ENERGY TRANSITIONS TOWARDS CLEANER, MORE FLEXIBLE AND TRANSPARENT SYSTEMS

ANNEX I
VOLUNTARY NATIONAL SELF-ASSESSMENTS

June 2018

Note: This document is only being shared among the G20 membership but will not be divulged publicly

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I-1 Survey of G20 Energy Transitions: Template used for Voluntary National Self-Assessments

Country:	
Evolution of the energy mix How has your energy mix evolved over what you consider to be a relevant period (eg, at least 2007-2016 - or longer, if considered more representative)? Please comment on the major changes in the country's total primary energy mix (TPES), greenhouse gas emissions/energy-related CO_2 emissions, the power mix and population/Gross Domestic Product (GDP).	
Energy transition outlook and policies 2030/2050 Describe briefly your energy transition outlook for 2030 and 2050. Please provide quantitative projections for 2030 for (i) demand, including energy efficiency targets, and (ii) supply, with a breakdown of the expected energy mix. Please also make reference to main policies, strategies, action plans, and institutional and governance frameworks.	
Towards cleaner energy systems What are the challenges and opportunities arising from the transition towards cleaner energy systems in your country? Please choose one sector, considered central to your country's energy transition (power, oil/gas, transport, industry etc.), describing the transition pathways and identifying key challenges and what has been done to address them in the policy framework, including public investment in cleaner energy technologies and programmes.	
Trends towards flexible energy systems What are the main sources of flexibility for your power system (dispatchable power plants, regional market integration, demand response, energy storage including hydroelectricity, others)? What actions are being undertaken to enhance the regulatory framework for these sources, and to address energy security concerns?	
Towards transparent energy systems Please describe trends and efforts made to increase transparency of the energy systems during the energy transition process, including societal dialogue, cost/price of energy, market reforms and policies to ensure the participation of the society and industry.	
G20 actions going forward In your view, what should be the most important priorities for future G20 collaboration on energy transitions with regard to cleaner energy technologies, flexibility, and transparency/energy data?	

I-2 Highlights of G20 Energy Transitions Submissions received

Sixteen countries shared their experiences through voluntary national self-assessments, out of which G20 members, Argentina, Brazil, China, Germany, India, Indonesia, Italy, Japan, Mexico, Republic of Korea, Turkey, the United Kingdom (UK) and G20 invited countries Chile, the Netherlands, Singapore and Spain. A short summary and overview of the responses received is provided below, which however, does not reflect the entire G20 energy transitions.

Country submissions gave insights into the fascinating energy transitions in sixteen countries, showing the evolution of the energy mix and the national energy transition strategies, outlook and policies. Moreover, the country self-assessments explain trends with regard to the progress made towards a cleaner, more flexible and transparent energy systems, a core theme of the Argentina G20 Presidency. Last but not least, most countries provided their views on the important priorities for future collaborative actions on energy transitions within the G20 format (clean energy technologies, flexibility, and transparency/energy data).

Evolution of the energy mix

Over the past decade, the total primary energy supply (TPES) has grown in G20 countries despite a temporary slow down during the global financial crisis in 2008/9. The energy intensity of this growth varies considerably by country across the G20. A decline is observed in some countries, while energy intensity has increased in others.

Despite many differences, fossil fuels continue to dominate the energy mix in many G20 countries (Argentina, China, India, Indonesia, Japan, Republic of Korea, and Turkey). After an increase in the coal consumption in over the past decades in Chile, India, Japan and Republic of Korea, in recent years the share of coal in energy consumption has been declining, notably in Argentina, China, Republic of Korea, and the UK. Oil is a very important driver of the economy in G20 countries, with a role in power generation in some. G20 countries heavily rely on energy imports to cover their fuel needs, despite being major energy suppliers. Many countries of the G20 rely on a high share of fossil fuels in its total energy supply, be it oil or coal as well as natural gas (Chile, China, India, Indonesia, Japan, the Netherlands and Turkey). India and Turkey still build on coal for their economic development. Japan has bridged the supply gap from the successive suspension of nuclear power plants after the Great East Japan Earthquake by additional gas- and oil-fired power, energy efficiency, renewables and coal.

