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HEARING BEFORE THE U.S. HOUSE OF REPRESENTATIVES
ENERGY AND COMMERCE SUBCOMMITTEE ON ENERGY AND POWER:
"AMERICAN ENERGY SECURITY AND INNOVATION:
AN ASSESSMENT OF NORTH AMERICA'S ENERGY RESOURCES"

February 5, 2013

Good morning, and thank you for the opportunity to contribute to the deliberations of this Subcommittee. My name is Jennifer Morgan, and I direct the Climate and Energy Program at the World Resources Institute (WRI). WRI is a non-profit, non-partisan think tank that focuses on the intersection of the environment and socio-economic development. We go beyond research to put ideas into action, working globally with governments, business, and civil society to build transformative solutions that protect the earth and improve people's lives. We operate globally because today's problems know no boundaries. We provide innovative paths to a sustainable planet through work that is accurate, fair, and independent.

I am delighted to speak with you today about America's energy resources and the smart choices we need to make in developing them. We have been blessed with abundant resources – not just of fossil fuels, but also of solar, wind, and other renewable resources. We also have a vast untapped resource in energy efficiency: the value we place on our resources comes from the energy they can provide, and we increase that value by using energy wisely.

Our energy choices need to factor in both opportunities and risks. In this testimony, I will give particular attention to why we must consider the risk of climate change, both on our resources being developed and utilized today, and on our choices for development into the future. America has a vast potential of low-carbon energy resources; tapping these will allow us to increase our reliance on home-grown resources and still be "climate secure." Innovation in clean energy technology has already created jobs and spurred economic growth, not only through deployment in the United States but also through export into new markets. And in both cases, the potential for expansion is great.

America's prosperity has long depended on our ability to rise above the challenges before us. The investment choices we make today will shape our energy and economic future for decades to come; thus we must deliberately think longer-term and consider the range of risks and costs that will be compounded if today's investments lock in a pollution-intensive energy future.

I will conclude this testimony by recommending actions that Congress can take to ensure that our future is sustainable – actions that will enable the United States to grow our economy and to lead globally on developing clean energy, fostering innovation, and realizing an energy-secure, climate-safe future.

The U.S. Must Integrate Climate Risks into Decision Making

Our climate is changing. In addition to a clear long-term warming trend, extreme weather events are on the rise, with tens of billions of dollars in damages in the United States each year.[1] It is also clear that human activities are the main culprit. In 2010,[2] at the request of Congress, the National Research Council of the U.S. National Academy of Sciences (NAS) published a report concluding that "*Climate change is occurring, is caused largely by human activities, and poses significant risks for—and in many cases is already affecting—a broad range of human and natural systems."* The NAS study was one of several comprehensive science assessments to have been conducted in recent years – including the recently released draft National Climate Assessment[3] – all of which have reached scientific consensus on the reality of climate change and humanity's major role in it.

Furthermore, the NAS[4] has also urged immediate strong policy actions to curb emissions, concluding that *"the risks associated with doing business as usual are a much greater concern than the risks associated with engaging in strong response efforts."*[5] Current U.S. energy policy lacks a framework for prudently assessing and managing the risks of climate change. Yet all of the evidence suggests that every year of deferred action vastly increases the cost to future generations of investing in a course correction that puts us on a prudent path toward climate stabilization.

[1] http://www.ncdc.noaa.gov/news/preliminary-info-2012-us-billion-dollar-extreme-weatherclimate-events
[2] http://www.nationalacademies.org/annualreport/Report_to_Congress_2010.pdf
[3] http://ncadac.globalchange.gov/download/NCAJan11-2013-publicreviewdraft-fulldraft.pdf
[4] National Academies, Committee on Climate Choices, Final Report, 2011. http://dels.nas.edu/Report/America-Climate-Choices-2011/12781
[5] http://dels.nas.edu/resources/static-assets/materials-based-on-reports/reports-in-brief/ACC-final-brief.pdf

In assessing America's energy resources, we must take into account the impact that climate change is having now on our energy infrastructure, as well as how our energy choices should be informed by the need to avoid greater climate impacts in the future.

Climate Change Impacts in the United States

Around the country, we are increasingly seeing the effects of climate change. From sea-level rise to drought and extreme weather events, our changing climate is increasing the probability and intensity of many impacts. Climate instability directly affects the future security of our energy sector – droughts and flooding threaten grid infrastructure and undermine the ability of power plants to operate; wildfires and extreme storms damage transmission infrastructure; powerful coastal storms threaten our ability to safely develop, refine, and deliver oil and gas to industry and consumers.

Temperature rise

Each successive decade in the last 50 years has been the warmest on record globally, and average global temperatures through the remainder of this century will continue to rise.[6] The average temperature in the United States has risen by 1.5^{o}F since 1895, and in the absence of significant mitigation efforts the increase is projected to be 5-10^{o}F by the end of the century.[7] Last year was the warmest year in observed U.S. history.[8]

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[6] http://ncadac.globalchange.gov/
[7] Ibid.
[8] http://www.ncdc.noaa.gov/sotc/

Sea-level rise

It has been well established[9] by scientific bodies such as the U.S. Global Change Research Program that global warming has resulted in rising seas. The 8-inch rise in average global sea level[10] over the last century has exacerbated the impacts of storm surge in the United States and abroad. Interestingly, sea-level rise does not affect all coasts in the same way. In recent decades no other place in the world has experienced higher[11] rates of sea-level rise than the northeastern coast of the United States.[12]

Sea-level rise and associated storm surges and coastal flooding have significant economic implications. For example, damage estimates from Hurricane Sandy have ranged from $30 to $50 billion.[13] In Florida, already occurring sea-level rise impacts are forcing Miami Beach to spend more than $200 million[14] to overhaul its storm drainage system, and Hallandale Beach to spend $10 million[15] on new wells because of saltwater intrusion. Sea-level rise will require[16] increased energy usage in the form of additional pumping for drainage and water supply, as well as for the energy-intensive process of desalinization. The vulnerability of the U.S. economy to sea-level rise is significant, with 41 million Americans living in coastal counties along the East Coast.[17]

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9 http://www.globalchange.gov/what-we-do/assessment/previous-assessments/global-climate-change-impacts-in-the-us-2009
10 http://ncadac.globalchange.gov/
11 http://www.nature.com/news/us-northeast-coast-is-hotspot-for-rising-sea-levels-1.10880
12 http://ncadac.globalchange.gov/
13 http://www3.cfo.com/article/2012/11/risk-management_superstorm-sandy-insurance-modeling-air-eqecat-rms-swiss-re-
14 http://miamibeachfl.gov/publicworks/scroll.aspx?id=27280
15 http://pdf.wri.org/sea_level_rise_in_florida.pdf
16 http://www.hq.nasa.gov/legislative/hearings/2012%20hearings/4-19-2012%20BERRY.pdf
17 http://www.census.gov/prod/2010pubs/p25-1139.pdf

Drought

According to the National Oceanic and Atmospheric Administration (NOAA), over 65 percent of the contiguous United States experienced drought last September,[18] causing widespread damage to the nearly $300 billion[19] in annual agricultural commodities within the United States.[20] Recent scientific findings have strengthened our understanding of the link between climate change, heat, and drought. For example, the heat wave leading to the Texas drought was found in a recent study[21] by NOAA and other institutions to be 20 times more likely to occur now than in the 1960s. According to the recent draft *National Climate Assessment*, disruptions to agricultural production from climate change have increased in recent years and are expected to increase further over the next 25 years.

