Building a sustainable energy future: risks and opportunities
With an expanding population and world economy powered by oil, coal and gas, fossil fuels have become a large part of our daily lives. But this has come at a price: greenhouse gas emissions, which adversely affect our climate. How much higher will this price rise before we achieve a more sustainable energy system? The Scenarios for Climate Change project, a research collaboration by Swiss Re and partners from the public and private sectors, gives insights into what tomorrow may hold for businesses, insurers and society at large.
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Towards a sustainable energy future

Fossil fuels have powered our economy and shaped our way of life for more than a century. Their use has helped create unprecedented wealth for more people than ever before and allowed them to lead longer and more productive lives. Accompanying these economic developments, the world’s population has grown from 1 billion to 7 billion over the last 200 years, having increased by only about 700 million in the previous eight centuries combined.

And yet for all their benefits, fossil fuels have also had a detrimental side effect: greenhouse gas emissions. These emissions trap heat in the atmosphere, pushing up average temperatures and adversely affecting the Earth’s climate system.1 Today we are living with the impact from decades of fossil fuel-driven growth and the effect it has had on our climate.2

As economies and populations expand, global demand for energy will continue to increase. The International Energy Agency estimates that world energy demand will rise by 40% between now and 2035 and that 90% of this demand is expected to come from non-OECD countries, notably China and India. To meet these growing energy needs, global investment of USD 38 trillion is required to build and maintain an adequate energy supply infrastructure over the next 25 years.3

But the world has hit a crossroads. Greenhouse gases in the atmosphere are continuing to rise as a result of burning fossil fuels. If current trends persist, rising emissions not only threaten to exacerbate climate change but cause abrupt and permanent environmental damage. Even a relatively low 2°C warming above pre-industrial temperatures – an ambitious and increasingly unrealistic goal agreed at the 2009 Copenhagen climate summit – would significantly alter weather patterns. The result would be more intense heat waves, erratic rainfall, storms and floods that jeopardise even more people and assets.5

Tackling climate change while meeting the energy needs of a growing and developing world is therefore a matter of urgency. But this dual objective is highly complex and fraught with risk. What is certain is that it will require a fundamental change in the way we produce and consume energy. This can only be achieved by improving energy efficiency and switching to low-carbon options, including renewable energy sources. As investment in these new technologies increases, so will the demand for improved risk management and insurance.

The key question, however, is how to advance a more sustainable energy system with the right incentives and in light of significant political, financial, environmental and technical challenges. The Scenarios for Climate Change (SCC) project, which Swiss Re supported with its risk expertise, provides some answers. It gives new insights into how the world’s energy and climate system could develop under six different scenarios which look at the world’s power supply mix in 2050.6 They highlight investment potential and risks which, if adequately addressed, could lead to cleaner growth and create long-term win-win situations both for our climate and our economy.

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1 While global atmospheric concentrations of carbon dioxide (CO₂), the most significant greenhouse gas, remained steady at 200–300 parts per million (ppm) for 800 000 years, they shot up to 387 ppm within the last 150 years – a phenomenon largely attributable to the burning of fossil fuels. As a result, near-surface atmospheric temperatures rose by an average of 0.7 degrees (0.07 degrees per decade) during the 20th century and by 0.5 degrees Celsius (0.17 degrees) between 1970 and 2000.

2 According to the Economics of Climate Adaptation (ECA) Working Group, in some locations annual financial losses from existing climate patterns already amount to anywhere between 1–12% of annual GDP, and they could jump to 19% of GDP by 2030 if affected communities fail to take protective measures. The range is based on studies in North and North East China, Maharashtra/India, Mali, Guyana, Hull/UK, Florida/US, Samoa and Tanzania.


4 Special Report of the Intergovernmental Panel on Climate Change: Managing the risks of extreme events and disasters to advance climate change adaptation (SREX), 2012.

5 This project was a research collaboration involving prominent partners from the public and private sectors, including BHP Billiton, ClimateWorks, DONG, McKinsey, Swiss Re, Vattenfall and the World Bank. However, the conclusions presented in this publication are those of Swiss Re and do not represent the collective views of all the partners.
Scenarios for Climate Change: a framework for decision-making

The worldwide increase in energy demand is putting pressure on companies, governments and consumers to find new sources of supply as well as ways to save energy. Whatever course of action we take today will not only determine the climate of tomorrow but also our ability to meet the energy needs of future generations.

To help companies and governments identify the most cost-effective opportunities for securing energy supplies while scaling back greenhouse gas (GHG) emissions, the researchers behind the Scenarios for Climate Change (SCC) project analysed the costs and benefits of numerous carbon-reducing measures. To do so, they used a proprietary global greenhouse gas abatement cost curve developed by consulting firm McKinsey.

