


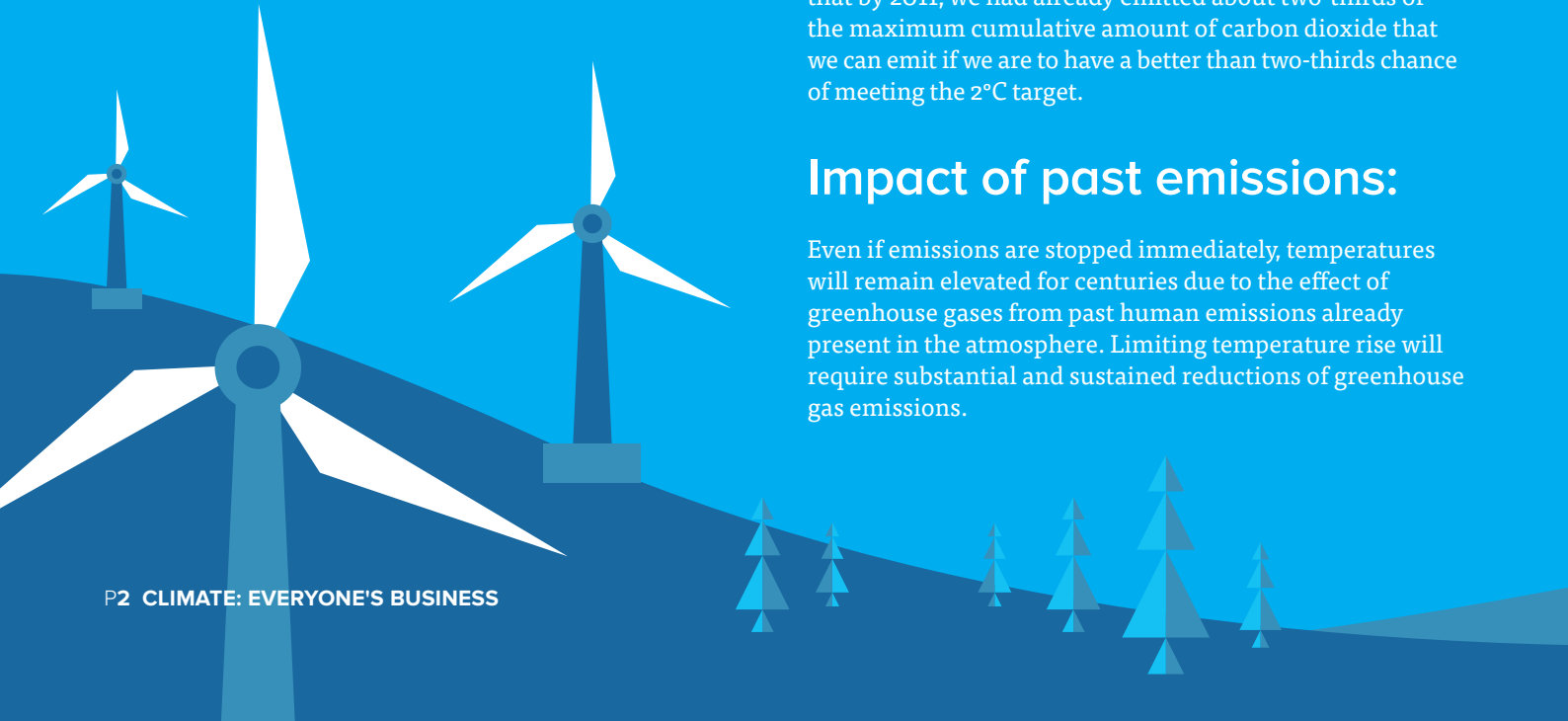
CLIMATE
EVERYONE'S
BUSINESS

Climate Change: Implications for the Energy Sector

Key Findings from the
Intergovernmental Panel
on Climate Change
Fifth Assessment Report



The Physical Science of Climate Change



Rising temperatures:

The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) concludes that climate change is unequivocal, and that human activities, particularly emissions of carbon dioxide, are very likely to be the dominant cause. Changes are observed in all geographical regions: the atmosphere and oceans are warming, the extent and volume of snow and ice are diminishing, sea levels are rising and weather patterns are changing.

Projections:

Computer models of the climate used by the IPCC indicate that changes will continue under a range of possible greenhouse gas emission scenarios over the 21st century. If emissions continue to rise at the current rate, impacts by the end of this century are projected to include a global average temperature 2.6–4.8 degrees Celsius (°C) higher than present, and sea levels 0.45–0.82 metres higher than present.

To prevent the most severe impacts of climate change, parties to the UN Framework Convention on Climate Change (UNFCCC) agreed a target of keeping the rise in average global temperature since pre-industrial times below 2°C, and to consider lowering the target to 1.5°C in the near future.