Extreme weather and climate events

According to NOAA, in 2012 the United States experienced 11 extreme weather events causing more than $1 billion in damages each.[22] The economic losses from extreme events – increased in part by the impacts of storm surge exacerbated by climate change – are significant. For example, hurricanes have cost the U.S. Gulf Coast alone an average of $14 billion in damages per year, and the region could accumulate $350 billion in cumulative hurricane-related damages over the next 20 years.[23] The 150-percent[24]

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[18] http://www.ncdc.noaa.gov/sotc/national/2012/13/supplemental/page-9/
[19] http://ncadac.globalchange.gov/download/NCAJan11-2013-publicreviewdraft-chap6-agriculture.pdf
[20] http://www1.ncdc.noaa.gov/pub/data/cmb/bams-sotc/2011-peterson-et-al.pdf
[21] Ibid.
[22] http://www.ncdc.noaa.gov/news/preliminary-info-2012-us-billion-dollar-extreme-weatherclimate-events
[23] http://www.entergy.com/content/our_community/environment/GulfCoastAdaptation/Building_a_Resilient_Gulf_Coast.pdf
[24] http://www.census.gov/prod/2010pubs/p25-1139.pdf

increase in population along the Gulf Coast over the last 50 years, to 14 million inhabitants, has further increased the potential for costly impacts from storm surge and associated hurricanes.

The increase in frequency and cost of extreme weather events has caused ripple effects throughout the insurance industry, which recent research shows has experienced steadily increasing weather-related losses over the last two decades.[25] Aggregate economic losses in 2011 attributed to extreme weather events were $55 billion,[26] and storms such as Tropical Storm Lee and Hurricane Irene were responsible for a combined $8.3 billion in damages that included coastal flooding. With the expectation that sea-level rise and future threats of storms such as Sandy will increase property losses, the financial risk will be transferred more to the public sector as the private sector cannot cover "high-risk" coastal properties.[27]

Climate Change Impacts on the Power Sector

When considering energy resources, we should take into account how climate change can impact America's energy infrastructure. For starters, energy demand is directly affected by rising temperatures; a recent study by the state of Massachusetts[28] estimates that rising temperatures could increase demand for electricity in that state by 40 percent by 2030, requiring substantial investments in increasing peak load capacity.

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[25] http://downloads.usgcrp.gov/NCA/technicalinputreports/Burkett_Davidson_Coasts_Final_.pdf
[26] Ibid.
[27] Ibid.
[28] http://www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf

Energy facilities will also likely be affected by sea-level rise. The contiguous United States has more than 280 electric power plants, oil and gas refineries, and other energy facilities which are situated on low-lying land and thus vulnerable to sea-level rise and episodic coastal flooding.[29] Sea-level rise poses especially substantial challenges for sustaining reliable energy infrastructure in states such as Florida, where 26 energy facilities are located in especially vulnerable areas.[30]

In addition, power sector reliability is affected by extreme weather events. For example, in the aftermath of Hurricane Sandy and the Nor'easter that immediately followed, more than 8 million customers lost power.[31] Refineries, natural gas distribution systems, and petroleum terminals were also affected by these storms. Meanwhile, because the majority of U.S. oil production and refining occurs in the Gulf Coast, hurricanes can impact national energy availability and price, as Hurricanes Katrina and Rita demonstrated in 2005.

The nation's power sector is also highly vulnerable to extreme drought. Water scarcity has emerged as one of the defining challenges of this century, yet a significant amount of water is needed to extract energy resources and use them to generate electricity. Limits on availability of ground and surface water are shaping the current operation and future location of America's power plants. In 2011, over 85% of total electricity generation in the United States was produced by thermoelectric power plants fueled by nuclear and

[29] http://slr.s3.amazonaws.com/SLR-Threats-to-Energy-Infrastructure.pdf
[30] Ibid.
[31] http://www.oe.netl.doe.gov/docs/SitRep13_Sandy-Nor'easter_120312_300PM.pdf

fossil energy sources,[32] most of which rely heavily on substantial water resources for cooling. As fossil energy extraction trends toward unconventional resources and "enhanced" production, more water is needed relative to extracting the same amount of energy using conventional methods. According to the National Energy Technology Laboratory,[33] there are 347 coal-fired power plants in 43 states vulnerable to water supply and/or demand concerns. In a future with increasing likelihood of droughts, our nation's ability to meet growing energy needs through thermoelectric power generation will be highly vulnerable to climate change.[34]

Investment Risks and Stranded Assets

Any company or government – at the national, state, or local level – that makes infrastructure investments needs to factor climate change into their decision-making, and many are already doing so, equating climate risks with those from traditional financial risks like liquidity or competition.[35] Intelligent policies can mitigate investment risk by encouraging investment in the low-carbon technologies that will be a foundational part of a successful 21st century economy. Investor networks around the world recognize this, and are advocating for well-designed policies that can help get money off the sidelines and into climate-secure industries.[36]

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[32] http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_1_1
[33] http://www.evs.anl.gov/pub/doc/DOENETL-2010-1429%20WaterVulnerabilities.pdf
[34] Tidwell, V., Kobos, P., Malczynski, L., Klise, G., and Castillo, C. (2012). "Exploring the Water-Thermoelectric Power Nexus." *J. Water Resour. Plann. Manage.*, 138(5), 491–501. http://ascelibrary.org/doi/abs/10.1061/%28ASCE%29WR.1943-5452.0000222

[35] See http://www.unglobalcompact.org/docs/issues_doc/Environment/Investor_Leadership_on_Climate_Change_An_Analysis.pdf.
[36] See http://www.ceres.org/incr/files/investor-files/2012-global-policy-letter.

According to IHS CERA,[37] the U.S. power sector will require as much as $828 billion in capital investments and expenses before the end of this decade. Many of these investments will be for very long-lived assets – from power plants to transmission systems. U.S. energy companies making investments today are considering 40+ year operational horizons and cannot ignore the potential for a future where climate policies and environmental risks influence the bottom line. One of the surest ways to saddle customers with higher costs from major stranded investments is to ignore the need to factor climate impacts into today's decision-making processes.