Swiss Re contributed to the project by quantifying the impact of risk on abatement costs. This exercise delivered a risk-adjusted GHG cost curve that takes into account the actual uncertainty inherent in climate and energy markets. In addition, by linking the cost curve to macroeconomic modelling of variables such as growth, energy prices, and interest rates, the SCC framework is more dynamic than a stand-alone cost curve.

The global cost curve presents an estimate of the maximum potential of all technical GHG abatement measures below USD 100 per ton of CO$_2$e – or carbon dioxide equivalent – if each was pursued aggressively. It shows that total abatement potential between now and 2030 amounts to over 35 billion tons (gigatons). This means that limiting emissions concentrations to 450 parts per million (ppm) would theoretically be possible with measures that cost less than USD 100 per ton, but only if these are implemented now. These include mitigation measures that address energy consumption and production, such as retrofitting houses, waste recycling, industrial efficiency improvements, cleaner fuels and renewable energy sources (Fig. 1).

However, developments in future climate and energy markets are unknown and difficult to predict. This is why SCC researchers developed six possible scenarios that lay out how the global climate and energy landscape could unfold by 2050 under varying circumstances. To make the scenarios span a wide range of possible outcomes, they identified and incorporated five key drivers which have a substantial influence on climate and energy markets but are also highly uncertain: economic growth, technology development, fossil fuel price development, climate and energy policies and public perception of climate change impacts.

Whatever action we take today to reduce greenhouse gas emissions will not only determine the climate of tomorrow but also our ability to meet the energy needs of future generations.

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4 The global greenhouse gas abatement cost curve was developed by consulting firm McKinsey and first published in January 2007. For the Scenarios for Climate Change project, the cost curve was updated with the most recent data and dynamically linked to a global macroeconomic equilibrium model from Oxford Economics. This allows for analysis of climate change economics under varying scenarios, giving users the option to first select macroeconomic parameters (growth, energy prices, interest rates, etc.) and then assess what carbon economics and the cost curve look like in that scenario, as well as the macroeconomic impact of different energy and GHG mitigation scenarios.

5 CO$_2$e, or “carbon dioxide equivalent,” is a standardized measure of GHG emissions designed to account for the differing global warming potentials of GHGs. Emissions are measured in metric tons CO$_2$e per year, i.e., millions of tons (megatons) or billions of tons (gigatons). All emissions values in this report are per-year CO$_2$e amounts, unless specifically noted otherwise.

6 To put this in perspective, total US greenhouse gas emissions in 2010 amounted to 6.822 billion metric tons of carbon dioxide. The abatement potential therefore equals about five years of total US emissions. Source: US Environmental Protection Agency.
The greenhouse gas abatement cost curve presents an estimate of the maximum potential of all technical GHG abatement measures below USD 100 per tCO\textsubscript{2}e if each lever was pursued aggressively. However, it is not a forecast of what role different abatement measures and technologies will actually play. Costs are presented from a societal perspective.

Onshore wind farm in North Rhine Westphalia, Germany.
Five drivers behind energy and climate markets: highly relevant but highly uncertain

**Economic growth:** Economic development is closely linked to growth in energy demand and greenhouse gas emissions. Therefore energy and emissions projections are very sensitive to growth assumptions. While future economic growth rates are highly uncertain, varying in the scenarios by 2–3% until 2025, they converge to the same long-run rate after 2030. Generally, fossil fuel prices tend to be higher when economic growth is high, making it easier for “green” policies to gain acceptance.

*Certain:* There is a very strong link between economic growth and energy demand.
*Uncertain:* World economic outlooks vary tremendously; will another big economy emerge by 2020?

**Energy technology:** Research and development investments in clean energy have increased substantially from USD 14 billion globally in 2004 to USD 68 billion in 2010 and costs have come down. But how fast will they develop in the future? Will declining relative costs of clean technology create a large scale green transition? If so, when?

*Certain:* Clean tech will develop rapidly, but shale gas has already had a disruptive impact in the US.
*Uncertain:* Will clean technology costs fall by 25, 50 or 75% by 2030? Will shale gas exploration expand globally?

**Fossil fuel prices:** Prices have fluctuated between USD 80 and 120 per barrel between 2010 and 2012 despite weak global economic growth. This is one reason to believe oil prices will remain high. But there are also large reserves of unconventional oil extracted by means other than oil wells which could be produced at costs below today’s prices. Shale gas production, for example, has already caused a major disruption in the gas market.