The first instalment of AR5 in 2013 (Working Group I on the physical science basis of climate change) concluded that by 2011, we had already emitted about two-thirds of the maximum cumulative amount of carbon dioxide that we can emit if we are to have a better than two-thirds chance of meeting the 2°C target.

Impact of past emissions:

Even if emissions are stopped immediately, temperatures will remain elevated for centuries due to the effect of greenhouse gases from past human emissions already present in the atmosphere. Limiting temperature rise will require substantial and sustained reductions of greenhouse gas emissions.

About this document

The Fifth Assessment Report from the Intergovernmental Panel on Climate Change is the United Nation's most comprehensive analysis of our changing climate. It provides the scientific fact base that will be used around the world to formulate climate policies in the coming years.

This document is one of a series synthesising the most pertinent findings of AR5 for specific economic and business sectors. It was born of the belief that the energy sector could make more use of AR5, which is long and highly technical, if it were distilled into an accurate, accessible, timely, relevant and readable summary.

Although the information presented here is a 'translation' of the key content relevant to this sector from AR5, this summary report adheres to the rigorous scientific basis of the original source material.

Grateful thanks are extended to all reviewers from both the science and business communities for their time, effort and invaluable feedback on this document.

The basis for information presented in this overview report can be found in the fully-referenced and peer-reviewed IPCC technical and scientific background reports at: www.ipcc.ch

PUBLISHED:

June 2014

FOR MORE INFORMATION:

E-mail: AR5@europeanclimate.org
www.cisl.cam.ac.uk/ipcc
www.worldenergy.org
www.europeanclimate.org

REVIEWERS:

Brian Statham, *Chairman of the Studies Committee, World Energy Council*,
Dr Christoph Frei, *Secretary General, World Energy Council*
Cambridge Team:
Nicolette Bartlett, Stacy Gilfillan,
David Reiner, Eliot Whittington

PROJECT DIRECTOR:

Tim Nuthall

PROJECT MANAGER/EDITOR:

Joanna Benn

EDITORIAL CONSULTANTS:

Carolyn Symon, Richard Black

PROJECT ASSISTANTS:

Myriam Castanié,
Simon McKeagney

LAYOUT DESIGN:

Lucie Basset, Burnthebook

INFOGRAPHIC:

Carl De Torres Graphic Design



Key Findings



- 1 Energy demand is increasing globally, causing greenhouse gas (GHG) emissions from the energy sector also to increase.** The trend is set to continue, driven primarily by economic growth and the rising population. In recent years the long-term trend of gradual decarbonisation of energy has reversed due to an increase in coal burning.
- 2 Climate change presents increasing challenges for energy production and transmission.** A progressive temperature increase, an increasing number and severity of extreme weather events and changing precipitation patterns will affect energy production and delivery. The supply of fossil fuels, and thermal and hydropower generation and transmission, will also be affected. However, adaptation options exist.
- 3 Significant cuts in GHG emissions from energy can be achieved through a variety of measures.** These include cutting emissions from fossil fuel extraction and conversion, switching to lower-carbon fuels (for example from coal to gas), improving energy efficiency in transmission and distribution, increasing use of renewable and nuclear generation, introduction of carbon capture and storage (CCS), and reducing final energy demand.
- 4 Strong global political action on climate change would have major implications for the energy sector.** Stabilisation of emissions at levels compatible with the internationally agreed 2°C temperature target will mean a fundamental transformation of the energy industry worldwide in the next few decades, on a pathway to complete decarbonisation.
- 5 Incentivising investment in low-carbon technologies will be a key challenge** for governments and regulators to achieve carbon reduction targets. Reducing GHG emissions also brings important co-benefits such as improved health and employment, but supply-side mitigation measures also carry risks.

The energy industry is both a major contributor to climate change and a sector that climate change will disrupt. Over the coming decades, the energy sector will be affected by global warming on multiple levels, and by policy responses to climate change. The stakes are high: without mitigation policies, the global average temperature is likely to rise by 2.6–4.8°C by 2100 from pre-industrial levels.

In the absence of strong mitigation policies, economic growth and the rising global population will continue to drive energy demand upwards, and hence GHG emissions will also rise. Climate change itself may also increase energy use due to greater demand for cooling.

The means and infrastructure to produce and transport energy will be adversely impacted by climate change. The oil and gas industry is likely to suffer from increased disruption and production shutdowns due to extreme weather events affecting both offshore and onshore facilities. Power plants, especially those in coastal areas, will be affected by extreme weather events and rising sea levels. Critical energy transport infrastructure is at risk, with oil and gas pipelines in coastal areas affected by rising sea levels and those in cold climates affected by thawing permafrost. Electricity grids will be impacted by storms, and the rise in global temperature may affect electricity generation including thermal and hydroelectric stations in some locations. Weather changes may also affect bioenergy crops. In general, the industry has options for adapting to climatic changes, but costs are likely to be incurred.

