THE WAY FORWARD

FIVE KEY ACTIONS TO ACHIEVE A LOW-CARBON ENERGY SECTOR

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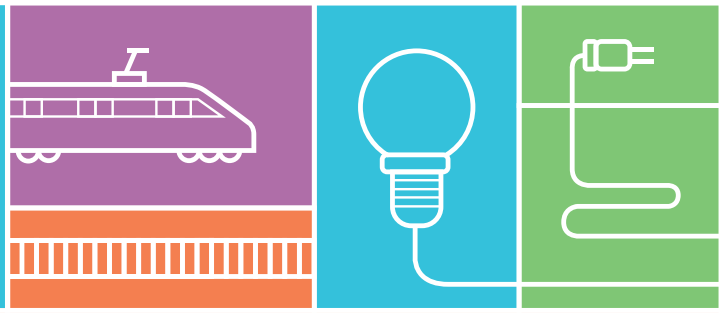
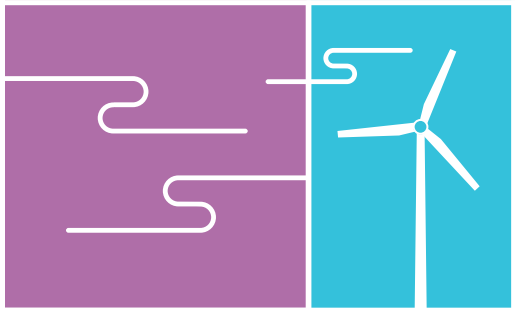
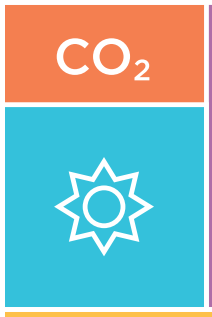
01 Seize the benefits of immediate action to bend the global emissions curve. To 2020, bridging 80% of the gap to an optimal 2°C path comes at no extra GDP cost.





02 Focus on electricity decarbonisation. Strong policies supporting low-carbon electricity could more than halve electricity emissions in 2030. This would save 9.5 Gt in 2030 - an amount larger than China's total 2012 energy emissions.

03 Reshape investment and accelerate innovation now in low-carbon technologies. Multilateral collaboration is critical to the development and tailoring of nationally appropriate technology solutions.



04 Mobilise non-climate goals to promote energy sector decarbonisation. Health, transport, energy security, and other goals can also drive emissions reductions.

05 Strengthen the resilience of the energy sector to climate change. Even in a 2°C world, climate change poses threats to energy security that need to be addressed through policy and commercial actions.

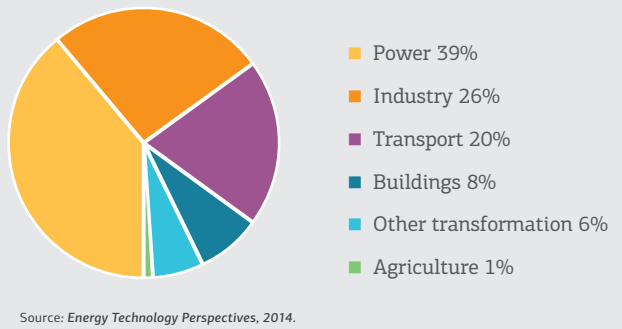
Introduction: Prosperity, Energy, and Climate

Energy is critical to global prosperity, as it underpins economic growth, social development, and poverty reduction. It has fuelled global economic development since the industrial revolution, and countries aspire to further inclusive economic growth. However, with more than 80% of global energy sourced from fossil fuels, growing energy demand has led to increasing greenhouse gas emissions. Today's challenge is to decouple economic growth and social development from increasing emissions. This requires action by central and local governments, publicly and privately owned businesses, communities, and individuals.

Energy sector emissions

The energy sector generates approximately two thirds of global greenhouse gas emissions and over 80% of total CO_2. It produced 31.7 Gt of CO_2 in 2012, the largest share of which came from power generation. If current energy policies remain unchanged, emissions will continue to grow, driven by increases in non-OECD countries and steady OECD emissions.