*Certain:* Supply and demand for oil will be stretched in the next 10–30 years, with possible oil price shocks.
*Uncertain:* How will the oil price develop? Will it be at 60–100 USD per barrel or USD 100–200 in the future?

**Global and national climate policy:** Policies play a major role in shaping climate and energy markets, but many questions remain: Will there be stronger policies in support of a green transition in the major economies? When and how strong? Will the global United Nations process lead to a binding agreement with solid commitments and supported by a global consensus? Will it be in place by 2015 and take effect in 2020, as envisaged at the Cancun climate summit?

*Certain:* Strong informal “green” mechanisms are already at work and will shape our future energy system.
*Uncertain:* Will strong, explicit carbon reducing policies be implemented or not? If so, where and by when?

**Public perception of climate change:** In large parts of the world, public support for tougher climate mitigation policies has been lukewarm. This has made it difficult for many policymakers to adopt regulations to cut emissions. Will there be major weather events or other clearly visible effects of global warming that will change this and create public pressure to reduce emissions?

*Certain:* Climate change will significantly impact developing countries and feature in the public debate.
*Uncertain:* Will climate change impacts shift public opinion to support strong mitigation efforts? If so, by when?
Six climate change scenarios: different shades of green

The five “high impact, high uncertainty” drivers described in the previous chapter help define six scenarios for how global climate and energy markets might evolve over time. These scenarios should not be seen as predictions of any future market developments. Instead, the following descriptions are based on the expert judgments of SCC consortium members and serve as illustrations of how the most important forces at work might play out.

1) GHG emissions reductions not pursued: In this scenario, action on climate change is de-prioritised, and climate change gradually disappears as a top item in public discourse. Global warming starts to be seen as an inevitable consequence of global industrialisation. Clean technology investments continue, but the pace is slow due to lower fossil fuel prices and fading expectations that the future economy will be predominantly green. Adaptation becomes the main response strategy once the physical effects of global warming become apparent, perhaps by 2025–2035.

2) Late and disruptive climate policy action: This scenario follows the same initial pathway as the scenario above, but dramatic weather-related events or other clearly observable physical effects lead to the widespread conviction that global warming is a reality and mitigation is essential. Faced with public pressure, the major economies act forcefully to reduce emissions, even at the expense of economic growth. Little new fossil fuel-based infrastructure is built, and carbon capture and storage (CCS) technology is deployed to reduce emissions from existing installations. This leads to a sharp decline of global emissions but at a high cost.

Six climate change scenarios

<table>
<thead>
<tr>
<th>Brief scenario rationale</th>
<th>Economic growth</th>
<th>Relevant policies</th>
<th>Energy technology</th>
<th>Fossil fuel price</th>
<th>Public perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) GHG emissions reductions not pursued</td>
<td>2.4% to 2025, 3.1% to 2050</td>
<td>Weak or little in addition to usual</td>
<td>Slow</td>
<td>USD 137 per barrel in 2050</td>
<td>Weak</td>
</tr>
<tr>
<td>(2) Late and disruptive climate policy action</td>
<td>2.9% to 2025, 3.1% to 2050</td>
<td>Weak to 2025, very strong thereafter</td>
<td>Moderate</td>
<td>USD 104 per barrel in 2050</td>
<td>Strong from 2025</td>
</tr>
<tr>
<td>(3) Slow greening of the economy</td>
<td>2.9% to 2025, 3.1% to 2050</td>
<td>Moderate, esp. where cost-effective</td>
<td>Medium</td>
<td>USD 128 per barrel in 2050</td>
<td>Moderate</td>
</tr>
<tr>
<td>(4) Clean technology breakthrough</td>
<td>3.3% to 2025, 3.2% to 2050</td>
<td>Moderate, esp. where cost-effective</td>
<td>Fast</td>
<td>USD 112 per barrel in 2050</td>
<td>Moderate</td>
</tr>
<tr>
<td>(5) High fossil fuel prices make world go green</td>
<td>3.4% to 2025, 3.3% to 2050</td>
<td>Moderate, esp. where cost-effective</td>
<td>Medium/fast</td>
<td>USD 155 per barrel in 2050</td>
<td>Moderate</td>
</tr>
<tr>
<td>(6) Policy consensus around climate change</td>
<td>3.3% to 2025, 3.2% to 2050</td>
<td>Strong, all-out effort in later decades</td>
<td>Medium/fast</td>
<td>USD 104 per barrel in 2050</td>
<td>Strong</td>
</tr>
</tbody>
</table>

Economic growth rates are kept constant at 2–3% in the calculation. Growth rates would otherwise overshadow all other parameters due to the strong correlation between energy consumption and economic activity. A barrel refers to oil barrel with a volume of 42 US gallons or 159 litres.
In these future climate change scenarios, emissions reductions do not eliminate global warming. This means adaptation will become even more important to soften the impact of a changing climate.

