International Energy Agency (IEA) Contribution to the Talanoa Dialogue

April 2018

The energy sector must be a top focus to achieve the long-term goals of the Paris Agreement: two-thirds of human-caused greenhouse gas emissions and 80% of CO_2 emissions are from energy production and use. The IEA, the global "all of energy" authority, works with countries, companies and other key actors to provide:

- **timely data** to track, monitor and drive energy and climate ambition;
- **rigorous analysis,** including energy transitions pathways to meet climate and other key objectives; and
- **real-world solutions**, including policy tools, technology guidance and best practice sharing that can help underpin ambitious nationally determined contributions (NDCs).

Tracking Clean Energy Progress (TCEP) 2018 is one of the IEA's key inputs to the Talanoa Dialogue. This analysis provides the current status of key energy sector indicators, including development and deployment of clean energy technologies, measuring their progress today against what would be needed by 2030 to be on track to achieve the Paris Agreement goals. Beyond tracking "where we are," TCEP can also help identify levers for further action and highlight key opportunities for technology development at the region level to inform future NDCs. TCEP 2018, which will be launched in May 2018, will be significantly enhanced from earlier versions, including at the country/regional and sectoral levels.

The IEA is pleased to submit this contribution to the Talanoa Dialogue and stands ready – with timely data, rigorous analysis, and real-world solutions – to further expand our efforts to help support countries, companies and other actors to meet their energy and climate goals.

IEA's contribution is structured around the three central questions of the Talanoa Dialogue and provides key opportunities and challenges within each. A number of IEA reports are individually referenced in the submission, and a full set of other IEA publications relevant to the Talanoa dialogue are included as an Annex.

Where are we?

Key Messages:

- **Energy efficiency is making important inroads**, although efficiency improvements slowed in 2017. Policy implementation **needs to accelerate** to maintain and increase efficiency gains.
- Over the last three decades, **the global energy supply has barely decarbonized**: fossil fuels remain 81% of the global energy mix, the same as in 1987.
- Investment trends are starting to shift away from fossil fuels, but a **22% improvement in the carbon intensity of the global energy supply by 2030** would be needed for consistency with the Paris Agreement's long-term goals.

Tracking energy system data and indicators, at global and national levels, is essential to help countries develop and implement NDCs and national policies to achieve long-term transitions to sustainable energy systems. Indicators underpin a country's ability to track progress to date, and can also drive ambition going forward. As the adage states "that which is measured, improves": tracking energy transition indicators of both outcomes (e.g. CO_2 emissions) and underlying drivers (e.g. clean energy investment) can help identify and propel further ambition and action.

In many countries, further investment and capacity-building is needed in the development of robust and consistent national energy data collection and monitoring systems to underpin tracking of energy data and indicators.

What global progress has been made in clean energy transitions?

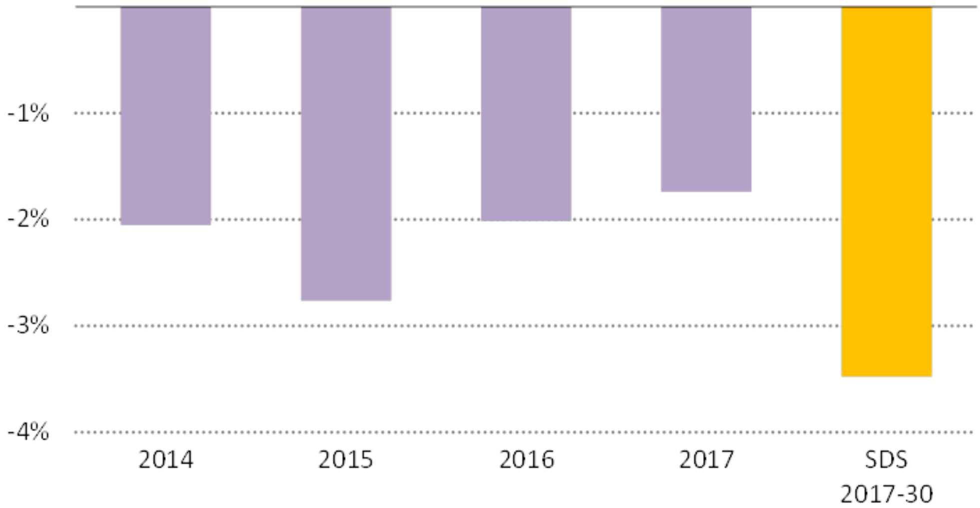
The IEA estimates that in 2017, **energy-related CO_2 emissions** rose 1.4% after remaining flat for three years, reaching a historic high of 32.5 Gt. This rise indicates that the emissions stall from 2014-2016 does not yet reflect a permanent peaking of emissions. Though the 2017 emissions rise is moderate compared to historical rates, it heightens the already monumental challenge ahead. IEA analysis in the *World Energy Outlook* shows that emissions must peak around 2020 then show a steep decline afterwards to meet Paris Agreement goals. The rise in 2017 was driven by an increase in consumption of all fossil fuels to meet robust economic growth, including coal, whose global consumption had declined in 2015 and 2016.

This headline figure for greenhouse gas emissions is the product of a complex set of underlying changes in energy supply and demand. A wider set of energy sector indicators is therefore critical to understand where we are, and to highlight the most important drivers of clean energy transitions going forward.

Growth in **energy demand** is the first critical factor to track. The increase in energy-related CO_2 emissions in 2017 reflects strong underlying growth in energy demand, which grew an estimated 2.1% in 2017, twice the rate of increase seen in 2016. Improving **energy intensity** (primary energy demand per unit of gross domestic product, GDP) had been the main factor behind the flattening of global energy-related CO_2 emissions from 2014-2016, but is not improving quickly enough (Figure 1). Improvements in global energy intensity slowed down in 2017: improving by only 1.7% compared with an average 2.3% over the last three years, and only half the annual improvement rate consistent with delivering the Paris Agreement goals. **Energy efficiency** being one element of energy intensity has been a key contributor to overall improvements: without efficiency improvements since

2000, both energy use and CO_2 emissions in 2016[1] would have been about 12% higher. However, a recent weakening of energy efficiency policy – on both coverage and stringency - contributed to the slower improvement in energy intensity. Energy efficiency gains will erode quickly if policy implementation is not accelerated.

Figure 1. Average annual change in energy intensity, historically (purple) and in IEA's Sustainable Development Scenario[2] (yellow, compatible with Paris Agreement long-term goals)



Note: Energy intensity is per unit of economic output in purchasing power parity terms.
Source: IEA (2018), *Global Energy and CO_2 Status Report.*

The second critical factor is to reduce **the carbon intensity of energy supply**. In 2017, CO_2 emissions per unit of total primary energy supply (the **Energy Sector Carbon Intensity Index, ESCII)** increased for the first time in three years, by 0.3%, as fossil fuels met over 70% of the growth in energy demand. However, these changes are small: over the past three decades, the ESCII has barely changed, indicating the energy supply has not become any "cleaner" on average over this time. While significant progress has been made in deploying renewables, in particular solar PV and wind, the deployment of low-carbon energy has not kept up with energy demand growth. As IEA Executive Director Fatih Birol stated in March 2018:

> *"In 1987, fossil fuels made up 81% of energy mix. In the last 30 years a lot has happened, but fossil fuels remain 81% of energy mix. They are stubborn."*

This remains a crucial challenge for the energy sector, as under an IEA scenario[3] compatible with meeting Paris Agreement goals, ESCII drops 22% from today's levels by 2030. This is achieved both through a redirection of new supply investments to low-carbon, and accelerated phase-out or retrofit of existing infrastructure.

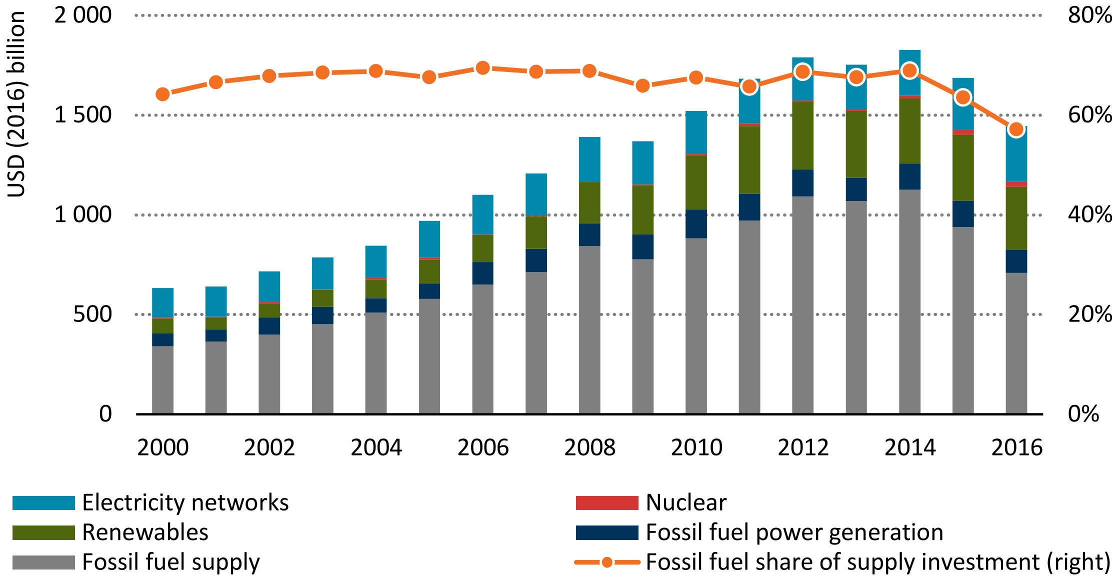
Overall energy sector **investment** in 2016[4] declined for the second year in a row. For the first time, investment in the electricity sector surpassed that in the oil, gas and coal sectors. In electricity, investment in coal power plants

[1] 2017 figures will be published in *Energy Efficiency 2018* (October 2018 release) and in IEA's Talanoa Dialogue submission for the October 2018 deadline.
[2] In IEA's Sustainable Development Scenario (SDS), which is compatible with meeting Paris Agreement long-term temperature goals while achieving universal access to modern energy by 2030 and significantly reducing air pollution. Details of the SDS are available in this IEA commentary and are published in the World Energy Outlook 2017.
[3] In IEA's Sustainable Development Scenario (SDS), which is compatible with meeting Paris Agreement long-term temperature goals while achieving universal access to modern energy by 2030 and significantly reducing air pollution. Details of the SDS are published in this IEA commentary and are published in the World Energy Outlook 2017.
[4] 2017 figures to be released in the *World Energy Investment Report 2018* (July 2018 release) and IEA's Talanoa Dialogue Submission for the October 2018 deadline.

sharply declined, while investment in renewables declined modestly despite record levels of solar PV deployment, in part due to cost declines. Investment in the electricity network, the backbone and enabler of the clean energy transition, rose by nearly 6%. The biggest investment growth story was in energy efficiency, with spending increasing by 9%.

Fossil fuels (coal, oil, and natural gas supply and fossil-fuel based power plants) still received the majority share of investment in energy supply, although the fossil fuel share of investment began to drop in 2015 and 2016 after more than a decade holding a steady share of investment, falling below 60% for the first time in 2016 (Figure 2). While this would be seen as a positive trend from a climate perspective, it raises significant energy security concerns as demand for fossil fuels – particularly oil demand for transportation - is not declining at the same pace. In a scenario compatible with meeting Paris Agreement goals, the fossil fuel share in investment falls to 40% in 2030.

