reducing the current RFS target. Timothy Gardner, "In win for Big Oil, U.S. proposes biofuel mandate cut," *Reuters*, 18 November 2013, http://planetark.org/wen/70402; David Ripplinger, "What is the long-term impact of the RFS cut?" AG Week, 9 December 2013, http://www.agweek.com/event/article/id/22237/.

137 Jim Lane, "Florida repeals E10 ethanol mandate," Biofuels Digest, 3 June 2013, http://www.biofuelsdigest.com/bdigest/2013/06/03/florida-repeals-e10-ethanol-mandate/; Isabel Lane, "Maine approves ethanol blend ban," Biofuels Digest, 13 May 2013, http://www.biofuelsdigest.com/bdigest/2013/05/13/maine-approves-ethanol-blend-ban/.

138 Erin Voegele, "European Parliament votes to cap crop-based biofuels," *Ethanol Producer*, 11 September 2013, http://www.ethanolproducer.com/articles/10226/european-parliament-votes-to-cap-crop-based-biofuels.

139 "Updated 2-Brazil throws troubled ethanol industry tax breaks, credit," *Reuters*, 23 April 2013, http://uk.reuters.com/article/2013/04/23/brazil-ethanol-taxes-idUKL2N0DA1E320130423?rpc=401&feedType=RSS&feedName=mnaNewsFinancialServicesAndRealEstate&rpc=401.

140 Poland from Eclareon, *Monthly Progress Update: Part of the project "Assessment of climate change policies in the context of the EU Semester"* (Brussels: European Commission, 5 November 2013), http://ec.europa.eu/clima/policies/g-gas/progress/docs/progress_201310_en.pdf; Jim Lane, "US DOE invests $22M in algae biofuels accelerators," Biofuels Digest, 2 August 2013, http://www.biofuelsdigest.com/bdigest/2013/08/02/us-doe-invests-22m-in-algae-biofuels-accelerators/.

141 Judy Hua, "UPDATE 1-China levies consumption tax on biodiesel, kerosene imports," *Reuters*, 2 January 2014, http://www.reuters.com/article/2014/01/02/china-fuel-tax-idUSL3N0KC0MM20140102.

142 Colum Murphy, "China Hopes Cities Can Help Boost Electric Car Sales," *Wall Street Journal*, 27 October 2013, http://blogs.wsj.com/chinarealtime/2013/11/27/china-hopes-cities-can-help-boost-electric-car-sales/; India from Sharish Garud, The Energy and Resources Institute (TERI), personal communication with REN21, 25 January 2014; Romania from Eclareon, *Monthly Progress Update: Part of the project "Assessment of climate change policies in the context of the EU Semester"* (Brussels: European Commission, 5 November 2013), http://ec.europa.eu/clima/policies/g-gas/progress/docs/progress_201310_en.pdf; South Africa from Jonathan Skeen, REN21, personal communication with REN21, 1 January 2014; Government of the United Kingdom, "Guidance: Plugged-in Places," https://www.gov.uk/government/publications/plugged-in-places.

143 Jan Burck, Germanwatch, personal communication with REN21, 9 December 2013.

144 "State agencies get B4bn in solar panel assistance," *Bangkok Post*, 5 December 2013, http://www.bangkokpost.com/business/news/383269/state-agencies-get-b4bn-in-solar-panel-assistance.

145 GTM Research, *PV News*, January 2014.

146 For example, see Philipp Schönberger, *Municipalities as Key Actors of German Renewable Energy Governance: An Analysis of Opportunities, Obstacles, and Multi-Level Influences*, Wuppertal Paper No. 186 (Wuppertal, Germany: January 2013), http://epub.wupperinst.org/frontdoor/index/index/docId/4676; Gino Van Begin, "Look to cities for real climate action!" *Outreach Magazine*, http://www.stakeholderforum.org/sf/outreach/index.php/previous-editions/cop-19/198-cop-19-day-9-cities-urban-governance-and-transport/11626-look-to-cities-for-real-climate-action; World Future Council, "Going Global with 100% Renewable Energy," October 2013, http://power-to-the-people.net/2013/10/going-global-with-100-renewable-energy/.

147 Kuna, "India to develop 60 Solar Cities," https://www.kuna.net.kw/ArticleDetails.aspx?id=2350114&language=en.

148 Go 100% Renewable Energy, "Energy City Frederikshavn—100% Renewable Energy Goal: 100% Renewable Electricity, Heat and Transportation by 2015," interview with Poul Rask Nielsen, http://www.go100percent.org/cms/?id=109, viewed December 2013.

149 Go 100% Renewable Energy, "Latest News from North America," http://www.go100percent.org/cms/index.php?id=121, viewed January 2013.

150 World Future Council, *From Vision to Action: A Workshop Report on 100% Renewable Energies in European Regions* (Hamburg: March 2013), pp. 36–37, www.worldfuturecouncil.org/fileadmin/user_upload/Climate_and_Energy/From_Vision_to_Action_Policy_Recommendations_for_100__RE_in_European_Regions.pdf; U.S. National Renewable Energy Laboratory, "Clean Energy Policy Analyses: Analysis of the Status and Impact of Clean Energy Policies at the Local Level" (Golden, CO: December 2010), www.nrel.gov/tech_deployment/state_local_activities/status_impact.html.

151 The Climate Institute, "China launching two more carbon markets," November 2013, http://www.climateinstitute.org.au/articles/media-briefs/china-launching-two-more-carbon-markets.html; World Resources Institute, China FAQs, "Emissions Trading in China: First Reports from the Field," January 2014, http://www.chinafaqs.org/blog-posts/why-does-china-want-carbon-trading; Carnegie Endowment for International Peace, "A New Focus for U.S.-China Cooperation: Low-Carbon Cities," July 2013, http://carnegieendowment.org/2013/07/24/new-focus-for-u.s.-china-cooperation-low-carbon-cities/ggf3.

152 IEA, *Cities, Towns and Renewable Energy – YIMFY* (Paris: IEA/OECD, 2009), http://www.iea.org/publications/freepublications/publication/Cities2009-1.pdf.

153 "UK DECC announces £10 million fund for urban community energy," *AltEnergy Mag*, January 2014, http://www.altenergymag.com/news/2014/01/27/decc-announces-pound10-million-fund-for-urban-community-energy/32109.

154 Nick Harrison, "Is It Time to Devolve Climate Change Policy Making?" Responding to Climate Change, 2 September 2013, http://www.rtcc.org/2013/09/02/is-it-time-to-devolve-climate-change-policy-making/#sthash.WoxO7fvO.dpufLocal.

155 Ethekwini municipality was selected in 2013 to participate in the national pilot programme and to develop a "vertically integrated" national appropriate mitigation action (v-NAMA). Training webinars will be held in 2014 by GIZ and ICLEI to build capacity on V-NAMA development. "Ethekwini Municipality Hosts Energy Efficiency Workshop," Journalismlziko, April 2013, http://journalismiziko.dut.ac.za/current-affairs/ethekwini-municipality-hosts-energy-efficiency-workshop/.

156 IEA, op. cit. note 152.

157 See the Urban-LEDS project with UN-HABITAT and ICLEI as implementation partners, funded by the European Commission, www.urban-leds.org. The results will be shared with another 21 satellite cities, per Urban Low Emission Development Strategies (Urban LEDS), "Urban-LEDS Eight Model Cities Selected," 3 December 2013, http://urbanleds.iclei.org/index.php?id=127&tx_ttnews%5Btt_news%5D=5&cHash=b1d7fcc5dd6237bb96b8bd3fa88a9f95 http://www.iclei.org/en/details/article/iclei-leads-national-subnational-integration-in-low-emission-development.html.

158 Diane Moss, "100% Renewable Energy: Becoming the New Normal?" Clean Technica, 22 February 2013, http://cleantechnica.com/2013/02/22/100-renewable-energy-becoming-the-new-normal/.

159 City of London, "Local Plan & Community Infrastructure Levy, Infrastructure Delivery Plan," July 2013, http://www.cityoflondon.gov.uk/services/environment-and-planning/planning/planning-policy/local-development-framework/Documents/infrastructure-delivery-plan-july-2013.pdf.

160 EU Covenant of Mayors, "Signatories," www.covenantofmayors.eu/about/signatories_en.html, viewed January 2014.

161 "Obama plan offers help to U.S. cities on climate's front lines," *Reuters*, 26 June 2013, http://planetark.org/wen/69054.

162 "Asheville Next City That Has Voted to Go Beyond Coal," *Grist*, 27 October 2013, http://grist.org/article/asheville-votes-to-move-beyond-coal/.

163 "Thousands of German Cities and Villages Looking to Buy Back Their Power Grid," GreenTech Media, 11 October 2013," http://www.greentechmedia.com/articles/read/Thousands-of-German-Cities-and-Villages-Looking-to-Buy-Back-Their-Power-Gri,.

164 "Recommunalization in Germany 72 new municipal power utilities since 2005," Renewables International, 13 September 2013, http://www.renewablesinternational.net/72-new-municipal-power-utilities-since-2005/150/537/72825/.

165 Cognisito, "The Transformation of America's Energy Economy," 15 November 2013, http://cognoscenti.wbur.org/2013/11/15/boulder-xcel-robert-massie; "City-Owned Texas Utility Already Serves 40% Renewable Energy," *Renewable Energy World*, 4 December 2013, http://www.renewableenergyworld.com/rea/blog/post/2013/12/city-owned-texas-utility-already-serves-40-renewable-energy?cmpid=WNL-Wednesday-December4-2013.

166 The new 100 MW FIT is the successor to the LADWP's 10 MW FIT Demonstration Program, launched in May 2012, which restricted projects to solar PV systems of 30–999 kW and helped gauge market pricing and test the initial programme's structure. Under the new FIT, the first 100 MW of local rooftop solar PV will be procured under a set-price FIT, while the second 50 MW will be priced competitively through an RFP system that is bundled with a utility-scale solar project (see articles for details). American Public Power Association, "Distributed Generation," November 2013, http://www.publicpower.org/files/PDFs/Distributed%20Generation-Nov2013.pdf; LA Business Council, "Largest in the Nation Feed in Tariff Solar Program Kicks Off," April 2013, http://www.labusinesscouncil.org/LargestintheNation-Feedin-Tariff-Solar-Program-Kicks-Off.

167 The FIT tariff for solar PV was initially set based on the utility's avoided cost of providing electricity. Vote Solar, "How a Municipal Utility Charted a Path to 48 Renewables by Going Big on Solar," webinar, 24 July 2013, http://votesolar.org/2013/07/24/palo-altos-path-to-48-renewable-power-webinar-recording/; Lindsay Joye, City of Palo Alto Utilities, personal communication with REN21, November 2013.

168 City of Palo Alto, "Palo Alto Plugs Into 100% Carbon-Free Electricity," press release (Palo Alto, CA: 4 March 2013), http://www.cityofpaloalto.org/civica/press/display.asp?layout=1&Entry=864; U.S. Energy Information Administration, "Feed-in Tariff: A Policy Tool Encouraging Deployment of Renewable Electricity Technologies," 30 May 2013, http://www.eia.gov/todayinenergy/detail.cfm?id=11471; Fort Collins City council approved rates at USD 0.18/kWh for 10–100 kW and USD 0.15/kWh for >100–1,000 kW, per City of Fort Collins Utilities, "Fort Collins Solar Power Purchase Program," 6 August 2013, http://www.fcgov.com/utilities/img/site_specific/uploads/Solar_Power_Purchasing_Fact_Sheet.pdf.

169 Shota Furuya, Institute for Sustainable Energy Policies (ISEP), personal communication with REN21, January 2014.

170 City of Sydney, "Submission by the City of Sydney to the Inquiry by the Public Accounts Committee into Cogeneration/Trigeneration in NSW," 2013, www.cityofsydney.nsw.gov.au.

171 The six states with CCA are California, Illinois, Massachusetts, Ohio, New Jersey, and Rhode Island. Tom's River, Montgomery County, Monroe, and Plumsted switched to aggregation in 2013. Monterey, Santa Cruz, Lowell, Ashby, Lynn, Swampscott, Natick, Greenfield, and the Hampshire Council of Governments (HCOG), which represents more than 20 municipalities, have initiated the process to create CCAs in 2013. San Diego and Yolo County are exploring CCA as an option. Tufts University, Metropolitan Area Planning Council, "Community Choice Aggregation: Municipal Bulk Buying of Electricity in Massachusetts," May 2013, http://ase.tufts.edu/uep/degrees/field_project_reports/2013/Team_7_Final_Report_2013.pdf; Triple Pundit, "Big Progress Towards Local Clean Energy Solutions, Community Choice Aggregation," October 2013, http://www.triplepundit.com/podium/big-progress-local-clean-energy-solutions-community-choice-aggregation/.

172 Triple Pundit, op. cit. note 171.

173 Tufts University, Metropolitan Area Planning Council, op. cit. note 171.

174 The cities are waiting approval from the Gujarat Electricity Regulatory Commission, per Edgar Meza, "India Sets 10 GW Solar Target by 2017," *PV Magazine*, 26 September 2013, http://www.pv-magazine.com/news/details/beitrag/india-sets-10-gw-solar-target-by-2017-_100012849.

175 Green Business Guide, "Reverse metering in the Nelson Mandela Bay Metro," 2013, http://www.greenbusinessguide.co.za/reverse-metering-in-the-nelson-mandela-bay-metro/.

176 "Guntur Emerging as a Solar Power House," *The Hindu*, 19 December 2013, http://www.thehindu.com/news/cities/Vijayawada/guntur-emerging-as-a-solar-power-house/article5477374.ece; Ashok Pradhan, "Green Rating in Housing Norms," *Times of India*, 10 November 2013, http://timesofindia.indiatimes.com/city/bhubaneswar/Green-rating-in-housing-norms/articleshow/25524418.cms; Nagpur is the second city in the country to kick off the model solar city project after Chandigarh, per Anjaya Anparthi, "4 Years on, Sun Rises on Solar City Works," *Times of India*, 23 October 2013, http://timesofindia.indiatimes.com/city/nagpur/4-years-on-sun-rises-on-solar-city-works/articleshow/24562773.cms; "Delegation to study feasibility of city's solar energy projects," *Times of India*, 6 October 2013, http://timesofindia.indiatimes.com/city/aurangabad/Delegation-to-study-feasibility-of-citys-solar-energy-projects/articleshow/23601715.cms.

177 Chris Meehan, "Kansas City Goes Solar at 80 Buildings," SolarReviews.com, 30 May 2013, http://www.solarreviews.com/news/Kansas-City-Goes-Solar-80-Buildings-5-29-13.

178 City of Sydney, "Renewable Energy," http://www.cityofsydney.nsw.gov.au/vision/sustainability/carbon-reduction/renewable-energy, viewed March 2014; Palmerston North City Council, "Largest Solar Farm in NZ to Be Built in Palmerston North," Scoop Independent News, 20 December 2013, http://www.scoop.co.nz/stories/AK1312/S00668/largest-solar-farm-in-nz-to-be-built-in-palmerston-north.htm.

179 The VPP project will run for four years after which the participants can take over the BlueGen unit for an administrative fee. These are fuel cell micro-CHP units to compensate for the varying output of the solar park (6 MW) once completed, per David Appleyard, "Dutch VPP using Solar PV and Fuel Cell Tech," *Renewable Energy World*, 14 November 2013, http://www.renewableenergyworld.com/rea/news/article/2013/11/dutch-vpp-uses-pv-and-fuel-cell-hybrid?cmpid=SolarNL-Saturday-November16-2013.

180 World Bank, "China—Green Energy for Low-Carbon City Project in Shanghai Project," 6 February 2013, http://www.worldbank.org/projects/P127034/green-energy-schemes-low-carbon-city-shanghai?lang=en.

181 The code covers all buildings larger than 50,000 square metres (m^2); it also applies to hotels and healthcare facilities larger than 20,000 m^2, and educational facilities larger than 10,000 m^2, per "Jakarta Set to See High-Rise 'Green' Buildings," *Jakarta Post*, 13

April 2013, http://www.thejakartapost.com/news/2013/04/13/jakarta-set-see-high-rise-green-buildings.html.