(3) Slow greening of the economy: In this scenario, climate change remains on the political agenda in spite of global economic problems and other shorter-term issues, but only as a second priority. As a result, policies favouring low-emission outcomes are strengthened, but only gradually. Importantly, however, companies continue to believe in a future low-emission economy and invest accordingly. The result is a gradual shift to a greener economy, but at too slow a pace compared to what climate scientists say is needed to avoid dangerous climate change. Adaptation still becomes a major part of the response strategy.

(4) Clean technology breakthrough: In this scenario, high levels of research and design, innovation and improvements in clean technology allow alternative energy sources to compete with fossil fuels by 2020. Market forces rather than policy action become the major response to climate change. However, fossil fuel-based technologies still represent a substantial share of energy-related investments. This is because significant fossil reserves can still be profitably extracted at costs much lower than current ones, particularly as demand for them drops. This could lead to a period of intense price competition among fuels, with energy prices going down in general and energy consumption increasing. So despite the rapid adoption of clean tech, this scenario also does not get the world economy onto a development path based on emissions concentrations of 450 parts per million (ppm).

(5) High fossil fuel prices make the world go green: Similar to the clean tech scenario, the shift from fossil fuels to cleaner alternatives happens for economic reasons. But in this scenario the shift towards cleaner alternatives is primarily driven by high fossil fuel prices. As the world economy continues to grow, suppliers of fossil fuels, specifically oil, struggle to create new production to meet growing energy demand. Some of them also have clear incentives to keep prices high. This creates a price shield under which clean technologies can grow quickly. By 2025, clean technologies are so cheap and provide so many local jobs that large energy importers (e.g., China, US) will have a vested interest in aggressively promoting a clean agenda.

(6) Policy consensus around climate change: In this scenario, policy is the main driver of a clean transition. Underpinned by a recovering economy, a strong greenhouse gas policy agreement is developed among the major economies of the world according to the timeline laid out at the UN climate summit in Durban, i.e., strict policies agreed by 2015 that come into effect by 2020. This clear policy signal spurs major investment in the development of clean and efficient technologies well before 2020. Such a strong policy agreement is far more likely if the economy in the largest economies start to recover and fossil fuel prices remain high.

As the scenario analysis shows, achieving the full technical mitigation potential is a formidable task. None of these scenarios, which reflect developments the SCC researchers thought likely, reaches the 450 parts per million (ppm) path which climate scientists say is needed to keep global warming at 2°C or less. Instead, they end up in the 550–700 ppm range (Fig. 2). This corresponds to a rise of 3–5°C in average global temperatures, an increase that would have very severe environmental and social consequences.\footnote{Intergovernmental Panel on Climate Change (IPCC) fourth assessment report.} Of course, these scenarios are not exhaustive. The analysis indicates that further emissions reductions are technically feasible, for instance through stronger and earlier policy intervention. In this respect, the conclusions of the scenario analysis are similar to other assessments, such as findings by the International Energy Agency.
Kuroyon Dam is one of the most prominent hydropower sites in Japan. It is a 492 metres long and 186 metres high variable-radius arch dam on the Kurobe River in Toyama Prefecture on the island of Honshū, Japan.
Since technology and innovation improvements alone will not suffice to keep global warming to 2°C, policy intervention is needed to minimise the impact of climate change as much as possible. But even if all emissions were stopped immediately, the climate would continue to change in coming decades. For this reason, climate policy must aim to help society adapt to some level of inevitable change as well as reduce the concentration of greenhouse gases in the atmosphere. In other words, adaptation must complement mitigation efforts to keep the threat of climate change manageable and climate risks insurable in highly exposed locations.

While the cost of mitigation, estimated at about 1–2% of global GDP, is substantially lower than the costs of adaptation, estimated to be in the 5–10% of global GDP range until 2050, adaptation measures present tangible and immediate positive effects for individuals, companies or countries that undertake them. Mitigation, by contrast, can be thought of as a long-term risk reduction measure and is only effective if a critical number of countries take concerted action.