Figure 2. Global investment in energy supply by fuel



Source: IEA (2017a), *World Energy Investment 2017*.

Aggregate energy sector indicators such as the ones just presented are important for providing an overall snapshot of progress – whether the entire sector is moving in the right direction. More detailed sub-sectoral indicators can help countries more clearly target key policy actions, including for low-carbon electricity supply, improving industrial productivity, enhancing demand for low carbon transportation modes and improving building energy efficiency. Progress in both energy sector-wide and sub-sectoral indicators (a preliminary list of which is in Table 1) will be presented in ***Tracking Clean Energy Progress 2018*** to be released in May 2018.

Table 1. Indicators tracking energy transition progress at the sub-sector level

Sub-sector				
Electricity	Role of fossil fuels in power generation	Low-carbon capacity additions	CO_2 intensity of generation	Investment in low-carbon electricity supply
Industry	Industrial productivity	Energy efficiency implementation and monitoring		
Transport	Total transport-related final energy use per GDP	Alternative transport fuel in demand	Coverage of mandatory energy efficiency policy	
Buildings	Coverage of mandatory energy efficiency policy	Energy use/m^2	Investment in building energy efficiency	

Without new policy action, where are we headed?

Though the message has been repeated many times, it cannot be overstated: without additional, near-term and ambitious policy action, the long-term goals of the Paris Agreement will slip out of reach. IEA analysis shows that in a scenario[5] consistent with meeting the Paris Agreement goals, emissions peak around 2020 – a very short time from today – and decline steeply thereafter. Based on current and announced policies including NDCs, we will fail to bend the curve quickly enough – in fact, at least two decades too late. IEA's New Policies Scenario (NPS) describes a future pathway for global energy accounting only for existing and announced policies, including the effects of NDCs. In the NPS scenario, energy-related CO_2 emissions do not peak before 2040, which together with other GHG emissions set the world on course for a global mean temperature rise of around 2.7 degrees Celsius by 2100, exceeding the target of the Paris Agreement by a wide margin.

WHERE ARE WE?

KEY SUCCESS: Energy efficiency is making important inroads. Energy efficiency investment rose 9% in 2016, 50% more than in 2015, although the improvement rate of overall global energy intensity – which is partly driven by energy efficiency – slowed down in 2017. Efficiency gains will erode quickly if the pace of energy efficiency policy implementation, which is estimated to have slowed down in 2017, does not accelerate.

KEY CHALLENGE: Over the last three decades, the global energy supply has barely decarbonised; that is, each unit of energy supplied has on average resulted in the same amount of CO_2 emissions. While certain types of low carbon technologies, such as solar PV and wind in electricity, have grown rapidly in recent years, this has been offset by slower growth in other low-carbon sources such as hydropower, nuclear, and low carbon energy in transport and heat.

[5] IEA's Sustainable Development Scenario (SDS), which is compatible with meeting Paris Agreement long-term temperature goals while achieving universal access to modern energy by 2030 and significantly reducing air pollution. Details of the SDS are published in this IEA commentary and are published in the World Energy Outlook 2017.

For further information:

Tracking Clean Energy Progress (TCEP) 2018 (released in May 2018)

Global Energy and CO_2 Status Report 2018

World Energy Investment 2017 (*World Energy Investment 2018* released July 2018)

World Energy Outlook 2017 (*World Energy Outlook 2018* released November 2018)

Energy Efficiency 2017 (*Energy Efficiency 2018* released October 2018)

Renewables 2017 (*Renewables 2018* released October 2018)

Energy Efficiency Indicators 2017 (*Energy Efficiency Indicators 2018* released December 2018)

Where do we want to go?

Key Messages:

- The IEAs Sustainable Development Scenario (SDS) shows that **climate, energy access, and air pollution goals can go hand-in-hand**.
- In the SDS by 2030:
  - energy related CO_2 emissions are 23% lower than 2017 levels.
  - increasing energy efficiency supports a much steeper decline in energy intensity per unit GDP of 3.4% per year, double the rate experienced in 2017.
  - the carbon intensity of global energy supply drops by around 22% from current levels.
  - the share of renewable energy in final energy consumption doubles.
  - universal access to modern energy by 2030 is achieved, meaning 1.3 billion people gain electricity access and 2.9 billion people gain access to clean cooking.
  - the number of premature deaths from the impacts of outdoor air pollution is reduced by 500 000 in 2030, due in part to the reduction in $PM_{2.5}$ emissions by about 60%.
- **Energy efficiency and renewable energy account for 87% of the cumulative CO_2 savings to 2030** in the SDS: two areas that can deliver multiple benefits for climate change, air quality and energy access.
- The role of **fossil fuels** in the energy mix in the SDS, particularly coal use without CCS, diminishes quickly: a substantial decline from their position in today's energy system. This poses particular challenges for countries and regions that are currently highly dependent on fossil fuels, although technology innovation and energy efficiency can help reduce costs of fossil fuel transition.

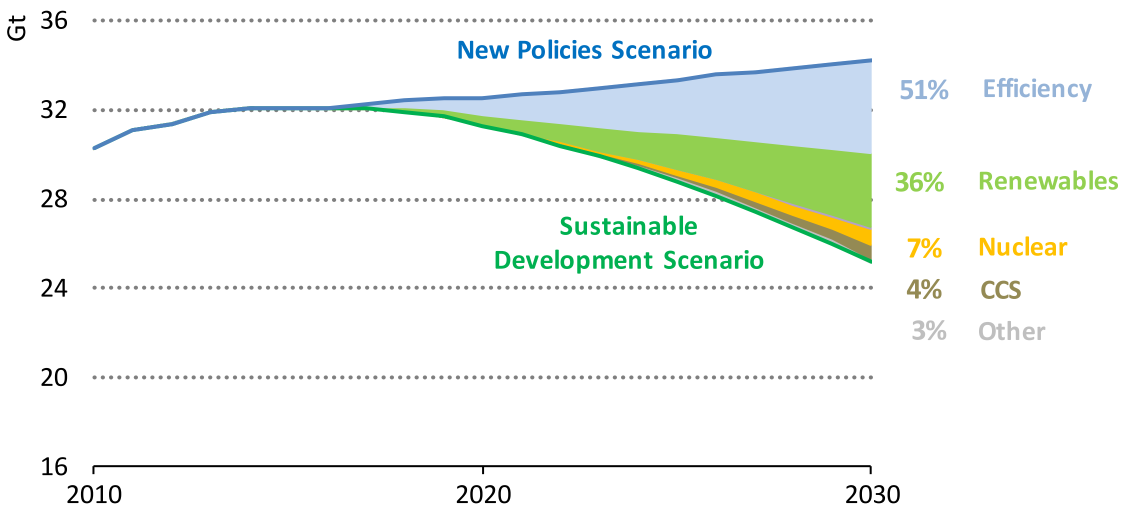
IEA's Sustainable Development Scenario (SDS) describes a pathway for the global energy sector (through to 2040) that keeps the world on track to meet the long-term mitigation goals of the Paris Agreement, while also achieving universal access to modern energy and substantially reducing air pollution. The SDS offers an integrated approach to addressing key challenges, recognizing that action against climate change must go hand-in-hand with strategies to achieve other Sustainable Development Goals, including to tackle poverty, build economic growth, promote energy security and address a range of other social and environmental protection needs.

By comparison, IEA's New Policies Scenario (NPS) illustrates a reference case pathway for global energy accounting only for existing and announced policies, including countries' nationally determined contributions (NDCs). This scenario is not compatible with reaching Paris Agreement goals: energy-related CO_2 emissions do not peak before 2040, which together with other GHG emissions set the world on course for an average temperature rise of around 2.7 degrees Celsius by 2100.

The SDS: an ambitious scenario meeting multiple energy challenges

In the SDS, energy related CO_2 emissions in 2030 fall to 25.1 Gt in 2030, 23% lower than 2017 levels. Cumulative emissions to 2030 are 55 Gt lower than in the NPS (Figure 3). Total primary energy demand barely grows over today's level, as increasing energy efficiency supports a much steeper decline in energy intensity per unit GDP of 3.4% per year, double the rate experienced in 2017. The energy sector carbon intensity index (ESCII), which measures carbon emissions of energy supply, drops by around 22% from current levels to 2030. The share of renewable energy in final energy consumption more than doubles in this same timeframe.

Figure 3. Global CO_2 emissions reductions in the New Policies and Sustainable Development Scenarios, 2010-2030



Source: IEA (2017b). *World Energy Outlook 2017*.

Importantly, universal access to modern energy by 2030 is achieved (SDG target 7.1), meaning 1.3 billion people gain electricity access (double as many as in the NPS) and 2.9 billion people gain access to clean cooking (two billion more than in the NPS). Other SDG 7 targets are also over-achieved in this scenario: SDG 7.2 (increasing substantially the share of renewable energy by 2030) and SDG 7.3 (doubling the global rate of energy efficiency improvement by 2030). With regards to air quality, the number of premature deaths from the impacts of outdoor air pollution is reduced by 500 000 in 2030, due in part to the reduction in $PM_{2.5}$ emissions drop by about 60% in 2030 compared to in the NPS.

Compared to scenarios addressing only the climate mitigation objective, the SDS places a stronger emphasis on decentralised, modular low-carbon technologies (such as solar PV and wind) as a means to achieve climate, energy access, and air quality objectives. For example, there is roughly 50% more solar PV in this scenario than in previous IEA scenarios focused primarily on decarbonisation.

Pathways to reach the goals of the Paris Agreement

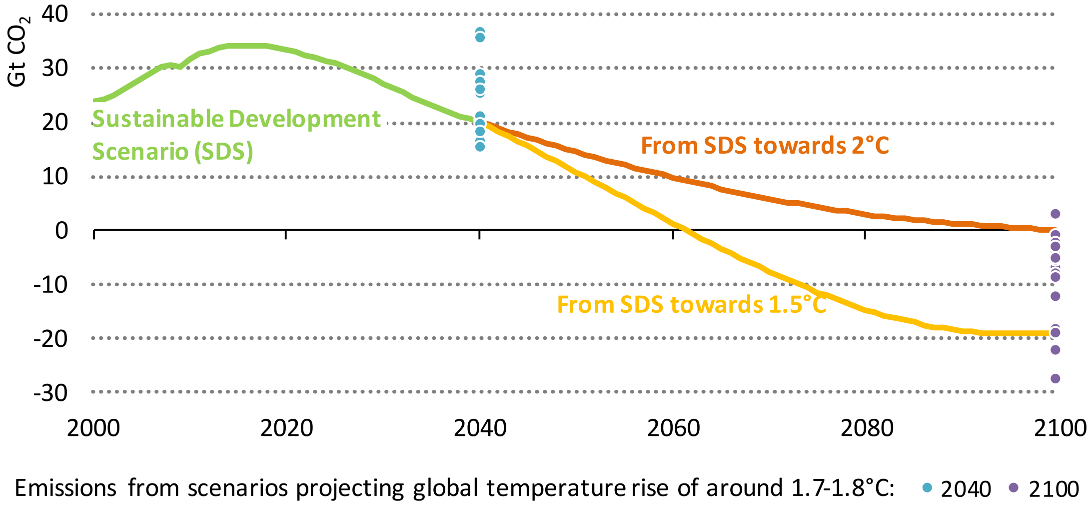
The central goal of the Paris Agreement is to keep global average temperature rise to "well below 2 °C above pre-industrial levels" and to "pursue efforts to limit the temperature increase to 1.5 °C". Achievement of the goal rests on three pillars: (i) "global peaking of GHG emissions as soon as possible, (ii) "rapid [emissions] reductions thereafter", and (iii) achievement of "a balance between anthropogenic emissions by sources and removals by sinks [i.e. net-zero emissions] in the second-half of this century."