182 For domestic buildings larger than 300 m^2 to install 500 W solar PV systems, non-domestic buildings larger than 500 m^2 (excluding five-star hotels) to install 2 kWp systems, and five-star hotels to install 5 kWp systems, per Ashok Pradhan, "Here comes the sun," *Times of India*, 3 March 2013, http://timesofindia.indiatimes.com/city/bhubaneswar/Here-comes-the-sun/articleshow/18771780.cms.

183 The cities are integrating the green rating for Integrated Habitat Assessment (Griha), the national rating system for green buildings, in city regulations. Griha, by its qualitative and quantitative assessment criteria, is able to rate a building on the degree of its greenness. Buildings getting Griha ratings get incentives from MNRE, per Ashok Pradhan, "Green Rating in Housing Norms," *Times of India*, 10 November 2013, http://articles.timesofindia.indiatimes.com/2013-11-10/bhubaneswar/43885245_1_bhubaneswar-development-authority-green-rating-griha.

184 Clean Technica, "Solar Mandate Approved By Sebastopol, California," 22 May 2013, http://cleantechnica.com/2013/05/22/solar-mandate-approved-by-sebastopol-california/; Matt Hickman, "Sebastopol Is Second California City Requiring Solar on New Homes," Mother Nature Network, 13 May 2013, http://www.greentechmedia.com/articles/read/solar-mandate-embraced-by-second-california-city; Miranda Green, "California Towns Pass Law Requiring New Buildings to Have Solar Panels," *The Daily Beast*, 10 May 2013, http://www.thedailybeast.com/articles/2013/05/10/california-towns-pass-law-requiring-new-buildings-to-have-solar-panels.html. In Sebastopol, new homes that are on lots of 7,000 square feet (650 m^2) or more must have solar panels that can produce up to 1 kW of energy at any given time. Lancaster requires solar PV systems of 1–1.5 kW for every new home built on lots larger than 7,000 square feet (650 m^2), and 1.5 kW systems for rural homes on lots up to 100,000 square feet (9,290 m^2); builders will also have the option of building distributed systems for new developments.

185 James Montgomery, "Reenergizing Cities with Solar Energy," *Renewable Energy World*, 1 October 2013, http://www.renewableenergyworld.com/rea/news/article/2013/10/reenergizing-cities-with-solar-energy?cmpid=WNL-Wednesday-October2-2013.

186 Bekezela Phakathi, "Cape Town to Launch Solar Water Heater Accreditation Programme," *Business Day*, 26 July 2013, http://www.bdlive.co.za/national/science/2013/07/26/cape-town-to-launch-solar-water-heater-accreditation-programme.

187 Tyler Hamilton, "Kathleen Wynne Fills Gap in Ontario Energy Policy," *Toronto Star*, 9 November 2013, http://www.thestar.com/business/2012/11/09/kathleen_wynne_fills_gap_in_ontario_energy_policy.html.

188 "Toronto Closer to Launching Ontario's First PACE Pilot Program This Fall," Clean Break, 27 June 2013, http://www.cleanbreak.ca/2013/06/27/toronto-closer-to-launching-ontarios-first-pace-pilot-program-this-fall/comment-page-1/; "Toronto City Council Unanimously Approves Residential PACE Pilot Project for Toronto—It's a Go!" Clean Break, 19 July 2013, http://www.cleanbreak.ca/2013/07/19/toronto-city-council-unanimously-approves-residential-pace-pilot-project-for-toronto-its-a-go/.

189 Thompson & Knight Attorneys and Counselors, "Texas Gov. Rick Perry Approves PACE Program for Low-Cost Financing of Water, Energy Conservation Projects," 19 June 2013, http://www.tklaw.com/texas-gov-rick-perry-approves-pace-program-for-low-cost-financing-of-water-energy-conservation-projects/; U.S. Department of Energy, Energy Efficiency and Renewable Energy, "Commercial Property Assessed Clean Energy (PACE) Primer," (undated), http://www1.eere.energy.gov/wip/pdfs/commercial_pace_primer_revised.pdf; "List of PACE Programs," PACENow.org, http://pacenow.org/resources/all-programs/, viewed 21 March 2014; "PACE Financing Option for Residential Solar Making a Comeback," CleanEnergyAuthority.com, 29 November 2013, http://www.cleanenergyauthority.com/solar-energy-news/pace-financing-for-solar-making-a-comeback-112913; "Focus on Michigan: Property Assessed Clean Energy (PACE) Market is Growing," PRWeb.com, 11 December 2013, http://www.prweb.com/releases/2013/12/prweb11406164.htm.

190 "Argentina: Other Municipalities Follow Frontrunner City Rosario, " Solar Thermal World, 7 August 2013, http://solarthermalworld.org/contentargentina-other-municipalities-follow-frontrunner-city-rosario.

191 Bekezela Phakathi, "Cape Town Steps Up Drive to Roll Out Solar Water Heaters," *Business Day*, 4 November 2013, http://www.bdlive.co.za/business/energy/2013/11/04/cape-town-steps-up-drive-to-roll-out-solar-water-heaters.

192 Loans are repaid by homeowners over a decade through an increased property tax, per Watercanada, "Halifax Solar City Program Reducing Water Use and CO_2 Emissions," 25 October 2013, http://watercanada.net/2013/halifax-solar-city-program-reducing-water-use-and-co2-emissions/.

193 "State Based and Municipal Corporation Based Incentives on Solar Water Heaters," *InSolTherm Times,* vol. I, Iss. 8, http://mnre.gov.in/file-manager/solar-thermal-newsletter/voloume-1-issue-8/EN/freatureStory.php.

194 C40, "London Must drive Smart Innovation and Investment," 16 April 2013, http://c40.org/c40blog/london-must-drive-smart-innovation-and-investment; "How Cities Can Reach 100% Renewable Energy," *AltEnergy Mag*, 28 January 2014, http://www.altenergymag.com/emagazine/2013/12/how-cities-can-reach-100-renewable-energy/2181. The city plan has identified "low carbon infrastructure zones," specific areas in the city that have high energy demand loads that will be supplied by low carbon energy via the thermal network. Key features of such a system are: renewable gas developed from waste converted into substitute natural gas and injected into the gas grid; the use of "power to gas" technologies for surplus renewable electricity from variable renewable electricity generation technologies, such as solar and wind converted into renewable hydrogen or renewable gas and injected into the gas grid; and heat recovered from decentralised electricity generation for supplying heating and cooling.

195 "Indianapolis: First US City to Require Electric Vehicles," Indianapolis: Sustainable Business News, December 2012, http://www.sustainablebusiness.com/index.cfm/go/news.display/id/24373; "New York City Mandates Biodiesel," *Render Magazine*, October 2013, http://www.rendermagazine.com/articles/2013-issues/october-2013/new-york-city-mandates-biodiesel/.

196 C40, "Bogotá Electrifies its Public Transportation System," 29 May 2013, http://c40.org/blog_posts/bogot%C3%A1-electrifies-its-public-transportation-system; "Volvo Sells 200 Hybrid Buses to Bogota, Colombia," Busworld Industry News, 11 August 2013, http://www.busworld.org/articles/detail/1864; EVsRoll, "Electric Taxis," http://www.evsroll.com/Electric_Taxis.html, viewed 17 March 2014.

197 "WEG Helps Equip Brazilian Bus with 100% Battery Drive," press release (Jaraguá do Sul, Brazil: 13 December 2013), http://www.weg.net/ca/Media-Center/News/Products-Solutions/WEG-helps-equip-Brazilian-bus-with-100-battery-drive. Adelaide, Australia, and Lublin, Poland, both launched solar-powered buses in 2013, per "First Solar Powered Public Transport," SA Breaking News, 20 September 2013, http://www.sabreakingnews.co.za/2013/09/20/first-solar-powered-public-transport/, and "Lublin Powers Buses with Solar Cell from Midsummer," PV Magazine, October 2013, http://www.pv-magazine.com/services/press-releases/details/beitrag/lublin-powers-buses-with-solar-cell-from-midsummer_100013066/.

198 City of Johannesburg, "City of Joburg's Metrobus Company issues tender for new buses as part of advancing green transport agenda," press release (Johannesburg: October 2013), http://www.joburg.org.za/index.php?option=com_content&view=article&id=8782:city-of-joburgs-metrobus-company-issues-tender-for-new-buses-as-part-of-advancing-green-transport-agenda&catid=217:press-releases-2013&Itemid=114#ixzz2toh1BceU; "London Mayor Calls for Waste Oil to Be Used as Biofuel for Buses," *Waste Management World*, July 2013, http://www.waste-management-world.com/articles/2013/07/london-mayor-calls-for-waste-oil-to-be-used-as-biofuel-for-buses.html; Stagecoach, "London Buses to Run on 'Chip Fat' in Pilot scheme," press release (Perth, Scotland, U.K.: 7 November 2013), http://www.stagecoach.com/media/news-releases/2013/2013-11-07.aspx.

199 Palo Alto from "New homes built in Palo Alto will be pre-wired for electric car chargers," Treehugger, 1 October 2013, http://www.treehugger.com/cars/new-homes-built-palo-alto-will-be-pre-wired-electric-car-chargers.html; "Palo Alto Looks to Require Electric Vehicle Chargers," *Mercury News*, 24 October 2013, http://www.mercurynews.com/breaking-news/ci_24162107/palo-alto-looks-require-electric-vehicle-chargers-new, October 2013; New York from "Green City Grids for EVs," *Renewable Energy World*, 21 March 2013, http://www.renewableenergyworld.com/

rea/news/article/2013/03/greening-city-grids-for-evs, and from Transportation Nation, "NYC Mayor wants 10000 New Electric Vehicle Charging Spaces," February 2013, http://www.wnyc.org/story/285133-nyc-mayor-wants-10000-new-electric-vehicle-charging-spaces.

200 ICLEI, "414 cities report raft of inspiring climate actions," November 2013, http://www.iclei.org/details/article/414-cities-report-raft-of-inspiring-climate-actions.html.

201 C40Cities Climate Leadership Group, "Year in Review: C40 Makes Great Strides in Research Agenda," 6 January 2014, http://www.c40.org/c40blog/year-in-review-c40-makes-great-strides-in-research-agenda; C40Cities Climate Leadership Group, "Expert Voices: Stephen Hammer, Lead Urban Specialist—Cities and Climate Change, The World Bank," 16 October 2013, http://c40.org/c40blog/expert-voices-stephen-hammer-lead-urban-specialist-—-cities-and-climate-change-the-world-bank; C40Cities Climate Leadership Group, "C40, ICLEI, WRI and Partners Achieve a Significant Milestone Towards Establishing a Single Standard for Measuring Emissions for Cities," 14 May 2012, http://www.c40.org/c40blog/c40-iclei-wri-and-partners-achieve-a-significant-milestone-towards-establishing-a-single-standard-for-measuring-emissions-for-cities.

202 C40Cities Climate Leadership Group, "C40 & Siemens Announce Broad Collaboration on Cities and Sustainability," press release (New York: 19 April 2013), http://www.c40.org/press_releases/press-release-c40-siemens-announce-broad-collaboration-on-cities-and-sustainability.

203 This led to the Durban Platform (ADP) decision text, which notes the inclusion of cities in technical meetings and in a sub-national forum to be held in the next ADP session, per International Institute for Sustainable Development, "Summary of the Warsaw Climate Change Conference, 11-23 November 2013," *Earth Negotiations Bulletin*, 26 November 2013, http://www.iisd.ca/vol12/enb12594e.html; Gino Van Begin, ICLEI, "Look to Cities for Real Climate Action!" *Outreach* (COP 19 – WARSAW), November 2013, http://www.stakeholderforum.org/sf/outreach/index.php/previous-editions/cop-19/198-cop-19-day-9-cities-urban-governance-and-transport/11626-look-to-cities-for-real-climate-action

DISTRIBUTED RENEWABLE ENERGY IN DEVELOPING COUNTRIES

1 International Energy Agency (IEA), *World Energy Outlook 2013* (Paris: IEA/OECD, 2013), http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/.

2 Ibid.

3 India from ibid.; Africa from IEA, *World Energy Outlook 2011* (Paris: IEA/OECD, 2011), and from IEA, op. cit. note 1, http://www.worldenergyoutlook.org/resources/energydevelopment/accesstoelectricity/.

4 International Renewable Energy Agency (IRENA), *Renewable Energy Jobs & Access* (Abu Dhabi: 2012), https://www.irena.org/DocumentDownloads/Publications/Renewable_Energy_Jobs_and_Access.pdf.

5 Lighting Africa, *Lighting Africa Market Trends Report 2012: Overview of the Off-Grid Lighting Market in Africa* (Nairobi: International Finance Corporation (IFC)/World Bank, 2013), http://africa.solarenergyevents.com/resource-centre/whitepaper/lighting-africa-market-trends-report-2012.

6 Ibid.

7 Daniel Schnitzer et al., *Microgrids for Rural Electrification* (Washington, DC: UN Foundation, February 2014), http://energyaccess.org/images/content/files/MicrogridsReportFINAL_low.pdf.

8 IEA, *World Energy Outlook 2011*, op. cit. note 3, p. 26, http://www.iea.org/media/weowebsite/energydevelopment/weo2011_energy_for_all.pdf; IEA, op. cit. note 1, http://www.worldenergyoutlook.org/media/weowebsite/energydevelopment/WEO2013_EnergyForAll.pdf.

9 United Nations (UN) Sustainable Energy for All, "Country Level Actions," http://www.se4all.org/actions-commitments/country-level-actions/, viewed 10 February 2014; UN Development Programme (UNDP) and World Health Organization (WHO), *The Energy Access Situation in Developing Countries, A Review Focusing on the Least Developed Countries and Sub-Saharan Africa* (New York: 2009), http://www.who.int/indoorair/publications/Energy_Access_Report_Brief.pdf. Note that U.S.-based Bank of America committed USD 50 billion over 10 years to finance Energy Efficiency, Renewable Energy and Energy Access and other activities that advance the low-carbon economy, per *Sustainable Development in Action*, Special Report of the SD in Action Newsletter, July 2013, p. 9, http://sustainabledevelopment.un.org/content/documents/930Report%20on%20Voluntary%20Commitments%20and%20Partnerships.pdf.

10 IFC, *From Gap to Opportunity: Business Models for Scaling Up Energy Access* (Washington, DC: 2012), Executive Summary, http://www.ifc.org/wps/wcm/connect/b7ce4c804b5d10c58d90cfbbd578891b/ExecutiveSummary.pdf?MOD=AJPERES.

11 Her Excellency Sheikh Hasina, Prime Minister, Government of the People's Republic of Bangladesh, "2 Million Solar Home Systems and 1 Million Improved Cook Stoves," presented at Ruposhi Bangla Hotel, Dhaka, 12 May 2013, http://www.pmo.gov.bd/index.php?option=com_content&task=view&id=1007&Itemid=353.

12 Practical Action, "Wind for Electricity Generation," Technical Brief (Bourton on Dunsmore, Rugby, Warwickshire, U.K.: undated), http://practicalaction.org/media/preview/10704.

13 J. Leary, A. While, and R. Howell, "Locally Manufactured Wind Power Technology for Sustainable Rural Electrification," *Energy Policy*, vol. 43 (2012).

14 Practical Action, "Micro-hydro Power," http://practicalaction.org/micro-hydro-power, viewed 18 February 2014.

15 B.P. Koirala et al., *Interconnected Mini-grids for Rural Energy Transition in Nepal* (Lalitpur, Nepal: Alternate Energy Promotion Centre, 2013).

16 Sierra Club, "The Water Wheels of Time: Micro Hydro Power in the Western Ghats of India," Compass, 20 June 2011, http://sierraclub.typepad.com/compass/2011/06/the-water-wheels-of-time-micro-hydro-power-in-the-western-ghats-of-india.html.

17 Thailand Department of Alternative Energy Development and Efficiency, *Thailand Energy Situation 2006* (Bangkok: 2007).

18 Sivan Kartha, Gerald Leach, and Sudhir Chella Rajan, *Advancing Bioenergy for Sustainable Development: Guideline for Policymakers and Investors, Volumes I, II and III* (Washington, DC: World Bank Energy Sector Management Assistance Programme, April 2005), http://www.energycommunity.org/documents/SustainableBioenergyFinal.pdf.