Figure 1 2012 Energy Sector CO_2 emissions

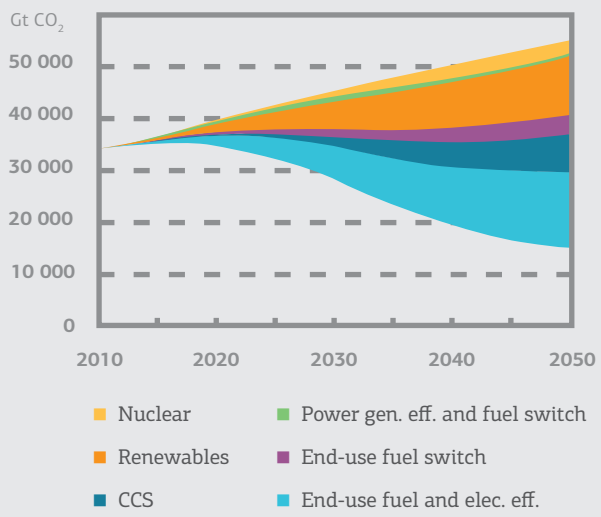


Source: *Energy Technology Perspectives, 2014.*

There are pathways to lower emissions. In the ***IEA Energy Technology Perspectives*** 2°C scenario (2DS), stringent policies cause emissions to fall 19% globally by 2030 compared to 2012 levels, instead of rising more than 30%. Likewise, OECD emissions fall by 38% in the same timeframe. Non-OECD emissions drop to 8% below 2012 levels by 2030 after peaking in the 2020s, rather than increasing 47%.

Challenges to this transition include locked-in infrastructure, short-term market conditions favouring coal, fossil fuel subsidies, and inadequate carbon pricing. Solutions lie in greater efficiency and switching to cleaner energy sources. This document sets out five priorities for immediate action: interventions with short-term impact, a focus on electricity emissions, long-sighted investment and innovation, and mobilising other goals in service of decarbonisation. Finally, while working to limit temperature rise, the energy sector needs to be more resilient to a changing climate.

Figure 2 Key decarbonisation technologies



Source: *Energy Technology Perspectives, 2014.*

The climate negotiations

Countries are negotiating a new United Nations climate agreement. Text proposals will be available in early 2015, as will countries' intended actions. By the December 2015 Paris COP21, countries intend to reach agreement. To inform these pivotal 12 months, the IEA offers the following insights into the immediate actions required to reduce short- and long-term energy sector emissions. This document focuses particularly on the period 2020 to 2030, to inform the first round of mitigation contributions (goals) in the new agreement.

With concerted efforts, energy emissions could fall 19% by 2030 instead of rising by 30%

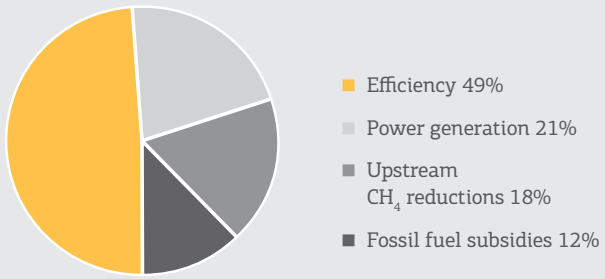
01 Seize the benefits of immediate action to bend the global emissions curve

Increasing short-term action is critical to keep the global goal of limiting temperature rise to below 2°C within reach. Actions taken before 2020 can pay off in their own right, and enable countries to achieve their post-2020 mitigation goals more easily.

Four key actions

In the period to 2020, the difference between the ***IEA World Energy Outlook 2014*** New Policies Scenario (3.6°C long-term warming), and the 450 Scenario (50% chance of below 2°C) is a set of four key actions that together have zero net GDP cost. These deliver 80% of the reductions needed to reach an economically optimal 2°C scenario, and provide additional co-benefits such as air quality improvements.