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Figure 2: Emissions outcomes across scenarios

Global CO₂e emissions

<table>
<thead>
<tr>
<th>Year</th>
<th>Emissions (Gt CO₂e/year)</th>
<th>Temperature increase (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>700</td>
<td>4.0</td>
</tr>
<tr>
<td>2015</td>
<td>650</td>
<td>3.6</td>
</tr>
<tr>
<td>2020</td>
<td>600</td>
<td>3.3</td>
</tr>
<tr>
<td>2025</td>
<td>550</td>
<td>2.9</td>
</tr>
<tr>
<td>2030</td>
<td>500</td>
<td>2.1</td>
</tr>
<tr>
<td>2035</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2040</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2045</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The numbers correspond to the Intergovernmental Panel on Climate Change (IPCC) estimates of the equilibrium temperature increase associated with the atmospheric concentration levels given in the chart. These are not an upper/lower limit. With continued increases in emissions beyond 2050 the long-term atmospheric concentration levels and thus equilibrium temperature increases also would be higher.

Source: Scenarios for Climate Change project, IPCC Fourth Assessment Report.

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10 See 2006 UK government review on the economics of climate change led by Lord Nicholas Stern or the UNDP 2010 Human Development Report.
Several important clean technologies seem likely to become cost-competitive with today’s rising fossil fuel prices. Solar photovoltaic, wind power, electric vehicles and LED lighting are examples. Depending on the scenario, low-carbon technologies, including nuclear power, could contribute anywhere between 34% and 92% of the global power supply mix in 2050 – a notably larger share than today’s 33% in all but one of the six scenarios (Fig. 3). This suggests that renewable sources of energy will play a greater role in future power generation even in the absence of a global deal on climate change.

According to a global survey conducted by McKinsey in November 2011, most senior business decision-makers expect a “slow greening of the economy” as the most likely future scenario (39%). However, some 35% believe in a more sudden shift driven by a “clean technology breakthrough” or “high fossil fuel prices.” The survey also revealed that respondents from China were the strongest believers in clean technology, rating it twice as likely to evolve compared to others. And they were more optimistic about climate action in general than the rest of the world (Fig. 4).

Figure 3: 2050 Power mix across the scenarios
Global power supply mix 2050

<table>
<thead>
<tr>
<th>Total PWh</th>
<th>21.2</th>
<th>45.9</th>
<th>40.4</th>
<th>43.5</th>
<th>46.0</th>
<th>45.8</th>
<th>42.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>% total contribution of low-carbon technologies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010 baseline</td>
<td>33%</td>
<td>34%</td>
<td>91%</td>
<td>42%</td>
<td>78%</td>
<td>57%</td>
<td>92%</td>
</tr>
<tr>
<td>GHG emission reduction not pursued</td>
<td>33%</td>
<td>34%</td>
<td>91%</td>
<td>42%</td>
<td>78%</td>
<td>57%</td>
<td>92%</td>
</tr>
<tr>
<td>Late and disruptive climate policy action</td>
<td>33%</td>
<td>34%</td>
<td>91%</td>
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<td>42%</td>
<td>78%</td>
<td>57%</td>
<td>92%</td>
</tr>
</tbody>
</table>

Fossil fuels
Coal, gas, oil 67% 66% 9% 58% 24% 43% 8%

Low-carbon technologies
- CCS 0% 0% 17% 0% 0% 0% 14%
- Nuclear 13% 10% 18% 11% 13% 12% 17%
- Large hydropower 17% 10% 11% 10% 10% 11% 11%
- Other renewables 4% 15% 46% 21% 53% 33% 50%

33% 34% 91% 42% 76% 57% 92%

Figures may not add up to the sum due to rounding.
Source: Scenarios for Climate Change project
Although fossil fuels will remain a dominant source of energy for a long time, the share of renewables in our global power mix is expected to increase. As new energy projects become larger and more complex, so will the risks involved. Managing them will be critical in the transition to a less carbon-intensive future.
The price of risk: investment needs and insurance potential in energy markets

The share of renewable energy in our global power mix is expected to increase, as all six SCC scenarios show. Yet fossil fuels will remain a dominant source for the foreseeable future. As renewable energy and energy efficiency projects increase in complexity and scale, so do their economic stakes and their risks. Helping the energy industry minimise risks to unlock the potential of best-practice technologies is therefore a critical step on the long road towards a less carbon-intensive future. This can be supported by offloading some of the risk to insurance markets.

Important questions, however, remain. What is the size of future capital requirements for renewable energy sources? How does it compare to non-renewable energy sources? To answer these questions, SCC researchers looked at the total investment needs for various energy sources and then quantified how the risks affect total greenhouse gas abatement costs. This is done by calculating the total capital expenditures (capex) for selected energy technologies and putting a price tag on their associated risks, expressed in total expected annual losses (risk).\(^\text{11}\)

Carbon-reducing abatement technologies included in the research are offshore and onshore wind, biofuels and carbon capture and storage. Conventional or “business as usual” technologies considered were gasoline, oil, coal and gas. The analysis shows that both the investment and insurance needs of the energy sector will increase by 2030. But the extent to which they do so differs widely across the six future scenarios, both by geographic location and technology type.