There is a clear trend towards cleaner energy sources, mainly in the power mix. In recent years, the proportion of renewable energy and the consumption of natural gas have been on the rise in Argentina, Chile, China, Italy, the Netherlands, Singapore, Republic of Korea, Spain, Turkey and the UK. Renewable electricity from onshore wind and solar PV has boomed in Germany, Italy, Spain, as a result of favourable government incentives. Brazil

and China saw a major increase in hydropower and offshore wind booms in Germany, the Netherlands and the UK.

Greenhouse gas emissions were on the rise in most G20 countries with a few notable exceptions. However, efforts to boost renewable energy and energy efficiency have contributed to keep at bay the increase in GHG emissions. However, the level of CO_2 emissions per capita is still below the global average in several large G20 economies.

Energy transition outlook and policies 2030/2050

Energy transitions with goals for 2030 and/or 2050 are framed in national energy strategies, legal acts, and/or long term energy scenarios and outlooks: Argentina's long term energy scenarios to 2030, Germany's Energy Concept, Mexico's Energy Transition Strategy and related Energy Transition Act and Energy Reform, Italy's National Energy Strategy of 2017, Japan's initiative for Long Term Energy Transitions and the FY2030 Long Term Energy Supply and Demand Outlook, Indonesia's National Energy Policy with targets for 2025/2050, Chile's "Energy 2050 – Chile's Energy Policy", Republic of Korea's upcoming 3rd Energy Master Plan and the related 8th Basic Plan for Long-term Electricity Supply and Demand and Renewable Plan 3020 and the UK 2008 Climate Act, Carbon Budgets and the 2017 Clean Growth Strategy. EU countries are working towards a national energy and climate plan within the EU framework for "Clean Energy for All" for 2030.

The objective of boosting renewable energy and energy efficiency is at the heart of all national strategies and many countries aim at reducing the share of fossil fuels (including through phase-out plans) and increasing the share of non-fossil fuels in electricity generation (Argentina, Brazil, China, India, Indonesia, Italy, Republic of Korea, the Netherlands, Turkey, and UK).

At the same time, national strategies emphasise different policy objectives. The reduction of GHG emissions and air pollution plays an important role in Argentina, Chile, India, Italy, Japan, the Netherlands, Singapore and the UK, while strengthening energy security is a top priority for the strategies of Japan and Turkey and investment in energy infrastructure (gas/electricity) is considered a key driver for reliability in China and Turkey. The expected increase in energy demand driven by economic growth requires countries to seek strong improvements of energy efficiency (China, Brazil, Japan, and Mexico) up to 2030. Others focus on the diversification of the energy mix by using domestic resources, such as coal (Turkey, India), nuclear (Argentina, Turkey), biofuels (Brazil's RenovaBio scheme), hydrogen (Japan) and natural gas (Argentina) to reduce dependence on oil use. The UK promotes increased economic growth and decreased emissions whilst ensuring affordable energy supply for businesses and consumers.

National strategies reflect a large variety of energy choices and pathways. In several countries the 2050 emissions reduction goal has become a strategic driver. The UK Climate Change Act of 2008 committed the UK to a legally binding 2050 target for emissions reductions, which is implemented through a process of setting five-year emissions caps (carbon budgets from 2008 to 2032) and related five-year strategies, the most recent being the Clean Growth Strategy, which contains an industrial and technology focus and three pathways of meeting the UK's 2050 target, reflecting different possible technology

outcomes. Japan's 2050 initiative is equally based on decarbonisation pathways that rely on a range of clean energy technology choices, such as advanced nuclear, renewables, hydrogen, electricity storage, power grids, digitalisation and the use of natural gas and high-efficient coal-fired power generation. Germany's Energiewende is based on 2030 and 2050 goals for electricity, heat and transport with a target architecture, which stipulates "energy efficiency first", an increase in the share of renewables in end-use sectors, second and a more and more renewables-based electricity use, third, with a targeted share in power generation of 65% by 2030 and 80% by 2050.