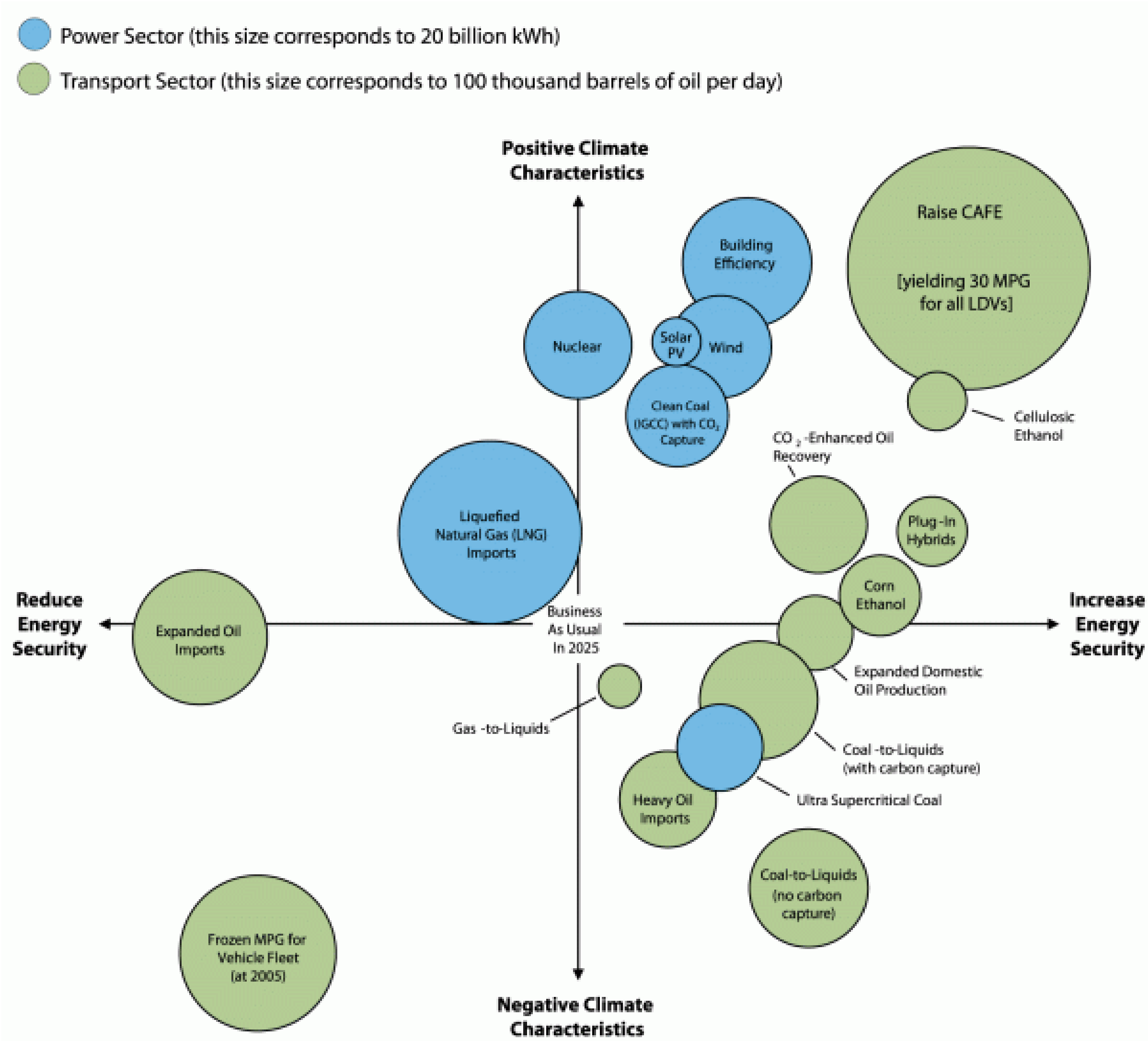
As a society, delaying the decision to act on climate change increases the overall cost of mitigating greenhouse gas (GHG) emissions.[38] A recent study by KMPG found that the costs of environmental impacts for a wide array of industries are doubling operational costs every 14 years. The cost resulting from climate change, specifically, was estimated at one percent per year if early action is taken, but five percent per year of delay in establishing climate policy certainty.[39] Other studies have found that climate change could put trillions of investment dollars at risk through 2030.[40]

[37] http://www.ihs.com/products/cera/energy-report.aspx?id=1065970374
[38] Rogelj, J., McCollum, D. L., Reisinger, A., Meinshausen, M. & Riahi, K. Nature 493, 79–83 (2013).
[39] http://www.kpmg.com/Global/en/IssuesAndInsights/ArticlesPublications/Documents/building-business-value.pdf
[40] See report at http://www.mercer.com/attachment.dyn?idContent=1407480&filePath=/attachments/English/04028-IC_ClimateChangeAssetAllocationStudy_Report_FNL_lowres.pdf.

America's Clean Energy and Climate-Secure Future

The United States cannot and should not make energy decisions without factoring in the risks associated with climate change. To avoid further climate impacts in the future we must lower greenhouse gas emissions by switching to clean energy and increasing energy efficiency. Scientists at the National Research Council (NRC) of the NAS have concluded that global carbon dioxide (CO_2) emissions need to be reduced in the coming decades by at least 80% below current levels to stabilize atmospheric CO_2 concentrations and thus avoid the worst impacts of global warming.[41] This has serious implications for the energy choices we make today. WRI published the chart below in 2008 to illustrate how various energy choices rate from both climate and energy security perspectives. Although some of the information is dated (i.e., today we talk about LNG exports rather than imports, and the Administration raised CAFE standards in 2011), it provides an important framing in the context of this hearing.

[41] National Research Council, 2011. "Climate Stabilization Targets: Emissions, Concentrations, and Impacts over Decades to Millennia," ISBN: 0-309-15177-5, 298 pages. http://www.nap.edu/catalog/12877.html



Source: WRI, 2008. http://www.wri.org/chart/climate-and-energy-security-impacts-and-tradeoffs-2025

As the chart indicates, making energy- and climate-secure choices require shifting away from carbon-intensive energy sources such as coal, and moving toward zero and low-carbon energy sources such as renewables as well as increased energy efficiency. It is worth noting that natural gas could play an essential bridging role in that transition, but, as outlined below, this requires both reducing the upstream GHGs produced during the extraction process, and — if gas-fired power plants are to be a part of a longer-term energy future — using carbon capture and storage (CCS) technology.

The good news is that the United States does not have to choose between energy security and a climate-secure future. Clean energy resources provide the opportunity to be energy independent and ensure economic growth while also protecting the climate.

Natural Gas and Climate – Risk or Opportunity?