19 Schnitzer et al., op. cit. note 7.

20 Ibid.

21 Debajit Palit, The Energy and Resources Institute (TERI), personal communication with REN21, December 2013.

22 UN Development Programme, *UNDP and Energy Access for the Poor: Energizing the Millennium Development Goals* (New York: October 2010), www.undp.org/content/dam/aplaws/publication/en/publications/environment-energy/www-ee-library/climate-change/undp-and-energy-access-for-the-poor/2593.EnergyAccess_Booklet_Revision02.pdf.

23 World Bank, *Scaling-Up Access to Clean Cooking Technologies and Fuels in Sub-Saharan Africa* (Washington, DC: 2012), http://siteresources.worldbank.org/EXTAFRREGTOPENERGY/Resources/WorldBank_ACCES_AFREA_AFTEG_ESMAP_FINAL.pdf.

24 Franck Jesus, Global Environment Facility, personal communication with REN21, January 2014.

25 Global Alliance for Clean Cookstoves, "The Solutions: Cookstove Technology," http://www.cleancookstoves.org/our-work/the-solutions/cookstove-technology.html, viewed 21 January 2014; Arnaldo Carvalho, Inter-American Development Bank (IDB) Multilateral Investment Fund (MIF), personal communication with REN21, December 2013. Gasifier stoves are generally less efficient than forced air stoves.

26 IFC, op. cit. note 10.

27 Ibid.

28 Global Alliance for Clean Cookstoves, op. cit. note 25.

29 International Institute for Applied Systems Analysis (IIASA), "Chapter 19: Energy Access for Development," in *Global Energy Assessment: Toward a Sustainable Future* (Cambridge, U.K. and Laxenburg, Austria: Cambridge University Press and IIASA, 2012), http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/GEA_Chapter19_energyaccess_hires.pdf.

30 Wim van Nes and Felix ter Heegde, SNV, "Building Viable Domestic Biogas Programmes: Success Factors in Sector Development," prepared for the Asia Clean Energy Forum, Manila, 2–7 June 2008, http://www.thepowerofhow.org/uploads/wysiwyg/documents/other_resources/snv/Building_viable_domestic_biogas_programmes.pdf.

31 Frank Haugwitz, Asia Europe Clean Energy Advisory Co., personal communication with REN21, December 2013.

32 Note that Indian figures are for fiscal years running April to March, with the 4.7 million mark likely estimated in March 2013, per Indian Ministry of New and Renewable Energy, provided by Hari Natarajan, Deutsche Gesellschaft für Internationale Zusammenarbeit – India, personal communication with REN21, December 2013. Construction was under the National Biogas and Manure Management Programme, and India had a total of 4.68 million plants as of October 2013, per SNV World, "Almost 42,000 small-scale biogas plants constructed in the first half of 2013," 5 December 2013, http://www.snvworld.org/en/sectors/renewable-energy/news/almost-42000-small-scale-biogas-plants-constructed-in-the-first-half.

33 Nepal installed an estimated 290,508 units under the National Biogas Programme, per Global Alliance for Clean Cookstoves, op. cit. note 25; Kenya installed an estimated 9,046 units under the Domestic Biogas Programme, per Energy for All, "Almost 34,000 small-scale biogas plants constructed under SNV supported programmes in Asia in the first half of 2013," 7 October 2013, http://www.energyforall.info/almost-34000-small-scale-biogas-plants-constructed-snv-supported-programmes-asia-first-half-2013/.

34 Solar Cookers International Network, "News and Recent Developments," http://solarcooking.wikia.com/wiki/Nepal, viewed 18 December 2013.

35 Bozhil Kondev, GIZ, personal communication with REN21, January 2014.

36 Global Alliance for Clean Cookstoves, op. cit. note 25.

37 P. Raman et al., "Evaluation of Domestic Cookstove Technologies Implemented Across the World to Identify Possible Options for Clean and Efficient Cooking Solutions" (New Delhi: TERI, October 2013).

38 Ernst & Young, *Renewable Energy Country Attractiveness Indices*, November 2012, http://www.ey.com/Publication/vwLUAssets/CAI_issue-35_Nov-2012/$FILE/CAI_issue-35_Nov-2012_DE0372.pdf.

39 World Bank, *Designing Sustainable Off-Grid Rural Electrification Projects: Principles and Practices* (Washington, DC: 2008), http://siteresources.worldbank.org/EXTENERGY2/Resources/OffgridGuidelines.pdf.

40 C. Mitchell et al., "Policy, Financing and Implementation," Chapter 11 in O. Edenhofer et al., eds., *IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation* (Cambridge, U.K. and New York: Cambridge University Press, 2011); Teresa Malyshev, *Looking Ahead: Energy, Climate Change and Pro-poor Responses* (Paris: IEA, 2009); Gabriela Azuela, World Bank, personal communication with REN21, December 2013.

41 Bangladesh data are for achievements by Grameen Shakti, which reached 1 million SHS installed in November 2012, per Justin Guay, "Small Is Big: Bangladesh Installs One Million Solar Home Systems," *Climate Progress*, 18 December 2012, http://thinkprogress.org/climate/2012/12/18/1353791/small-is-big-bangladesh-installs-one-million-solar-home-systems/; Lighting Africa, op. cit. note 5, p. 11.

42 Frankfurt School–UNEP Collaborating Centre for Climate & Sustainable Energy Finance (FS–UNEP Centre) and Bloomberg New Energy Finance (BNEF), *Global Trends in Renewable Energy Investment 2013* (Frankfurt: 2013), http://www.unep.org/pdf/GTR-UNEP-FS-BNEF2.pdf.

43 Renata Grisoli, MGM Innova, personal communication with REN21, December 2013; GNESD, "Energy access program in Brazil: 'Lighting for all'," http://energy-access.gnesd.org/index.php?option=com_content&view=article&id=104:energy-access-program-in-brazil-lighting-for-all-&catid=3:projects&Itemid=24, viewed 12 February 2014; R. Deshmukh et al., "Sustainable Development of Renewable Energy Mini-grids for Energy Access: A Framework for Policy Design," Clean Energy Ministerial, March 2013, http://www.cleanenergyministerial.org/Portals/2/pdfs/Sustainable_Development_of_Renewable_Energy_Mini-grids_for_Energy_Access.pdf.

44 Grisoli, op. cit. note 43; GNESD, op. cit. note 43.

45 Government of China, National Energy Administration (NEA), "National Energy Board Held a Comprehensive Solution to the Problem of People without Electricity," Electricity Conference, 31 July 2013, translated using Google Translate, http://www.nea.gov.cn/2013-07/31/c_132590749.htm.

46 ECOWAS Centre for Renewable Energy and Energy Efficiency (ECREEE), *Baseline Report for the ECOWAS Renewable Energy Policy (EREP)* (Praia, Cape Verde: 2012).

47 Francisca M. Antman, "The Impact of Migration on Family Left Behind" (Boulder, CO: University of Colorado at Boulder Department of Economics, 2010), http://spot.colorado.edu/~antmanf/Antman_LeftBehindBookChapter.pdf.

48 Koffi Ekouevi and Reto Thoenen, "Top-Down Concessions for Private Operators in Mali and Senegal," PowerPoint presentation, undated http://siteresources.worldbank.org/EXTAFRREGTOPENERGY/Resources/717305-1264695610003/6743444-1268073476416/3.3.TopDown_concessions_private_operators_Senegal_N_Mali.pdf.

49 IRENA, *Financial Mechanisms and Investment Frameworks for Renewables in Developing Countries* (Abu Dhabi: December 2012), p. 105, http://www.irena.org/DocumentDownloads/Publications/IRENA%20report%20-%20Financial%20Mechanisms%20for%20Developing%20Countries.pdf.

50 MIF and BNEF *Climatescope* data provided by Arnaldo Carvalho, IDB, personal communication with REN21, December 2013.

51 European Union Energy Initiative – Partnership Dialogue Facility (EUEI-PDF), REN21, and Alliance for Rural Electrification (ARE), *Mini Grid Policy Toolkit* (Brussels: forthcoming 2014); IFC, op. cit. note 10.

52 Ibid.

53 Mali from IFC, op. cit. note 10; India subsidies, under the Remote Village Electrification Programme, per Hari Natarajan, Indo-German Energy Programme-GIZ (GIZ-IGEN), personal communication with REN21, December 2013; Afghanistan subsidies, under the National Solidarity Programme and the National Area-based Development Programme, per Government of Afghanistan, "National Solidarity Programme," http://mrrd.gov.af/Content/files/MRRD-Brochure.pdf.

54 EUEI-PDF, REN21, and ARE, op. cit. note 51.

55 IFC, op. cit. note 10.

56 Ibid.

57 World Bank, "Solar Power Lights Up Future for Mongolian Herders," 20 September 2012, www.worldbank.org/en/news/feature/2012/09/20/solar-power-lights-up-future-for-mongolian-herders.

58 IRENA, op. cit. note 49.

59 Government of China, op. cit. note 45.

60 UN Foundation, "Country Level Action," viewed 21 January 2014, http://www.energyaccess.org/our-work/country-level-action.

61 Atul Raturi, The University of the South Pacific School of Engineering and Physics Faculty of Science, Technology and Environment, personal communication with REN21, January 2014.

62 UN Industrial Development Organization (UNIDO), "UNIDO Projects for the promotion of small hydro power for productive use" (Vienna: 2010), http://www.unido.org/fileadmin/user_media/About_UNIDO/Evaluation/Project_reports/e-book_small-hydro.PDF.

63 Ibid.

64 World Bank, *Towards a Sustainable Energy for All: Directions for the World Bank Group's Energy Sector* (Washington, DC: 2013), http://www.worldbank.org/content/dam/Worldbank/document/SDN/energy-secm2013-0281-2.pdf.

65 R. Bellanca and B. Garside, "An approach to designing energy delivery models that work for people living in poverty" (London: CAFOD and International Institute for Environment and Development (IIED), 2013), http://pubs.iied.org/pdfs/16551IIED.pdf.

66 Deshmukh et al., op. cit. note 43.

67 D.L. Gazzoni et al., "Science for a Better Life: Developing Regional Scientific Programs in Priority Areas for Latin America and the Caribbean," in ICSU-LAC/CONACYT, *Sustainable Energy in Latin America and the Caribbean: Potential for the Future*, Volume 3 (Rio de Janeiro and Mexico City: 2010).

68 This is the first clean cook stoves project to be funded by the Climate Investment Funds. Michael Hoffman, Climate Investment Funds, MIF, personal communication with REN21, December 2013. Information based on SREP Honduras Sustainable Rural Energization, 2013, https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/ERUS_Parts_I_and_III_IDB_Submission_with_cover_page.pdf.

69 Ibid.

70 Dalberg Global Development Advisors, *India Cookstoves and Fuels Market Assessment* (Washington, DC: Global Alliance for Clean Cookstoves, February 2013), http://www.dalberg.com/documents/Dalberg-india-cookstove-and-fuels-market-assessment.pdf.

71 Global Alliance for Clean Cookstoves, "Health Impacts," http://www.cleancookstoves.org/our-work/the-issues/health-impacts.html, viewed 21 January 2014.

72 GIZ- IGEN, *Ingredients for Sustainable Cookstove Interventions Lessons Learned from the Indian National Programme for Improved Cookstoves (NPIC)* (New Delhi: November 2013), http://www.igen-re.in/files/igen-re_2013__ingredients_for_sustainable_cookstove_interventions.pdf.

73 IFC, op. cit. note 10.

74 Ibid.

75 Ibid.

76 The model is being replicated with support from the Asian Development Bank (ADB), per Jiwan Acharya, ADB, personal communication with REN21, December 2013.

77 Justin Guay, "Clean Energy's Next Big Market: Off-Grid Solar," Greentech Media, 5 November 2013, http://www.greentechmedia.com/articles/read/cleantechs-next-big-market-off-grid-solar; Athena Ballesteros et al., "Implementation Strategies for Renewable Energy Services in Low-Income, Rural Areas," Brief 1, *Keys to Achieving Universal Energy Access Series* (Washington, DC: World Resources Institute, 2013), http://www.wri.org/sites/default/files/pdf/implementation_strategies_renewable_energy_services_low_income_rural_areas.pdf.

78 David Wogan, "Pay-as-You-Go Solar Energy Finds Success in Africa," *Scientific American,* 22 November 2013, http://www.scientificamerican.com/article.cfm?id=pay-as-you-go-solar-energy.

79 The pay-as-you-go model is being used by start-up company Azuri in Kenya, Uganda, Tanzania, Ethiopia, Rwanda, Sierra Leone, Ghana, South Africa, Zimbabwe, and South Sudan, per ibid.

80 India from Acharya, op. cit. note 76; Africa from Wogan, op. cit. note 78.

81 This is a programme of the Bright Green Energy Foundation, per Ballesteros et al., op. cit. note 77.

82 World Bank, op. cit. note 39.

83 This is a campaign of TERI, per Ballesteros et al., op. cit. note 77.

84 Nancy Wimmer, "Clean Energy Access for All: Grameen Installs Over 500 Solar Homes Systems a Day in Rural Bangladesh," Climate Progress, 26 July 2012, http://thinkprogress.org/climate/2012/07/26/569071/clean-energy-access-for-all-grameen-installs-over-500-solar-homes-systems-a-day-in-rural-bangladesh/.

85 IFC, op. cit. note 10.

86 Ibid.

87 Ibid.

88 Ibid.

89 FS–UNEP Centre and BNEF, op. cit. note 42.

90 Emma Wilson, "How Can Business Help Boost Access to Energy for Those Who Need It Most?" IIED, 7 June 2013, http://www.iied.org/how-can-business-help-boost-access-energy-for-those-who-need-it-most.

91 Justin Guay, "Solar Crowdfunding's Lessons Learned," *Huffington Post,* 13 August 2013, http://www.huffingtonpost.com/justin-guay/solar-crowdfundings-lesso_b_3751247.html.

92 "Summary for Policymakers" in Edenhofer et al., eds., op. cit. note 40, p. 18, http://srren.ipcc-wg3.de/report/IPCC_SRREN_SPM.pdf.

TRACKING THE GLOBAL ENERGY TRANSITION:
A DECADE OF UNPRECEDENTED MOMENTUM FOR RENEWABLES

1 Renewable Energy Policy Network for the 21st Century (REN21), *Renewables Global Futures Report 2013* (Paris: REN21 Secretariat, 2013), http://www.ren21.net/Portals/0/REN21_GFR_2013_print.pdf.

2 Ibid.; REN21, *Renewables 2007 Global Status Report* (Paris: REN21 Secretariat, 2007), http://www.ren21.net/Portals/0/documents/activities/gsr/RE2007_Global_Status_Report.pdf.

3 REN21, *Renewables 2013 Global Status Report* (Paris: REN21 Secretariat, 2013), http://www.ren21.net/Portals/0/documents/Resources/GSR/2013/GSR2013_lowres.pdf; see also data in relevant sections of this report.

4 REN21, *Renewables 2005 Global Status Report* (Paris: REN21 Secretariat, 2005), http://www.ren21.net/Portals/0/documents/activities/gsr/RE2005_Global_Status_Report.pdf; *REN21, Renewables 2013…*, op. cit. note 3; see also data in relevant sections of this report.

5 Global Wind Energy Council, *Global Wind Report – Annual Market Update 2013* (Brussels: 2014); REN21, *Renewables 2005…*, op. cit. note 4; REN21, *Renewables 2013…*, op. cit. note 3; data in relevant sections of this report.

6 International Energy Agency (IEA), *Technology Roadmap: Wind Energy* (Paris: Organisation for Economic Co-operation and Development (OECD)/IEA, 2013), http://www.iea.org/publications/freepublications/publication/Wind_2013_Roadmap.pdf.

7 REN21, *Renewables 2005…*, op. cit. note 4; REN21, *Renewables 2013…*, op. cit. note 3; see also data in relevant sections of this report.

8 IEA Energy Technology Systems Analysis Program (IEA-ETSAP) and International Renewable Energy Agency (IRENA), *Technology Brief E11 – January 2013* (Paris and Abu Dhabi/Bonn: 2013), http://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP%20Tech%20Brief%20E11%20Solar%20PV.pdf.

9 European Commission Joint Research Centre, "PV Production Grows Despite a Crisis-driven Decline in Investment," press release (Brussels: 30 September 2013), http://ec.europa.eu/dgs/jrc/downloads/jrc_20130930_newsrelease_pv_status.pdf; see also section on Solar PV in this report.