Countries noted that energy transitions bring about significant changes for a range of sectors, including industry, transport, residential and power generation, and the economy as a whole. Governments have adopted institutional and governance structures that support this multi-sector angle, as energy transitions require collaboration across federal government and regional structures. Energy transition commissions or comittees were established in several countries. As an example, Mexico adopted an Energy Transition Act, based on the work of the Consultative Council for Energy Transition and its *Transition Strategy to promote the cleaner use of fuels and technologies* and implemented a comprehensive energy reform. Chile established an advisory committee leading to the adoption of its Energy 2050 vision. Spain has set up a committee of experts on energy transition to help formulate the future Climate Change and Energy Transition Law, while the Netherlands is working on a Climate Agreement for 2030 with the support of the Social and Economic Council. Argentina signed a Federal Agreement between the national and provincial governments. The independent Climate Change Committee in the UK advises the government on the policies needed to drive the implementation of the carbon budgets.

Towards cleaner energy systems

To promote renewable energy many G20 countries have put in place competitive auctions (for example, Argentina's Renovar, Mexico's long term clean energy auctions and renewable zones, Chile's Strategic Solar Programme and Public Solar Roofs Programme, Turkey's Renewable Energy Resource Zone Projects (YEKA) auctions). Mexico is implementing a clean power target of 50% by 2030 through a comprehensive Energy Reform, aimed at encouraging open markets and private investment. The Netherlands has promoted offshore wind energy auctions; the UK's Contract-for-Difference scheme supports low carbon investment in nuclear and offshore energy; Singapore and Chile focus on solar PV (including through use of solar PV in public buildings).

The power sector has been the key focus of clean energy investment for a decade, but transport and heat have gained attention as the deployment of clean energy progresses and the power sector decarbonises. The rapid increase in electric vehicles demonstrates this shift in sector focus. Spain will provide incentives for the decarbonisation of transport. Republic of Korea plans to implement the Zero Energy Building Certification System to all kinds of buildings by 2030. The Netherlands requires the built environment to be totally carbon free by 2050 and aims to render 30 000 to 50 000 existing buildings per year natural gas-free homes by 2030.

Several governments introduced energy price reforms, including carbon pricing and taxation to ensure cleaner energy, natural gas or renewables, can compete against carbon-intensive fuels (Argentina, Chile, Japan, Indonesia, Republic of Korea, Spain and the UK, among others).

Trends towards flexible energy systems

As the share of variable renewable energy grows, power systems need to rely on a higher range of flexibility options, well beyond existing power system flexibility. Old power plants need to be operated in a more flexible manner. Also domestic electricity grid expansion and interconnections across borders and regions can provide flexibility, besides battery/energy storage, including through hydrogen, and demand response.

IEA analysis shows that today Indonesia, Saudi Arabia, South Africa, Republic of Korea and the Russian Federation do not have any system integration concerns, while other G20 countries draw heavily on existing flexibility from thermal & hydro plants and grids to support the shift to cleaner sources (Australia, Brazil, Canada, Chile, China, France, Germany, India, Japan, and United States). Investments in new flexibility options are progressing in many others (European Union, Germany, Italy, the Netherlands, Spain and UK).

The lack of integrated grids at national and/or regional level can become a bottleneck as the share of renewable energy grows. Brazil, Chile, China, Germany, Indonesia, Italy, Japan and Republic of Korea focus on investment in grid expansion to enable the wider deployment of clean energy sources, improve interconnectivity between consumer/producer regions and increase flexibility. Japan established the Organization for Cross-regional Coordination of Transmission Operators (OCCTO) to enhance cross-regional electricity use.