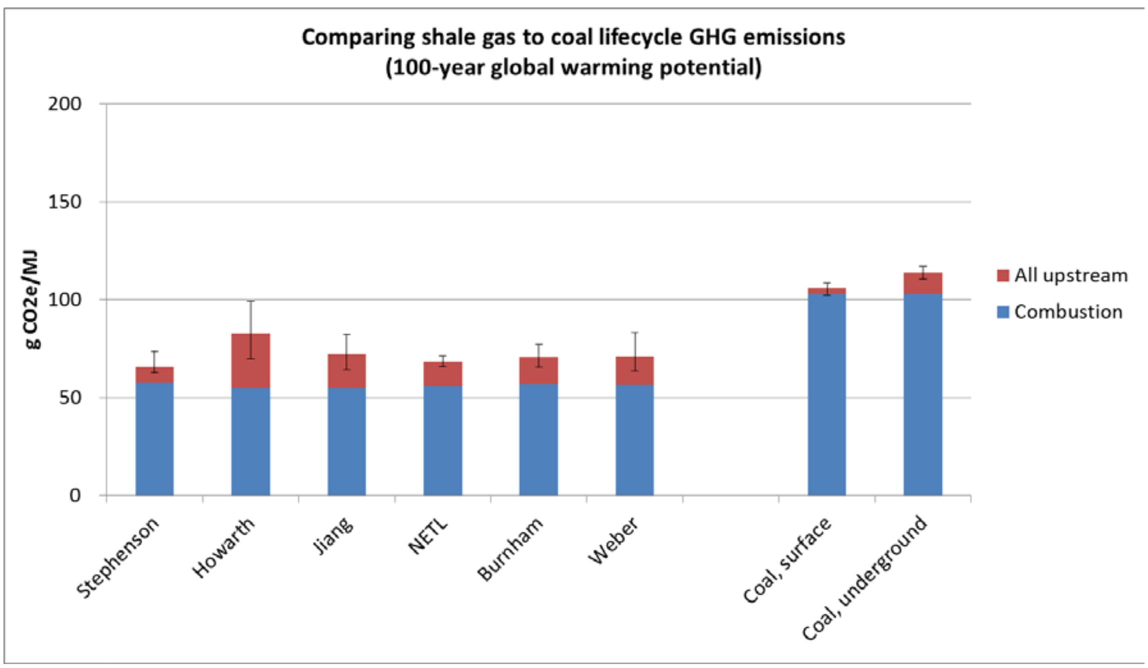
The recent boom in producing natural gas from shale formations has transformed – and will likely continue to transform – the way we generate electricity in the United States.[42] While there are a variety of issues related to shale gas development, for this testimony I am focusing specifically on the opportunities and risks natural gas presents in relation to climate change.

Although natural gas burns cleaner than coal, upstream emissions of methane that occur during exploration and production threaten to reduce or eliminate any advantage natural gas has over coal from a lifecycle GHG perspective. Recent WRI analysis, to be published in a forthcoming working paper, examines the question of upstream methane emissions, evaluates the impacts of recent EPA rules[43] on those emissions, and looks at ways to further reduce natural gas's contribution to climate change.

[42] The Energy Information Administration's Annual Energy Outlook for 2012 projects shale gas production growing by 78% between 2012 and 2035 in the reference case scenario, with the share of total U.S. production from shale gas increasing from roughly one-third to roughly one-half over that period. See http://www.eia.gov/forecasts/aeo/IF_all.cfm, Figure 56.

[43] See text of final rule at: http://www.epa.gov/airquality/oilandgas/pdfs/20120417finalrule.pdf

The International Energy Agency has shown[44] that as the upstream leakage rate of methane increases, natural gas's climate advantage over coal erodes and then disappears. Unfortunately, there is a paucity of measurement data for upstream emissions, making reliable estimates difficult to produce. However, current understanding is that leakage rates for both conventional and unconventional gas (i.e., gas from shale, coal bed methane, and tight sands formations) are in the range of 1.5 - 3%. Several studies are currently underway that should provide more clarity as to the accuracy of these assumptions.



Source: WRI analysis of Stephenson et al. (2011), Howarth et al. (2011), Jiang et al. (2011), NETL (2011), Burnham et al. (2011) and Weber et al. (2012).

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44 International Energy Agency, "Golden Rules for a Golden Age of Gas." Available at: http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/weo2012_goldenrulesreport.pdf

Recent EPA air pollution standards[45] for the oil and gas industry help address upstream methane emissions from shale gas systems. The standards will reduce those emissions by 40-45% below a business-as-usual baseline, and from all natural gas systems by 13-25%, according to WRI analysis (reductions increase over time as shale gas production increases). Yet much more can and should be done to further reduce methane leaks and vents. The EPA maintains a list of technologies[46] that industry can use to reduce or capture leaking gas on a voluntary basis, though WRI analysis shows that implementation of many of these technologies should be required if leakage is to be successfully addressed.

Yet even if upstream methane emissions from natural gas were eliminated entirely, combustion emissions – which make up approximately 80-85% of all natural gas emissions – must be significantly reduced if natural gas is to play an effective role in the carbon-constrained economy of the near future. Natural gas still produces significant GHGs, and if the United States wants gas to be a long-term energy solution then it must find ways of controlling or eliminating GHG emissions from this source.

America Is Blessed With Clean Energy Opportunities

The United States is rich in clean energy resources and options, including renewable energy, energy efficiency, and know-how on CCS. Such capacity provides new and untapped opportunities to not only increase energy and climate security, but also to create American jobs and spur economic growth.

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[45] http://www.epa.gov/airquality/oilandgas/pdfs/20120417finalrule.pdf
[46] http://www.epa.gov/gasstar/tools/recommended.html

According to the National Renewable Energy Laboratory (NREL), the United States can meet 80% of its electricity needs in 2050 through renewable generation.[47] However, if the

United States wishes to harness its renewable resources it needs to put in place a set of clear incentives and frameworks for success.[48]

The United States has immense remaining potential for improving efficiency in its industrial, transportation, and buildings sectors. The NAS found that energy efficiency technologies could save 30% of the energy used in the United States.[49] A series of Department of Energy studies[50] have concluded that significant energy efficiency potential exists across a number of key industrial sectors, as summarized in the table below from a forthcoming WRI report ("*Can The U.S. Get There From Here? Using Existing Federal Laws and State Action to Reduce Greenhouse Gas Emissions*").