In the Sustainable Development Scenario, CO_2 emissions from energy and industrial processes peak before 2020 and show a steep decline through the *World Energy Outlook* period. By 2040, CO_2 emissions in the Sustainable Development Scenario are at the lower end of a range of estimates drawn from the most recent publicly available emissions scenarios, all of which project a mean global temperature rise in 2100 of between 1.7 °C and about 1.8 °C (figure below). The wide range of 2040 emissions levels is due to differing assumptions affecting not only the peak and decline of energy-related CO_2, but also emissions of other GHGs and CO_2 from land-use.

The long-term temperature outcome will depend on how quickly the third pillar of net-zero global emissions in the second half of the century is achieved, and whether global emissions subsequently become negative. If CO_2 emissions decline steadily to net-zero by 2100, this would be in line with holding global warming to 2 °C (red line in figure). To increase the likelihood of a lower ultimate temperature rise, emissions will need to decline more quickly to zero and, potentially, turn negative.

To be in line with staying below 1.5 °C (yellow line), emissions could fall to zero by 2060 and then become very significantly net-negative, reaching about -19 Gt by 2100. Although this level of negative emissions falls within the range projected by some other scenarios, the challenge of achieving it should not be underestimated. Global negative emissions would require large-scale deployment of technologies that achieve net removal of CO_2 from the atmosphere. All such technologies face severe technical, economic and resource constraints, underscoring the need for rapidly accelerated innovation support to enable these decarbonisation pathways.

2040 emissions in IEA's Sustainable Development Scenario (SDS) are at the lower end of a range of other recent decarbonisation scenarios, which estimate a temperature increase around 1.7-1.8°C in 2100



Note: Chart shows energy and process-related CO_2 emissions. Dots represent emissions in 2040 and 2100 from all Representative Concentration Pathway (RCP) 2.6 scenarios in the most recent Shared Socioeconomic Pathways (SSP) database (IIASA, 2017).
Source: IEA (2017b). *World Energy Outlook 2017.*

Ambitious policies will be needed to achieve an SDS trajectory: in the SDS, carbon prices reach 75-100 USD by 2030 in major countries and fossil fuel subsidies are phased out by 2025 in net-importers and by 2035 in net-exporters. Furthermore, there would need to be co-ordinated decarbonisation policy efforts across all sectors, partly to ensure the market uptake of technologies that are currently only at the stage of RD&D or early deployment such as some applications of carbon capture and storage (CCS) and advanced biofuels, underscoring the need for accelerated innovation to enable such transformative changes.

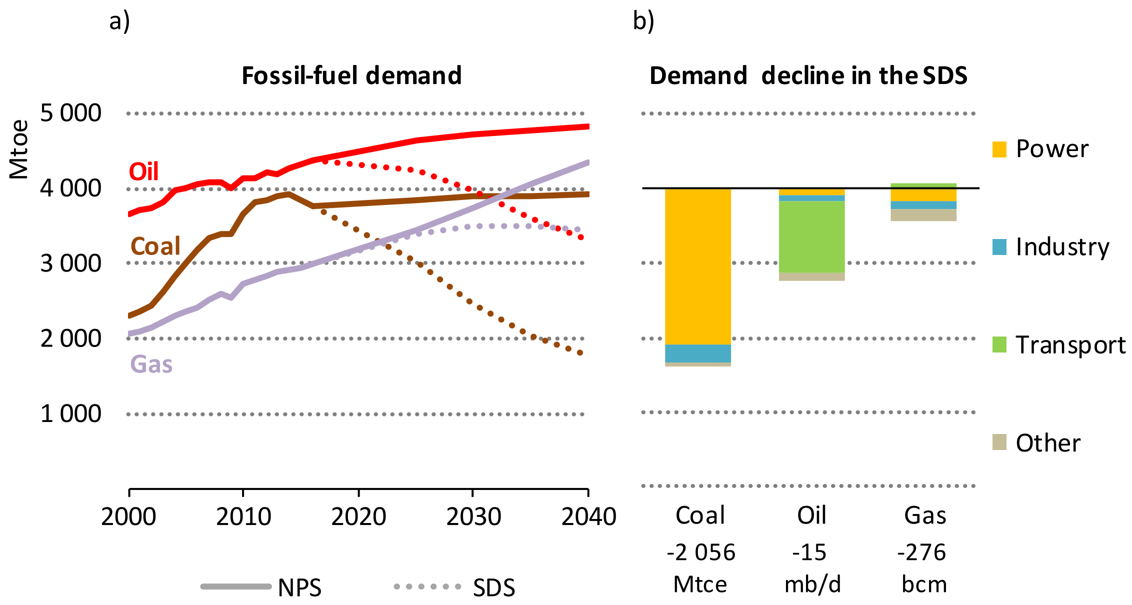
Fossil fuels in energy transitions

In the SDS, coal demand peaks in the short term – by around 2020 – and is cut by one-third (to just above 3 500 million tonnes of coal equivalent) in 2030 compared the NPS (Figure 4). While coal demand growth has been slowing, the challenge remains stark. The IEA estimates that coal demand grew in 2017 after a two-year decline and forecasts continued demand growth at least for the next five years, absence a change in policy and market conditions.

87% of the coal decline in the SDS occurs in the power sector, where the share of coal is more than halved, falling to 15% in 2030 from 37% today. Phasing out unabated coal-fired power generation (i.e. without carbon capture and storage, CCS) is a key feature of the power sector transition in the SDS; by 2030, 55 gigawatts (GW) of coal-fired generation is equipped with CCS, albeit confined to a small number of countries (notably China and the United States).

In the SDS, oil demand peaks soon after coal and declines to 87 million barrels per day in 2030. The majority of oil demand decline comes in the transport sector, with electric vehicles making up over 40% of new passenger car sales by 2030. The petrochemicals sector, however, bolsters oil demand in the SDS, given ongoing demand for plastics and other products.

Figure 4. Fossil fuel demand (a) by scenario and (b) decline by sector in the Sustainable Development Scenario relative to New Policies Scenario, 2030



Source: IEA (2017b). *World Energy Outlook 2017.*

For further information:

World Energy Outlook 2017 (*World Energy Outlook 2018* released November 2018)

Energy Technology Perspectives 2017

Perspectives for the Energy Transition (2017)

WHERE DO WE WANT TO GO?

KEY OPPORTUNITIES: To meet Paris Agreement goals, two key opportunity areas emerge: (1) increasing energy productivity – the amount of economic growth spurred by each unit of energy consumed – through accelerated energy efficiency, and (2) the deployment of renewable energy, in particular decentralised solar PV and wind. Energy efficiency and renewable energy account for 87% of the cumulative CO_2 savings to 2030 in the IEA's Sustainable Development Scenario: two areas that can deliver multiple benefits for climate change, air quality, and energy access.

KEY CHALLENGE: In a Paris Agreement-compatible world, the role of fossil fuels in the energy mix, particularly coal use without CCS, diminishes quickly: a substantial decline from their position in today's energy system. This poses particular challenges for countries and regions that are currently highly dependent on fossil fuels, although technology innovation and energy efficiency can help reduce costs of fossil fuel transition.

How do we get there?

Key Messages:

- Energy transitions consistent with meeting Paris Agreement goals, universal energy access to modern energy, and significant reduction in air pollution can be realized at a modest global cost. As technology and fuel costs decline, these goals can be achieved with only 13% additional investment in the energy sector by 2030. Well-integrated policy packages can be used to re-direct investment toward energy efficiency and low carbon energy supply.
- As countries think toward their new or updated NDC targets for 2030, they could consider:
  - Expected technology costs in 2030, not just today's costs
  - What changes in energy investment patterns are consistent with the long-term goals of the Paris Agreement
  - What forward-looking indicators can be used to track progress of energy sector transition and inform national policymaking
  - How to integrate energy policy and technology components
  - Where ambition could be enhanced with greater national capacity

The stated goals of the Talanoa Dialogue are to "take stock of the collective efforts of Parties in relation to progress towards the Paris Agreement long-term goal" and to "inform the preparation of nationally determined contributions (NDCs)". To address the latter, the IEA presents key questions that country policymakers could consider to inform the development of the next round of increasingly ambitious NDCs. These questions address the need for countries to have strong understanding of technology options including costs, low carbon policy expertise, and robust data and indicators to drive forward progress. To shed light on each question at the global level, we share some insights from IEA analysis, though we invite countries to address these questions based on their national circumstances.

1. How much are clean energy technology costs expected to decline in the future?

The accelerated development and deployment of clean energy technologies is crucial to realizing cost-effective low carbon energy transitions. As technology costs continue to decline and as more becomes economically possible, ambition can be further raised.

Past declines in the costs of certain renewable energy technologies – namely solar photovoltaic (solar PV) technology and on-shore and off-shore wind – have been well publicized. Looking ahead in the next five years, IEA forecasts that global average generation costs (levelised costs of electricity, LCOE[6]) are expected to drop further by almost a quarter for large (utility) scale solar PV, almost 15% for onshore wind, and a third for offshore wind between 2017-2022. Specific costs will vary widely based on the project size (capacity) and by country including its associated policy and regulatory framework. Towards 2030, costs are expected to continue declining. For instance, in IEA's New Policies Scenario (NPS)[7] for new utility-scale solar PV and electric vehicle batteries, costs approximately halve from 2016 to 2030 (Figure 5).

While the rates of cost reductions will vary across technologies and regions, policy support at all levels of technology innovation will accelerate cost declines. Policy support remains critical even where technologies

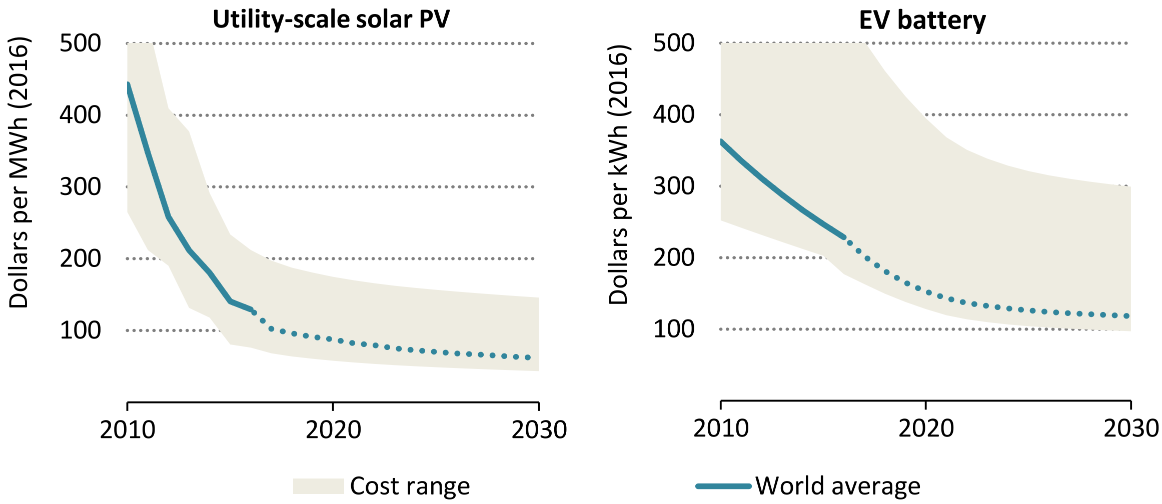
---

[6] Levelised cost of electricity is calculated as the average lifetime levelised costs on the basis of the costs for investment, operation and maintenance, fuel, carbon emissions and decommissioning and dismantling (IEA, 2015).