The energy sector is the largest contributor to global GHG emissions. In 2010, 35% of direct GHG emissions came from energy production. In recent years the long-term trend of gradual decarbonisation of energy has reversed. From 2000 to 2010, the growth in energy sector emissions outpaced the growth in overall emissions by around 1% per year. This was due to the increasing share of coal in the energy mix.

From annual emissions of 30 gigatonnes (Gt) of carbon dioxide (CO₂) in 2010, projections indicate that in the absence of policies to constrain emissions, the emissions associated with fossil fuel use, including the energy supply sector but also energy use in transport, industry and buildings would contribute 55–70 GtCO₂ per year by 2050. To reduce emissions to levels commensurate with the internationally agreed goal of keeping the temperature increase since pre-industrial times below 2°C, the share of low-carbon electricity generation by 2050 will need to triple or quadruple. Use of fossil fuels without carbon capture would virtually disappear by 2100 at the latest. The energy sector would be completely decarbonised, and it is likely that technologies able to withdraw CO₂ from the atmosphere would need to be deployed. Bioenergy with carbon capture and storage is one such technology (BECCS).

Replacing existing coal-fired heat and/or power plants by highly efficient natural gas combined cycle (NGCC) power plants or combined heat and power (CHP) plants can reduce near-term emissions (provided that fugitive methane release is controlled) and be a ‘bridging technology’ to a low-carbon economy. Increased use of CHP plants can reduce emissions. CCS, nuclear power and renewables provide low-carbon electricity, while increasing energy efficiency and reducing final energy demand will reduce the amount of supply-side mitigation needed. In 2012, more than half of the net investment in the electricity sector was in low-carbon technologies.

Nevertheless, a variety of barriers and risks to accelerated investment exist, including cost. Additional supply-side investments required to meet the 2°C target are estimated at USD 190–900 billion per year on average up to 2050. Much of this investment would yield co-benefits such as reduced air and water pollution, and increased local employment. But supply side mitigation typically also carries risks.

The energy sector, as defined by the IPCC, comprises all energy extraction, conversion, storage, transmission and distribution processes with the exception of those that use final energy in the end-use sectors (industry, transport, building, agriculture, forestry).

Executive Summary

Impacts of climate change

Three climate-change phenomena will have a particular impact on the energy sector: global warming, changing regional weather patterns (including hydrological patterns) and an increase in extreme weather events. Not only will these phenomena affect energy demand, in some regions they will also affect the entire spectrum of energy production and transmission. While most climate change impacts are likely to be negative, there could be some positive impacts such as lower energy demand in cold climates.

Rising temperatures coupled with a growing world population and economic growth will drive an increase in **overall demand for energy**. Rising income levels in poorer countries in warm climates are likely to lead to increased use of air-conditioning. Global energy demand for residential air-conditioning in summer is projected to increase rapidly from nearly 300 TWh in 2000, to about 4000 TWh in 2050. Much of this growth is due to increasing income in emerging market countries, but some is due to climate change. Colder, richer countries will see energy demand for heating fall, but could still see overall energy use increase.

Although **thermal power plants** (currently providing about 80% of global electricity) are designed to operate under diverse climatic conditions, they will be affected by the decreasing efficiency of thermal conversion as a result of rising ambient temperatures. Also, in many regions, decreasing volumes of water available for cooling and increasing water temperatures could lead to reduced power operations, operation at reduced capacity or even temporary shutdowns.

Extreme weather events pose a major threat to all power plants but particularly to **nuclear plants**, where they could disrupt the functioning of critical equipment and processes that are indispensable to safe operation including reactor vessels, cooling equipment, control instruments and back-up generators.

Changing regional weather patterns are likely to affect the hydrologic cycle that underpins **hydropower generation**. In some regions, a decline in rainfall levels and a rise in temperature, leading to increased water loss, could result in reduced or more intermittent ability to generate electricity. Although projections contain large uncertainties, hydropower capacity in the Zambezi river basin in Africa may fall by as much as 10% by 2030, and 35% by 2050. On the other hand, hydropower capacity in Asia could increase.



The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) is the most detailed assessment of climate change ever.

Changing weather patterns and extreme weather events present challenges to **solar and wind energy**. An anticipated increase in cloudiness in some regions would affect solar technologies, while an increase in the number and severity of storms could damage equipment. Global warming and changing weather patterns are likely to adversely impact agricultural yields, with a knock-on effect on the production and availability of **biomass for energy generation**. While there might be some benefits in temperate climates, the reduction in yields in tropical areas is more likely than not to exceed 5% by 2050.

In some rainy regions, open pits in the **coal industry** are likely to be impacted by increasing rainfall leading to floods and landslides.

Climate and weather related hazards in the **oil and gas sector** include tropical cyclones with potentially severe effects on offshore platforms and onshore infrastructure, leading to more frequent production interruptions. However, the decline in Arctic sea ice could lead to the opening up of new areas for oil and gas exploration, potentially increasing global oil and gas reserves.