Enhancing the development of interconnections across borders with neighbouring countries to enhance system security is also considered a priority issue in many countries. The continuous promotion of regional integration is expected to improve the flexibility of the energy system (Argentina, Chile, Italy, Spain, and Turkey). Regional market integration through so-called market coupling (EU) or regional electricity markets (Indonesia) can facilitate higher trades across poorly interconnected energy systems. Spain aims to increase the power exchange capacity between the Iberian Peninsula and Europe.

For the integration of large shares of offshore wind, hydrogen or battery storage are seen as essential for a flexible energy system (the Netherlands, UK). Singapore for instance invests in solar forecasting and energy storage technologies to deal with variability at the system level. GB electricity system operator, National Grid 'Power Responsive' programme stimulates the participation of industry and other large energy users in different forms of flexible technology, including demand side response and storage, in line with the UK government and Ofgem strategic orientation of the Smart Systems and Flexibility Plan.

Today, many G20 countries rely on dispatchable power plants, which are already in place for decades and will have to be refurbished or otherwise retired: coal-fired power plants (China, India, the Netherlands,); hydroelectric power plants including fast responding

pumped storage hydro plants (Argentina, Chile, China, Spain, Turkey). Market design of balancing and reserve capacity markets is critical in this regard. For instance, India aims to increase the flexibility of large thermal plants and shorten balancing intervals to reduce the curtailment of renewables. The German Electricity Market Act and related regulations have set up a range of capacity reserves that do not participate to the electricity market but serve to safeguard electricity supply.

In addition, the power and gas sectors are increasingly interlinked, where the use of natural gas in the power system grows. The provision of flexible gas makes regional market integration a key priority. Italy focuses on increasing the access to liquid and affordable natural gas through interconnections and LNG. Chile and Argentina agreed in December 2017 and through agreements of April 2018 to intensify LNG swaps, so Argentina can export LNG to Chile.

Towards transparent energy systems

Openness, impartiality and transparency are key components for good governance, public acceptance and the development of public policies. Energy data and statistics are critical for the preparation of meaningful energy scenarios, the monitoring of policy progress and the provision of accurate information to the public about the choices, progress and decision making with regard to the energy transitions. Such publically available and verifiable data will reduce information asymmetries and enhance transparency. For example, Chile and Argentina launched an integrated energy information system, integrated with the national statistics, which aims to provide consistent and high quality data to public under the principles of openness and transparency. Argentina's Ministry of Energy and Mining created an open data portal (datos.minem.gob.ar) to provide access to information on energy supply and demand, including via mobile applications, critical in a more and more digitalised world. German energy regulator Federal Network Agency created an open internet-based electricity market information platform (www.smard.de).

Moreover, many governments have programmes which provide a comprehensive picture of the energy landscape to citizens through a detailed coverage of various energy related topics and scenarios (Argentina, Chile and Singapore). Countries publish annual reports to track and monitor progress towards the energy and climate targets.

To encourage public participation and engagement in critical energy reforms for energy transitions, countries provide opportunities for citizens to contribute through national polls, public consultations, and dialogues including online (Brazil, Republic of Korea, and Spain). The creation of energy transition councils and committees (Chile, Italy, Mexico, and the Netherlands) are successful ways to reach a cross-party and societal consensus on the targets and policies needed, involving industry, consumers, citizen and NGOs alike. Public acceptance of new energy infrastructure is part of the energy transition challenge (Chile, Republic of Korea noted this). Direct participation of citizens in decentralised renewable investment with community shareholdings is used in several countries, besides underground cables or HVDC lines to reduce impacts of network expansion on citizens. Citizens´ participation in the decision-making process on where and how to construct new power lines is critical for public acceptance.