[7] In the New Policies Scenario, accounting only for implemented and announced policies. In a scenario with strengthened policy support, technology costs would be expected to decline further.

reach price parity with fossil fuel-based technologies. For example, as variable renewable electricity such as solar PV and wind develop into mainstream technologies, grid integration and management and energy storage become key issues requiring attention and policy support.

Figure 5. Global average cost reductions of utility-scale solar PV and EV batteries in the New Policies Scenario, 2010-2030



Notes: Levelised cost of electricity are presented for solar PV and investment costs are presented for EV batteries.
Source: IEA (2017b). *World Energy Outlook 2017.*

For more information:

Technology Roadmaps, a set of 21 roadmaps identifying priority actions for governments, industry, financial partners and civil society to advance development of a wide range of technologies.

Renewable Energy 2017 (*Renewables 2018* released October 2018)

Global EV Outlook 2017 (*Global EV Outlook 2018* released May 2018)

World Energy Outlook 2017 (*World Energy Outlook 2018* released November 2018)

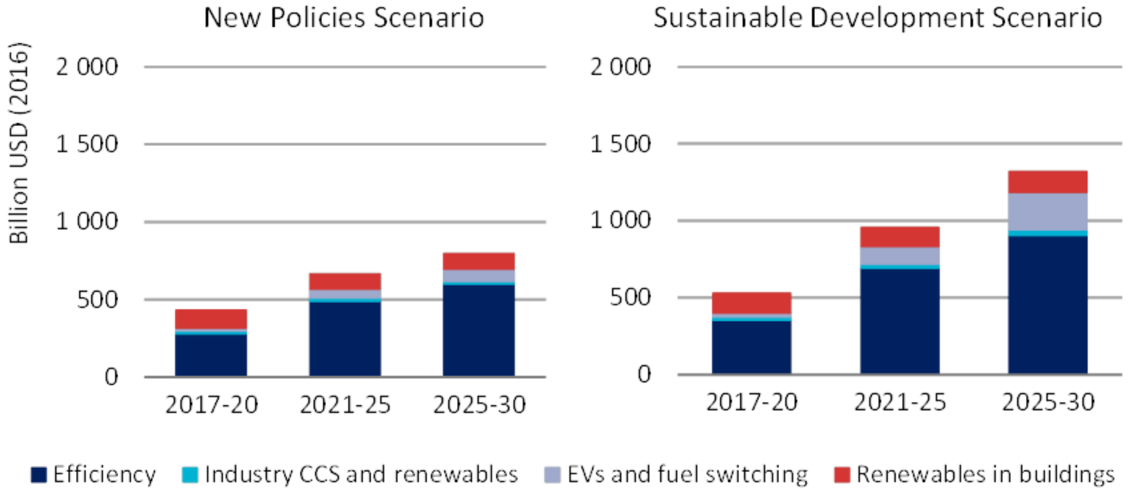
Energy Technology Perspectives 2017

2. How do investment patterns need to change to reach Paris Agreement goals?

In IEA's Sustainable Development Scenario (SDS), only 13% additional investment in energy is required to 2030, a net of USD 4 trillion, relative to investment that would be required under current trends in the New Policies Scenario (NPS). Within this overall envelope, annual supply-side investment to 2030 remains relatively flat from today's levels, although a substantial shift occurs in where investment is directed. There is a strong shift away from fossil-fuel supply and fossil-fuel power generation, for which investment reduces by $2.8 trillion through 2030, toward low-carbon power supply and improving the energy efficiency of end-use sectors (Figures 6 and 7).

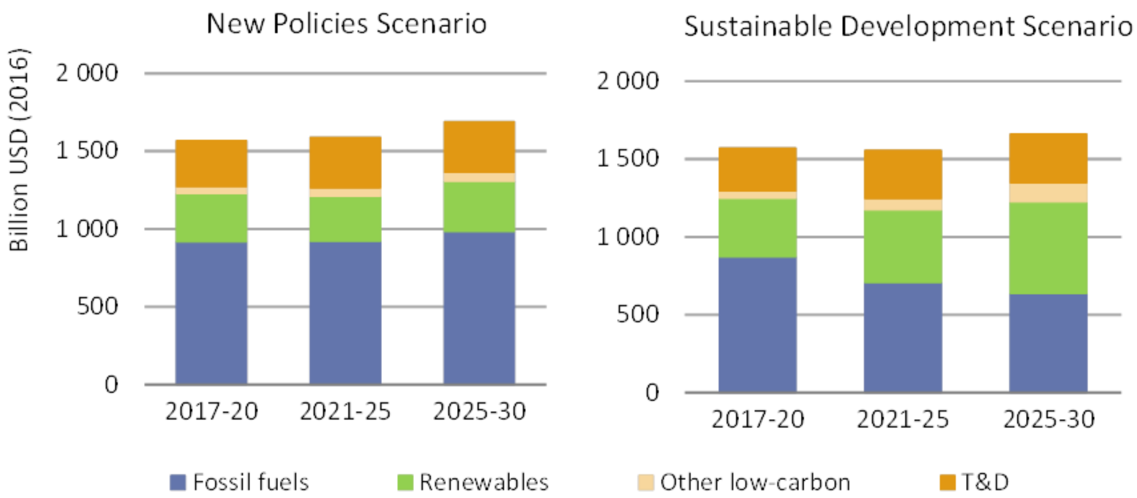
In energy supply, from 2017 to 2030, investment in renewable power rises 65%, alongside a decline in upstream coal, oil, and gas investment by 20% and decline in fossil fuel power generation investment by around 60%.

Figure 6. Estimated annual average investment in energy end-use sectors in the New Policies Scenario and Sustainable Development Scenario, 2017-2030



Data source: IEA (2017b). *World Energy Outlook 2017.*

Figure 7. Estimated annual average investment in energy supply in New Policies Scenario and Sustainable Development Scenario, 2017-2030



Data source: IEA (2017b). *World Energy Outlook 2017.*

In the power sector, pursuing the SDS trajectory will require investments of about 12.5 trillion USD to 2030, with an average of 900 billion USD per year invested in new power plants and networks as well as refurbishing and upgrading ageing infrastructure. Power plant investments will be dominated by renewables, which account for three quarters of the total investment to 2030. At the technology level, current investment in solar PV is broadly consistent with the IEA's SDS, however investments in other low-carbon technologies including wind power, hydroelectric and nuclear electricity, and carbon capture and storage currently fall short. If investments in the latter technologies do not accelerate, solar PV would need to scale up even further to make up the difference and to enable achievement of Paris Agreement goals.

For further information:

World Energy Investment 2017 (*World Energy Investment 2018* released July 2018)

World Energy Outlook 2017 (*World Energy Outlook 2018* released November 2018)

Perspectives for the Energy Transition (2017)

Tracking Clean Energy Progress 2018 (released May 2018)

3. What forward-looking indicators can be used to guide policy action?

As mentioned in the section "where are we?", not only can indicators provide information on the distance already travelled, but they can also reveal opportunities for future action. Table 2 contains a preliminary set of key indicators being prepared for *Tracking Clean Energy Progress 2018* that reflect important areas in the short-term where policymakers can focus efforts. They include indicators tracking progress of both desired outcomes (e.g. CO_2 emissions) and the underlying drivers of energy transitions (e.g. investment in clean energy and share of low carbon capacity additions in power generation), which can help understanding of the potential for further ambition including in country NDCs.

Aggregate energy sector indicators are important for driving overall progress across the sector. More detailed sub-sectoral indicators can help countries more clearly target key policy actions, including for low-carbon electricity supply, improving industrial productivity, enhancing demand for low carbon transportation modes, and improving building energy efficiency. Examples of sub-sectoral indicators that may be considered are presented in Table 1 – the preliminary status of some these are highlighted here. Full analysis of key indicators will be released in *Tracking Clean Energy Progress 2018* in May 2018.

Table 2. Indicators of energy transition outcomes and drivers for understanding current progress and driving future action

Sub-sector

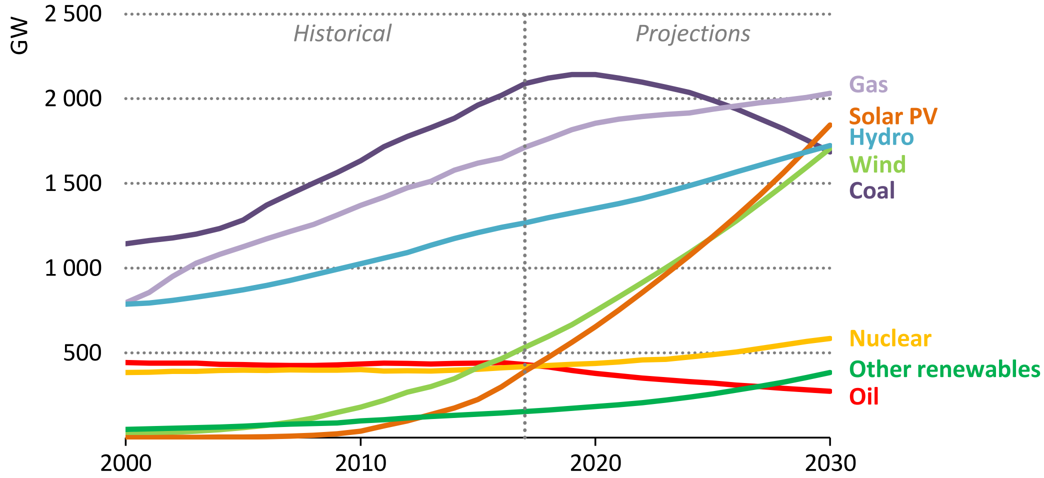
Whole energy sector	Energy intensity	Energy sector carbon intensity index (ESCII)	Energy efficiency improvement rate	Public and private investment in clean energy RDD&D
Electricity	Role of fossil fuels in power generation	Low-carbon capacity additions	CO_2 intensity of generation	Investment in low-carbon electricity supply
Industry	Industrial productivity	Energy efficiency implementation and monitoring		
Transport	Total transport-related final energy use per GDP	Alternative transport fuel in demand	Coverage of mandatory energy efficiency policy	
Buildings	Coverage of mandatory energy efficiency policy	Energy use/m^2	Investment in building energy efficiency	

Tracking indicators beyond CO_2 emissions enables a more complete understanding of energy transitions, including actions that may not produce short-term CO_2 benefits but are fundamental for longer-term transitions. An example is clean energy investment, which may produce a lagged CO_2 emissions impact. IEA analysis of investment activity indicates the increased deployment of low-carbon energy sources and switching from coal to gas – the primary drivers of global emissions levelling off between 2014-2016 – largely benefited from projects launched several years prior to this when market conditions were much more favourable than today.