Energy transmission infrastructure, such as **pipelines and power lines**, is also likely to be affected by higher temperatures and extreme weather events. Pipelines are at risk from sea-level rise in coastal regions, thawing permafrost in cold regions, floods and landslides triggered by heavy rainfall, and bushfires caused by heat waves or extreme temperatures in hot regions. Extreme weather events, especially strong wind, are projected to affect power lines.

Impacts and risks

- Increased number and severity of extreme weather events will impact on energy production and power generation for electricity.
- Hydropower and other weather-driven renewables could be adversely or positively impacted by changing weather patterns.
- The reliability of pipelines and electricity grids may be adversely impacted.



Energy Sector Faces Major Challenges from Climate Change

Without strong mitigation policies, the global average temperature is likely to rise above the internationally agreed 2°C target. As a major source of carbon emissions, the energy sector will be affected by mitigation policies as well as by climate impacts in multiple ways.



Impacts and Adaptations

Power Stations



Thermal power plants will be affected by the decreasing efficiency of thermal conversion as a result of rising ambient temperatures. Reduced water for cooling and increasing water temperatures could lead to reduced power operations or temporary shutdowns.

Pipelines



Energy transport infrastructure is at risk, with oil and gas pipelines in coastal areas affected by rising sea levels and those in cold climates by thawing permafrost. May require new land zoning codes and risk-based design and construction standards and structural upgrades to infrastructure.



Emission Reduction Options

Carbon Capture & Storage



Adoption of carbon capture and storage (CCS) for fossil fuel plants can reduce emissions. CO₂ storage capacity is large and all parts of the technology have been demonstrated. CCS units burning bioenergy (BECCS) can draw CO₂ from the air. But barriers to CCS and BECCS remain, including cost.

Increasing Efficiency



Energy efficiency can be improved by retrofitting existing plants and adopting efficient new ones; improving transmission and distribution and through technology improvements in fossil fuel extraction and conversion.



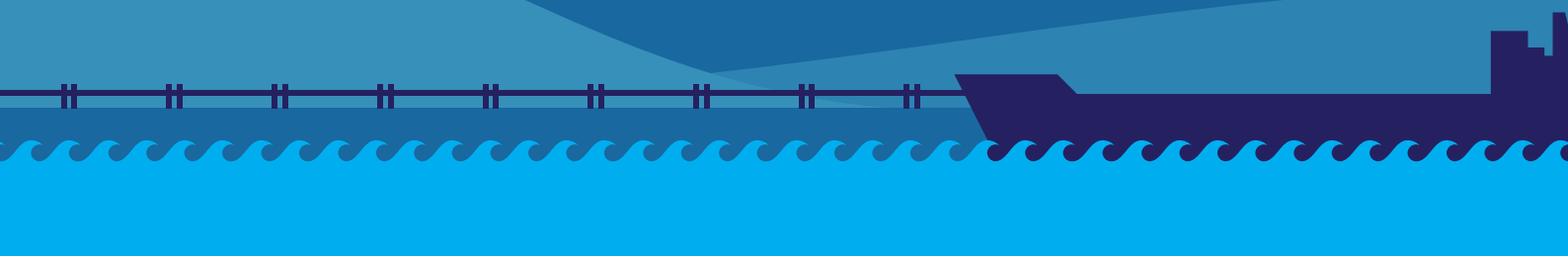
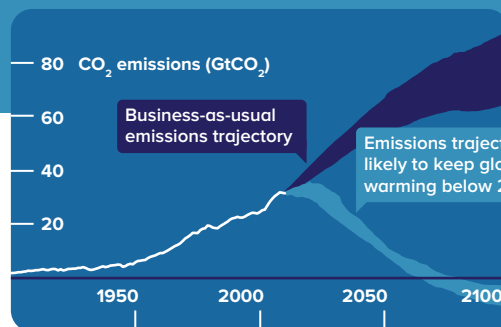
Policy Framework

Additional investments, which could be bolstered by fiscal measures and/or subsidies are required in the energy supply sector to keep the global temperature increase below 2°C.



Largest GHG Contributor

The energy sector is the largest source of greenhouse gas (GHG) emissions. Meeting the 2°C target implies swiftly halting the rise in emissions for the full energy system and bringing them to zero before the end of the century, with a likely need for 'negative emissions' technology such as BECCS.



Global warming, changing regional weather patterns and extreme weather events will affect demand and impact energy production and transmission. Strong global policy action would also have major implications on investments.



Climate Change



Changes in Regional Weather Patterns



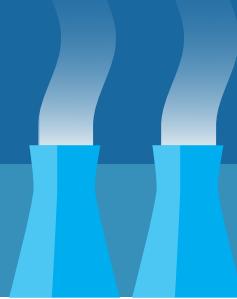
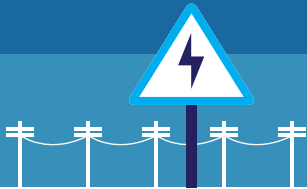
Extreme Weather Events



Government Policy



Investment



Power lines



Extreme weather events, especially strong wind, could damage power lines. Standards can be amended to implement appropriate adaptation measures, including re-routing lines away from high-risk areas.