Figure 3 GDP-neutral set of pre-2020 actions



Source: *World Energy Outlook Special Report: Redrawing the Energy-Climate Map, 2013.*

The most important element is energy efficiency, which provides half of the projected savings. The energy efficiency package consists of quick-to-implement improvements to heating and cooling in buildings, appliances and lighting, industrial motors, and vehicle fuel economy standards. Other energy efficiency actions can also have large impacts. The IEA has produced ***25 Energy Efficiency Recommendations***, and an energy efficiency indicators framework to enable countries to track progress.

The second of the four key actions is reduced use of inefficient coal-fired power generation, and the final two are a partial phase-down of fossil fuel subsidies, which is beneficial economically and environmentally, and reduced methane venting and flaring in upstream oil and gas production.

This set of actions is GDP neutral for all regions, with different combinations of the four actions applied in each. For example, in the Middle East, priority actions are fossil fuel subsidy phase-down and reduced methane emissions, while in Europe they are energy efficiency and addressing inefficient coal generation.

Other priority actions

Other actions can also deliver pre-2020 results, notably accelerated expansion of renewables in power and heat. While these may come at additional cost, many countries may see this as justified given the wider co-benefits of renewable power generation. These co-benefits will vary depending on country-specific resources, policies, and goals such as improving local air quality.

Transport actions can also produce emissions reductions by 2020, and greater savings afterwards. With fuel economy standards for passenger and freight vehicles and a transition to hybrid and electric vehicles, transport emissions are almost 20% lower in 2030 in the ***World Energy Outlook 2014*** 450 Scenario than the New Policies Scenario.

Long-term impacts of short-term actions

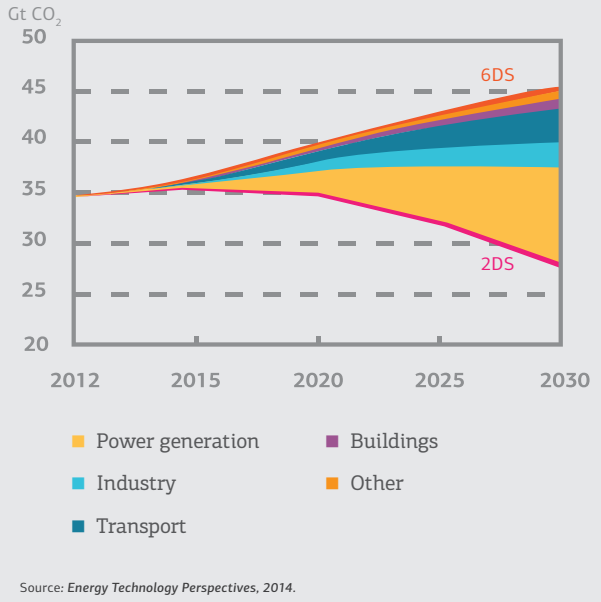
When considering what package of short-term measures to deploy, countries should also keep in mind consistency with longer-term decarbonisation. For example, switching to natural gas power generation can reduce emissions from coal, but by 2030 power generation must be moving beyond natural gas to a greater share of zero-carbon options. New investments in gas infrastructure should take this into account.

To 2020, bridging 80% of the gap to an optimal 2°C path comes at no extra GDP cost

02 Focus on electricity decarbonisation

Electricity generates 25% of all global GHG emissions. With current policies, ***Energy Technology Perspectives*** finds that annual electricity emissions could increase to nearly 18 Gt by 2030, while in the 2°C Scenario (2DS) they decrease to 8 Gt, 53% lower. Reduced demand and cleaner supply make electricity the largest contributor to emissions savings over this timeframe.