**Capex: global investment needs in the energy sector**

In all future scenarios, the global energy system is expected to face a fundamental shift towards a more diversified mix of energy sources. This change will need to be supported by greater investments in all energy technologies. We have undertaken a deep-dive for six key energy sources spanning electricity generation and transport fuels.\(^\text{12}\) While global capital expenditures across these technologies amounted to USD 4.3 trillion in 2010, of which USD 201 billion or 5% invested in abatement technologies, they are set to increase to USD 4.6–6.1 trillion by 2030 (Fig. 5).

Depending on scenario, capital expenditures for biofuels, wind power and carbon capture and storage (CCS) alone are expected to amount to USD 683 billion to USD 3.1 trillion and make up 14–52% of the total annual investment potential by 2030. Compared to today, this constitutes at least a tripling of the share in low-carbon energy sources and a ten-fold increase if reductions in greenhouse gas emissions are pursued aggressively by the international community. In the most likely middle-of-the-road scenario, characterised by a “slow greening of the economy,” abatement technologies will require capital expenditures amounting to USD 1.4 trillion a year in 2030 or 29% of the total asset base across these technologies.

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11 Total capital expenditures for selected energy technologies were derived using the mitigation cost curve. To estimate total expected annual losses, natural catastrophe risk models were used. This approach relies on the selection of a natural hazard event and then a detailed analysis of hazard frequency and severity as well as of the spatial distribution of assets.

12 The capex in upstream oil production is not included.
### Fossil fuels

| Coal, gas, oil | 96% | 34% | 86% | 67% | 80% | 82% | 74% | 48% |

### Low-carbon technologies

| CCS | 0% | 20% | 0% | 12% | 0% | 0% | 0% | 21% |
| Onshore wind | 4% | 37% | 11% | 14% | 17% | 14% | 22% | 25% |
| Offshore wind | 0% | 6% | 2% | 2% | 2% | 2% | 3% | 3% |
| Biofuels | 0% | 3% | 1% | 2% | 1% | 2% | 1% | 3% |

| 4% Latin America | 66% Asia-Pacific | 14% Europe, Middle East, Africa | 30% North America | 20% | 18% | 26% | 52% |

Figures may not add up to the sum due to rounding.

Source: Scenarios for Climate Change project

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**Figure 5: Total investment across scenarios**

Global capex, USD bn per year, 2030

The regional share of capex remains largely stable across scenarios. A shift from Europe, the Middle East and Africa (EMEA) to the Asia-Pacific region (APAC) becomes apparent when comparing the “low-green” and “high-green” scenarios. This is largely driven by CCS developments in China.
Aerial view showing three 80 MW sites of the Solar Energy Generating Systems (SEGS) installation in the Mojave Desert, California. At 354 MW of total installed capacity, it is the largest solar thermal energy generating facility in the world.
The regional share of energy-related capital expenditures remains largely stable across all six scenarios. The Asia-Pacific (APAC) region will consume the lion’s share of investments, requiring 46–51% of total energy financing. Europe, the Middle East and Africa (EMEA) come in a distant second, with a 25–29% share, followed by North America (20–21%) and Latin America (4%). The variation in the case of Asia and EMEA is explained by a substantial increase in the use of CCS technology in China under a “high-green growth” scenario in which a global policy consensus drives action on climate change.

Risk: global annual expected losses in the energy sector

Five basic categories of engineering-related risk affect the energy sector: property risks, liability risks, business interruption, societal externalities and business case risks. Of these, only the first three types of risk can be fully diversified away or transferred and are therefore included in the SCC analysis. In insurance terms, these risks translate into a potential economic loss of assets, such as physical damage to property caused by natural or man-made catastrophes, liabilities for negligent acts, missed profits due to production downtimes or damage incurred by society at large. Together, they define the business potential for insurance in energy markets.

Across all six SCC scenarios, the energy sector is expected to face a marked increase in future losses. In 2010, total annual expected losses across all considered technologies amounted to USD 19.5 billion. Less than 6% of that, namely USD 900 million, was attributable to renewable energy (Fig. 6).

With rising investments in renewable and other abatement technologies, the expected loss potential in the energy sector is set to increase substantially by 2030 – and with it the potential demand for insurance. For example, annual expected losses in 2030 will be at least 25% higher than today at USD 25.6 billion and in the “greenest” scenario more than double to USD 41.7 billion. Much of this increase is due to higher investments in newer and less mature technologies, including renewables.