Renewables



Changes in regional weather patterns threaten to impact the hydrologic cycle that underpins hydropower. An increase in cloudiness in some regions would affect solar technologies, while an increase in the number and severity of storms could damage equipment.

Nuclear



Lack of water and extreme weather events may threaten nuclear plants by disrupting the functioning of critical equipment and processes.



Switching Fuels



Switching to lower-carbon fuels (eg from coal to gas) can reduce emissions. Moving from world-average efficiency coal plant to state-of-the-art gas can halve emissions if fugitive methane release is controlled, and can act as a 'bridging technology'.



Alternatives



Increasing use of renewables such as solar, wind and biofuels. Increasing use of nuclear power. Hydropower is currently the largest single RE contributor, but solar, wind and bioenergy are expected to experience the biggest incremental growth.



Reducing Demand



Reducing consumer demand is a key mitigation strategy. The level of demand reduction determines the size of the mitigation challenge facing the energy sector. Potential limitations from 'rebound effect' to be taken into consideration.



Regulatory Frameworks



Governments may facilitate an increased use of emission reduction options by creating an attractive fiscal and regulatory framework.



Investment in Technology



New technologies can be used for efficiency improvements, power generation, extraction, storage, transmission and distribution.



Carbon Pricing



For government and regulators, a key challenge will be to ensure a price of carbon that incentivises extra investment in low-carbon technologies.



Global
°C

Resilience



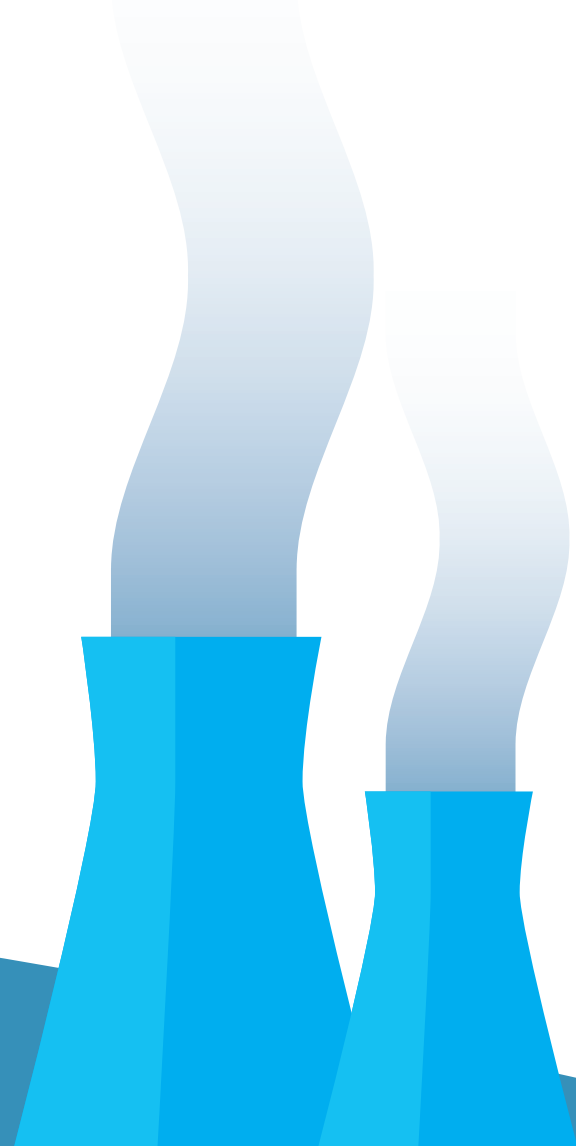
There are various options by which the energy sector can improve its resilience to climate change.

A number of technological improvements are available for thermal power plants which, if implemented, will bring efficiency gains that more than compensate for losses due to higher ambient temperatures. Preventative and protective measures for nuclear power plants include technical and engineering solutions and adjusting operation to extreme conditions, including reducing capacity or shutting down plants. Weather resistance of solar technologies and wind power turbines continues to increase.

Coal mining companies can improve drainage and run-off for on-site coal storage, as well as implementing changes in coal handling due to the increased moisture content of coal. Pipeline operators may be forced to follow new land zoning codes and to implement risk-based design and construction standards for new pipelines, and structural upgrades to existing infrastructure.

Technical standards for power transmission lines are likely to be amended to force grid operators to implement appropriate adaptation measures, including in some cases re-routing lines away from high-risk areas.