Figure 4 Emission reductions by sector to 2030



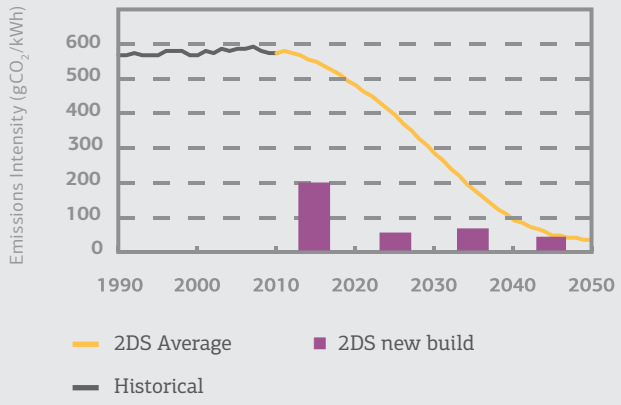
Source: *Energy Technology Perspectives, 2014.*

Improvements on the demand side include energy efficiency measures and more flexible, responsive demand that can balance variable renewable supply. Early investments in electrification of transport and buildings bring early benefits (lowered noise, improved air quality, reduced gas demand, increased flexibility options), and enable these sectors to begin decarbonising with the power sector.

Electricity supply must shift to lower-carbon options. More efficient coal can assist this goal in the short term. Natural gas will be part of the mix for longer, but the average emissions intensity of power generation must fall to below that of natural gas generation before 2030. This fall is propelled primarily by new investments in zero-carbon sources: between 2020 and 2030, the average emissions intensity of new power generation in the 2DS is only 52 gCO_2/kWh.

Maintaining momentum in the expansion of renewable power generation will require financial support mechanisms to adapt to falling technology costs, while maintaining policy and regulatory stability. In the 2DS, between 2020 and 2030 renewables increase their share of power generation from 29% to 42%. Carbon capture and storage will need to be deployed commercially for continued use of fossil fuels, scaling up from 50 Mt captured annually in 2020 to 1.5 Gt by 2030. Additionally, nuclear power generation can play an important role. Integrating these low-carbon technologies in a cost-effective manner requires a system-wide transformation involving smart grid infrastructure and flexible demand.

Figure 5 Fleet-average and new-build emissions intensity of electricity generation



Source: *Energy, Climate Change and Environment: 2014 Insights.*

Much high-emissions infrastructure has already been built and can be considered "locked in", but policy interventions for early retirement or retrofit can "unlock" these assets. Many of these policy options are already being implemented, with some motivated by non-climate objectives.

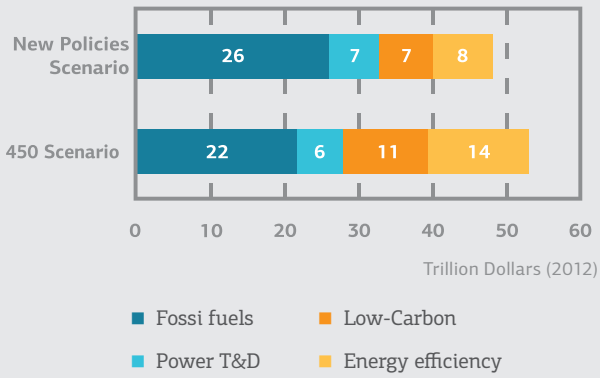
To propel power sector decarbonisation forward, strong policies with wide reach are required. Carbon pricing (including carbon taxes and emissions trading) is critical, and is being used increasingly in developed and developing countries. A challenge will be to achieve the high carbon price levels needed to shift plant investment and retirement decisions. Regulation (such as fleetwide or individual technology performance standards) can also be a useful, pragmatic policy tool.

Strong policies supporting low-carbon electricity could more than halve electricity emissions in 2030

03 Reshape investment and accelerate innovation now in low-carbon technologies

Lowering emissions will require shifting energy supply investment from fossil fuels to clean energy, and mobilising additional investments in energy efficiency. These investments will be most cost effective and impactful when coupled with innovation in technological development and deployment. While investment and innovation actions may not significantly impact short-term emissions, they are essential to long-term decarbonisation.

Figure 6 Cumulative investments in the New Policies and 450 Scenarios 2014 to 2035



Source: *World Energy Investment Outlook, 2014.*

Shifting investment

Investment in the energy sector is expected to grow substantially, particularly in emerging economies. The *World Energy Investment Outlook* finds that average annual energy investment 2026-2030 is expected to be USD 0.9 trillion in OECD countries and USD 1.3 trillion in non-OECD countries. Much of this financing will be from domestic resources, but international capital flows also play an important role.