And yet, although substantial, these risks are relatively small compared to the total investment needs of USD 683 billion to USD 3.1 trillion. This makes a strong case for investments in renewable energy sources. Depending on scenario, the risks associated with biofuels, wind and CCS will lead to expected annual losses of USD 4.5 to 25.6 billion in the same year. That represents a share of the total loss potential between 17% and 62%. In a theoretical “full abatement” case, losses of renewable assets would make up 73% of all expected losses in the energy sector.

In line with the enormous investment potential in Asia-Pacific, this region will play a dominant role in energy markets and accrue between 50% and 59% of total expected losses globally in 2030.

Risks associated with new energy technologies are expected to drive future losses. But these risks are small relative to total investments. With insurance, this builds a strong case for sustainable energy projects.
Swiss Re  Building a sustainable energy future: risks and opportunities

The price of risk: investment needs and insurance potential in future energy markets

Figure 6: Expected losses in all scenarios
Global annual expected losses, USD bn per year, 2030

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2010 baseline</th>
<th>Full abatement case</th>
<th>GHG emission reduction not pursued</th>
<th>Late and disruptive climate policy action</th>
<th>Slow greening of the economy</th>
<th>Clean technology breakthrough</th>
<th>High fossil fuel prices make the world go green</th>
<th>Policy consensus around climate change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal, gas, oil</td>
<td>60</td>
<td>19.5</td>
<td>25.6</td>
<td>31.7</td>
<td>27.5</td>
<td>25.3</td>
<td>29.6</td>
<td>41.7</td>
</tr>
</tbody>
</table>

Fossil fuels
Coal, gas, oil 94% 27% 83% 59% 78% 77% 72% 38%

Low-carbon technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>CCS</th>
<th>Onshore wind</th>
<th>Offshore wind</th>
<th>Biofuels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0%</td>
<td>32%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>CCS</td>
<td>0%</td>
<td>32%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Onshore wind</td>
<td>4%</td>
<td>21%</td>
<td>9%</td>
<td>2%</td>
</tr>
<tr>
<td>Offshore wind</td>
<td>1%</td>
<td>18%</td>
<td>8%</td>
<td>1%</td>
</tr>
<tr>
<td>Biofuels</td>
<td>1%</td>
<td>2%</td>
<td>1%</td>
<td>2%</td>
</tr>
</tbody>
</table>

Figures may not add up to the sum due to rounding.
Source: Scenarios for Climate Change project

Regional share of capex in two scenarios, in %
GHG emission reduction not pursued
Policy consensus around climate change

The regional share of expected losses remains stable across most scenarios. A shift from Europe, the Middle East and Africa (EMEA) to the Asia-Pacific region (APAC) becomes apparent when comparing the “low-green” and “high-green” scenarios, driven by CCS developments in China.
With China emerging as an energy giant in both low-carbon and conventional technologies, energy-related insurance opportunities are expected to be most pronounced in this region. Regional shares of expected losses across the six scenarios are 18–25% for EMEA, a relatively stable 19–20% for North America and 3–4% for Latin America. Once again, the greater variability in the case of Asia and Europe stems from strong investments in CCS in China in a scenario of “policy consensus around climate change.”

And yet when making decisions about the most appropriate climate mitigation measures, it will be not enough to identify the costs, mitigation and insurance potential of different technologies. It is equally important to consider their broader “societal risk footprint.” This includes being aware of risks that are not diversified away or transferred but must instead be borne by society at large, such as damage to the planet’s biodiversity or health implications for the general public. This argument supports the reasoning behind measures such as a carbon tax.

Taking into account the potential cost implications for society gives decision-makers a more complete picture of the risks and opportunities associated with different energy technologies. While some technologies may offer substantial mitigation potential, such as nuclear energy or CCS, their societal risk footprint makes them riskier than other abatement technologies (Fig. 7). So getting the energy mix right and keeping risk manageable are two sides of the same coin when promoting a clean and sustainable energy future.

**Managing the risk in renewable energy**

Based on the risk analysis, green scenarios supported by concerted action on climate change offer the greatest market potential for renewable energy sources. This is largely due to a more rapid transition to a green economy supported by coordinated low-carbon policies. The unique risks associated with renewable energy make a strong case for insurance.