47 See http://www.nrel.gov/analysis/re_futures/
48 http://pdf.wri.org/delivering_clean_energy_economy.pdf
49 http://www.nap.edu/catalog.php?record_id=12621
50 Bandwidth Studies, prepared for the U.S. Department of Energy, are available here: http://www1.eere.energy.gov/manufacturing/resources/energy_analysis.html
Interlaboratory Working Group. 2000. Scenarios for a Clean Energy Future (Oak Ridge, TN; Oak Ridge National Laboratory and Berkeley, CA; Lawrence Berkeley National Laboratory), ORNL/CON-476 and LBNL-44029, November. Available at: http://www.ornl.gov/sci/eere/cef/

TABLE A-13 Energy Savings and Energy-Related Carbon Dioxide Intensity Improvements in the Manufacturing Sector (percent)

	ENERGY SAVINGS WITH BEST PRACTICE (BANDWIDTH)	ENERGY SAVINGS WITH PRACTICAL MINIMUM (BANDWIDTH)	TOTAL ENERGY SAVINGS IN 2035 WHEN COMBINE SAVINGS FROM CEF AND AEO2012	MODELED CO_2 INTENSITY IMPROVEMENT 2035 VS. 2012 (TONS CO_2 FROM COMBUSTION/VALUE OF SHIPMENT)			
				Base Case	Lackluster (10 percent efficiency gain all boilers)	Middle-of-the-Road (CEF)	Go-Getter (CEF + natural gas emissions rate for new units)
Food Products	NA	NA	33	20	26	37	40
Paper	26	39	11	19	25	38	42
Bulk Chemical	18	71	38	27	33	37	38
Glass	35	52	21	11	12	18	19
Cement	NA	NA	31	9	9	32	46
Iron & Steel	3	31	34	33	33	37	45
Aluminum	NA	NA	48	25	28	47	51

Note: The bandwidth study determined baseline energy consumption for paper manufacturing using 2002 Manufacturing Energy Consumption Survey (MECS) data, plus data collected for the report. The bandwidth study for glass was based on data collected through surveys collected for the report prior to publication in 2007. The bandwidth study for steel was based on energy-use data from 2000. The bandwidth study for bulk chemicals was based on energy data collected in 2004 for the report.[140]
Source: Steel Industry Energy Bandwidth Study. Energetics, Inc., U.S. Department of Energy, October 2004; Chemical Bandwidth Study Exergy Analysis: A Powerful Tool for Identifying Process Inefficiencies in the U.S. Chemical Industry. Dickson Ozokwelu, Joseph Porcelli, and Peter Akinjiola, U.S. Department of Energy, December 2006; Industrial Glass Bandwidth Analysis, David Rue, James Servaites, and Warren Wolf, U.S. Department of Energy, December 2006; Pulp and Paper Industry Energy Bandwidth Study, Jacobs Institute of Paper Science and Technology, American Institute of Chemical Engineers, August 2006.

Source: WRI, "*Can The U.S. Get There From Here? Using Existing Federal Laws and State Action to Reduce Greenhouse Gas Emissions*".

Integrating renewable energy with the existing electric generation fleet

Renewable energy systems – even those with intermittent generation, such as wind and solar – can and should be integrated with the existing framework of primarily fossil-based electricity generation. The technical, regulatory, and economic barriers to such integration can be overcome. The technical barriers are being addressed through research and development, while the regulatory and economic barriers can be eliminated with straightforward policies that reward businesses for investing in renewable generation and set clear frameworks for integrating renewable electricity into the grid. Policies that provide transparency, longevity, and certainty – such as well-designed feed-in tariffs, renewable energy standards, or long-term power purchase agreements – have a proven track record of increasing renewable generation at low cost, a cost which is likely to decline over time as the price of renewable generation falls with increasing economies of scale.[51] Distributed generation and integrating renewable energy systems with fossil generation can also enhance grid reliability, especially during times of natural disaster.[52]

Cost of clean energy

Renewable energy (including hydropower) continues to grow by leaps and bounds around the world, increasing by 72% between 2000 and 2011; solar and wind saw the greatest growth over that period, with global wind generation growing by a factor of 13 and solar photovoltaic generation by a factor of 51.[53] In the United States, renewable generation has grown at an average rate of 4.2% per year between 2000 and 2011, with wind and solar again representing the fastest growing renewable energy sectors.[54] Just last week, the American Wind Energy Association announced that more than 13,000 MW were installed in 2012, putting U.S. wind capacity at 60 GW.[55] This deployment has led to a dramatic reduction in the cost of electricity produced by these technologies, a trend

[51] See, for example, "The German Feed-in Tariff for PV: Managing Volume Success with Price Response" from the Deutsche Bank Group's DB Climate Change Advisors. Available at: https://www.dbadvisors.com/content/_media/DBCCA_German_FIT_for_PV_0511.pdf.

[52] See, for example, http://insights.wri.org/news/2012/11/rebuilding-cities-after-sandy-3-keys-climate-resilience and http://www.forbes.com/sites/williampentland/2012/10/31/where-the-lights-stayed-on-during-hurricane-sandy/.

[53] National Renewable Energy Laboratory's 2011 Renewable Energy Data Book, available at http://www.nrel.gov/docs/fy13osti/54909.pdf.

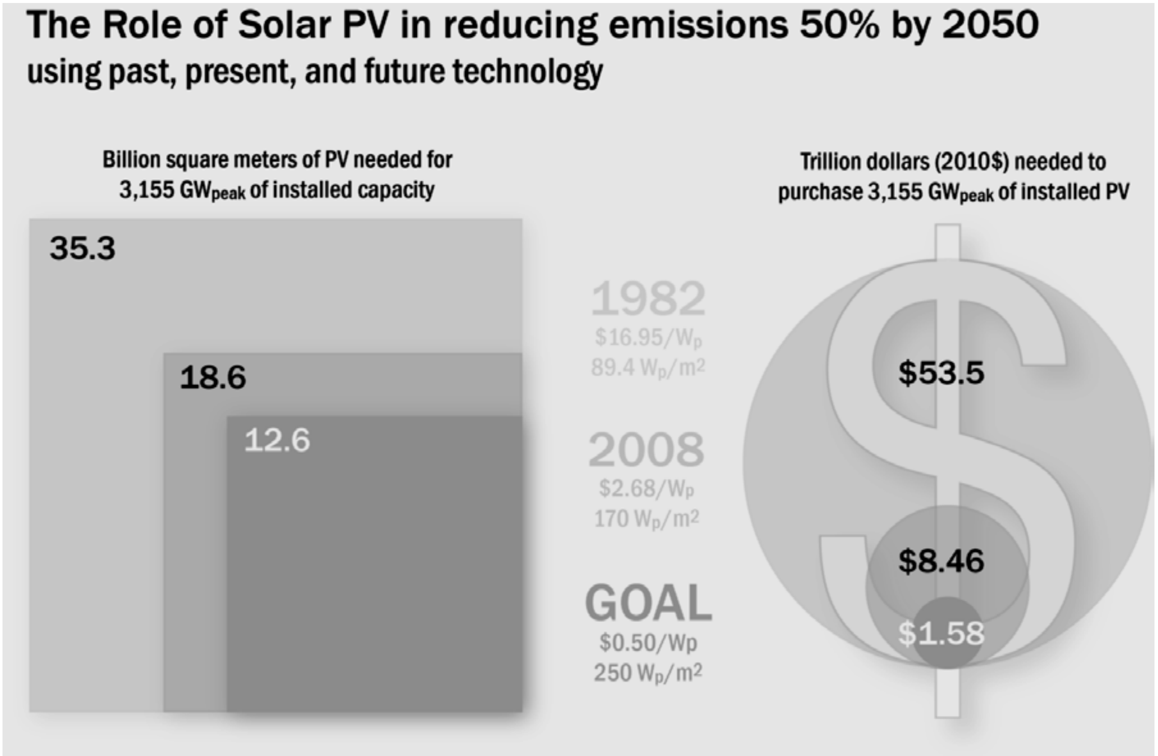
[54] Ibid.