Long-term decarbonisation requires a significant shift in investment patterns. For example, in the 450 Scenario, 80% of power plant investment needs to be in low-carbon technologies after 2020, and 90% after 2025. Credible, ambitious, and effective domestic policy frameworks that have been adapted to national energy market structures encourage such investment. An international climate agreement can improve countries' willingness to implement climate policy and establish financing structures such as risk sharing for high-capital investments. International financing (such as the Green Climate Fund) can also be a catalyst.

State-owned enterprises and financial institutions will be key actors in implementation and investment funding, notably in many large emerging economies. Often, their motivations will differ from those of private sector investors; so incentive frameworks need to be adapted.

Innovation in technology development and deployment

Advances in the availability and cost of low-carbon technologies will underpin long-term decarbonisation. For example, photovoltaic modules have reduced dramatically in cost from USD 4/W in 2008 to USD 0.8/W in 2012, and are expected to further halve by 2030. At this time, however, most technologies are not developing at a rate consistent with the 2°C goal. Increased support for technology development is required.

The IEA technology roadmaps identify how to accelerate key technologies such as solar energy and biofuels. One critical technology is carbon capture and storage (CCS). As long as fossil fuels are a significant contributor to future energy supply, CCS will be required.

Innovation also relates to improved implementation, including developing locally-adapted low-tech solutions, fostering local innovation capacity, improving policy frameworks, and strengthening business practices. Multilateral collaborations are critical. For example, the IEA portfolio of technology Implementing Agreements and collaborative work on technology roadmaps enable OECD and non-OECD countries, the private sector, and other stakeholders to share knowledge and best practices regarding both technologies and polices.

Multilateral collaboration is critical to the development and tailoring of nationally appropriate technology solutions

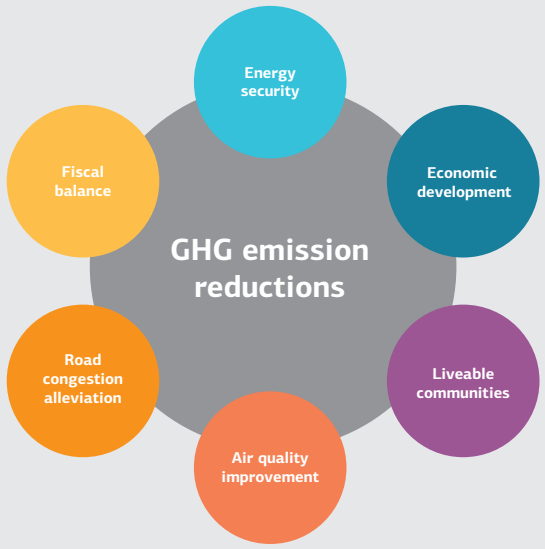
04 Mobilise non-climate goals to promote energy sector emission reductions

Climate change policies are not the only catalyst for energy sector decarbonisation: there are a number of motives for introducing cleaner energy supplies or reducing energy demand that also lead to GHG emission reductions:

- Air quality and the associated public health efforts to improve air quality by targeting energy efficiency, conventional coal generation, and transport emissions.
- Energy security and initiatives to diversify energy sources and reduce energy dependence through vehicle fuel economy.
- Generation diversity, renewable energy development, and energy efficiency.
- Reduced road congestion and measures to improve public transit and land-use planning to achieve net mobility benefits along with net reductions in transport spending, energy use, and emissions.
- Growth and sustainable economic development, including increased green energy productivity, power generation efficiency to support access, research and development of such technologies as nuclear energy, renewable energy, low or zero energy buildings, and efficient transport modes that create new jobs.
- Quality of life improvements through upgrades in city infrastructure, including efficient and expanded public transport, and more efficient and comfortable buildings.
- Stronger government budgets and related initiatives to phase out fossil fuel subsidies that put strain on budgets (in 2013, global fossil fuel subsidies totalled USD 550 billion).