Authorities can plan for evolving demand needs for heating and cooling by assessing the impact on the fuel mix. Heating often involves direct burning of fossil fuels, whereas cooling is generally electrically powered. More demand for cooling and less for heating will create a downward pressure on direct fossil fuel use, but an upward pressure on demand for electricity.



Mitigation Options



As the sector producing the largest share of GHG emissions, the energy sector would be substantially affected by policies aimed at meeting the internationally agreed 2°C target for global warming. A number of mature options exist that can, if scaled up, result in substantial mitigation of the sector's GHG emissions. However, the scale of the challenge is considerable. Pathways compatible with the 2°C target typically envisage achieving virtual decarbonisation of the energy supply at some point between 2050 and the end of the century. It is likely that 'negative emissions' – technologies that absorb CO₂ from the atmosphere – will also be needed.

Options for mitigation include:

- Cutting emissions from fossil fuel extraction and conversion
- Switching to lower-carbon fuels, for example from coal to gas
- Improving energy efficiency in transmission and distribution
- Increasing use of renewable energy technologies
- Increasing use of nuclear energy
- Introduction of carbon capture and storage (CCS), and an extension into CCS plants that use bioenergy crops (BECCS) as an approach to achieving 'negative emissions'
- Reducing final energy demand.



Fuel extraction and conversion

Fossil fuel extraction and distribution currently contribute 5–10% of total fossil-fuel related GHG emissions. The move towards more energy-intensive production of oil and gas from unconventional sources such as shale and tight gas reserves, production requiring greater energy inputs at mature fields, mining of coal from deeper mines and longer transportation distances may increase this contribution. Mitigation options include:

- Reducing emissions associated with fuel production and transport through higher energy efficiency and the use of low-carbon energy sources in mines, oil and gas fields, and transportation networks
- Capture and utilisation of methane from coal mining
- Reducing venting and flaring from oil and gas exploration, production and transportation.

The impact of fuel switching from coal to gas (see below) can be compromised if fugitive methane release is not controlled. There is substantial variation in the amount of methane released from different sites.

Fuel switching

Replacing a higher-carbon fuel with a lower-carbon alternative can reduce overall emissions. For example, shifting from a current world-average coal-fired power plant to a modern natural gas combined cycle (NGCC) unit can halve emissions, provided that fugitive methane emissions are controlled.

However, by 2050, average power station emissions need to be below the best available from NGCC plants if the 2°C trajectory is to be followed, putting the coal-to-gas approach into the category of a 'bridging technology'. As power stations operate on average for more than 30 years, a continued global programme of investment over the next few decades in natural gas-fired generation without CCS would compromise the 2°C target.

Increasing efficiency

Improving energy efficiency in power transmission and distribution could help reduce GHG emissions. Losses as a fraction of energy generated vary widely between countries, with some developing countries having losses of over 20%. Combined transmission and distribution losses for the OECD countries taken together were 6.5% of total electricity output in 2000. Increased use of improved transformers and distributed power generation would reduce losses, while new technologies such as dynamic loading, gas-insulated transmission lines and high voltage DC transmission (HVDC) could offer reductions.

Renewables

Renewable energy (RE) sources have significant potential for reducing GHG emissions, and are becoming more competitive. RE provides just over one fifth of the world's electricity supply, and in 2012 accounted for just over half of the new electricity-generating capacity added globally. Generation from wind grew five-fold and from solar photovoltaics 25-fold in the period 2005–2012. But only a small fraction of renewable potential has been tapped so far; estimates suggest that in every region of the world, RE sources can produce at least 2.6 times the energy demand.

Hydropower is currently the largest single RE contributor, but solar, wind and bioenergy are expected to experience the biggest incremental growth. However, much will depend on regional specificities, with hydropower and geothermal continuing to be important in certain countries. RE is likely to penetrate most rapidly in electricity generation, at least in the near to medium term, followed by heating/cooling and transport.

RE technologies still need direct support (e.g. feed-in tariffs, RE quota obligations, and tendering/bidding) and/or indirect support (e.g. sufficiently high carbon prices for the internalisation of other externalities), if their market shares are to increase. Expanding the use of RE in the electricity mix will bring increasing challenges associated with integrating generation facilities into the grid. Technical options exist for meeting these challenges, but may need additional policy support and may result in higher costs.

Nuclear energy

Nuclear energy could make an increasing contribution to a low-carbon energy supply, but a variety of barriers and risks exists. Continued use and expansion of nuclear energy worldwide will require greater efforts to improve the safety, economics, uranium utilisation, waste management, and proliferation of materials. Research and development of next generation nuclear energy systems, including new fuel cycles and reactor technologies, are currently underway.

CCS and bioenergy

Carbon capture and storage technologies are capable of significantly reducing the CO₂ emissions of fossil fuel-fired power plants. Global warming is unlikely to be kept under 2°C without introduction and widespread adoption of CCS, and the cost of mitigation would be higher in the absence of CCS. However, while all of the components of integrated CCS systems already exist, it has not yet been applied to a large, commercial fossil fuel-fired generation facility.