[55] http://www.awea.org/learnabout/publications/reports/upload/AWEA-Fourth-Quarter-Wind-Energy-Industry-Market-Report_Executive-Summary-4.pdf
http://www.awea.org/learnabout/publications/reports/upload/AWEA-Fourth-Quarter-Wind-Energy-Industry-Market-Report_Executive-Summary-4.pdf

that is expected to continue as technology improves and manufacturing achieves economies of scale.[56,57]

Currently, the average levelized cost of energy for wind energy is comparable to that for coal, though the low price of natural gas in the United States makes it difficult for any technology – renewable, coal, or nuclear – to compete on the basis of price alone.[58,59] Renewable energy provides price stability, as it is not subject to volatile swings in the cost of fuel.[60] In fact, renewable energy systems – especially using several renewable technologies in conjunction with one another (for example, wind, solar, and hydropower) as well as energy efficiency – can reduce peak load and actually lower the overall cost of electricity, especially during times of high demand.[61]

[56] See, for example, Figures 10-12 and 10-13 in Volume 2 of NREL's Renewable Electricity Futures Study, available at: http://www.nrel.gov/docs/fy12osti/52409-2.pdf, and NREL's "The Past and Future Cost of Wind Energy," available at: http://www.nrel.gov/docs/fy12osti/53510.pdf.
[57] http://pdf.wri.org/working_papers/two_degrees_of_innovation.pdf
[58] See Table 1 here: http://www.eia.gov/forecasts/aeo/electricity_generation.cfm.
[59] http://insights.wri.org/news/2012/04/electricity-markets-increasingly-favor-alternatives-coal.
[60] See historical natural gas prices here: http://www.eia.gov/dnav/ng/hist/n9190us3m.htm and historical coal prices here: http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0709.
[61] See, for example, "Matching Hourly and Peak Demand by Combining Different Renewable Energy Sources: A Case Study for California in 2020" (available at http://www.stanford.edu/group/efmh/jacobson/Articles/I/CombiningRenew/HosteFinalDraft) and "Examining the Peak Demand Impacts of Energy Efficiency: A Review of Program Experience and Industry Practices" (available at http://www.epa.gov/statelocalclimate/documents/pdf/york_paper_ee_peak_demand_4-12-2007.pdf).



Source: WRI, http://pdf.wri.org/working_papers/two_degrees_of_innovation.pdf

American jobs

American exports of energy equipment and the high-skill jobs required to bring the American energy industry into the 21st century will grow as the market share for renewable energy grows. The United States generated about 12% of its electricity from renewable sources in 2011;[62] at that level of generation, the Environmental and Energy Study Institute estimates that the renewable energy sector employed between 850,000-950,000 people, as compared to 731,000 people in the oil, gas, and coal industries.[63]

[62] National Renewable Energy Laboratory's 2011 Renewable Energy Data Book, available at http://www.nrel.gov/docs/fy13osti/54909.pdf.
[63] Sources: For jobs in renewable energy, see: http://files.eesi.org/jobs_reee_060111.pdf. Coal mining employed 83,420 people in 2011, according to the Bureau of Labor Statistics – see

According to the United Nations Environment Programme, there could be 8.4 million jobs in solar photovoltaic and wind energy, and 12 million jobs in biofuels, globally by 2030.[64]

In fact, transitioning from fossil fuels to renewable sources (or increased energy efficiency) for electricity generation can lead to significant growth in jobs. One recent study published in *Energy Policy* found that a 30% renewable portfolio standard, combined with aggressive measures to promote energy efficiency, could create over 4 million jobs by 2030.[65] The same study looks at average employment over the life of electricity generation facilities, normalizing this data by comparing job-years per gigawatt-hour across ten different generation technologies, as well as CCS and energy efficiency. The authors found that natural gas and coal both created 0.11 job-years per gigawatt-hour; the equivalent numbers for renewable technologies were 0.17 for wind, 0.21 for biomass, 0.23 for solar thermal, 0.25 for geothermal, 0.27 for small hydropower, 0.38 for energy efficiency, 0.72 for landfill gas, and 0.87 for solar photovoltaics. This study demonstrates that getting serious about reducing emissions, reducing peak load, enhancing grid reliability, and providing price stability through increased utilization of renewable energy and energy efficiency will not adversely impact employment. On the contrary, focusing on America's abundant *clean* energy resources will be a boon for both the environment and the economy.

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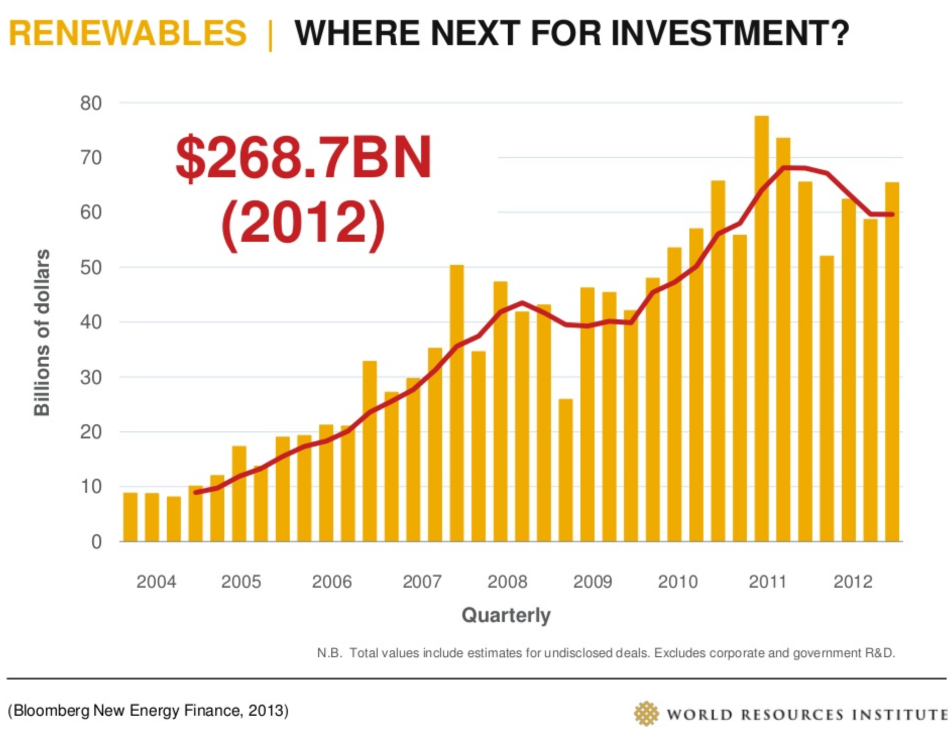
http://www.bls.gov/oes/current/naics4_212100.htm. And 648,000 people were employed in oil and gas extraction, support activities, pipeline construction, petroleum refineries and pipeline transportation – see http://www.bls.gov/iag/.