10 REN21, *Renewables 2005…*, op. cit. note 4; REN21, *Renewables 2013…*, op. cit. note 3; see also relevant sections of this report.

11 Ibid.

12 Ibid.

13 Ibid.

14 O. Edenhofer et al., *Intergovernmental Panel on Climate Change Special Report on Renewable Energy Sources and Climate Change Mitigation* (New York: Cambridge University Press, 2012), http://www.ipcc.ch/pdf/special-reports/srren/SRREN_Full_Report.pdf.

15 Lazard Ltd., *Lazard's Levelized Cost of Energy Analysis – Version 7.0* (New York: August 2013).

16 Frankfurt School–United Nations Environment Programme Collaborating Centre for Climate & Sustainable Energy Finance (FS–UNEP Centre) and Bloomberg New Energy Finance (BNEF), *Global Trends in Renewable Energy Investment 2014* (Frankfurt: 2014), http://fs-unep-centre.org/publications/gtr-2014.

17 José Jaime de Domingo, "Accessible Energy for Rural Communities without Electricity," Empowering the Sun blog (ISOFOTON), 31 July 2013, http://empoweringthesun.wordpress.com/2013/07/; see also section on Distributed Renewable Energy in Developing Countries in this report.

18 IEA, *World Energy Outlook 2006* (Paris: OECD/IEA, 2006), http://www.worldenergyoutlook.org/media/weowebsite/2008-1994/WEO2006.pdf; World Bank, *Global Tracking Framework* (Washington, DC: 2013), http://www.worldbank.org/en/topic/energy/publication/Global-Tracking-Framework-Report.

19 United Nations Sustainable Energy for All, "Universal Energy Access," 2013, http://www.se4all.org/our-vision/our-objectives/universal-energy/.

20 FS-UNEP Centre and BNEF, op. cit. note 16.

21 Ibid.

22 Ibid.

23 Ibid.

24 BNEF, "Global Trends in Clean Energy Investment," 15 January 2014, http://about.bnef.com/files/2014/01/BNEF_PR_FactPack_Q4_CleanEnergyInvestment_2014-01-15.pdf.

25 FS–UNEP Centre and BNEF, op. cit. note 16.

26 Ibid.

27 "Financial Innovations Spur Renewable Energy Investment in Global Markets," *PV Magazine*, 15 January 2014, http://www.pv-magazine.com/news/details/beitrag/financial-innovations-spur-renewable-energy-investment-in-global-markets_100013942/#axzz2sHJ3IFNV.

28 REN21, *Renewables 2005…*, op. cit. note 4; REN21, Renewables 2013…, op. cit. note 3; see also the Policy Landscape section and related tables in this report.

29 REN21, *Renewables 2013…*, op. cit. note 3.

30 EU Covenant of Mayors, "Covenant in Figures," 2013, http://www.eumayors.eu/about/covenant-in-figures_en.html; ICLEI–Local Governments for Sustainability, "Frequently Asked Questions," 2013, http://www.iclei.org/iclei-global/who-is-iclei/faq.html.

31 100% Renewables Web site, http://go100re.net/.

32 European Commission, "The EU Climate and Energy Package," 6 January 2014, http://ec.europa.eu/clima/policies/package/index_en.htm.

33 Eurostat, "Renewable Energy in the EU28: Share of Renewables in Energy Consumption Up to 14% in 2012," press release (Brussels: 10 March 2014), http://epp.eurostat.ec.europa.eu/cache/ITY_PUBLIC/8-10032014-AP/EN/8-10032014-AP-EN.PDF.

34 Bernard Chabot, "Analysis of the 2003-2012 Global Electricity Production with a Focus on the Contribution from Renewables," Renewables International, December 2013, http://cf01.erneuerbareenergien.schluetersche.de/files/smfiledata/3/3/5/2/4/1/49WorldElecRE0312.pdf; World Energy Council, *World Energy Perspective: Nuclear Energy One Year After Fukushima* (London: 2012), http://www.worldenergy.org/documents/world_energy_perspective__nuclear_energy_one_year_after_fukushima_world_energy_council_march_2012_1.pdf.

REFERENCE TABLES

1 **Table R1** derived from the following sources: **Bio-power** based on 83 GW of capacity at end-2012 (see GSR 2013), preliminary data from International Energy Agency (IEA), *Medium-Term Renewable Energy Market Report 2014* (Paris: OECD/IEA, forthcoming 2014), and national level data from the following: U.S. Federal Energy Regulatory Commission, Office of Energy Projects, "Energy Infrastructure Update for December 2013," https://www.ferc.gov/legal/staff-reports/2013/dec-energy-infrastructure.pdf; Arbeitsgruppe Erneuerbare Energien-Statistik (AGEE-Stat), *Erneuerbare Energien im Jahr 2013* (Berlin: Bundesministerium für Wirtschaft und Energie (BMWi), 2014), http://www.bmwi.de/BMWi/Redaktion/PDF/A/agee-stat-bericht-ee-2013,property=pdf,bereich=bmwi2012,sprache=de,rwb=true.pdf; China National Renewable Energy Centre, "CNREC 2013 Activities within China National Renewable Energy Centre" (Beijing: March 2014); Brazilian electricity regulatory agency (ANEEL), 2013, provided by Maria Beatriz Monteiro, CENBIO, personal communication with REN21, 16 April 2014; IEA, *Medium-Term Renewable Energy Market Report 2013* (Paris: OECD/IEA, 2013); Red Eléctrica de España (REE), "Potencia instalada Peninsular (MW)," as of 31 December 2013, updated March 2014, http://www.ree.es; Government of India, Ministry of New and Renewable Energy (MNRE), "Physical Progress (Achievements)," 31 December 2013, http://www.mnre.gov.in/mission-and-vision-2/achievements/; Directorate General for Energy and Geology (DGEG), provided by Lara Ferreira, Portuguese Renewable Energy Association, personal communication with REN21, May 2014; U.K. Department of Energy and Climate Change (DECC), *Statistics, Energy Trends Section 6: Renewables, Department of Energy and Climate Change,* March 2014 (updated 10 April 2014), p. 6, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/295356/6_Renewables.pdf; Institute for Sustainable Energy Policies (ISEP), *Renewables Japan Status Report 2014* (Tokyo: March 2014) (in Japanese), data provided by Hironao Matsubara, ISEP, personal communication with REN21, 23 April 2014; Luca Benedetti, Energy Studies and Statistics, Gestore dei Servizi Energetici (GSE S.p.A.), Rome, personal communication with REN21, 16 May 2014; Government Offices of Sweden, "Sweden's second progress report on the development of renewable energy pursuant to Article 22 of Directive 2009/28/EC," 23 December 2013, http://ec.europa.eu/energy/renewables/reports/2013_en.htm. **Geothermal power** from Geothermal Energy Association (GEA), per Benjamin Matek, GEA, personal communication with REN21, March 2014, and other sources provided in Endnote 5 of this section. **Hydropower** from International Hydropower Association (IHA), personal communication with REN21, March-April 2014; from preliminary estimates in IEA, *Medium-Term Renewable Energy Market Report 2014*, op. cit. this note; and from Hydropower Equipment Association (HEA) data based on its members' aggregated input, personal communication with REN21, April 2014. **Ocean power** from Ocean Energy Systems (OES), "Ocean Energy in the World," http://www.ocean-energy-systems.org/ocean_energy_in_the_world/; from OES, *Annual Report 2012* (Lisbon: 2012), Table 6.1, http://www.ocean-energy-systems.org/oes_reports/annual_reports/2012_annual_report/; and from Électricité de France (EDF), "Usine marémotrice de La Rance," http://energie.edf.com/hydraulique/energies-marines/carte-des-implantations-marines/usine-maremotrice-de-la-rance/presentation-51516.html. See Ocean Energy section and related endnotes for more information. **Solar PV** from sources in Endnote 7 of this section. **CSP** from sources in Endnote 8 of this section. **Wind power** from sources in Endnote 10 of this section. **Modern bio-heat** based on 293 GW_{th} in GSR 2013, which was estimated from the 297 GW_{th} in 2008 quoted in Helena Chum et al., "Bioenergy," Chapter 2 in O. Edenhofer et al., eds., *IPCC Special Report on Renewable Energy Resources and Climate Change Mitigation*, prepared by Working Group III of the Intergovernmental Panel on Climate Change (Cambridge, U.K. and New York: Cambridge University Press, 2011) and the 270 GW_{th} in 2009 referenced in *Global Energy Assessment – Toward a Sustainable Future* (Cambridge, U.K. and Laxenburg, Austria: Cambridge University Press and the International Institute for Applied Systems Analysis, 2012), and assuming a 1% growth rate for 2013. No more-accurate data currently exist. **Geothermal heating** capacity derived from the average of two estimated values. The first (25.8 GW_{th}) was derived from global annual direct use in 2009–2011, from IEA, World Energy Statistics (Paris: OECD/IEA, 2013), data for 2011, and from a capacity factor of about 46% for 2009, calculated from John W. Lund, Derek H. Freeston, and Tonya L. Boyd, "Direct Utilization of Geothermal Energy 2010 Worldwide Review," *Proceedings World Geothermal Congress 2010*, (Bali, Indonesia: 25–29 April 2010), and escalated at the observed two-year average growth rate (2009–2011) to 2012 and 2013; the second (19.3 GW_{th}) was derived from global capacity of 15,346 MW_{th} in 2009, from Lund, Freeston, and Boyd, op. cit. this note, which was escalated first at the annual growth rate from IEA data to 2011 and then by the two-year average growth rate (2009–2011) to 2013, as above. The average of these two values is the estimated global heat capacity at 22.6 GW_{th}, with estimated increase of 1.3 GW_{th} during 2013. The divergence between the two sources for geothermal heat output, and the need to extrapolate over 2–4 years, makes these estimates subject to great uncertainty. **Solar collectors for water heating** estimates based on end-2012 total capacity, and preliminary estimate for end-2013 capacity, from Franz Mauthner, AEE – Institute for Sustainable Technologies (AEE-INTEC), Gleisdorf, Austria, personal communication with REN21, March-May 2014, and on Franz Mauthner and Werner Weiss, *Solar Heat Worldwide: Markets and Contribution to the Energy Supply 2012* (Gleisdorf, Austria: IEA Solar Heating and Cooling Programme (SHC), forthcoming May 2014). See Solar Thermal Heating and Cooling section and related endnotes for more details. **Ethanol, biodiesel, and HVO production** data from sources in Endnote 4 of this section.

2 **Table R2** derived from the following sources: **For all global data**, see Endnote 1 for this section and other relevant reference tables. For more specific data and sources, see Global Market and Industry Overview section and Market and Industry section and related endnotes. **Bio-power** for EU-28 and individual European countries based on the following: AGEE-Stat, op. cit. note 1; Benedetti, op. cit. note 1; REE, op. cit. note 1; DGEG, op. cit. note 1; DECC, op. cit. note 1; Réseau de Transport d'Électricité, (RTE), *Bilan Électrique 2013* (Paris: 2014), p. 21, http://www.rte-france.com/uploads/Mediatheque_docs/vie_systeme/annuelles/Bilan_electrique/bilan_electrique_2013.PDF; Government Offices of Sweden, op. cit. note 1; E-Control Austria, "Entwicklung der anerkannten 'sonstigen' Ökostromanlagen (exclusive Kleinwasskraft) von 2002–2013," updated May 2014, http://www.e-control.at/portal/page/portal/medienbibliothek/oeko-energie/dokumente/pdfs/Entwicklung%20anerkannter%20%C3%96kostromanlagen%202002-2013_Tabelle_Stand%20Mai%202014.pdf; preliminary data from IEA, *Medium-Term Renewable Energy Market Report 2014*, op. cit. note 1; United States from FERC, op. cit. note 1.; BRICS and individual countries from ANEEL, op. cit. note 1; CNREC, op. cit. note 1; MNRE, op. cit. note 1; Russia and South Africa from IEA, *Medium-Term Renewable Energy Market Report 2013,* op. cit. note 1. **Geothermal power** from global inventory of geothermal power plants by GEA (unpublished database), provided by Benjamin Matek, GEA, personal communication with REN21, March-May 2014; for other sources, see Endnote 5 in this section. **Hydropower** from sources in Endnotes 1 and 6 for this section. **Ocean power** from OES, *Annual Report 2012* op. cit. note 1; OES, *Annual Report 2013* (Lisbon: 2013), Table 6.2, http://www.ocean-energy-systems.org/documents/82577_oes_annual_report_2013.pdf/; IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1, p. 179, and other sources provided in Ocean Energy section. **Solar PV** data for EU-28 from Gaëtan Masson, IEA Photovoltaic Power Systems Programme (IEA-PVPS) and iCARES Consulting, personal communication with REN21, 2 May 2014; European Photovoltaic Industry Association (EPIA), *Global Market Outlook for Photovoltaics 2014–2018* (Brussels: June 2014); data for BRICS based on Brazil from IEA, *Medium-Term Renewable Energy Market Report 2013*, op. cit. note 1, p. 119; South Africa from EScience Associates, Urban-Econ Development Economists, and Chris Ahlfeldt, *The Localisation Potential of Photovoltaics (PV) and a Strategy to Support Large Scale Roll-Out in South Africa*, Integrated Report, Draft Final v1.2, prepared for the South African Department of Trade and Industry, March 2013, p. x, http://www.sapvia.co.za; for other countries and sources, see Endnote 7 in this section. **CSP** from sources in Endnote 8 for this section. **Wind power** data for EU-28 from European Wind Energy Association (EWEA), *Wind in Power: 2013 European Statistics* (Brussels: February 2014); data for BRICS based on data for Brazil from Francine Martins Pisni, Associação Brasileira de Energia Eólica (ABEEólica), communication with REN21 via Suani Coelho, CENBIO, 29 April 2014; Russia from EWEA, op. cit. this note; South Africa from World Wind Energy Association (WWEA), *World Wind Energy Report 2013* (Bonn:

2014); for other sources, see Endnote 10 for this section. **Population** data for 2012 from World Bank, "World development indicators - Population (total)," 2014, http://data.worldbank.org/indicator/SP.POP.TOTL, viewed 7 March 2014.

3 Trade data used in this analysis are complex and are not always standardised among countries. **Table R3** derived from the following sources: P.A. Lamers, Mountain View Research, Denver, CO, personal communication with REN 21, 9 January 2014; P. Lamers et al., "Woody Biomass Trade for Energy," in M. Junginger, C.S. Goh, and A. Faaij, eds., *International Bioenergy Trade: History, status and outlook on securing sustainable bioenergy supply, demand and markets* (Berlin: Springer, 2013), pp. 41–64; European Biomass Association (AEBIOM), *European Bioenergy Outlook - Statistical Report* (Brussels: 2013); Hawkins Wright, "The Outlook for Wood Pellet Demand," presented at the U.S. Industrial Pellet Association 3rd Annual Exporting Pellets Conference, Miami, FL, 28 October 2013; C.S. Goh et al., "Wood Pellet Market and Trade: A Global Perspective," *Biofuels, Bioproducts and Biorefining,* vol. 7 (2013), pp. 24–42; P. Lamers et al., "Developments in International Solid Biofuel Trade – An Analysis of Volumes, Policies, and Market Factors," *Renewable & Sustainable Energy Reviews,* vol. 16 (2012), pp. 3176–99.

4 **Table R4** derived from the following sources: ethanol and biodiesel production and comparison with 2012 based on data from F.O. Licht, "Fuel Ethanol: World Production, by Country," 2014, and from F.O. Licht, "Biodiesel: World Production, by Country," 2014, with permission from F.O. Licht / Licht Interactive Data; preliminary 2012 data that appeared in GSR 2013 have been updated where possible; ethanol data converted from cubic metres to litres using 1,000 litres/cubic metre; biodiesel data converted from units of 1,000 tonnes using a density value for biodiesel to give 1,136 litres per tonne based on U.S. National Renewable Energy Laboratory, *Biodiesel Handling and Use Guide*, Fourth Edition (Golden, CO: 2009); other major sources of biofuel production data are IEA and United Nations Food and Agriculture. Note that data can vary considerably among sources. For further details, see Bioenergy section in Market and Industry Trends by Technology, and related endnotes.