Furthermore, investment in technology innovation could take even longer to bear fruit in terms of measurable CO_2 impact, but is a critical element of driving longer term decarbonisation. Unfortunately, recent trends show flat rates of investment in clean energy research and development, both from government sources as well as the private sector.

In the SDS, the share of low carbon energy sources increases by 1.2 % each year from today's levels to 2030, more than six times the growth registered in 2017. In the power sector specifically, generation from renewable sources requires a faster annual growth of 7% to almost double the renewable share of generation from an estimated 25% in 2017 to 47% in 2030. Pursuing these targets will require a significant shift in the type of capacity that is added to the power system in the coming decade and beyond. In the SDS, solar PV and wind become the fastest growing technologies, with 1 550 GW and 1 310 GW respective capacity additions from today to 2030 (Figure 8).

Figure 8. Installed power generation capacity by type in the Sustainable Development Scenario



Source: IEA (2017b). *World Energy Outlook 2017.*

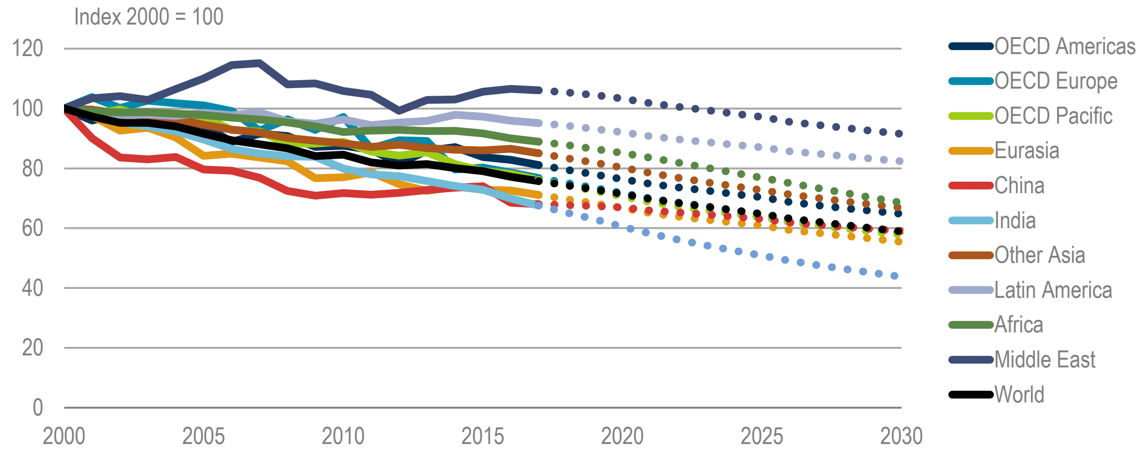
In industry, improving energy efficiency and shifting towards best available technologies contribute to reducing emissions and improving industrial productivity. In the SDS, annual global industrial productivity (value-added per unit of energy used), increases 2.0% from 2016 to 2030, an accelerated rate compared to the 1.6% growth observed in recent years[8].

In transport, the share of alternative fuels (biofuels and low-carbon electricity) in the SDS, increases from 4% globally today to 13% in 2030. In this scenario, Central and South America maintains the highest share at 25% in 2030, followed by Europe and North America at around 20%.

In buildings, energy intensity defined as energy use per m^2 in the SDS improves by at least an average annual rate of 1.9% globally to 2030 to keep pace with floor area growth during that period, from a current growth rate of 1.6% (Figure 9). While this acceleration in energy intensity improvement may seem marginal, in some of the critical emerging markets, particularly Africa (dark green line), Latin America (light purple line) and other developing Asia (brown line), the rate of change needs to double or more in coming years. This is equally true for major developed economies, which would need to step up significantly deep energy renovations of existing buildings.

[8] From 2010 to 2016

Figure 9. Building sector energy performance, historical and in the Sustainable Development Scenario, 2000-2030



Data sources: IEA (2017c). *Energy Technology Perspectives 2017* and IEA (2017b) *World Energy Outlook 2017.*

For further information:

Tracking Clean Energy Progress (TCEP) 2018 (released in May 2018)

Energy Efficiency Indicators 2017 (*Energy Efficiency Indicators 2018* released December 2018)

Global Energy and CO_2 Report 2018

World Energy Outlook 2017 (*World Energy Outlook 2018* released November 2018)

4. How can an integrated policy and technology approach deliver additional benefits?

A fundamental message emerging from all facets of IEA analysis is the need for an integrated approach to drive and accelerate clean energy transitions, with regards to both energy technologies and policy. One key reason for taking a holistic perspective to energy transitions is that action to address climate change must be contextualized within a country's priorities to tackle a range of other social, economic and environmental challenges. Meeting multiple objectives requires a portfolio of policies and technologies based on a country's national context.

Meeting multiple objectives

IEA's Sustainable Development Scenario (SDS) describes a pathway for the global energy sector (through to 2040) that is compatible with meeting the long-term goals of the Paris Agreement, and also achieving goals of universal access to modern energy and substantially reducing air pollution. The SDS offers an integrated approach to addressing energy challenges, recognizing that climate change must be go hand-in-hand with strategies that tackle energy access and air quality.

During energy transitions, the operative term "transitions" require a host of actions to manage both the growth of new sectors and technologies, as well as the decline of others. Focused attention is needed to support and re-train affected workers and to manage associated negative impacts, for instance, possible changes in energy costs for end users.

For further information:

World Energy Outlook 2017 (*World Energy Outlook 2018* released November 2018)

Real world policy packages for sustainable energy transitions (2017)

Capturing the Multiple Benefits of Energy Efficiency (2015)

Integrated technology approach

Many low carbon energy transitions will feature more diverse and renewable energy sources and rely more heavily on distributed generation, which will need to be better integrated and managed from a systems perspective. This can increase efficiency and decrease system costs, and it will require a broader range of technologies and fuels. However, success depends not only on individual technologies but also on how the overall energy system functions based on a portfolio of diverse technologies that fit a country's particular context. A key challenge for energy policy makers will be to move away from a siloed, supply-driven perspective towards one that enables systems integration including enhanced demand response.

An integrated technology approach also requires acting on various time dimensions, based on the level of technology maturity. Technologies at early stages of development, such as carbon capture and storage and advanced biofuels, require strengthened support now to accelerate their development through the stages of technology innovation to ensure at-scale deployment when needed. Support for mainstream technologies takes a different form, for example, variable renewables require action to support system integration and flexibility including for grid infrastructure and market reform.

International collaboration can help share technology best practices and accelerate innovation. For example, the IEA Technology Collaboration Programmes (TCPs) have been bringing together 6,000 experts from 56 countries, including governments, key companies, and top research institutions to accelerate energy technology innovation around the world. In the context of an increasingly complex and multi-lateralised global energy landscape, the breadth of TCPs' analytical expertise is a unique asset to accelerate energy transitions worldwide.

For further information:

Energy Technology Perspectives 2017

Status of Power System Transformation 2017

Digitalization and Energy 2017

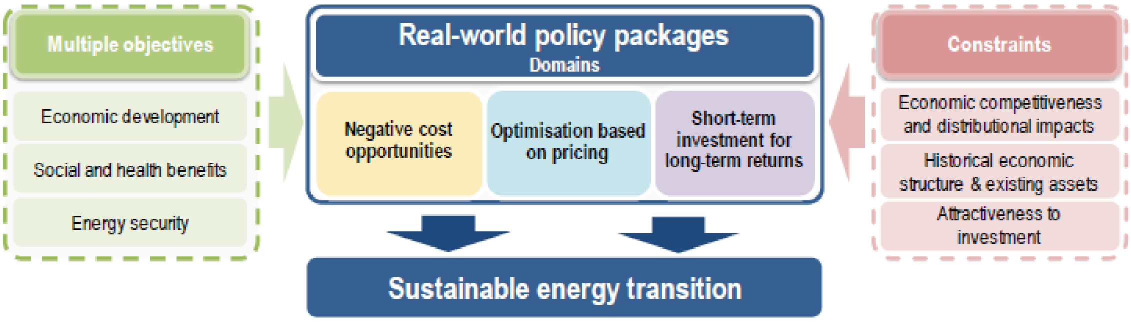
Renewable and Energy Efficiency Integration

Technology Collaboration Programmes: the 38 TCPs operating today span across the full range of energy technologies, from CCS to buildings, from smart grids to energy efficiency, from fusion to bioenergy

Policy Packages

A variety of integrated policy tools will also be critical to drive successful clean energy transitions. Policy packages are needed to achieve a whole-scale shift in energy systems in all sub-sectors with key elements covering three domains: 1) negative cost opportunities (e.g. energy efficiency standards), 2) optimization based on pricing (e.g. carbon pricing) and 3) short-term investment for long-term returns (e.g. support for technology innovation) (Figure 10). The recent declines in upstream fossil fuel investment illustrate the need for policy coordination (see section "Where are we?"). Although this change in itself may align with a low-carbon pathway, continued decreases in supply-side investment without commensurate measures to address rising energy demand create significant risks for energy security. As a second example, policies driving electrification will produce greater environmental benefits if implemented alongside ones to decarbonize electricity supply.

Figure 10. Comprehensive policy packages for clean energy transitions cover three domains and are shaped by national objectives and constraints



Source: IEA (2017c). Real world policy packages for sustainable energy transition.

Integration of policies across time scales is critical. As countries develop the next round of NDCs, it will be important to align these commitments with short-term (pre-2020) action as well as longer term (e.g. mid-century) pathways and goals. By creating consistent and predictable policy signals across time scales, both the effectiveness and cost efficiency of energy transitions can be enhanced by avoiding lock-in of high carbon assets and implementation of conflicting policies.

Although energy transitions do not rely on any individual policy, IEA analysis highlights the importance of certain key domestic policy measures. In the Sustainable Development Scenario compatible with meeting the Paris Agreement goals, carbon price levels by 2030 reach USD 75/tonne in key emerging countries and USD 100/tonne in advanced economies. Fossil fuel subsidies are removed by 2035 at the latest, with many countries having fully phased them out by 2025. To support accelerated deployment of renewable energy and energy efficiency improvement, extensive electricity market reforms and infrastructure investment for large-scale renewables integration, and stringent low-carbon and energy efficiency mandates will also be important.

For further information:

World Energy Investment 2017 (World Energy Investment 2018 released July 2018)

Perspectives for the Energy Transition (2017)

Real world policy packages for sustainable energy transitions (2017)

Renewable and Energy Efficiency Integration

5. How could ambition be enhanced with greater national capacity?

As described above, integrated approaches can lead to policies having greater impact, being more adaptable and being easier to sustain over time. Doing so can, however, require a much greater degree of consultation and co-ordination within national governments, as well as with sub-national governments and a broader set of key stakeholders. In addition, it requires being able to assess different technology options appropriate to a country's domestic context and having the tools to explore pathways for future climate-compatible development.

All this requires building up of various types of technical knowledge and capacities, which in many countries has taken considerable time and resource. For countries seeking to design and implement an integrated policy approach, international collaboration, co-operation and support can therefore be an important means for gathering the appropriate expertise and knowledge, as well as building or strengthening various capacities.