[64] UNEP "Green Jobs: toward decent work in a sustainable, low carbon world" (24 Sep 2008) p.8.

[65] See "Putting Renewables and Energy Efficiency to Work: How Many Jobs can the Clean Energy Industry Generate in the US?" Available at: http://rael.berkeley.edu/sites/default/files/WeiPatadiaKammen_CleanEnergyJobs_EPolicy2010.pdf.

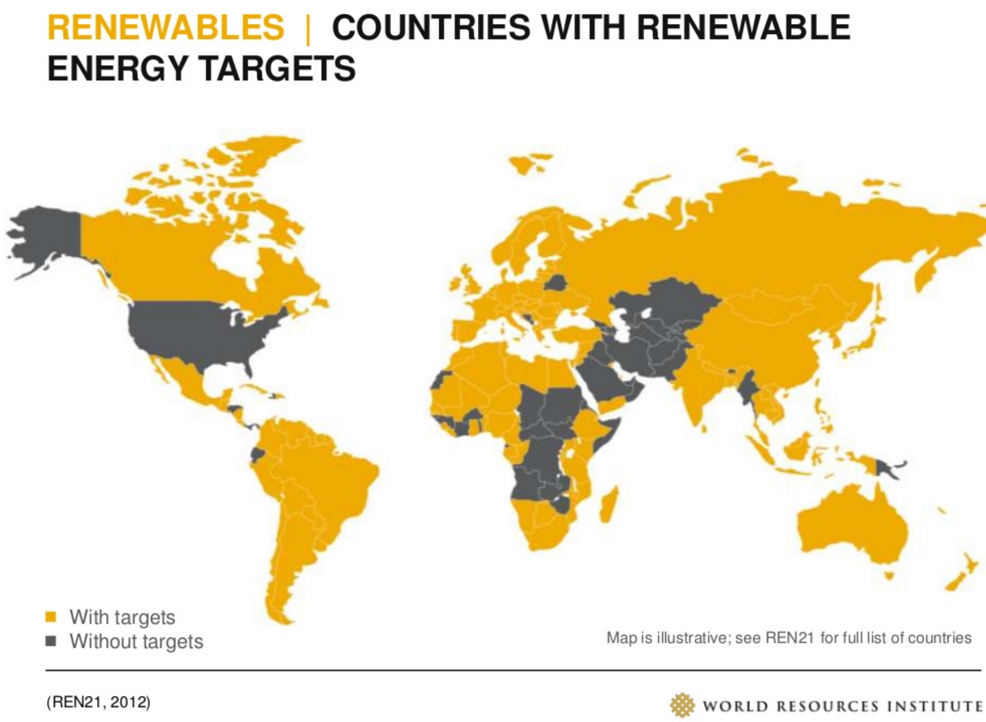
Global Perspective on the Way of the Future

Throughout the world, countries are making significant investments in clean energy technology and infrastructure. Globally, clean energy investment in 2012 was $268.7 billion, five times higher than in 2004. Approximately half of the estimated 208 GW of new electric capacity added globally in 2011 came from renewable energy sources.[66] In 2011, global investments in non-hydro renewable energy surpassed net investment in fossil-energy power plants.[67] The market opportunities are significant. The global market for low-carbon technology could double or even triple, to between $1.5 and $2.7 trillion annually by 2020.[68]



66 REN 21, Renewables 2012: Global Status Report
67 UNEP - BNEF, Global Trends in RE Investment
68 HSBC. "Sizing the Climate Economy." September 2010. These estimates include investment in energy efficiency, accounting for roughly half of all investment in the authors' "most likely" scenario.

Source: WRI, Stories to Watch 2013



Source: WRI, Stories to Watch 2013

How competitive is the U.S. in the clean energy race?[69]

The United States is the world leader in clean energy research and development (R&D) and has been among the top three countries globally in renewable energy investment for years. This could provide a good base for a strong U.S. renewable energy industry. However, the United States has been less successful relative to countries in deploying renewable energy technologies into the market and capturing these new industries and related jobs, because of a lack of policy and regulatory certainty.

[69] WRI recently released a comparative study across five countries (U.S., China, India, Germany, Japan) to assess which countries have been most successful in deploying wind and solar energy domestically and also in capturing global markets through domestic manufacturing. This section of the testimony draws heavily on the study. For details, see http://www.wri.org/publication/delivering-on-the-clean-energy-economy

In terms of R&D:

China's 12th Five Year Plan has a target for R&D expenditure in all industries to account for 2.2% of GDP by 2015. By comparison, the United States and Germany both spend about 2.8% of GDP on R&D.[70] Compared to health ($34 billion) or defense-related research ($81 billion), the amount spent by the United States each year on clean energy technology R&D ($4.7 billion) is small. [71] Nonetheless, the United States spends more than any other country on R&D, and public and private R&D spending on renewable energy in the United States accounts for 30% of the global total.[72,73] However, the clean energy innovations created in U.S. national laboratories and universities often do not get manufactured or deployed into the marketplace. For instance, a recent WRI report comparing clean energy industries across major countries highlighted that the United States had the highest public investments in wind energy R&D. Yet, it was the only wind energy market among the five countries analyzed that maintained a long-term trade deficit in wind equipment, importing more than it exports, due largely to the uncertainty surrounding the longevity of support policies.[74]

In terms of investment:

In 2012, $44.2 billion was invested in clean energy in the United States, a 32% decline