5 **Table R5** derived from the following sources: total global installed capacity in 2013 of 12 GW is based on inventory of existing capacity and installed capacity in 2013, from GEA, op. cit. note 1, with the following supplemental information, by country: **New Zealand** from Contact Energy, "Continued performance improvement," press release (Wellington: 18 February 2014), http://www.contactenergy.co.nz/web/pdf/financial/cen-hy14-media-release.pdf; Robert Peltier, "Contact Energy Ltd.'s Te Mihi Power Station Harnesses Sustainable Geothermal Energy," *Power Magazine*, 1 August 2013, http://www.powermag.com/contact-energy-ltd-s-te-mihi-power-station-harnesses-sustainable-geothermal-energy/; Mighty River Power, "PM opens showcase geothermal plant: boost for MRP, benefits for NZ," press release (Auckland: 3 October 2013), http://www.mightyriver.co.nz/PDFs/PDFs/New-Geothermal-plant-boosts-MRP-and-benefits-NZ.aspx; Ormat, "Ormat Successfully Completed the Ngatamariki Geothermal Plant," press release (Reno, NV: 3 September 2013), http://www.ormat.com/news/latest-items/ormat-successfully-completed-ngatamariki-geothermal-plant; **Turkey** from Phillip Dumas, European Geothermal Energy Council, personal communication with REN21, February 2014; Özgür Çağlan Kuyumcu, "Middle East Geothermal Potential," presentation at Geothermal Resources Council Annual Meeting 2013 (Las Vegas, NV, 29 September–2 October 2013, http://www.geothermal.org; Mahmut Parlaktuna et al., "Geothermal Country Update report of Turkey (2012-2013)," prepared for the European Geothermal Congress 2013, Pisa, Italy, 3–7 June 2013, http://www.geothermal-energy.org/pdf/IGAstandard/EGC/2013/EGC2013_CUR-32.pdf; Fuji Electric, "Introduction to Fuji Electric's Recent Experiences in Geothermal Power Plant Business," presentation, October 2013, http://www.jica.go.jp/information/seminar/2013/ku57pq00001ktre1-att/20131101_01_06.pdf; "Zorlu's geothermal power plant opened," *Hurriyet Daily News*, 30 September 2013, http://www.hurriyetdailynews.com/zorlus-geothermal-power-plant-opened.aspx?pageID=238&nID=55378&NewsCatID=345; MB Holding [Menderes Geothermal Elektrik Üretim (MEGE)], "Dora-3 Produces, Turkey Wins," 17 September 2013, http://www.mb.com.tr/en/basinda-mb-holding; BM Holding, "Gümüşköy GEPP Project," http://www.bmholding.com.tr/group_companies/geothermal.asp?show=gumuskoy_gepp_project&menu=power_generation; **United States** from Enel Green Power, "Enel Green Power: The Cove Fort Geothermal Power Plant Starts Operations in Utah," press release (Rome and Boston: 27 November 2013), http://www.enelgreenpower.com/en-GB/ena/events_news/press_releases/release.aspx?iddoc=1661220; U.S. Department of Energy, "Nevada Deploys First U.S. Commercial, Grid-Connected Enhanced Geothermal System," 12 April 2013, http://www.energy.gov/articles/nevada-deploys-first-us-commercial-grid-connected-enhanced-geothermal-system; In-field and near-field EGS are located within or near existing conventional geothermal installations, while greenfield projects would be located on previously undeveloped sites, from GEA, *2013 Geothermal Power: International Market Overview* (Washington, DC: September 2013); Ormat, "Ormat Completes the Don A. Campbell Geothermal Power Plant with Full 16 Megawatt (net) Output," press release (Reno, NV: 6 January 2014), http://www.ormat.com/news/latest-items/ormat-completes-don-campbell-geothermal-power-plant-full-16-megawatt-net-output; Alexander Richter, "Gradient Resources starts operation of Patua plant in Nevada," Think Geoenergy, 15 January 2014, http://thinkgeoenergy.com/archives/17677; Gradient Resources Web site, http://www.gradient.com/; Ormat, "Ormat Becomes Sole Owner of the Mammoth Complex in Mammoth Lakes, California," press release (Reno, NV: 2 August 2010), http://www.ormat.com/news/acquisitions/ormat-becomes-sole-owner-mammoth-complex-mammoth-lakes-california; Ormat, "Ormat Reaches Commercial Operation of the Newly Refurbished Mammoth G1 Power Plant," press release (Reno, NV: 23 January 2014), http://www.ormat.com/news/latest-items/ormat-reaches-commercial-operation-newly-refurbished-mammoth-g1-power-plant; Ormat, "Ormat Reaches Commercial Operation of the Newly Refurbished Mammoth G1 Power Plant," press release (Reno, NV: 23 January 2014), http://www.ormat.com/news/latest-items/ormat-reaches-commercial-operation-newly-refurbished-mammoth-g1-power-plant; **Kenya** from Ormat, "Ormat Technologies Commences Operation of 36 MW Geothermal Power Plant In Kenya," press release (Reno, NV: 2 May 2013), http://www.ormat.com/news/latest-items/ormat-technologies-commences-operation-36-mw-geothermal-power-plant-kenya; Ormat "Olkaria III Geothermal Complex in Kenya Reaches 110 MW with Commercial Operation of Plant 3," press release (Reno, NV: 4 February 2014), http://www.ormat.com/news/latest-items/olkaria-iii-geothermal-complex-kenya-reaches-110-mw-commercial-operation-plant-3; **Philippines** from Maibarara Geothermal Inc., "20 MW Maibarara Geothermal Power Project Starts Commercial Operations," 9 February 2014, http://maibarara.com.ph/news/20-mw-maibarara-geothermal-power-project-starts-commercial-operations; Maibarara Geothermal Inc., "Maibarara Geothermal Power Project Gets CDM Approval," 15 May 2013, http://maibarara.com.ph/uncategorized/maibarara-geothermal-power-project-gets-cdm-approval; Manuel S. Ogena and Ariel Fronda, Philippines Department of Energy, "Prolonged Geothermal Generation and Opportunity in the Philippines," presentation at Geothermal Resources Council Annual Meeting 2013, Las Vegas, NV, 30 September 2013, http://www.geothermal.org; **Mexico** from Alstom, "Los Humeros II, Units 9 & 10," http://www.alstom.com/Global/Power/Resources/Documents/Brochures/los-humeros-II-mexico-geothermal-power-plant-datasheet.pdf; Alstom, "Alstom to build "Los Humeros III" geothermal project in Mexico," 19 December 2013, http://www.alstom.com/press-centre/2013/11/alstom-to-build-los-humeros-iii-geothermal-project-in-mexico/; United Nations Framework Convention on Climate Change, "Project 8861: Los Humeros II Phase A+B Geothermal Project," http://cdm.unfccc.int/Projects/DB/DNV-CUK1355831407.2/view; Luis Gutierrez-Negrin, Mexican Geothermal Association, personal communication with REN21, April 2014.

6 **Table R6** derived from the following sources: **China:** China Electricity Council (CEC), summary of electricity supply and demand from CEC's 2014 Annual Report, http://www.cec.org.cn/guihuayutongji/gongxufenxi/dianligongxufenxi/2014-02-25/117272.html; Shi Pengfei, China Wind Energy Association, personal communication with REN21, 12 March 2014; **Brazil:** 1,533 MW (264 MW small hydro and 1,264 MW large hydro) added in 2013, per National Agency for Electrical Energy (ANEEL), "Fiscalização dos serviços de geração," February 2013, http://www.aneel.gov.br/area.cfm?idArea=37; large hydro capacity is listed as 81.093 GW at end-2013 and small hydro at 4.656 GW, for a total of 85,749 MW; generation from National Electrical System Operator of Brazil (ONS), "Geração de Energia," http://www.ons.org.br/historico/geracao_energia.aspx; **United States:** 2012 capacity from U.S. Energy Information Administration (EIA), *Electric Power Annual*, Table 4.3 Existing Capacity by Energy Source, http://www.eia.gov/electricity/annual/html/epa_04_03.html; projected

net additions in 2013 of 201 MW from idem, Table 4.5 Planned Generating Capacity Changes by Energy Source, 2013–2017, http://www.eia.gov/electricity/annual/html/epa_04_05.html; generation from EIA, *Electric Power Monthly,* February 2014, Table 1.1, http://www.eia.gov/electricity/monthly; **Canada:** Canadian Hydropower Association, communication with REN21, February 2014; Hydropower Equipment Association (HEA) data based on its members' aggregated input, personal communication with REN21, April 2014; generation from Statistics Canada, "Table 127-0002 Electric Power Generation, by class of electricity producer," http://www5.statcan.gc.ca/cansim; **Russia:** capacity and generation from System Operator of the Unified Energy System of Russia, *Report on the Unified Energy System in 2013* (Moscow: undated), http://www.so-ups.ru/fileadmin/files/company/reports/disclosure/2014/ups_rep2013.pdf; **India:** installed capacity in 2013 (units larger than 25 MW) of 39,893.4 MW from Government of India, Ministry of Power, Central Electricity Authority, "Installed capacity as of 31 December 2013," http://www.cea.nic.in/reports/monthly/inst_capacity/dec13.pdf, and idem, "List of H.E. Stations in the Country with Station Capacity Above 25 MW," http://www.cea.nic.in/reports/hydro/list_he__stations.pdf; capacity additions in 2013 (>25 MW) of 554 MW from Central Electricity Authority, "Executive Summary of the Power Sector (monthly)," http://www.cea.nic.in/exesum_cood.html; installed capacity in 2013 (<25 MW) of 3,763.15 MW from MNRE, op. cit. note 1; capacity additions in 2013 (<25 MW) of 267 MW based on difference of year-end 2013 figure (above) and year-end 2012 figure (3,496.15 MW) from MNRE, *Annual Report 2012-2013* (New Delhi: undated), Table 3.7, http://www.mnre.gov.in/mission-and-vision-2/publications/annual-report-2; generation for plants larger than 25 MW from Central Electricity Authority, "Executive Summary of the Power Sector (monthly)," op. cit. this note, and output from hydropower plants smaller than 25 MW estimated, based on capacity from MNRE, *Annual Report 2012–2013*, op. cit. this note and on average capacity factor for large hydropower facilities in India; **Turkey:** capacity was 19,609.4 MW at the end of 2012 and 22,493.6 MW by 31 January 2014, from Dr. Öztürk Selvitop, Ministry of Energy and Natural Resources, Republic of Turkey, "Hydropower in Turkish Energy Sector," presentation, Ankara, 4 March 2014, http://suyonetimi.ormansu.gov.tr/Libraries/su/Hydropower_in_Turkish_Energy_Sector.sflb.ashx; see also Turkish Electricity Transmission Company, capacity projections, http://www.teias.gov.tr/YayinRapor/APK/projeksiyon/KapasiteProjeksiyonu2013.docx; **Vietnam:** late 2013 capacity from Do Duc Quan, director, Hydropower Department, General Department of Energy, "Policies on Sustainable Hydropower Development in Vietnam, presentation, Second Mekong River Commission Summit and International Conference, Ho Chi Minh City, 2–5 April 2014, http://www.mrcsummit.org/presentations/track2/1.2-d-policy-for-sustainable-dev-ofhydro-QuanDoDuc.pdf; 2012 year-end capacity of 12.95 GW from National Electricity Center of Vietnam, http://www.nldc.evn.vn/News/7/661/Bao-cao-tong-ket-nam-2012.aspx; **World** based on International Hydropower Association (IHA) Hydropower Database, personal communication with REN21, March 2014; from preliminary estimates in IEA, *Medium-Term Renewable Energy Market Report 2014*, op. cit. note 1.

7 **Table R7** derived from the following sources: **Germany**: 32,643 MW at end-2012, added 3,305 MW in 2013 for a total of 35,948 MW, from AGEE-Stat, op. cit. note 1; 3,304 MW added for a total of 35,500 MW, from IEA–Photovoltaic Power Systems Programme (IEA-PVPS), *PVPS Report – Snapshot of Global PV 1993–2013: Preliminary Trends Information from the IEA PVPS Programme* (Brussels: March 2014), http://www.iea-pvps.org/fileadmin/dam/public/report/statistics/PVPS_report_-_A_Snapshot_of_Global_PV_-_1992-2013_-_final_3.pdf; **China**: 7 GW at end-2012 from EPIA, op. cit. note 2; added 12.92 GW from China National Energy Administration, provided by Gaëtan Masson, IEA PVPS and iCARES Consulting, May 2014; for an estimated total of 19.9 GW from Masson, op. cit. this note; **Italy**: 16.4 GW at end 2012, from IEA-PVPS, *Trends in Photovoltaic Applications 2013: Survey Report of Selected IEA Countries Between 1992 and 2012* (Brussels: 2013), http://iea-pvps.org/fileadmin/dam/public/report/statistics/FINAL_TRENDS_v1.02.pdf; added 1,461 MW in 2013 for a total of 17.6 GW from IEA-PVPS, *PVPS Report*, op. cit. this note; **Japan**: 6,631 MW at end 2012, from IEA-PVPS, *Trends in Photovoltaic Applications 2013*, op. cit. this note; added 6,900 MW for a total of 13,643 MW, from IEA-PVPS, *PVPS Report*, op. cit. note 7; **United States**: 7.2 GW at end 2012, from IEA-PVPS, *Trends in Photovoltaic Applications 2013*, op. cit. this note; added 4,751 MW for a total of 12.1 GW from GTM Research and U.S. Solar Energy Industries Association, *U.S. Solar Market Insight Report: 2013 Year-in Review* (Washington, DC: 2014), Executive Summary, http://www.seia.org/research-resources/solar-market-insight-report-2013-year-review; added 4,750 MW for a total of 12,020 MW from IEA-PVPS, *PVPS Report*, op. cit. this note; **Spain**: 5.4 GW at end 2012 from Gaëtan Masson, IEA PVPS and iCARES Consulting, personal communications with REN21, February–May 2014; added 152 MW in 2013 for a total of 5,566 MW, from IEA-PVPS, *PVPS Report*, op. cit. this note; **France**: 4,033 MW at end 2012 from IEA-PVPS, *Trends in Photovoltaic Applications 2013*, op. cit. this note; 613 MW added in 2013 for a total of 4,632 MW from IEA-PVPS, *PVPS Report*, op. cit. this note; **United Kingdom**: 1,829 MW at end 2012, from IEA-PVPS, *Trends in Photovoltaic Applications 2013*, op. cit. this note; added 1.5 GW in 2013 for a total of 3.3 GW from EPIA, op. cit. note 2; **Australia**: 2,415 MW at end-2012, from IEA-PVPS, *Trends in Photovoltaic Applications 2013*, op. cit. this note; added 848 MW in 2013 for a total of 3,255 MW, from IEA-PVPS, *PVPS Report*, op. cit. this note; **Belgium**: 2,698 MW at end-2012, from IEA-PVPS, *Trends in Photovoltaic Applications 2013*, op. cit. this note; added 215 MW in 2013 for a total of 2,983 MW, from IEA-PVPS, *PVPS Report*, op. cit. this note; **Rest of World** based on other data provided in table; **World Total**: 99,690 MW at end-2012, from EPIA, *Market Report 2013* (Brussels: March 2014), http://www.epia.org/uploads/tx_epiapublications/Market_Report_2013_02.pdf; added more than 39 GW for a total of 139 GW based on: 39—40 GW installed for a total of 138—140 GW, from Masson, op. cit. this note, and preliminary estimates from IEA-PVPS, PVPS Report, op. cit. this note, and from EPIA, op. cit. note 2.

8 **Table R8** derived from the following sources: REN21, *Renewables 2013 Global Status Report* (Paris: REN21 Secretariat, June 2013), http://www.ren21.net/Portals/0/documents/Resources/GSR/2013/GSR2013_lowres.pdf; Luis Crespo, ESTELA, personal communication with REN21, February 2014; Fred Morse, Morse Associates, Inc., personal communication with REN21, February 2014; "CSP World Map," CSP World, http://www.csp-world.com/cspworldmap; "CSP Today Global Tracker," CSP Today, http://social.csptoday.com/tracker/projects; U.S. Solar Energy Industries Association (SEIA), "Solar Energy Facts: 2013 Year in Review," 5 March 2014, http://www.seia.org/sites/default/files/YIR%202013%20SMI%20Fact%20Sheet.pdf; SEIA, "Major Solar Projects in the United States: Operating, Under Construction, or Under Development," 6 March 2014, http://www.seia.org/sites/default/files/resources/Major%20Solar%20Projects%20List%203.6.14.pdf; "NextEra dedicates 250 MW Genesis CSP Plant," Solar Server, 25 April 2014, http://www.solarserver.com/solar-magazine/solar-news/current/2014/kw17/nextera-dedicates-250-mw-genesis-csp-plant.html; Abengoa Solar, "Mojave Solar Project," http://www.abengoasolar.com/web/en/nuestras_plantas/plantas_en_construccion/estados_unidos/.