In the context of the UNFCCC and the Paris Agreement, as well as beyond it, providing such support to countries is rightfully growing in importance, and will hopefully continue to be strengthened through various capacity-building initiatives, as well as funding sources such as the Green Climate Fund and the Global Environment Facility.

For several years, the IEA has also contributed to such efforts, working with countries to build capacities for energy data, statistics and analysis to support policy making. The Programme will build upon existing IEA collaborations with major emerging economies, including the Energy Efficiency in Emerging Economies (E4) programme, the Grid Integration of Variable Renewables (GIVAR) programme, various Clean Energy Ministerial work streams, and a wide variety of other IEA training and capacity-building activities. The IEA also provides a unique platform for governments, research institutes and companies from around the world to collaborate on their priority clean energy technologies, through its Technology Collaboration Programmes (TCPs).

The IEA Clean Energy Transitions Programme (CETP), launched in November 2017 with the support of 13 IEA member countries, will significantly enhance and expand IEA technical co-operation activities. The EUR 30 million programme will provide cutting-edge technical support to governments whose energy policies will significantly impact the speed of, and prospects for, a global transition toward more sustainable energy production and use, including reductions in greenhouse gas emissions in line with the objectives of the Paris Agreement. Key countries of focus include Brazil, China, India, Indonesia, Mexico and South Africa, as well as other IEA Association and Partner countries and regions where the programme can have high impact. The CETP involves six work streams: data and statistics; energy efficiency; electricity transitions and renewable energy; policy guidance and modelling; energy transitions in sectors; and technology development and innovation.

For example, under the CETP, IEA is working with individual countries to: develop and refine data collection practices and surveys; assess options for enhancing the flexibility of their electricity systems; better understand RD&D spending and how this can be best channelled toward nationally-relevant innovation; and explore different options for developing long-term low-carbon energy transition pathways. In addition, IEA work under the CETP also involves extensive convening to bring experts and policy-makers together, ensuring knowledge sharing and the strengthening of expert networks both within and among countries. The IEA's CETP efforts are greatly enhanced with the enlargement of the IEA family of countries over the past two years to include Brazil, China, India, Indonesia, Morocco, Singapore, and Thailand. In implementing the CETP, the IEA will also endeavour to work in even greater partnership with other relevant organisations with relevant and complementary capabilities.

For further information:

Clean Energy Transitions Programme launch document and announcement (2017)

IEA Training and Capacity Building

Energy Efficiency in Emerging Economies (E4) Programme

IEA Technology Collaboration Programmes (TCPs): the 38 TCPs operating today span across the full range of energy technologies, from CCS to buildings, from smart grids to energy efficiency, from fusion to bioenergy

World Energy Outlook and Energy Technology Perspectives

System Integration of Renewables

Technology Roadmaps, a set of 21 roadmaps identifying priority actions for governments, industry, financial partners and civil society to advance development of a wide range of technologies, and other work on Clean Energy Technologies

HOW DO WE GET THERE?

KEY OPPORTUNITY:

Energy transitions consistent with meeting Paris Agreement goals, universal energy access to modern energy, and significant reduction in air pollution can be realized at a modest global cost. As technology and fuel costs decline, these goals can be achieved with only 13% additional investment in the energy sector by 2030. Well-integrated policy packages can be used to re-direct investment toward energy efficiency and low carbon energy supply.

KEY CHALLENGE:

Applying an integrated policy approach to achieve a diverse and integrated technology portfolio for successful clean energy transitions requires significant national coordination and capacity including domestic technology and policy expertise. Sharing international best practices and advice can help.

Annex: relevant IEA reports

1. IEA Latest

- CO_2 Emissions from Fuel Combustion Highlights 2017; Data (.xls)
- World Energy Outlook 2017 - Executive Summary
- Energy Technology Perspectives 2017 - Executive Summary
- Tracking Clean Energy Progress 2017
- World Energy Investment 2017 - Executive Summary
- Market Report Series: Energy Efficiency 2017
- Market Report Series: Renewables 2017 - Executive Summary
- Digitalization & Energy (2017)
- Global EV Outlook 2017

- Key World Energy Statistics 2017
- World Energy Balances 2017 (Overview)
- Electricity Information 2017 (Excerpt)
- Renewables Information 2017 (Overview)

- World Energy Outlook 2017 Special Report: South East Asia
- World Energy Outlook 2017 Special Report: Energy Access Outlook 2017 – From Poverty to Prosperity
- World Energy Outlook 2017 China Energy Outlook
- World Energy Outlook 2016 Special Report - Energy and Air Pollution
- World Energy Outlook 2015 Special Briefing for COP21
- World Energy Outlook 2015 Special Report - Energy and Climate Change

- Insights Series: Getting Wind and Sun onto the Grid (2017)
- Insights Series: Market-based Instruments for Energy Efficiency (2017)
- Insights Series: Real-world policy packages for sustainable energy transitions (2017)
- Insights Series: Renewable Energy in Industry Manufacturing (2017)
- Insights Series: The Future of Trucks (2017)
- Insights Series: Tracking Fossil Fuel Subsidies in APEC Economies (2017)
- Perspectives for the Energy Transition: Investment Needs for a Low-Carbon Energy System (2017)
- Status of Power System Transformation 2017

- Energy Policies Beyond IEA Countries: Mexico 2017 Review
- Energy Policies of IEA Countries: Greece Review 2017
- Energy Policies of IEA Countries: Hungary 2017 Review
- Energy Policies of IEA Countries: New Zealand 2017 Review
- Energy Policies of IEA Countries: Norway 2017 Review

2. Modelling the Energy Sector Decarbonisation Transition

- Energy Technology Perspectives 2017 - Executive Summary
    - Translations: Chinese, French, German, Japanese, Korean, Portuguese, Russian, Spanish
- Perspectives for the Energy Transition: Investment Needs for a Low-Carbon Energy System (2017)
- Tracking Clean Energy Progress 2017
- World Energy Outlook 2017 - Executive Summary
    - Translations: Arabic, Chinese, French, German, Italian, Japanese, Russian, Spanish, Korean, Polish

- World Energy Outlook 2017 Special Report: South East Asia
- World Energy Outlook 2017 Special Report: Energy Access Outlook 2017 – From Poverty to Prosperity
    - Translations (Executive Summary): French; Italian
- Energy, Climate Change and Environment: 2016 Insights
- World Energy Outlook 2016 - Executive Summary
- Energy Technology Perspectives 2016 - Executive Summary
    - Translations: Chinese; French; German; Japanese; Portuguese; Russian; Spanish
- Solutions, analysis, and data for the global energy transition (2016)
- Tracking Clean Energy Progress 2016: IEA Input to the Clean Energy Ministerial
- WEO 2016 Special Report - Energy and Air Pollution
    - Executive Summary: English; Chinese; French
- WEO 2016 Special Report - Mexico Energy Outlook
    - Executive Summary: English; Spanish
- Energy Matters (2015)
- Track the energy transition: Where we are, how we got here, and where we need to be (2015)
- WEO 2015 Special Briefing for COP21
- WEO 2015 Special Report - Energy and Climate Change
    - Executive Summary: English; Chinese; French; German; Japanese; Korean; Polish; Portuguese; Russian; Spanish; Turkish
- WEO 2015 Special Report - India Energy Outlook
- WEO 2015 Special Report - Southeast Asia Energy Outlook
- WEO 2014 Special Report: Africa Energy Outlook
- WEO 2014 Special Report: World Energy Investment Outlook
- WEO 2013 Special Report: Redrawing the Energy-Climate Map
- WEO 2013 Special Report: Southeast Asia Energy Outlook

3. Statistics and Indicators

- CO_2 Emissions from Fuel Combustion Highlights 2017
- CO_2 Emissions from Fuel Combustion 2017 Highlights Excel (.xlsx)
- Key World Energy Statistics 2017
- World Energy Balances 2017 (Overview)
- Electricity Information 2017 (Excerpt)
- Renewables Information 2017 (Overview)
- Natural Gas Information: Overview (2017)
- Coal Information: Overview (2017)
- Oil Information: Overview (2017)
- Tracking Clean Energy Progress 2017
- International Comparison of Light-Duty Vehicle Fuel Economy 2005-2015 Ten Years of Fuel Economy Benchmarking (2017)
- Solutions, analysis, and data for the global energy transition (2016)
- Tracking Clean Energy Progress 2016: IEA Input to the Clean Energy Ministerial
- Track the energy transition: Where we are, how we got here, and where we need to be (2015)
- WEO 2015 Special Briefing for COP21
- WEO 2015 Special Report - Energy and Climate Change
- Energy Efficiency Indicators: Essentials for Policy Making (2014)
    - Translations: Chinese; Spanish; Russian
- Energy Efficiency Indicators: Fundamentals on Statistics (2014)
    - Translations: Chinese; Spanish; Russian
- Energy, Climate Change, and Environment: 2014 Insights
- Development of Energy Efficiency Indicators in Russia (2011)
- Energy Statistics Manual (2005)

4. Climate Policy for the Energy Sector

- Insights Series: Getting Wind and Sun onto the Grid (2017)
- Insights Series: Real-world policy packages for sustainable energy transitions (2017)
- Energy, Climate Change and Environment: 2016 Insights
- Solutions, analysis, and data for the global energy transition (2016)
- Tracking Clean Energy Progress 2016: IEA Input to the Clean Energy Ministerial
- WEO 2016 Special Report - Energy and Air Pollution
    - Executive Summary: English; Chinese; French
- Complementary measures for decarbonisation (2015)
- Energy Matters (2015)
- Making the energy sector more resilient to climate change (2015)
- WEO 2015 Special Briefing for COP21
- WEO 2015 Special Report - Energy and Climate Change
- Capturing the Multiple Benefits of Energy Efficiency (2015)
- Emissions Trading in the People's Republic of China: A Simulation for the Power Sector (2014)
- Energy, Climate Change, and Environment: 2014 Insights
    - Executive Summary translations: Chinese; Japanese
- Energy Policy Highlights (2013)
- Managing interactions between carbon pricing and existing energy policies (2013)
- WEO 2013 Special Report: Redrawing the Energy-Climate Map
- Electricity in a Climate-Constrained World - Data & Analyses (2012)
- Policy Options for Low-Carbon Power Generation in China: Designing an emissions trading system for China's electricity sector (2012)
- Energy Efficiency and Carbon Pricing (2011)
- Interactions of Policies for Renewable Energy and Climate (2011)
- Summing up the Parts: Combining Policy Instruments for Least-Cost Climate Mitigation Strategies (2011)

5. Financing the Energy Transition

- World Energy Investment 2017 - Executive Summary
    - Translation: Chinese; Japanese; Korean
- Perspectives for the Energy Transition: Investment Needs for a Low-Carbon Energy System (2017)
- World Energy Investment 2016 - Executive Summary
    - Translation: Chinese
- WEO 2014 Special Report: World Energy Investment Outlook
- Mobilising investment in energy efficiency: Economic instruments for low-energy buildings (2012)
- Plugging the Energy Efficiency Gap with Climate Finance (2012)
- Policy Pathways: Joint Public Private Approaches for Energy Efficiency Finance (2011)