Geological storage capacity is large and sufficient to meet demand over the 21st century, but capacity is unevenly distributed and not geographically matched with the emission centres. Global underground CO₂ practical storage capacity is estimated at 3900 Gt CO₂, of which just 0.03 Gt CO₂ has been utilised to date. By comparison, annual average GHG emissions from fossil fuels and industrial sources are currently estimated at around 30 Gt CO₂. Economic incentives such as a carbon tax on emissions or subsidies will be required if CCS plants are to become widespread. Furthermore, well defined regulations concerning short- and long-term responsibilities for storage are essential for large-scale future deployment of CCS.

Even with swift adoption of CCS and other mitigation measures, scenarios indicate that the 2°C target is likely to be missed unless ‘negative emission’ technologies (also known as carbon dioxide removal, or CDR) are introduced. Producing electricity and heat by burning bioenergy crops, then capturing and storing the carbon emissions (BECCS) is one of the few options available. However, the technology carries risks, mainly associated with the large-scale production of bioenergy crops. These include unreliable supply (particularly given projections of changes to precipitation and extreme weather events under climate change), impacts on biodiversity, and competition with other land uses including food production.

Reducing final energy demand

Demand reduction in energy end-use sectors is a key strategy for mitigation (and for achieving wider sustainability objectives), and largely determines the scale of the mitigation challenge for the energy supply side. Limiting energy demand has multiple benefits, including:

- The ability to maintain a wide portfolio of energy technologies
- Reducing the need for new low-carbon energy supplies
- Avoiding lock-in to new, or a potentially premature retirement of, carbon-intensive infrastructure
- Maximising co-benefits for other policy objectives
- Reducing risks associated with supply-side mitigation (e.g. bioenergy crops)
- Increasing the cost-effectiveness of the transition.

However, potential limitations from the ‘rebound effect’ need to be taken into consideration.

Co-benefits and risks

Switching to low-carbon technologies can bring significant co-benefits. In 2010, China’s investment in solar technologies created nearly half a million power sector jobs. Projections indicate that the renewables industries in Germany and Spain could each employ 500 000 to 600 000 people by 2030. However, the net impact of a low-carbon transition on employment is uncertain. Jobs in the coal and gas sectors could be retained through adoption of CCS. Other benefits of the low-carbon transition include energy security, rural development (particularly in poor countries), and health improvements through reduced air and water pollution.

All low-carbon generation technologies carry risks. Hydropower systems disrupt river flows, wind turbines can affect birds, and all renewables (but particularly bioenergy crops) need more land than their fossil fuel alternatives. Nuclear energy carries risks to human health and safety. However, fossil fuel-based technologies also carry risks (over and above their climate impact), and well-designed low-carbon electricity supply systems outperform fossil fuel-based approaches on most indicators. The environmental performance of fossil fuel-based technologies is expected to decline with increasing use of unconventional resources, given the adverse impacts of extraction. Mitigating emissions through demand reduction eliminates some of the risks associated with supply-side interventions.

Policy

Overall, the success of energy policies depends on capacity building, the removal of financial barriers, the development of a solid legal framework, and sufficient regulatory stability. Property rights, contract enforcement, and emissions accounting are essential for the successful implementation of climate policies in the energy supply sector. Furthermore, the impact of policies may be less than envisaged owing to factors such as the ‘rebound effect’, wherein (for example) an increase in energy efficiency reduces the cost of appliance use to the consumer, who reacts by increasing use.

Climate change mitigation policies could devalue fossil fuel assets and reduce revenues for fossil fuel exporters, but differences between regions and fuels exist. Most mitigation scenarios are associated with reduced revenues from coal and oil for major exporters. Impacts on gas producers are less clear, and could involve increased profits for gas exporters up to 2050. Availability of CCS in some scenarios would mitigate impacts on revenue.





Climate change will affect the entire energy sector, through impacts and through policy.



Conclusion

Climate change will affect the entire energy sector, through impacts and through policy. While the cost of mitigating emissions across all sectors could reduce annual consumption growth by 0.04–0.14%, the scale of the low-carbon transition and the opportunities for investment are likely to be larger in the energy sector than in others. Additional investments required in the energy system in order to keep the temperature increase since pre-industrial times below 2°C are estimated to be USD 190–900 billion per year on the supply-side alone, although this investment could realise important co-benefits for economies as a whole. However, infrastructure tends to be used for at least 30 years once built; so decisions made in the next couple of decades will be crucial in deciding whether the energy sector leads the way towards or away from a 2°C future.

Scenarios project that a fundamental transformation will be necessary if governments are to meet the globally agreed 2°C target. Generally, these scenarios envisage three parallel processes: decarbonisation of the electricity supply, expansion of the electricity supply into areas such as home heating and transport that are currently fuelled in other ways, and reduction in final energy demand. Much of the incremental investment will be in developing countries where demand is growing at a faster rate than in developed countries. The additional capital would be partly offset by the lower operating costs of many low-GHG energy supply sources.