9 **Table R9** derived from the following sources: Mauthner and Weiss, op. cit. note 1; Mauthner, op. cit. note 1. The Mauthner and Weiss report covers an estimated 95% of the world total, which REN21 has adjusted to 100% to derive the world total. See Solar Heating and Cooling section and endnotes for further details.

10 **Table R10** derived from the following sources: year-end world and country data for 2012 from Global Wind Energy Council (GWEC), *Global Wind Report—Annual Market Update 2013* (Brussels: April 2014), GWEC), http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf; data for 2013 from the following sources: **China**: added 16,089 MW for a total of 91,412 MW installed by the end of 2013, from Chinese Wind Energy Association (CWEA), provided by Shi Pengfei, CWEA, personal communication with REN21, 14 March 2014; official data for grid-connected and operational by year's end, including 60.8 GW at end-2012, 14.1 GW added in 2013, and 75.5 GW at year's end, are from China Electricity Council, provided by Shi Pengfei, CWEA, personal communication with REN21, 15 April 2014; **United States**: added 1,087 MW for a total of 61,110 MW, from American Wind Energy Association, "U.S. Capacity & Generation," *U.S. Wind Industry Annual Market Report 2013* (Washington, DC: 10 April 2014), http://www.awea.org/AnnualMarketReport.aspx?ItemNumber=6305&RDtoken=35392&userID=; **Germany**: added 3,592 MW of capacity, of which 3,237 MW was grid-connected and 236 MW was used for repowering, for a total of 34,660 MW installed and 34,305 MW grid-connected at year's end, based on C. Ender, "Wind Energy Use in Germany—Status 31.12.2013," *DEWI Magazin*, February 2014, http://www.dewi.de/dewi/fileadmin/pdf/publications/Magazin_44/07.pdf; added 3,238 MW (2,980 MW net additions, accounting for repowering)

to grid for a total of 34,250 MW, from GWEC, op. cit. this note; **Spain**: added 175 MW for a total of 22,959 MW, from European Wind Energy Association (EWEA), *Wind in Power: 2013 European Statistics* (Brussels: February 2014), p. 4, http://www.ewea.org/fileadmin/files/library/publications/statistics/EWEA_Annual_Statistics_2013.pdf; 173 MW net additions for total of 22,746 MW, from REE, op. cit. note 1; **India** added 1,729 MW in 2013 for a total of 20,150 MW, from GWEC, op. cit. this note, p. 17; **United Kingdom** added 1,883 MW for a year-end total of 10,531 MW, from EWEA, op. cit. this note, pp. 4–5; **Italy** added 444 MW for a total of 8,551 MW, from idem, pp. 4–5; **France** added 631 MW for a total of 8,254 MW, from idem, pp. 3–5; **Canada** added nearly 1,600 MW for a total of 7,802.72 MW, from Canadian Wind Energy Association, "Installed Capacity," http://canwea.ca/wind-energy/installed-capacity/, viewed 11 April 2014; **Denmark**: added 657 MW for a total of 4,772 MW, from EWEA, op. cit. this note, pp. 4–5; added net 626 MW for total of 4,792 MW at year's end, from Carsten Vittrup, "2013 Was a Record-Setting Year for Danish Wind Power," Energinet.DK, 15 January 2014, http://www.energinet.dk/EN/El/Nyheder/Sider/2013-var-et-rekordaar-for-dansk-vindkraft.aspx; **Rest of World** based on other data provided in table; **Global**: added 35,289 MW during the year, bringing the total to 318,105 MW, from GWEC, op. cit. this note, p. 16; 35,550 MW added for a total of 318,529 MW, from World Wind Energy Association, *World Wind Energy Report 2013* (Bonn: 2014); and 36,134 MW added for a total of 321,559 MW, from Navigant Research, *World Market Update 2013: International Wind Energy Development. Forecast 2014–2018* (Copenhagen: March 2014), Executive Summary; 35,572 MW installed for a total of 318,576 MW, from EurObserv'ER, *Wind Energy Barometer* (Paris: February 2014), p. 2, http://www.energies-renouvelables.org/observ-er/stat_baro/observ/baro-jde14-gb.pdf. See Wind Power text and related endnotes for further world and country statistics and details.

11 **Table R11** from Frankfurt School–UNEP Collaborating Centre for Climate & Sustainable Energy Finance and Bloomberg New Energ Finance, *Global Trends in Renewable Energy Investment 2014* (Frankfurt: 2014).

12 **Table R12** from the following sources: REN21 database; submissions by report contributors; various industry reports; EurObserv'ER, *The State of Renewable Energies in Europe* (Paris: 2014), http://www.energies-renouvelables.org/observ-er/stat_baro/barobilan/barobilan13-gb.pdf. For online updates, see the "Renewables Interactive Map" at www.ren21.net.

13 **Table R13** from the following sources: REN21 database; submissions by report contributors; various industry reports; EurObserv'ER, *Worldwide Electricity Production from Renewable Energy Sources: Stats and Figures Series* (Paris: 2014) Targets for the EU-28 were set in each country's National Renewable Energy Action Plan (NREAP), available at http://ec.europa.eu/energy/renewables/action_plan_en.htm. Certain NREAP targets have been revised subsequently. For online updates, see the "Renewables Interactive Map" at www.ren21.net.

14 **Table R14** from REN21 database compiled from all available policy references plus submissions from report contributors. Targets for the EU-28 were set in each country's NREAP. Certain NREAP targets have been revised subsequently.
For online updates, see the "Renewables Interactive Map" at www.ren21.net.

15 **Table R15** from ibid.

16 **Table R16** from all available policy references, including the IEA/IRENA online Global Renewable Energy Policies and Measures database, published sources as given in the endnotes for the Policy Landscape section of this report, and submissions from report contributors.

17 **Table R17** from ibid.

18 **Table R18** from ibid.

19 **Table R19** derived from the following sources: For selected targets and policies, see the EU Covenant of Mayors, ICLEI – Local Governments for Sustainability; REN21, *Global Futures Report* (Paris: 2013); and REN21, ISEP, and ICLEI, 2011 *Global Status Report on Local Renewable Energy Policies* (Paris: May 2011). For selected examples in urban planning, see: City of Glasgow, Environment, *Sustainable Glasgow Report* (Glasgow: January 2010), http://www.glasgow.gov.uk/chttphandler.asx?id=10159&p=0; City of Hong Kong, *Blueprint for Sustainable Use of Resources 2013 – 2022* (Hong Kong: May 2012), http://www.enb.gov.hk/en/files/WastePlan-E.pdf; "Green Hong Kong" (Hong Kong: May 2012), http://www.brandhk.gov.hj/en/facts/factsheets/pdf/05_green_hongkong_en.pdf; City of Malmö, "Environmental Programme for the City of Malmö 2009-2020" (Malmo: 2009), http://www.malmo.se/download/18.6301369612700a2db9180006227/Environmental-Programme-for-the-City-of-Malmo-2009-2020.pdf; IRENA, "Renewable Energy Policy in Cities: Selected Case Studies - Malmo, Sweden"(Abu Dhabi: January 2013), www.irena.org/Publications/RE_Policy_Cities_CaseStudies/IRENA%20cities%20case%207%20Malmo.pdf; City of Seoul, City Initiatives, "Overview of Seoul City's Administration Plan" (Seoul: 2011), http://english.seoul.go.kr/gtk/cg/policies.php; "City Planning of Seoul" (Seoul: 2013), http://english.seoul.go.kr/library/common/download.php?fileDir=/community/&fileName=04_City_Planning_of_Seoul.pptx; City of Sydney, *Decentralised Energy Master Plan Renewable Energy* (Sydney: 2013), http://www.cityofsydney.nsw.gov.au/2030/makingithappen/documents/Building_Water_Energy_Retrofit_EOI.pdf; City of Sydney, *Decentralised Energy Master Plan Trigeneration 2010–2030* (Sydney: 2013), http://www.cityofsydney.nsw.gov.au/__data/assets/pdf_file/0003/153282/Renewable-Energy-Master-Plan.pdf; City of Vancouver, Green Vancouver, "Greenest City 2020 Action Plan" (Vancouver: November 2012), http://vancouver.ca/files/cov/greenest-city-action-plan.pdf; City of Yokohama, "Climate Change Policy-related Pages of the Mid-Term Plan of the City of Yokohama" (Yokohama: 2013), http://www.city.yokohama.lg.jp/ondan/english/pdf/policies/mid-term-plan-of-the-city-of-yokohama.pdf.

20 **Table R20** from the following sources: REN21 database; IEA, *World Energy Outlook 2013*, Energy Access Database, http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/; submissions from report contributors.

21 **Table R21** from IEA, op. cit. note 20

METHODOLOGICAL NOTES

This 2014 report follows eight previous editions of the *Renewables Global Status Report* (GSR), produced since 2005 (with the exception of 2008). Readers are directed to the previous GSR editions for historical details.

Most 2013 data for national and global capacity, output, growth, and investment portrayed in this report are preliminary. Where necessary, information and data that are conflicting, partial, or older are reconciled by using reasoned expert judgment. Endnotes provide additional details, including references, supporting information, and assumptions where relevant. (See Sidebar 1 on renewable energy data and related challenges.)

Each edition draws from thousands of published and unpublished references, including: reports from international organisations and industry associations; input from the GSR community via hundreds of questionnaires submitted by country, regional, and technology contributors, and feedback from several rounds of formal and informal reviews; additional personal communications with scores of international experts; as well as a variety of electronic newsletters, news media, and other sources.

Much of the data found in the GSR is built from the ground up by the authors with the aid of these resources. This often involves extrapolation of older data, based on recent changes in key countries within a sector, or based on recent growth rates and global trends. Other data, often very specific and narrow in scope, come more-or-less prepared from third parties. The GSR attempts to synthesise these datapoints into a collective whole for the focus year.

The GSR endeavours to cover accurately, on a global level, all data related to renewable energy markets and industries, policy developments, as well as renewable energy-related advances to expand energy access in developing countries. It aims to provide the best data available in each successive edition; as such, data should not be compared with previous versions of this report to ascertain year-by-year changes.

NOTE ON ACCOUNTING AND REPORTING

A number of issues arise when counting renewable energy capacities and energy output. Some of these are discussed below:

1. CAPACITY VERSUS ENERGY DATA

The GSR aims to give accurate estimates of capacity additions and totals, as well as of electricity, heat, and transport fuel production in the past year. These measures are subject to some uncertainty, with the level of uncertainty differing from technology to technology. The section on Market and Industry Trends includes estimates for energy produced where possible but, due to data constraints, focusses mainly on electricity or heat capacity data. This is because capacity data generally can be estimated with a greater degree of certainty. Further, actual heat and electricity generation data for most countries are usually available only 12 months or more after the fact, and sometimes not at all. In addition, capacity data better mimic investment trends over time.

2. CONSTRUCTED CAPACITY VERSUS CONNECTED CAPACITY AND OPERATIONAL CAPACITY

Over the past few years, the solar PV and wind power markets have seen increasing amounts of capacity that was connected to the electricity grid but not yet deemed officially operational, or constructed capacity that was not connected to the grid by year-end (and, in turn, capacity that was installed in one year but connected to the grid during the next). This phenomenon has been particularly evident for wind power installations in China (2009–2013), as well as for solar PV in some European countries in recent years.

Starting with the 2012 edition, the GSR has aimed to count only capacity additions that were grid-connected, or that otherwise went into service (e.g., capacity intended for off-grid use), during the previous calendar year. However, there may be exceptions borne out of necessity of data availability (as with China, for example). Known deviations to this approach are outlined in the text and/or endnotes for the technology sections.

The reasoning is that the sources from which the GSR draws have varying methodologies for counting installations, and many official bodies report grid connection statistics. As a result, in many countries the data for actual installations are becoming increasingly difficult to obtain. Some renewable industry groups, including the European Photovoltaic Industry Association and the Global Wind Energy Council, have shifted to tracking and reporting on operational/grid-connected rather than installed capacities.

3. BIO-POWER DATA

Given existing complexities and constraints (see Figure 5 in this report, and Sidebar 2 in GSR 2012), the GSR strives to provide the best and latest available data regarding biomass energy developments. The reporting of biomass-fired combined heat and power (CHP) systems varies among countries, which adds to the challenges experienced when assessing total heat and electricity capacities and total bioenergy outputs. Wherever possible, the bio-power data presented include capacity and generation from both electricity-only and CHP systems using solid biomass, landfill gas, biogas, and liquid biofuels.

4. GEOTHERMAL HEAT AND HEAT PUMPS

Starting with GSR 2014, ground-source (geothermal) heat pump capacity and output is not included in the section on geothermal energy. Ground-source, air-source (aerothermal), and water-source (hydrothermal) heat pumps are all discussed in Sidebar 4. Consequently, estimates of geothermal heat capacity and utilisation provided in the geothermal section are lower than in some previous editions. This change is also reflected in Figure 1, although the scale of the change relative to other technologies is so small that it does not affect the figure.

This adjustment was made for several reasons: 1) ground-source heat pumps are but one of three categories of heat pumps, differentiated only by their source/sink, and should be covered along with other types; 2) data are severely lacking on global installed heat pump capacity and output; and 3) although a common methodology on defining the renewable component of heat pump output has been formulated in Europe, uncertainty about specific technology and operating efficiencies globally make the data on heat-pump derived/enabled renewable energy output even murkier. (See Sidebar 4.)

5. HYDROPOWER DATA REVISION AND TREATMENT OF PUMPED STORAGE

The GSR 2013 reported a global total of 990 GW at the end of 2012. This figure has been revised downward in this edition by 30 GW, due primarily to the availability of improved data. The reduction also reflects further removal of capacity that has been identified as pure pumped storage (see below).

The adjustment to global hydropower capacity also affects reported total global renewable power capacity relative to previous editions of the GSR and, thus, such data should not be compared directly with statistics in previous editions. (Note, however, that historical capacity data in the Renewable Energy Indicators Table on page 15 account for this change.) For future editions of the GSR, ongoing efforts are being made to further improve data.

Moreover, starting with the 2012 edition, the GSR has attempted to report hydropower generating capacity without including pure pumped storage capacity (the capacity used solely for shifting water between reservoirs for storage purposes). The distinction is made because pumped storage is not an energy supply source but rather a means of energy storage. It involves conversion losses and is potentially fed by all forms of electricity, renewable and non-renewable. However, some conventional hydropower facilities do have pumping capability that is not separate from, or additional to, their normal generating capability. It is the aim of the GSR to distinguish and separate only the pure (or incremental) pumped storage component. (As noted in Sidebar 3 of GSR 2013, pumped storage can play an important role as balancing power in a grid system, particularly where a large share of variable renewable resources appears in the generation mix.)

This method of accounting is accepted practice by the industry. The International Hydropower Association is working to track and report pure pumped storage numbers separately. In addition, several countries report data for pumped storage separately from data for conventional hydropower and other renew¬ables.

6. SOLAR THERMAL HEAT DATA

Starting with this edition, the GSR includes all solar thermal collectors that use water as the heat-transfer medium (or heat carrier) in global capacity data and ranking of top 12 countries. Previous GSRs focussed primarily on glazed water collectors (both flat plate and evacuated tube); this edition also includes unglazed water collectors, which are used predominantly for swimming pool heating, in data throughout. This change affects reported global capacity data, as well as the rankings of top countries, relative to previous GSR editions.

Most countries that report data for solar water collectors gather information on glazed collectors only. Furthermore, glazed water collectors represent more than 90% of cumulative global installed solar thermal capacity, and more than 95% of newly installed capacity. Thus, past GSRs focussed primarily on glazed water collectors to avoid mixing countries that have detailed data across all collectors with those that do not. However, because most of the largest markets for unglazed water collectors now gather data on this collector type, and data are improving elsewhere, unglazed collectors are covered more fully starting with GSR 2014.