6. Energy Transition in Emerging Economies

- District Energy Systems in China Options for Optimisation and Diversification (2017)
- Digitalization and Energy - Executive summary - Chinese (2017)
- Market Report Series: Energy Efficiency 2017 - Indonesia Focus - Bahasa Indonesia (2017)
- Energy Technology Perspectives 2017 - Executive Summary

- Energy Efficiency Outlook for India – Sizing up the opportunity (2017)
- Insights Series: Tracking Fossil Fuel Subsidies in APEC Economies (2017)
- Prospects for Distributed Energy Systems in China (2017)
- World Energy Outlook 2017 Special Report: Energy Access Outlook 2017 – From Poverty to Prosperity
    - Translations (Executive Summary): French; Italian
- World Energy Outlook 2017 Special Report: South East Asia
- World Energy Outlook 2017 China Energy Outlook
- World Energy Outlook 2016 - Executive Summary
- Energy Policies of IEA Countries - Turkey 2016 Review
- Energy Technology Perspectives 2016 - Executive Summary
    - Translations: Chinese; French; Portuguese; Russian; Spanish
- Medium-Term Energy Efficiency Market Report 2016
- Medium-Term Energy Efficiency Market Report 2016 - Special Report - Energy Efficiency in China (Chinese) (2016)
- Medium-Term Renewable Energy Market Report 2016 Executive Summary
- Partner Country Series - Boosting the Power Sector in Sub-Saharan Africa: China's Involvement (2016)
    - Translation: Chinese (促进撒哈拉以南 非洲电力发展 中国的参与)
- Partner Country Series - China's Engagement in Global Energy Governance (2016)
    - Translation: Chinese (中国参与全球 能源治理之路)
- Partner Country Series - Clean Energy Technology Assessment Methodology Pilot Study: Belarus (2016)
- Partner Country Series - Clean Energy Technology Assessment Methodology Pilot Study: Kazakhstan (2016)
- Partner Country Series - Clean Energy Technology Assessment Methodology Pilot Study: Morocco (2016)
- Partner Country Series - Fossil Fuel Subsidy Reform in Mexico and Indonesia (2016)
- Partner Country Series - Thailand Electricity Security Assessment (2016)
    - Translation: Thai
- WEO 2016 Special Report - Energy and Air Pollution
    - Executive Summary: English; Chinese; French
- WEO 2016 Special Report - Mexico Energy Outlook
    - Executive Summary: Spanish
- World Energy Investment 2016 - Executive Summary - Chinese
- Complementary measures for decarbonisation (2015)
- Eastern Europe, Caucasus and Central Asia 2015 Highlights (2015)
- Enabling Renewable Energy and Energy Efficiency Technologies: Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean (2015)
- Energy Efficiency Policy Priorities - Ukraine (2015)
- Energy Efficiency Policy Recommendations for Latin America and the Caribbean (2015)
    - Translation: Spanish
- Energy Policies Beyond IEA Countries - Eastern Europe, Caucasus and Central Asia 2015
- Energy Policies Beyond IEA Countries - Indonesia 2015
- Energy Policies Beyond IEA Countries - Mexico 2017 Review
- Partner Country Series - Development Prospects of the ASEAN Power Sector: Towards an Integrated Electricity Market (2015)
- Partner Country Series - Energy Use in the Chinese Building Sector (2015)
- Policy Pathways: Modernising Building Energy Codes (Turkish) (2015)
- Regional EEPR: Southeast Asia Region (2015)
- Technology Roadmap: Nuclear Energy (2015) - Chinese
- WEO 2015 Special Report - Energy and Climate Change
    - Executive Summary: English; Chinese; French; German; Japanese; Korean; Polish;

Portuguese; Russian; Spanish; Turkish

- WEO 2015 Special Report - India Energy Outlook
- WEO 2015 Special Report - Southeast Asia Energy Outlook
- Emissions Trading in the People's Republic of China: A Simulation for the Power Sector (2014)
- Energy Efficiency Indicators: Essentials for Policy Making (2014)
  - Translations: Chinese; Russian; Spanish
- Energy Efficiency Indicators: Fundamentals on Statistics (2014)
  - Translations: Chinese; Russian; Spanish
- Energy, Climate Change, and Environment: 2014 Insights Executive Summary (Chinese)
- Partner Country Series - Emissions Reduction through Upgrade of Coal-Fired Power Plants (2014)
- Partner Country Series - The Asian Quest for LNG in a Globalising Market (2014)
- Regional EEPR: Arab-Southern and Eastern Mediterranean (SEMED) Region (2014)
  - Translation: Arabic; French
- Technology Roadmap: A Guide to Development and Implementation (2014)
  - Translation: Chinese; Russian; Arabic
- WEO 2014 Special Report: Africa Energy Outlook
- WEO 2014 Special Report: World Energy Investment Outlook
- Energy Investments and Technology Transfer Across Emerging Economies: The Case of Brazil and China (2013)
- Energy Technology Initiatives (2013)
- Global Tracking Framework 2013
- Technology Roadmap: Low-Carbon Technology for the Indian Cement Industry (2013)
- WEO 2013 Special Report: Southeast Asia Energy Outlook
- Facing China's Coal Future: Prospects and Challenges for Carbon Capture and Storage (2012)
  - Translation: Chinese (面向中国煤炭未来发展)
- Policy Options for Low-Carbon Power Generation in China: Designing an emissions trading system for China's electricity sector (2012)
- Technology Roadmap: Biofuels for Transport - Chinese (2012)
- Technology Roadmap: High-Efficiency, Low-Emissions Coal-Fired Power Generation - Chinese version (2012)
- Development of Energy Efficiency Indicators in Russia (2011)
- Energy Transition for Industry: India and the Global Context (2011)
- Integration of Renewables - Status and Challenges in China (2011)
- Technology Development Prospects for the Indian Power Sector (2011)
- Technology Roadmap: Carbon Capture and Storage in Industrial Applications - Chinese version (2011)
- Technology Roadmap: China Wind Energy Development 2050 - Chinese version (2011)
- Technology Roadmap: China Wind Energy Development Roadmap 2050 (2011)

7. Energy Efficiency

- Market Report Series: Energy Efficiency 2017
- Market Report Series: Energy Efficiency 2017 - Indonesia Focus - Bahasa Indonesia (2017)
- Energy Efficiency Outlook for India – Sizing up the opportunity (2017)
- Insights Series: Market-based Instruments for Energy Efficiency (2017)
- Policy Pathways Brief: Modernising Building Energy Codes (2017)
- Policy Pathways Brief: Monitoring, Verification and Enforcement (2017)
- Policy Pathways Brief: Joint Public-Private Approaches for Energy-Efficiency Finance
- Policy Pathways Brief: Building Energy Performance Certification (2017)
- Medium-Term Energy Efficiency Market Report 2016
- Medium-Term Energy Efficiency Market Report 2016 - Special Report - Energy Efficiency in China (Chinese) (2016)

- The Clean Energy Technology Assessment Methodology: A Methodology for Assessing Renewable Energy and Energy Efficiency Technology Markets (2016)
- Achievements of appliance energy efficiency standards and labelling programs (2015)
- Building Energy Performance Metrics (2015)
- Enabling Renewable Energy and Energy Efficiency Technologies: Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean (2015)
- Energy Efficiency Policy Priorities - Ukraine (2015)
- Energy Efficiency Policy Recommendations for Latin America and the Caribbean (2015)
    - Translation: Spanish
- Partner Country Series - Energy Use in the Chinese Building Sector (2015)
- Policy Pathways: Accelerating Energy Efficiency in Small and Medium-sized Enterprises: Powering
- SMEs to catalyse economic growth (2015)
    - Translation: Russian
- Policy Pathways: Modernising Building Energy Codes (Turkish) (2015)
- Regional EEPR: Southeast Asia Region (2015)
- Capturing the Multiple Benefits of Energy Efficiency (2015)
- Energy Efficiency Indicators: Essentials for Policy Making (2014)
    - Translations: Chinese; Russian; Spanish
- Energy Efficiency Indicators: Fundamentals on Statistics (2014)
    - Translations: Chinese; Russian; Spanish
- More Data, Less Energy (2014)
- Regional EEPR: Arab-Southern and Eastern Mediterranean (SEMED) Region (2014)
    - Translation: Arabic; French
- 25 Bright Ideas from the IEA's 25 Energy Efficiency Recommendations (2013)
- Policy Pathways: A Tale of Renewed Cities: A policy guide on how to transform cities by improving energy efficiency in urban transport systems (2013)
- Policy Pathways: Modernising Building Energy Efficiency Codes (2013)
- Technology Roadmap: Energy Efficient Building Envelopes (2013)
- Transition to Sustainable Buildings: Strategies and Opportunities to 2050 (2013)
- Mobilising investment in energy efficiency: Economic instruments for low-energy buildings (2012)
- Plugging the Energy Efficiency Gap with Climate Finance (2012)
- Policy Pathways: Energy Management Programmes for Industry: Gaining through saving (2012)
- Policy Pathways: Improving the Fuel Economy of Road Vehicles - A policy package (2012)
- Technology Roadmap: Fuel Economy of Road Vehicles (2012)
- 25 Energy Efficiency Recommendations 2011 Update
- Development of Energy Efficiency Indicators in Russia (2011)
- Energy Efficiency and Carbon Pricing (2011)
- Policy Pathways: Joint Public Private Approaches for Energy Efficiency Finance (2011)
- Saving Electricity in a Hurry (2011)
- Technology Roadmap: Energy Efficient Buildings: Heating and Cooling Equipment (2011)
- Policy Pathways: Monitoring, Verification and Enforcement - Improving compliance within equipment energy efficiency programmes (2010)

8. Carbon Capture and Storage

- 20 Years of Carbon Capture and Storage (2016)
- Carbon Capture and Storage: The solution for deep emissions reductions (2015)
- Carbon Capture and Storage: Legal and Regulatory Review (Edition 4) (2014)
- What Lies in Store for CCS? (2014)
- Global Action to Advance Carbon Capture and Storage - a focus on industrial applications (2013)
- Methods to Assess Geological CO_2 Storage Capacity: Status and Best Practice (2013)
- Technology Roadmap: Carbon Capture and Storage (2013)
- A Policy Strategy for Carbon Capture and Storage (2012)

- CCS Retrofit: Analysis of the Global Installed Power Plant Fleet (2012)
- Facing China's Coal Future: Prospects and Challenges for Carbon Capture and Storage (2012)
    - Translation: Chinese (面向中国煤炭未来发展)
- Tracking Progress in CCS: IEA/Global CCS Institute: Report to the Third Clean Energy Ministerial (2012)
- Technology Roadmap: Carbon Capture and Storage in Industrial Applications (2011)
    - Translation: Chinese
- Cost and Performance of Carbon Dioxide Capture from Power Generation (2010)