Even for energy efficiency – the most important contributor to emission reduction – climate benefits are not necessarily of primary importance. Energy efficiency actions can be taken to save on energy bills and improve health outcomes. They are also an essential mechanism to reduce energy import bills and enhance energy security while also stimulating economic growth and reducing air pollutants and GHG emissions. Carbon capture and storage (CCS) is the only energy sector action that would be undertaken mostly for climate-change mitigation, and even this has been developing in association with enhanced oil recovery in early stages and could also create new jobs and other local economic benefits.

Figure 7 Non-climate drivers of GHG reductions



As explored in ***Energy, Climate Change and Environment***, while economy-wide GHG targets are critical to keeping emissions at a level consistent with global warming of less than 2°C, they alone may not stimulate sufficient decarbonisation of energy supplies, nor provide an adequate motivation for national action. By integrating multiple energy policy objectives and accounting for their various benefits up front, including non-climate goals, energy and climate policies could have increased overall effectiveness. Policy packages that address multiple objectives simultaneously could lead to more cost-effective outcomes by helping to rationalise long-term investment decisions and creating synergies between actions.

Health, transport, energy security, and other goals can also drive emission reductions

05 Strengthen energy sector resilience to climate change

Energy security – the uninterrupted availability of energy sources at an affordable price – is critical for economic and social development. As highlighted in the recent Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), climate change poses a new threat to energy security. Risks arise from both long-term gradual changes, such as rising air and water temperatures, and more frequent and stronger extreme events, such as heat waves, droughts, heavy precipitation, and storms. Even with aggressive efforts to reduce greenhouse gas emissions, the temperature increase that we face from emissions already locked in will pose important threats to energy infrastructure and challenges for the energy system as a whole. Even in a strong mitigation scenario, temperatures are expected to be 1.6°C above pre-industrial levels by 2035, twice the current level of increase.

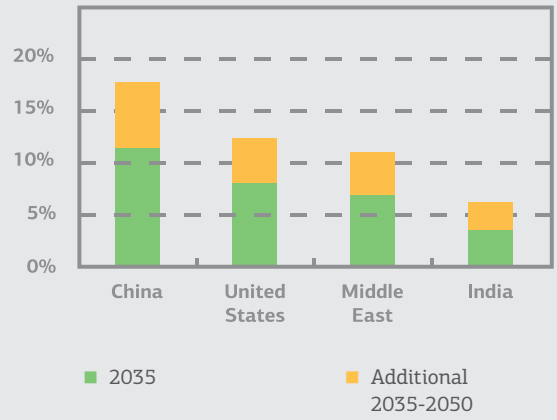
To ensure that energy assets and systems can cope with a more challenging future, action is needed. Impacts can be expected on energy supply, whether renewable, nuclear, or fossil fuel technologies, and on energy demand patterns, particularly in fast-growing urban areas.

There are already examples of major disruptions in the energy sector due to extreme weather. In 2012, Hurricane Sandy cut power to more than 8 million customers in the north-eastern United States. Since 2000, heat waves have impaired cooling processes at nuclear reactors in Europe and the United States, forcing production cuts. In India, a delayed monsoon in 2012 raised power demand and reduced hydropower output, causing blackouts that affected more than 600 million people.

One degree celsius of warming can be expected to reduce available electricity generation capacity in the summer by up to 19% (Europe) and 16% (the United States) by the 2040s. Transmission and distribution networks' efficiency is also compromised by a rise in temperature. Higher temperatures will either require additional peak generation and transmission capacity or greater demand-side response at peak times.

The ***World Energy Outlook Special Report Re-drawing the Energy-Climate Map*** explored climate change impacts on global energy demand for space cooling and heating. With climate change, demand for heating decreases, but demand for space cooling increases.

Figure 8 Increases in energy demand for space cooling after accounting for climate change



Source: *World Energy Outlook Special Report Re-drawing the Energy-Climate Map, 2013.*

Reduced water availability and increased competition for water resources are major threats to the energy sector in the coming years. Water is needed, in particular, for thermal power plant cooling and hydropower generation. A changing climate can also reduce the availability of fuels for electricity generation.