Note that data for solar air collectors (solar thermal collectors that use air as the heat carrier) are far more uncertain, and these collector types play a minor role in the market overall. Solar thermal air collectors are included where specified.

Concentrating solar thermal systems used for industrial processes, or to drive double- or triple-stage absorption chillers, are included in the section Solar Thermal Heating and Cooling. These systems—including parabolic trough, dish, and Fresnel collectors—are smaller than their concentrating solar thermal power (CSP) relatives, and are adapted to provide high-temperature heat (typically 120–250 °C, and up to 400 °C) that is not used to generate electricity.

7. OTHER

Editorial content of this report closed by 17 May 2014 for technology data, and by 1 May for other content.

All exchange rates in this report are as of 31 December 2013, and are calculated using the OANDA currency converter (http://www.oanda.com/currency/converter/).

GLOSSARY

ABSORPTION CHILLERS. Chillers that use heat energy from any source (solar, biomass, waste heat, etc.) to drive air conditioning or refrigeration systems. The heat source replaces the electric power consumption of a mechanical compressor. Absorption chillers differ from conventional (vapour compression) cooling systems in two ways: the absorption process is thermo-chemical in nature rather than mechanical, and water is circulated as a refrigerant, rather than chlorofluorocarbons (CFCs) or hydro chlorofluorocarbons (HCFCs, also called freon). The chillers are generally supplied with district heat, waste heat, or heat from cogeneration, and they can operate with heat from geothermal, solar, or biomass resources.

BIODIESEL. A fuel produced from oilseed crops such as soy, rapeseed (canola), and palm oil, and from other oil sources such as waste cooking oil and animal fats. Biodiesel is used in diesel engines installed in cars, trucks, buses, and other vehicles, as well as in stationary heat and power applications. Also see Hydro-treated vegetable oil.

BIOENERGY. Energy derived from any form of biomass, including bio-heat, bio-power, and biofuel. Bio-heat arises from the combustion of solid biomass (such as dry fuel wood) or other liquid or gaseous energy carriers. The heat can be used directly or used to produce bio-power by creating steam to drive engines or turbines that drive electricity generators. Alternatively, gaseous energy carriers such as biomethane, landfill gas, or synthesis gas (produced from the thermal gasification of biomass) can be used to fuel a gas engine. Biofuels for transport are sometimes also included under the term bioenergy (see Biofuels).

BIOFUELS. A wide range of liquid and gaseous fuels derived from biomass. Biofuels—including liquid fuel ethanol and biodiesel, as well as biogas—can be combusted in vehicle engines as transport fuels and in stationary engines for heat and electricity generation. They also can be used for domestic heating and cooking (for example, as ethanol gels). Advanced biofuels are made from sustainably produced non-food biomass sources using technologies that are still in the pilot, demonstration, or early commercial stages. One exception is hydro-treated vegetable oil (HVO), which is now produced commercially in several plants.

BIOGAS/BIOMETHANE. Biogas is a gaseous mixture consisting mainly of methane and carbon dioxide produced by the anaerobic digestion of organic matter (broken down by micro-organisms in the absence of oxygen). Organic material and/or waste is converted into biogas in a digester. Suitable feedstocks include agricultural residues, animal wastes, food industry wastes, sewage sludge, purpose-grown green crops, and the organic components of municipal solid wastes. Raw biogas can be combusted to produce heat and/or power; it can also be transformed into biomethane through a simple process known as scrubbing that removes impurities including carbon dioxide, siloxanes, and hydrogen sulphides. Biomethane can be injected directly into natural gas networks and used as a substitute for natural gas in internal combustion engines without fear of corrosion.

BIOMASS. Any material of biological origin, excluding fossil fuels or peat, that contains a chemical store of energy (originally received from the sun) and is available for conversion to a wide range of convenient energy carriers. These can take many forms, including liquid biofuels, biogas, biomethane, pyrolysis oil, or solid biomass pellets.

BIOMASS PELLETS. Solid biomass fuel produced by compressing pulverised dry biomass, such as waste wood and agricultural residues. Torrefied pellets produced by heating the biomass pellets have higher energy content per kilogram, as well as better grindability, water resistance, and storability. Pellets are typically cylindrical in shape with a diameter of around 10 millimetres and a length of 30–50 millimetres. Pellets are easy to handle, store, and transport and are used as fuel for heating and cooking applications, as well as for electricity generation and combined heat and power.

BRIQUETTES. Blocks of flammable matter made from solid biomass fuels, including cereal straw, that are compressed in a process similar to the production of wood pellets. They are physically much larger than pellets, with a diameter of 50–100 millimetres and a length of 60–150 millimetres. They are less easy to handle automatically but can be used as a substitute for fuelwood logs.

CAPACITY. The rated capacity of a heat or power generating plant refers to the potential instantaneous heat or electricity output, or the aggregate potential output of a collection of such units (such as a wind farm or set of solar panels). Installed capacity describes equipment that has been constructed, although it may or may not be operational (e.g., delivering electricity to the grid, providing useful heat, or producing biofuels).

CAPACITY FACTOR. The ratio of the actual output of a unit of electricity or heat generation over a period of time (typically one year) to the theoretical output that would be produced if the unit were operating without interruption at its rated capacity during the same period of time.

CAPITAL SUBSIDY. A subsidy that covers a share of the upfront capital cost of an asset (such as a solar water heater). These include, for example, consumer grants, rebates, or one-time payments by a utility, government agency, or government-owned bank.

COMBINED HEAT AND POWER (CHP) (ALSO CALLED COGENERATION). CHP facilities produce both heat and power from the combustion of fossil and/or biomass fuels, as well as from geothermal and solar thermal resources. The term is also applied to plants that recover "waste heat" from thermal power-generation processes.

CONCENTRATING PHOTOVOLTAICS (CPV). Technology that uses mirrors or lenses to focus and concentrate sunlight onto a relatively small area of photovoltaic cells that generate electricity (see Solar photovoltaics). Low-, medium-, and high-concentration CPV systems (depending on the design of reflectors or lenses used) operate most efficiently in concentrated, direct sunlight.

CONCENTRATING SOLAR THERMAL POWER (CSP) (ALSO CALLED CONCENTRATING SOLAR POWER OR SOLAR THERMAL ELECTRICITY, STE). Technology that uses mirrors to focus sunlight into an intense solar beam that heats a working fluid in a solar receiver, which then drives a turbine or heat engine/generator to produce electricity. The mirrors can be arranged in a variety of ways, but they all deliver the solar beam to the receiver. There are four types of commercial CSP systems: parabolic troughs, linear Fresnel, power towers, and dish/engines. The first two technologies are line-focus systems, capable of concentrating the sun's energy to produce temperatures of 400 °C, while the latter two are point-focus systems that can produce temperatures of 800 °C or higher. These high temperatures make thermal energy storage simple, efficient, and inexpensive. The addition of storage—using a fluid (most commonly molten salt) to store heat—usually gives CSP power plants the flexibility needed for reliable integration into a power grid.

CONVERSION EFFICIENCY. The ratio between the useful energy output from an energy conversion device and the energy input into it. For example, the conversion efficiency of a PV module is the ratio between the electricity generated and the total solar energy received by the PV module. If 100 kWh of solar radiation is received and 10 kWh electricity is generated, the conversion efficiency is 10%.

CROWD FUNDING. The practice of funding a project or venture by raising small amounts of money from a large number of people ("crowd"), generally using the Internet and social media. The money raised through crowdfunding does not necessarily buy the lender a share in the venture, and there is no guarantee that money will be repaid if the venture is successful. However, some types of crowd funding reward backers with an equity stake, structured payments, and/or other products.

DISTRIBUTED GENERATION. Generation of electricity from dispersed, generally small-scale systems that are close to the point of consumption.

ENERGY. The ability to do work, which comes in a number of forms including thermal, radiant, kinetic, chemical, potential, and electrical. Primary energy is the energy embodied in (energy potential of) natural resources, such as coal, natural gas, and renewable sources. Final energy is the energy delivered to end-use facilities (such as electricity to an electrical outlet), where it becomes usable energy and can provide services such as lighting, refrigeration, etc. When primary energy is converted into useful energy, there are always losses involved.

ENERGY SERVICE COMPANY (ESCO). A company that provides a range of energy solutions including selling the energy services from a renewable energy system on a long-term basis while retaining ownership of the system, collecting regular payments from customers, and providing necessary maintenance service. An ESCO can be an electric utility, co-operative, NGO, or private company, and typically installs energy systems on or near customer sites. An ESCO can also advise on improving the energy efficiency of systems (such as a building or an industry) as well as methods for energy conservation and energy management.

ENERGIEWENDE. German term that means "transformation of the energy system." It refers to the move away from nuclear and fossil fuels towards an energy system based primarily on energy efficiency improvements and renewable energy.

ETHANOL (FUEL). A liquid fuel made from biomass (typically corn, sugar cane, or small cereals/grains) that can replace gasoline in modest percentages for use in ordinary spark-ignition engines (stationary or in vehicles), or that can be used at higher blend levels (usually up to 85% ethanol, or 100% in Brazil) in slightly modified engines such as those provided in "flex-fuel vehicles." Note that some ethanol production is used for industrial, chemical, and beverage applications and not for fuel.

FEE-FOR-SERVICE MODEL. An arrangement to provide consumers with an electricity service, in which a private company retains ownership of the equipment and is responsible for maintenance and for providing replacement parts over the life of the service contract. A fee-for-service model can be a leasing or ESCO model.

FEED-IN POLICY. A policy that: (a) sets a guaranteed payment over a stated fixed-term period when renewable power can be sold and fed into the electricity network, and (b) usually guarantees grid access to renewable electricity generators. Some policies provide a fixed tariff or minimum price (see Feed-in tariff), whereas others provide premium payments that are added to wholesale market prices or cost-related tariffs (see Feed-in premium). Feed-in policies are sometimes combined with tendering, e.g. electricity producers have to qualify in a bidding procedure. Other variations exist, and feed-in policies for heat are evolving.

FEED-IN PREMIUM (FIP). A type of feed-in policy. Producers of electricity from renewable sources sell electricity at market prices, and a premium is added to the market price to compensate for higher costs and thus to mitigate financial risks of renewables production. Premiums are set as fixed premiums (a fixed amount is added to the market price for a certain period of time) or as flexible premiums (the exact amount is dependent from other criteria, e.g., market price, electricity demand, defined cap, defined floor). Normally, fixed premiums expose electricity producers to higher market risks, whereas flexible premiums mitigate at least some of the market price volatility and the resulting risks.

FEED-IN TARIFF (FIT). The basic form of feed-in policies. A guaranteed minimum price (tariff) per unit (normally kWh or MWh) is guaranteed over a stated fixed-term period when electricity can be sold and fed into the electricity network, normally with priority or guaranteed grid access and dispatch.

FINAL ENERGY. The part of primary energy, after deduction of losses from conversion, transmission, and distribution, that reaches the consumer and is available to provide heating, hot water, lighting, and other services. Final energy forms include electricity, district heating, mechanical energy, liquid hydrocarbons such as kerosene or fuel oil, and various gaseous fuels such as natural gas, biogas, and hydrogen. Final energy accounts only for the conversion losses that occur upstream of the end-user, such as losses at refineries and power plants.

FISCAL INCENTIVE. An economic incentive that provides individuals, households, or companies with a reduction in their contribution to the public treasury via income or other taxes, or with direct payments from the public treasury in the form of rebates or grants.

GENERATION. The process of converting energy into electricity and/or useful heat from a primary energy source such as wind, solar radiation, natural gas, biomass, etc.

GEOTHERMAL ENERGY. Heat energy emitted from within the Earth's crust, usually in the form of hot water or steam. It can be used to generate electricity in a thermal power plant or to provide heat directly at various temperatures for buildings, industry, and agriculture.

GREEN ENERGY PURCHASING. Voluntary purchase of renewable energy—usually electricity, but also heat and transport fuels—by residential, commercial, government, or industrial consumers, either directly from an energy trader or utility company, from a third-party renewable energy generator, or indirectly via trading of renewable energy certificates (RECs, also called green tags or guarantees of origin). It can create additional demand for renewable capacity and/or generation, often going beyond that resulting from government support policies or obligations.

HEAT PUMP. A device that transfers heat from a heat source to a heat sink using a refrigeration cycle that is driven by external electric or thermal energy. It can use the ground (geothermal), the surrounding air (aerothermal), or a body of water (hydrothermal) as a heat source in heating mode, and as a heat sink in cooling mode. A heat pump's final energy output can be several multiples of the energy input, depending on its inherent efficiency and operating condition. The output of a heat pump is at least partially renewable on a final energy basis. However, the renewable component can be much lower on a primary energy basis, depending on the composition and derivation of the input energy; in the case of electricity, this includes the efficiency of the power generation process. The output of a heat pump can be fully renewable energy if the input energy is also fully renewable.

HYDROPOWER. Electricity derived from the potential energy of water captured when moving from higher to lower elevations. Categories of hydropower projects include run-of-river, reservoir-based capacity, and low-head in-stream technology (the least developed). Hydropower covers a continuum in project scale from large (usually defined as more than 10 MW of installed capacity, but the definition varies by country) to small, mini, micro, and pico.

HYDROTREATED VEGETABLE OIL (HVO). A "drop-in" biofuel produced by using hydrogen to remove oxygen from waste cooking oils, fats, and vegetable oils. The result is a hydrocarbon fuel that blends more easily with diesel and jet fuel than does biodiesel produced from triglycerides as fatty acid methyl esters (FAME).

INVESTMENT. Purchase of an item of value with an expectation of favourable future returns. In this report, new investment in renewable energy refers to investment in: technology research and development, commercialisation, construction of manufacturing facilities, and project development (including construction of wind farms, purchase and installation of solar PV systems). Total investment refers to new investment plus merger and acquisition (M&A) activity (the refinancing and sale of companies and projects).

INVESTMENT TAX CREDIT. A taxation measure that allows investments in renewable energy to be fully or partially deducted from the tax obligations or income of a project developer, industry, building owner, etc.

JOULE / KILOJOULE / MEGAJOULE / GIGAJOULE / TERAJOULE PETAJOULE / EXAJOULE. A Joule (J) is a unit of work or energy equal to the energy expended to produce one Watt of power for one second. For example, one Joule is equal to the energy required to lift an apple straight up by one metre. The energy released as heat by a person at rest is about 60 J per second. A kilojoule (kJ) is a unit of energy equal to one thousand (103) Joules; a megajoule (MJ) is one million (106) Joules; and so on. The potential chemical energy stored in one barrel of oil and released when combusted is approximately 6 GJ; a tonne of oven dry wood contains around 20 GJ of energy.

LEASING OR LEASE-TO-OWN. A fee-for-service arrangement in which a leasing company (generally an intermediary company, co-operative, or NGO) buys stand-alone renewable energy systems and installs them at customer sites, retaining ownership until the customer has made all payments over the lease period. Because the leasing periods are longer than most consumer finance terms, the monthly fees can be lower and the systems affordable to a larger segment of the population.

LEVELISED COST OF ENERGY (LCOE). The unique cost price of energy outputs (e.g., USD/kWh or USD/GJ) of a project that makes the present value of the revenues equal to the present value of the costs over the lifetime of the project.

MANDATE/OBLIGATION. A measure that requires designated parties (consumers, suppliers, generators) to meet a minimum, and often gradually increasing, target for renewable energy, such as a percentage of total supply or a stated amount of capacity. Costs are generally borne by consumers. Mandates can include renewable portfolio standards (RPS); building codes or obligations that require the installation of renewable heat or power technologies (often in combination with energy efficiency investments); renewable heat purchase requirements; and requirements for blending biofuels into transport fuel.

MARKET CONCESSION MODEL. A model in which a private company or NGO is selected through a competitive process and given the exclusive obligation to provide energy services to customers in its service territory, upon customer request. The concession approach allows concessionaires to select the most appropriate and cost-effective technology for a given situation.

MERIT ORDER. A way of ranking available sources of energy (particularly electricity generation) in ascending order based on short-run marginal costs of production, such that those with the lowest marginal costs are the first ones brought on line to meet demand, and those with the highest are brought on last. The merit-order effect is a shift of market prices along the merit-order or supply curve due to market entry of power stations with lower variable costs (marginal costs). This displaces power stations with the highest production costs from the market (assuming demand is unchanged), and admits lower-priced electricity into the market.