9. Renewable Energy

- Insights Series: Renewable Energy in Industry Manufacturing (2017)
- Market Report Series: Renewables 2017 - Executive Summary
- Renewables Information 2017 (Overview)
- How2Guide for Bioenergy Roadmap Development and Implementation (2017)
- Technology Roadmap: Delivering Sustainable Bioenergy (2017)
- Medium-Term Renewable Energy Market Report 2016 Executive Summary
- Next Generation Wind and Solar Power From Cost to Value (2016)
- Re-powering Markets: Market design and regulation during the transition to low-carbon power systems (2016)
- The Clean Energy Technology Assessment Methodology: A Methodology for Assessing Renewable Energy and Energy Efficiency Technology Markets (2016)
- Enabling Renewable Energy and Energy Efficiency Technologies: Opportunities in Eastern Europe, Caucasus, Central Asia, Southern and Eastern Mediterranean (2015)
- Medium-Term Renewable Energy Market Report 2015
- Heating Without Global Warming - Market Developments and Policy Considerations for Heat (2014)
- Linking Heat and Electricity Systems (2014)
- Technology Roadmap: Energy Storage (2014)
- Technology Roadmap: How2Guide for Wind Energy Roadmap (2014)
- Technology Roadmap: Solar Photovoltaic Energy (2014)
- Technology Roadmap: Solar Thermal Electricity (2014)
- Technology Roadmap: Wind Energy (2013)
- Technology Roadmap: Bioenergy for Heat and Power (2012)
- Technology Roadmap: Biofuels for Transport - Chinese (2012)
- Technology Roadmap: Hydropower (2012)
- Technology Roadmap: Solar Heating and Cooling (2012)
- Deploying Renewables (2011)
- Harnessing Variable Renewables (2011)
- Integration of Renewables - Status and Challenges in China (2011)
- Interactions of Policies for Renewable Energy and Climate (2011)
- Solar Energy Perspectives (2011)
- Technology Roadmap: Biofuels for Transport (2011)
- Technology Roadmap: China Wind Energy Development Roadmap 2050 (2011)
    - Translation: Chinese
- Technology Roadmap: Geothermal Heat and Power (2011)
- Technology Roadmap: Concentrating Solar Power (2010)

10. Technology Partnerships and Development

- Global EV Outlook 2017

- Status of Power System Transformation 2017
- Technology Roadmap: Delivering Sustainable Bioenergy (2017)
- Tracking Clean Energy Progress 2017
- Partner Country Series - Clean Energy Technology Assessment Methodology Pilot Study: Belarus (2016)
- Partner Country Series - Clean Energy Technology Assessment Methodology Pilot Study: Kazakhstan (2016)
- Partner Country Series - Clean Energy Technology Assessment Methodology Pilot Study: Morocco (2016)
- Solutions, analysis, and data for the global energy transition (2016)
- Technology Collaboration Programmes: Highlights and Outcomes (2016)
- The Clean Energy Technology Assessment Methodology: A Methodology for Assessing Renewable Energy and Energy Efficiency Technology Markets (2016)
- Tracking Clean Energy Progress 2016: IEA Input to the Clean Energy Ministerial
- Technology Roadmap: How2Guide for Smart Grids in Distribution Networks (2015)
- Technology Roadmap: Hydrogen and Fuel Cells (2015)
- Technology Roadmap: Nuclear Energy (2015)
  - Translation: Chinese
- Technology Roadmap: A Guide to Development and Implementation (2014)
  - Translation: Chinese; Russian; Arabic
- Technology Roadmap: Energy Storage (2014)
- Technology Roadmap: How2Guide for Wind Energy Roadmap (2014)
- Technology Roadmap: Solar Photovoltaic Energy (2014)
- Technology Roadmap: Solar Thermal Electricity (2014)
- Energy Technology Initiatives (2013)
- Global Tracking Framework 2013
- Technology Roadmap: Carbon Capture and Storage (2013)
- Technology Roadmap: Energy and GHG Reductions in the Chemical Industry via Catalytic Processes (2013)
  - Translation: Portuguese
- Technology Roadmap: Energy Efficient Building Envelopes (2013)
- Technology Roadmap: Low-Carbon Technology for the Indian Cement Industry (2013)
- Technology Roadmap: Wind Energy (2013)
- Technology Roadmap: Bioenergy for Heat and Power (2012)
- Technology Roadmap: Fuel Economy of Road Vehicles (2012)
- Technology Roadmap: High-Efficiency, Low-Emissions Coal-Fired Power Generation (2012)
  - Translation: Chinese
- Technology Roadmap: Hydropower (2012)
- Technology Roadmap: Solar Heating and Cooling (2012)
- Good Practice Policy Framework for Energy Technology RD&D (2011)
- Technology Development Prospects for the Indian Power Sector (2011)
- Technology Roadmap: Biofuels for Transport (2011)
  - Translation: Chinese
- Technology Roadmap: Carbon Capture and Storage in Industrial Applications (2011)
  - Translation: Chinese
- Technology Roadmap: China Wind Energy Development Roadmap 2050 (2011)
  - Translation: Chinese
- Technology Roadmap: Electric and Plug-in Hybrid Electric Vehicles (EV/PHEV) (2011)
- Technology Roadmap: Energy Efficient Buildings: Heating and Cooling Equipment (2011)
- Technology Roadmap: Geothermal Heat and Power (2011)
- Technology Roadmap: Smart Grids (2011)
  - Translation: Chinese
- Technology Roadmap: Concentrating Solar Power (2010)
- Technology Roadmap: Cement (2009)

11. Power Sector

- Insights Series: Getting Wind and Sun onto the Grid (2017)
- Status of Power System Transformation 2017
- Electricity Information 2017 (Excerpt)
- Next Generation Wind and Solar Power From Cost to Value (2016)
- Partner Country Series - Boosting the Power Sector in Sub-Saharan Africa: China's Involvement (2016)
  - Translation: Chinese (促进撒哈拉以南 非洲电力发展 中国的参与)
- Partner Country Series - Thailand Electricity Security Assessment (2016)
  - Translation: Thai
- Re-powering Markets: Market design and regulation during the transition to low-carbon power systems (2016)
- Making the energy sector more resilient to climate change (2015)
- Partner Country Series - Development Prospects of the ASEAN Power Sector: Towards an Integrated Electricity Market (2015)
- Technology Roadmap: How2Guide for Smart Grids in Distribution Networks (2015)
- Technology Roadmap: Nuclear Energy (2015)
  - Translation: Chinese
- WEO 2015 Special Report - India Energy Outlook
- Emissions Trading in the People's Republic of China: A Simulation for the Power Sector (2014)
- Linking Heat and Electricity Systems (2014)
- Partner Country Series - Emissions Reduction through Upgrade of Coal-Fired Power Plants (2014)
- Partner Country Series - The Asian Quest for LNG in a Globalising Market (2014)
- Seamless Power Markets: Regional Integration of Electricity Markets in IEA Member Countries (2014)
- Technology Roadmap: Energy Storage (2014)
- Technology Roadmap: How2Guide for Wind Energy Roadmap (2014)
- Technology Roadmap: Solar Photovoltaic Energy (2014)
- Technology Roadmap: Solar Thermal Electricity (2014)
- Secure and Efficient Electricity Supply: During the Transition to Low Carbon Power Systems (2013)
- Technology Roadmap: Carbon Capture and Storage (2013)
- Technology Roadmap: Wind Energy (2013)
- CCS Retrofit: Analysis of the Global Installed Power Plant Fleet (2012)
- Electricity in a Climate-Constrained World - Data & Analyses (2012)
- Policy Options for Low-Carbon Power Generation in China: Designing an emissions trading system for China's electricity sector (2012)
- Technology Roadmap: Bioenergy for Heat and Power (2012)
- Technology Roadmap: High-Efficiency, Low-Emissions Coal-Fired Power Generation (2012)
  - Translation: Chinese
- Technology Roadmap: Hydropower (2012)
- Technology Roadmap: Solar Heating and Cooling (2012)
- Harnessing Variable Renewables (2011)
- Impact of Smart Grid Technologies on Peak Load to 2050 (2011)
- Saving Electricity in a Hurry (2011)
- Technology Development Prospects for the Indian Power Sector (2011)
- Technology Roadmap: Geothermal Heat and Power (2011)
- Technology Roadmap: Smart Grids (2011)
  - Translation: Chinese
- Cost and Performance of Carbon Dioxide Capture from Power Generation (2010)
- Technology Roadmap: Concentrating Solar Power (2010)

12. Buildings

- Policy Pathways Brief: Modernising Building Energy Codes (2017)
- Policy Pathways Brief: Monitoring, Verification and Enforcement (2017)
- Market Report Series: Energy Efficiency 2017
- Medium-Term Energy Efficiency Market Report 2016
- Building Energy Performance Metrics (2015)
- Partner Country Series - Energy Use in the Chinese Building Sector (2015)
- Policy Pathways: Modernising Building Energy Codes (Turkish) (2015)
- Heating Without Global Warming - Market Developments and Policy Considerations for Heat (2014)
- Linking Heat and Electricity Systems (2014)
- Policy Pathways: Modernising Building Energy Efficiency Codes (2013)
- Technology Roadmap: Energy Efficient Building Envelopes (2013)
- Transition to Sustainable Buildings: Strategies and Opportunities to 2050 (2013)
- Technology Roadmap: Bioenergy for Heat and Power (2012)
- Technology Roadmap: Energy Efficient Buildings: Heating and Cooling Equipment (2011)

13. Industry

- Insights Series: Renewable Energy in Industry Manufacturing (2017)
- Insights Series: The Future of Trucks (2017)
- Market Report Series: Energy Efficiency 2017
- Medium-Term Energy Efficiency Market Report 2016
- Policy Pathways: Accelerating Energy Efficiency in Small and Medium-sized Enterprises - Powering SMEs to catalyse economic growth (2015)
- Global Action to Advance Carbon Capture and Storage - a focus on industrial applications (2013)
- Technology Roadmap: Carbon Capture and Storage (2013)
- Technology Roadmap: Energy and GHG Reductions in the Chemical Industry via Catalytic Processes (2013)
- Technology Roadmap: Low-Carbon Technology for the Indian Cement Industry (2013)
- Policy Pathways: Energy Management Programmes for Industry: Gaining through saving (2012)
- Energy Transition for Industry: India and the Global Context (2011)
- Technology Roadmap: Carbon Capture and Storage in Industrial Applications (2011)
- Technology Roadmap: Cement (2009)

14. Transport

- Nordic EV Outlook (2018)
- Global EV Outlook 2017
- Insights Series: The Future of Trucks (2017)
- International Comparison of Light-Duty Vehicle Fuel Economy 2005-2015 Ten Years of Fuel Economy Benchmarking (2017)
- Policy Pathways Brief: Improved Urban Transport Systems for Sustainable Cities (2017)
- Market Report Series: Energy Efficiency 2017
- Global EV Outlook 2016: Beyond One Million Electric Cars
- Medium-Term Energy Efficiency Market Report 2016
- Technology Roadmap: How2Guide for Smart Grids in Distribution Networks (2015)
- Technology Roadmap: Hydrogen and Fuel Cells (2015)

- Global Land Transport Infrastructure Requirements: Estimating road and railway infrastructure capacity and costs to 2050 (2013)
- Policy Pathways: A Tale of Renewed Cities: A policy guide on how to transform cities by improving energy efficiency in urban transport systems (2013)
- EV City Casebook (2012)
- Policy Pathways: Improving the Fuel Economy of Road Vehicles - A policy package (2012)
- Technology Roadmap: Fuel Economy of Road Vehicles (2012)
- Technology Roadmap: Biofuels for Transport (2011)
- Technology Roadmap: Electric and Plug-in Hybrid Electric Vehicles (EV/PHEV) (2011)