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[70] http://www.rdmag.com/articles/2011/12/2012-global-r-d-funding-forecast-r-d-spending-growth-contin
[71] http://www.brookings.edu/~/media/Research/Files/Papers/2012/4/18%20clean%20investments%20muro/0418_clean_investments_final%20paper_PDF.PDF
[72] http://battelle.org/docs/default-document-library/2012_global_forecast.pdf
[73] http://www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/FINAL_forweb_WhoIsWinningTheCleanEnergyRace-REPORT-2012.pdf, p. 12
[74] http://www.wri.org/publication/delivering-on-the-clean-energy-economy

compared to the record $65.4 billion invested in 2011.[75] China led the world in clean energy investment with $67.7 billion in 2012, a 20% increase over 2011.[76] China is also investing in clean energy abroad, and in joint ventures with global partners. Chinese firms invested $264 million in the U.S. clean energy sector in 2011, with an annual growth rate of 130% over the previous two years.[77] Although the United States has traditionally been among the world's top three clean energy investors, such investment in the United States has grown neither as steadily nor as fast as clean energy investment elsewhere in the world. The five-year rate of investment growth between 2006 and 2011 was 37% in China, 23% in India, 22% both in Japan and Germany, and only 12% in the United States. The United States does not even make the top 10 among the G-20 economies in investment growth, and risks falling behind in the long run.[78]

In terms of installed capacity:

Countries with comprehensive, predictable, and targeted policies have seen the biggest scale-up of domestic renewable energy installations. This trend is evidenced in both Germany and China, where supportive policy frameworks are integrated into national economic and energy plans that have at least a five-year lifespan. Germany's comprehensive renewable energy law incorporates feed-in tariffs, and provisions for grid interconnection and priority power dispatch. This has been instrumental in providing fast project realization times, investment certainty, and lower overall transaction costs for

[75] http://bnef.com/WhitePapers/download/266, p. 11
[76] http://about.bnef.com/2013/01/14/new-investment-in-clean-energy-fell-11-in-2012-2/
[77] Linden Ellis, Devin Kleinfield-Hayes, and Jennifer Turner. "Chinese Investment in Clean Energy." China Business Review. https://www.chinabusinessreview.com/public/1204/ellis.html
[78] http://www.pewenvironment.org/uploadedFiles/PEG/Publications/Report/FINAL_forweb_WhoIsWinningTheCleanEnergyRace-REPORT-2012.pdf, p. 12

installations. These policies have helped Germany become the country with the most solar photovoltaic capacity and the third-most wind and biomass capacity in the world.[79] China has recently tied support policies into broader economic development goals in its 5-Year Economic Development Plans. A package of renewable energy policies – supporting installations, domestic manufacturing, and R&D – all helped the industry triple its solar PV installations from 1 GW to 3 GW, and increase its on-shore wind capacity from 44 GW to 62 GW in 2011 alone. The United States, with a patchwork of national and state policies, has not seen comparable scale-up.

In terms of manufacturing:

In developing a domestic clean energy manufacturing industry, the United States has lagged behind those countries that have used the stable and predictable incentives highlighted above and supplemented this market creation with targeted support for innovative manufacturing. To date, the United States has had a largely passive approach to supporting renewable energy manufacturing, with short bursts of national investment and policy support (e.g., through the 2009 stimulus package). This seems to have been ineffective in the context of global competition. Meanwhile, in the realm of solar photovoltaics, Japan has the highest average module prices but has still managed to maintain module manufacturing production comparable with Germany (~2 GW) and twice that of the United States (~1 GW), due to a concerted focus on policy strategies that support quality and performance. This has been supported through collaborative innovation between industry, government, and academics.

[79] See the National Renewable Energy Laboratory's 2011 Renewable Energy Data Book, available at http://www.nrel.gov/docs/fy13osti/54909.pdf.

In wind power, America has suffered from the fact that short-term policies have not sent a clear signal that there will be a market for wind turbines beyond the end of any calendar year. This has meant that equipment suppliers have preferred to import rather than to produce in the United States. As noted above, the United States was the only one of the 5 major markets WRI analyzed that maintained a long-term trade deficit in wind equipment. It is not just the size of the market that matters; predictability and investor certainty are crucial.

Concluding Recommendations

1. The risks associated with climate change and federal capacity to address these risks must be better understood. Congress should request that the National Climate Assessment and Development Advisory Committee review the current authorities of federal agencies and national laboratories, and recommend how consideration of risks associated with climate change can be more directly incorporated into decision-making. The recommendations should include actions that each agency can take to most effectively limit the magnitude of climate change and improve our ability to adapt to it.

2. The impacts of climate change on America's energy infrastructure must be better assessed and incorporated into planning and current investment decisions. To support such efforts, Congress can:
    - Adopt policies that encourage hazard mitigation approaches which make the electricity and energy supply sectors more resilient to climate impacts.

- Adopt policies that require a systematic assessment of climate impacts as part of the planning processes so that all new energy investments take into account climate risks.

3. We must build out America's renewable energy sector. The United States is one of a small set of countries that currently lack a federal renewable energy target. As Congress considers how to achieve growth in renewable energy, there are four important criteria for a policy to drive more effective clean energy growth and competitiveness:[1]

   First, any energy policy should be **comprehensive** – extending beyond deployment subsidies and incorporating support for manufacturing.

   Second, it should be **long-term** – with a predictable time horizon extending a minimum of three years, particularly for manufacturing.

   Third, it should be **targeted** – technology-neutral policies such as carbon prices need to be complemented with support that takes issues such as tradability of renewable energy components into account.

   Fourth**,** it should be **inclusive** of the complete value chain for renewable energy technologies – since economic benefit opportunities extend beyond just the manufacturing sector.

[1] http://www.wri.org/publication/delivering-on-the-clean-energy-economy

4. We must capture energy efficiency across the economy. The federal government can play a constructive role in two key areas:

   Informed consumer choice: the relative performance of energy services and energy-consuming products – including vehicles, appliances, and buildings – should be more visible to consumers so that they can make informed choices about the true cost and value of their investments. Congress should support and expand such programs to help ensure product labeling is accurate and publicly reported in a timely manner, to encourage energy-wise investment decisions throughout the U.S. economy.

   Efficiency standards: Several federal agencies have been charged by Congress with setting energy efficiency standards for vehicles, appliances, and other energy-consuming equipment that is sold into U.S. commerce. Congress should support and extend the ability of agencies to develop and update such standards, in the interest of consumer protection and to increase the energy productivity of the U.S. economy. For example, the recently finalized vehicle efficiency standards are projected to save consumers $1.7 trillion at the pump while reducing U.S. oil consumption by 12 billion barrels of oil per year by 2025.[2]

5. Finally and most importantly, Congress must work toward reaching bipartisan agreement on national energy policies that encourage more efficient energy

[2] http://www.whitehouse.gov/the-press-office/2012/08/28/obama-administration-finalizes-historic-545-mpg-fuel-efficiency-standard

consumption, increase the diversity of domestic energy production, maximize deployment of low-carbon energy technologies, and minimize environmental impacts throughout our energy systems. In the near-term, it is also critical for Congress to provide funding and incentives for low-carbon and clean energy technologies. The most effective way to achieve all these goals would be to move forward on comprehensive national energy and climate legislation.