For government and regulators, a key challenge will be to ensure a price of carbon that incentivises extra investment in low-carbon technologies, continued investment in research and development, and an attractive fiscal and regulatory framework.



ADAPTATION

The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In natural systems, human intervention may facilitate adjustment to expected climate and its effects.

BECCS

Bio-energy with carbon capture and storage.

BIOENERGY

Energy derived from any form of biomass such as recently living organisms or their metabolic by-products.

BIOMASS

The total mass of living organisms in a given area or volume. The term is also used to denote solid biofuels.

CARBON CAPTURE AND STORAGE (CCS)

A process in which carbon dioxide from industrial and energy related sources is separated (captured), conditioned, compressed, and transported to an underground storage location for long-term isolation from the atmosphere.

CO-BENEFIT

The positive effect that a policy or measure aimed at one objective might have on other objectives.

COMBINED HEAT AND POWER (CHP)

Integrates the production of usable heat and power (electricity) in one single, highly efficient process.

CLIMATE CHANGE

Any significant change in climate that persists for an extended period, typically decades or longer.

CLIMATE IMPACT

The effects of climate change on natural and human systems.

DECARBONISATION

The process by which countries or other entities aim to achieve a low-carbon economy, or by which individuals aim to reduce their carbon emissions.

EMERGING ECONOMIES

Economies in the low- to middle-income category that are advancing rapidly and are integrating with global capital and product markets.

ENERGY EFFICIENCY

The ratio of useful energy output of a system, conversion process, or activity to its energy input.

FINAL ENERGY USE

All energy supplied to the final consumer for all energy uses.

FUGITIVE EMISSIONS

Emissions of gases or vapours from pressurised equipment due to leaks and other unintended or irregular releases of gases, mostly from industrialised activities including natural gas extraction and processing.

GREENHOUSE GAS

A gas in the atmosphere, of natural and human origin, that absorbs and emits thermal infrared radiation. Water vapour, carbon dioxide, nitrous oxide, methane and ozone are the main greenhouse gases in the Earth's atmosphere. Their net impact is to trap heat within the climate system.

LOCK-IN

Occurs when a market is stuck with a standard even though participants would be better off with an alternative.

LOW CARBON ELECTRICITY

Low-carbon electricity or power comes from processes or technologies that, produce power with substantially lower amounts of carbon dioxide emissions than is emitted from conventional fossil fuel power generation.

MITIGATION

A human intervention to reduce the sources or enhance the sinks of greenhouse gases.

NATURAL GAS COMBINED CYCLE (NGCC) PLANT

Gas-fired unit for generating electricity in which waste heat from the initial gas combustion is captured and used to power a secondary turbine, usually using steam. This substantially increases the overall efficiency.

PROJECTION

A potential future evolution of a quantity or set of quantities, often computed by a model. Projections involve assumptions that may or may not be realised, and are therefore subject to substantial uncertainty; they are not predictions.

RENEWABLE ENERGY

Any form of energy from solar, geophysical or biological sources that is replenished by natural processes at a rate that equals or exceeds its rate of use.

RESILIENCE

The capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure.

TIGHT GAS RESERVE

A natural gas that has gathered in small, poorly connected cavities between the rocks (mostly sandstone). Because this rock is not very porous the natural gas cannot flow freely to the well and is a tight reserve.

“Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions.”

IPCC, 2013

Disclaimer:

This publication has been developed and released by the European Climate Foundation (ECF), the World Energy Council (WEC) and the University of Cambridge's Judge Business School (CJBS) and Institute for Sustainability Leadership (CISL).

This project is initiated and financed by ECF and endorsed by CJBS and CISL.

The family of summaries, of which this report is part, is not meant to represent the entirety of the IPCC's Fifth Assessment Report (AR5) and they are not official IPCC documents. The summaries have been peer-reviewed by experts both from the business and science communities. The English version constitutes the official version.

About us:

The University of Cambridge Institute for Sustainability Leadership (CISL) brings together business, government and academia to find solutions to critical sustainability challenges.

Cambridge Judge Business School (CJBS) is in the business of transformation. Many of our academics are leaders in their field, creating new insight and applying the latest thinking to real-world issues.

The World Energy Council is the principal impartial network of leaders and practitioners promoting an affordable, stable and environmentally sensitive energy system for the greatest benefit of all.

For more information:

E-mail: AR5@europeanclimate.org
www.cisl.cam.ac.uk/ipcc
www.worldenergy.org
www.europeanclimate.org

Reproduction and use: The materials can be freely used to advance discussion on the implications of the AR5 and consequences for business. The report is made available to any and all audiences via the Creative Commons License BY-NC-SA. This document is available for download from the CISL website: www.cisl.cam.ac.uk/ipcc