To address these threats, the energy sector will need to develop resilience through technological solutions, flexible management, and preventive emergency preparedness and response measures. As governments encourage action through policy and regulatory frameworks, the private sector needs to reflect on how best to bring climate change risks into its investment decision-making, particularly regarding critical or long-lived energy assets.

Even in a 2°C world, climate change poses threats to energy security that need to be addressed through policy and commercial action

Possible inputs to UNFCCC: INDCs and the 2015 Agreement

This document has highlighted five key areas where immediate action is required to put the energy sector on course to meet short- and long-term climate goals. Strong domestic policies will drive these actions, and an international climate agreement can help motivate policy implementation. The following table presents a range of possible ways that countries could address these five issues in their Intended Nationally Determined Contributions (INDCs) and negotiators could address them in the 2015 agreement. These ideas are intended to spark thinking, and should not be seen as prescriptions or desired outcomes.

	In INDCs	In the 2015 Climate Agreement
01 Promoting emissions reductions before 2020		
	■ Set ambitious 2020 starting point: countries should undertake cost-effective action pre-2020.	■ Ambitious post-2020 mitigation targets will encourage pre-2020 action. ■ Continue technical expert meetings process to share best-practice.
02 Decarbonising electricity supply and demand		
	■ Complementing GHG goals, countries could set INDCs for the power sector such as emissions intensity, energy efficiency or renewables, based on country-specific opportunities.	■ Encourage countries to report on actions targeting underlying drivers of change in the electricity sector, in addition to overall GHG outcomes ■ Support carbon markets for those countries wishing to use them.
03 Promoting clean investment and technology development and deployment		
	■ Complementing GHG goals, countries could set INDCs for drivers of long-term transformation (investment, technology development). ■ Mitigation INDCs for 2025 and 2030 should take into account the future availability and costs of technologies.	■ Set long-term global and/or national emissions goal(s), with tracking based on energy sector decarbonisation metrics as well as GHG levels. ■ Publish a review of technology progress and availability (including 10 year forecasts) ahead of each round of mitigation target-setting ■ Parties to report RD&D actions in National Communications. ■ The UNFCCC Technology Executive Committee (TEC), or an agency such as the IEA, could track adequacy of RD&D of key technologies.
04 Mobilising non-climate goals to drive emissions-reducing actions		
	■ Consider whether setting additional INDCs in terms of non-GHG drivers could support greater ambition than emissions targets alone. ■ Work with other ministries to identify non-climate goals that can address mitigation objectives and design policies that achieve win/win outcomes.	■ Create reporting and tracking frameworks that support achievement of short- and long-term GHG goals by complementary use of non-GHG metrics (e.g., share of renewables, energy efficiency, fossil fuel subsidies) and long-term decarbonisation metrics (e.g. investments, RD&D). ■ Recognise non-UNFCCC (including sub-national) goals and actions. ■ UNFCCC, or an agency outside the UNFCCC such as the IEA, could track aggregate global progress in key drivers such as energy efficiency.
05 Building energy sector resilience		
	■ Explore mitigation actions that can serve to enhance resilience (e.g., energy efficiency, decentralized renewables generation, etc.).	■ Encourage resilience and adaptation measures in the energy sector by all countries. Facilitate exchange of best practices and technologies. ■ Provide financial support to developing countries to enhance their energy sector's resilience to climate change impacts. ■ Incorporate climate risks to energy infrastructure, supply and demand in Green Climate Fund investments decisions.

Refer to these IEA publications for in-depth analysis:
Energy, Climate Change and Environment: 2014 Insights
IEA Technology Roadmaps
Energy Efficiency Indicators Manual 2014
Energy Technology Perspectives 2014
World Energy Outlook 2014
World Energy Outlook Special Report Re-drawing the Energy-Climate Map 2013
World Energy Investment Outlook 2014
Energy Efficiency Policy Pathways
25 Energy Efficiency Recommendations

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