MINI-GRIDS. Small electric grids that serve entire communities through distribution networks. Until recently, most mini-grids relied on diesel fuel. Hydro-powered mini-grids are mature technologies, whereas gas-fired generator mini-grids, powered by agricultural waste or biogas, are maturing technologies. The use of inverter-connected mini-grids that incorporate a variety of renewable and other technologies (including battery banks) is developing rapidly.

MODERN BIOMASS ENERGY. Energy derived from combustion of solid, liquid, and gaseous biomass fuels in efficient small domestic appliances to large-scale industrial conversion plants for modern applications of space heating, electricity generation, combined heat and power, and transport (as opposed to traditional biomass energy).

NET METERING. A regulated arrangement in which utility customers who have installed their own generating systems pay only for the net electricity delivered from the utility (total consumption minus on-site self-generation). A variation that employs two meters with differing tariffs for purchasing electricity and exporting excess electricity off-site is called "net billing."

OCEAN ENERGY. Energy captured from ocean waves (generated by wind passing over the surface), tides, currents, salinity gradients, and ocean temperature differences. Wave energy converters capture the energy of surface waves to generate electricity; tidal stream generators use kinetic energy of moving water to power turbines; and tidal barrages are essentially dams that cross tidal estuaries and capture energy as tides flow in and out.

PAY-AS-YOU-GO (PAYG) MICRO-PAYMENT SCHEMES. A flexible metering solution that allows consumers to acquire modern energy on an installment basis and to purchase varying amounts of energy credit using a mobile phone's short message service. After a small down-payment, customers decide how much energy credit to buy and continue to buy more depending on their needs.

POWER. The rate at which energy is converted per unit of time, expressed in Watts (Joules/second).

PRIMARY ENERGY. The theoretically available energy content of a naturally occurring energy source (such as coal, oil, natural gas, uranium ore, geothermal and biomass energy, etc.) before it undergoes conversion to useful final energy delivered to the end-user. Conversion of primary energy into other forms of useful final energy (such as electricity and fuels) entails losses. Some primary energy is consumed at the end-user level as final energy without any prior conversion.

PRODUCTION TAX CREDIT. A taxation measure that provides the investor or owner of a qualifying property or facility with an annual tax credit based on the amount of renewable energy (electricity, heat, or biofuel) generated by that facility.

PUBLIC COMPETITIVE BIDDING (ALSO CALLED AUCTION OR TENDER). A procurement mechanism by which public authorities solicit bids for a given amount of renewable energy supply or capacity, generally based on price. Sellers offer the lowest price that they would be willing to accept, but typically at prices above standard market levels.

PUMPED-STORAGE HYDROPOWER. Plants that pump water from a lower reservoir to a higher storage basin using surplus electricity, and that reverse the flow to generate electricity when needed. They are not energy sources but means of energy storage and can have overall system efficiencies of around 80–90%.

REGULATORY POLICY. A rule to guide or control the conduct of those to whom it applies. In the renewable energy context, examples include mandates or quotas such as renewable portfolio standards, feed-in tariffs, biofuel blending mandates, and renewable heat obligations.

RENEWABLE ENERGY CERTIFICATE (REC). A certificate awarded to certify the generation of one unit of renewable energy (typically 1 MWh of electricity but also less commonly of heat). In systems based on RECs, certificates can be accumulated to meet renewable energy obligations and also provide a tool for trading among consumers and/or producers. They also are a means of enabling purchases of voluntary green energy.

RENEWABLE ENERGY TARGET. An official commitment, plan, or goal set by a government (at the local, state, national, or regional level) to achieve a certain amount of renewable energy by a future date. Some targets are legislated while others are set by regulatory agencies or ministries.

RENEWABLE PORTFOLIO STANDARD (RPS). An obligation placed by a government on a utility company, group of companies, or consumers to provide or use a predetermined minimum renewable share of installed capacity, or of electricity or heat generated or sold. A penalty may or may not exist for non-compliance. These policies are also known as "renewable electricity standards," "renewable obligations," and "mandated market shares," depending on the jurisdiction.

SMART ENERGY SYSTEM. A smart energy system aims to optimise the overall efficiency and balance of a range of interconnected energy technologies and processes, both electrical and non-electrical (including heat, gas, and fuels). This is achieved through dynamic demand- and supply-side management; enhanced monitoring of electrical, thermal, and fuel-based system assets; control and optimisation of consumer equipment, appliances, and services; better integration of distributed energy (on both the macro and micro scales); as well as cost minimisation for both suppliers and consumers.

SMART GRID. Electrical grid that uses information and communications technology to co-ordinate the needs and capabilities of the generators, grid operators, end-users, and electricity market stakeholders in a system, with the aim of operating all parts as efficiently as possible, minimising costs and environmental impacts, and maximising system reliability, resilience, and stability.

SOLAR COLLECTOR. A device used for converting solar energy to thermal energy (heat), typically used for domestic water heating but also used for space heating, industrial process heat, or to drive thermal cooling machines. Evacuated tube and flat-plate collectors that operate with water or a water/glycol mixture as the heat-transfer medium are the most common solar thermal collectors used worldwide. These are referred to as glazed water collectors because irradiation from the sun first hits a glazing (for thermal insulation) before the energy is converted to heat and transported away by the heat transfer medium. Unglazed water collectors, often referred to as swimming pool absorbers, are simple collectors made of plastics and used for lower-temperature applications. Unglazed and glazed air collectors use air rather than water as the heat-transfer medium to heat indoor spaces, or to pre-heat drying air or combustion air for agriculture and industry purposes.

SOLAR HOME SYSTEM (SHS). A stand-alone system composed of a relatively small power photovoltaic module, battery, and sometimes a charge controller, that can power small electric devices and provide modest amounts of electricity to homes for lighting and radios, usually in rural or remote regions that are not connected to the electricity grid.

SOLAR PHOTOVOLTAICS (PV). A technology used for converting solar radiation (light) into electricity. PV cells are constructed from semi-conducting materials that use sunlight to separate electrons from atoms to create an electric current. Modules are formed by interconnecting individual solar PV cells. Monocrystalline modules are more efficient but relatively more expensive than polycrystalline silicon modules. Thin film solar PV materials can be applied as flexible films laid over existing surfaces or integrated with building components such as roof tiles. Building-integrated PV (BIPV) generates electricity and replaces conventional materials in parts of a building envelope, such as the roof or façade. Bifacial PV modules are double-sided panels that generate electricity with sunlight received on both sides (direct and reflected) and are used primarily in the BIPV sector.

SOLAR PHOTOVOLTAIC-THERMAL (PV-T). Solar PV-thermal hybrid system that includes solar thermal collectors mounted beneath PV modules to convert solar radiation into electrical and thermal energy. The solar thermal collector removes waste heat from the PV module, enabling it to operate more efficiently.

SOLAR PICO SYSTEM (SPS). A very small solar PV system—such as a solar lamp or an information and communication technology (ICT) appliance—with a power output of 1–10 W that typically has a voltage up to 12 volt.

SOLAR WATER HEATER (SWH). An entire system—consisting of a solar collector, storage tank, water pipes, and other components—that converts the sun's energy into "useful" thermal (heat) energy for domestic water heating, space heating, process heat, etc. Depending on the characteristics of the "useful" energy demand (potable water, heating water, drying air, etc.) and the desired temperature level, a solar water heater is equipped with the appropriate solar collector. There are two types of solar water heaters: pumped solar water heaters use mechanical pumps to circulate a heat transfer fluid through the collector loop (active systems), whereas thermo-siphon solar water heaters make use of buoyancy forces caused by natural convection (passive systems).

SUBSIDIES. Government measures that artificially reduce the price that consumers pay for energy or reduce production costs.

TRADITIONAL BIOMASS. Solid biomass, including gathered fuel wood, charcoal, agricultural and forest residues, and animal dung, that is usually produced unsustainably and typically used in rural areas of developing countries by combustion in polluting and inefficient cookstoves, furnaces, or open fires to provide heat for cooking, comfort, and small-scale agricultural and industrial processing (as opposed to modern biomass energy).

TORREFIED WOOD. Solid fuel, often in the form of pellets, produced by heating wood to 200–300 °C in restricted air conditions. It has useful characteristics for a solid fuel including relatively high energy density, good grindability into pulverised fuel, and water repellency.

WATT / KILOWATT / MEGAWATT / GIGAWATT / TERAWATT-HOUR. A Watt is a unit of power that measures the rate of energy conversion or transfer. A kilowatt is equal to one thousand (103) Watts; a megawatt to one million (106) Watts; and so on. A megawatt electrical (MW) is used to refer to electric power, whereas a megawatt-thermal (MWth) refers to thermal/heat energy produced. Power is the rate at which energy is consumed or generated. For example, a light bulb with a power rating of 100 Watts (100 W) that is on for one hour consumes 100 Watt-hours (100 Wh) of energy, which equals 0.1 kilowatt-hour (kWh), or 360 kilojoules (kJ). This same amount of energy would light a 100 W light bulb for one hour or a 25 W bulb for four hours. A kilowatt-hour is the amount of energy equivalent to steady power of 1 kW operating for one hour.

ENERGY UNITS AND CONVERSION FACTORS

METRIC PREFIXES

kilo (k) = 10^3

mega (M) = 10^6

giga (G) = 10^9

tera (T) = 10^{12}

peta (P) = 10^{15}

exa (E) = 10^{18}

VOLUME

1 m^3 = 1,000 litres (l)

1 U.S. gallon = 3.78 l

1 Imperial gallon = 4.55 l

Example: 1 TJ = 1,000 GJ = 1,000,000 MJ = 1,000,000,000 kJ = 1,000,000,000,000 J = 1012 J

1 J = 0.001 MJ = 0.000001 GJ = 0.000000001 TJ

ENERGY UNIT CONVERSION

multiply by:	GJ	Toe	MBtu	MWh
GJ	1	0.024	0.948	0.278
Toe	41.868	1	39.683	11.630
MBtu	1.055	0.025	1	0.293
MWh	3.600	0.086	3.412	1

Toe = tonnes oil equivalent

1 Mtoe = 41.9 PJ

Example: 1 MWh x 3.600 = 3.6 GJ

HEAT OF COMBUSTION (HIGH HEAT VALUES)

1 l gasoline = 47.0 MJ/kg = 35.2 MJ/l (density 0.75 kg/l)

1 l ethanol = 29.7 MJ/kg = 23.4 MJ/l (density 0.79 kg/l)

1 l diesel = 45.0 MJ/kg = 37.3 MJ/l (density 0.83 kg/l)

1 l biodiesel = 40.0 MJ/kg = 35.2 MJ/l (density 0.88 kg/l)

Note: 1) These values can vary with fuel and temperature.
2) Around 1.5 litres of ethanol is required to equate to 1 litre of gasoline.

SOLAR THERMAL HEAT SYSTEMS

1 million m^2 = 0.7 GW_{th}

Used where solar thermal heat data have been converted from square metres (m^2) into gigawatts thermal (GW_{th}), by accepted convention.

G

LIST OF ABBREVIATIONS

BIPV	Building-integrated solar photovoltaics
BNEF	Bloomberg New Energy Finance
BOS	Balance of system
BRICS	Brazil, Russia, India, China, and South Africa
CDM	Clean Development Mechanism
CHP	Combined heat and power
CO_2	Carbon dioxide
CPV	Concentrating solar photovoltaic
CSP	Concentrating solar (thermal) power
DRE	Distributed renewable energy
DSM	Demand-side management
ECOWAS	Economic Community of West African States
ECREEE	ECOWAS Centre for Renewable Energy and Energy Efficiency
EEG	German Renewable Energy Law – "Erneuerbare-Energien-Gesetz"
EMEC	European Marine Energy Centre
EPA	U.S. Environmental Protection Agency
ESCO	Energy service company
EU	European Union (specifically the EU-28)
EV	Electric vehicle
FIP	Feed-in premium
FIT	Feed-in tariff
FPIC	Free, Prior and Informed Consent
FUNAE	Energy Fund of Mozambique – "Fundo de Energia"
GACC	Global Alliance for Clean Cookstoves
GEF	Global Environment Facility
GFR	Global Futures Report
GHG	Greenhouse gas
GHP	Ground-source heat pump
GSR	Renewables Global Status Report
GW / GWh	Gigawatt / gigawatt-hour
GW_{th}	Gigawatt-thermal
HSAP	Hydropower Sustainability Assessment Protocol
HVO	Hydrotreated vegetable oil
IEA	International Energy Agency
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
kW / kWh	Kilowatt / kilowatt-hour
LED	Light-emitting diode
LCOE	Levelised cost of energy
m^2	Square metre
MENA	Middle East and North Africa
MFI	Microfinance institution
MSW	Municipal solid waste
Mtoe	Million tonnes of oil equivalent
MW / MWh	Megawatt / megawatt-hour
NGO	Non-governmental organisation
NREAP	National Renewable Energy Action Plan
OECD	Organisation for Economic Co-operation and Development
PPP	Public-private partnership
PTC	Production tax credit
PV	Solar photovoltaics
RPS	Renewable portfolio standard
SE4ALL	UN Sustainable Energy for All initiative
SHS	Solar home system
SPS	Solar pico system (pico PV)
SWH	Solar water heater / solar water heating
TW / TWh	Terawatt/terawatt-hour
UNIDO	United Nations Industrial Development Organization
USD	United States dollar
VAT	Value-added tax
Wp	Watt-peak (nominal power)
WTO	World Trade Organization

PHOTO CREDITS

Page 18 Ethanol fuel plant at the countryside shutterstock
Page 18 Green mountain / shutterstock
Page 18 Tidal power generation / shutterstock
Page 19 Photovoltaic cells / shutterstock
Page 19 Wind power, Netherlands / shutterstock
Page 27 Galizia, Spain / shutterstock
Page 29 City Train in Frankfurt, Germany / Art Konovalov
Page 29 Electric car to rent, Brussels / Artens shutterstock
Page 37 Biofuel factory / Aigars Reinholds
Page 40 Geothermal power station in northern Iceland / shutterstock
Page 44 Dam, Vietnam / Duc Den Thui
Page 49 Solar power station / shutterstock
Page 52 Solar thermal electric generating plant shutterstock
Page 55 Vacuum solar water heating system / shutterstock
Page 57 Aerial view of a wind farm / B. Brown
Page 58 Offshore Windfarm, Denmark / V. Schlichting
Page 61 Aragon, Spain / Pedrosala, shutterstock
Page 62 Workers install solar panels, California, USA / Spirit of America
Page 71 Kartell small hydro power plant in St. Anton, Austria / VOITH
Page 72 Construction of aerogenerator, Czech Republic / shutterstock
Page 73 New family homes with solar panels on the roof / shutterstock
Page 76 Wind Turbine on Lantau Island / shutterstock
Page 82 Residential photovoltaic solar system / Mana Photo
Page 83 SWH / Alexander Tihonov
Page 85 Free Recharging Station / shutterstock
Page 87 Solar panels on the roof of administrative building / Mik Lav
Page 88 New London Routemaster, April 5, 2014, London / Ron Ellis
Page 93 Offgrid Solar India/ UNWTO
Page 94 Bar Zimbabwe / Phaesun
Page 95 Cookstove / Himalayanstove
Page 96 Mini grid, Kenya/ Practical Action
Page 97 Man with solar cooker, Zanskar, Ladakh, India / Falk
Page 98 Lighting / EnDev
Page 99 DRE Solar-Wind / Phaesun
Page 101 Wind power plants at Thar desert, India / shutterstock
Page 102 Solar paneled covered parking, Arizona / Tim Roberts
Page 103 High voltage electricity pillars in desert / Protasov AN
Page 104 Wind turbine with clouds / shutterstock

COPYRIGHT & IMPRINT

Renewable Energy Policy Network for the 21st Century

REN21 Secretariat
c/o UNEP
15 rue de Milan
75441 Paris, France

RENEWABLES
GLOBAL STATUS REPORT
2014

ISBN 978-3-9815934-2-6

REN21
c/o UNEP
15, Rue de Milan
F-75441 Paris CEDEX 09
France

www.ren21.net

REN21 Renewable Energy Policy Network for the 21st Century