While the basic categories of risk apply equally to renewable and non-renewable energy sources, renewable energy projects face very specific challenges that distinguish them from fossil fuel-powered installations. This is because they use novel and less mature technologies, are exposed to the impact of adverse weather, often operate in difficult geographic locations such as offshore wind farms and for the time being rely on public subsidies and regulations to be competitive on a commercially large scale.

Renewable energy projects face very specific challenges due to their use of new technologies and exposure to weather impacts. This requires unique risk management and risk transfer solutions that offer a viable alternative to conventional insurance products.
The price of risk: investment needs and insurance potential in future energy markets

Figure 7: Low-carbon technologies can be rank-ordered on societal risk footprint

Abatement cost USD/MtCO₂e

Mitigation potential MtCO₂e

For all these reasons, the risks associated with renewable energy require unique risk management practices and new risk transfer options that offer a viable alternative to some of the more conventional insurance products. This recognition is increasingly motivating insurers to forge partnerships with the renewable energy industry to help advance innovations in solar, wind and hydro-electric technologies. Central to these partnerships is the aim of enhancing risk management expertise and developing new, cost-effective insurance products that will enable the risk-taking essential to growth and innovation in the renewable energy sector.

An example of these joint efforts is the European Wind Turbine Committee (EWTC), initiated by Swiss Re. It gives European insurers and reinsurers a forum to discuss trends and technologies with representatives from the wind energy sector, including wind turbine manufacturers, project developers, plant owners and operators, lenders and engineers. The EWTC dialogue aims to support the development of tailored insurance products that better meet the needs of the industry.

The EWTC has also called to life an initiative to ensure minimum risk management standards for offshore wind energy projects, which are particularly complex and large in scale. Participants in this effort are insurers, reinsurers and the offshore industry. With the adoption of risk management standards, participating companies want to support the long-term insurability of offshore wind projects, which includes the development of new risk transfer products for the construction and operation of offshore wind farms.

A number of innovative risk transfer products are already available to reduce renewable energy risks. These comprise insurance products to manage weather volume risks and risks associated with the construction and operation of renewable power infrastructure, including third party liability, contractor plant and equipment and assets.
As renewable energy grows in strategic importance for power companies and as investments in renewable energy assets expand, risk considerations are clearly moving higher up on the agenda among investors in and operators of renewable energy projects.

Innovative risk transfer products, including insurance, are available to cover risks along the entire value chain of a renewable energy project, from plant construction to operation as well as energy and power distribution:

- Project-specific solutions
- Construction professional indemnity & general liability
- Project finance solutions
- Property, casualty & offshore energy
- Weather risk solutions
- Weather and commodity price risk solutions
- Outage risk solutions

These types of products cover resource risks, price risks and other risks associated with the construction and operation of renewable power infrastructure, including third party liability, contractor plant and equipment and assets.

Partnerships between the insurance and energy industries can improve risk management expertise and develop new insurance products which will enable the kind of risk-taking essential to growth and innovation in the renewable energy sector.
International policymakers have set a target of 2°C as the maximum permissible increase in global warming. Temperature rises above that could lead us to a climate of irreparable ecological damage and one in which people, businesses and economies are much less likely to thrive.

The analysis indicates that this target is still technically within reach. However, across all six scenarios that the Scenarios for Climate Change (SCC) research partners thought likely, emissions exceed the required limits with possible temperature increases in the range of 3–5°C by the end of the century. Although costly, adaptation is therefore expected to be a major part of a global response to climate change. Without any adaptive measures, climate risks could become uninsurable in the most exposed locations.

If we want to tackle climate change while providing energy for a growing and developing world, there is no alternative to reducing greenhouse gas emissions. This will require a fundamental change in the way we produce and consume energy. Based on the analysis of future climate and energy markets, renewable energy is set to become an increasingly important part of the electricity generation mix. But fossil fuel energy will remain the dominant energy source for power generation for quite some time. Supporting best practice approaches, efficiency gains and carbon capture and sequestration technologies are therefore of great importance to limit emissions as much as possible.

At the same time, the risks associated with new technologies in renewable energy projects are set to increase expected annual losses and with that the demand for insurance. This shift will be most pronounced in Asia where much of the required investment will go.

The SCC research is intended to help companies and governments identify the most cost-effective ways to secure energy supplies while scaling back greenhouse gas emissions. Since long-term developments are unknown and difficult to predict, it offers six distinct scenarios for the future. These consider the main drivers behind climate and energy markets and lay out how the global climate and energy landscape could unfold under different circumstances by 2050.

With this approach, the SCC analysis delivers key insights into the complex links between economic growth, energy markets and climate change. It also provides a glimpse of what our global energy mix might look like by the middle of this century. Yet the fundamental question remains: which scenario will we opt for?