Many governments are committed to legislate or revise the various energy-related laws in order to secure supply security, affordability, efficiency, and transparency of the power system over time. Countries reformed their renewable support schemes to ensure financial stability of the electricity system (Germany, Spain). The cost of energy during the transition is a focus for the UK government, which is conducting a comprehensive review.

Openness and transparency are also critical for attracting energy investment. According to many countries' submissions, the key principles to encourage market responses and price signals to secure private and public investment needed are transparent and open procedures for clean energy auctions, tenders, bidding mechanisms and the award of contracts and licenses, besides deregulated prices, dedicated regulatory and market authorities as well as transparent energy market laws and regulations. For example, Mexico informed about its clean energy auctions, which are organised by the Mexican authorities (SENER, CRE and CENACE, the national control center) and operated via an open Market Information Centre.

G20 actions going forward

A broad range of possible G20 actions on energy transitions were suggested, including a call upon the G20 to:

- send strong signals on energy transitions and for energy policy, share best practices and strengthen technology collaboration among all member countries (Argentina, Japan, Singapore)
- share experience in planning and monitoring of policies to support compliance with the Paris Agreement (Brazil)
- build consensus on future-oriented strategies, policies and collective action to address common challenges and towards common goals (China)
- monitor and implement existing G20 commitments (Republic of Korea) and previous G20 action plans (China)
- collaborate on ambitious energy systems transformations in line with the priorities of the G20 Hamburg Climate and Energy Action Plan for Growth of 2017 (Germany)establish standards for the interoperability of energy information (Argentina)
- strengthen technical cooperation of G20 with non-G20 countries on energy efficiency, gathering, dissemination and analysis of knowledge and information for G20 members, and identifying potential trilateral activities to have better data collection for building energy efficiency indicators (Mexico, Spain, Turkey)
- support policies in order to achieve further climate change adaptation and resilience (Mexico)
- support adoption of best practices to increase flexibility (Brazil), promote energy security (Turkey) and encourage members to improve energy market design and enable further market integration at national and regional level (Argentina, Brazil, Indonesia, Spain)

- develop a G20 vision-roadmap that includes market design options that can provide some useful guidance to cost-effectively integrate and adapt electricity markets to higher VRE (Spain)
- cooperative mechanisms that enhance global gas value chains, diversify LNG contract terms and promote gas trade, including small scale LNG and bunkering and facilitate innovative financial and investment models through IFIs for infrastructure projects to expand the use of natural gas beyond power (Singapore)
- boost the rate at which policy innovations and effective policy practices focused on digitalisation spread internationally through G20 analysis (Spain)
- foster collaboration on R&D&D in clean technologies to better afford energy transition and contribute to decarbonisation (Italy) and technology transfer (Indonesia, Singapore, Turkey) and technology innovation to foster energy productivity (Spain)
- encourage discussion on mechanisms to support technology transfer, financial access and business-friendly mechanism in energy investment in capital intensive energy infrastructure (Argentina, India, Indonesia, Turkey) and boost finance and investment in clean energy through the G20 Finance work stream (Spain)
- strengthen interaction with non-government national organisations on energy transitions (Republic of Korea).

I-3 Voluntary National Self-Assessments submitted

Argentina

Country:	Argentina

Evolution of the energy mix

One key feature of Argentina's energy mix is its high share of hydrocarbons. Although such feature has been maintained over time, its evolution during the last decades marks a process of substitution of oil by natural gas. According to the National Energy Balances (NEB), it can be seen, as indicated before, that while in 1960 the share of oil reached 72 %, and the share of natural gas reached 7 %, in 2016 these shares were considerably modified. Oil share decreased to 32 % in the Total Primary Energy Supply (TPES), whereas natural gas increased its incidence to 54 %. Additionally, in this same period, the share of mineral coal decreased from 6 % to less than 1 %.

Regarding the rest of the energy sources, Argentina´s energy mix currently shows a significant share of hydroelectric and nuclear energy (4 % and 3 % respectively), although such shares have been decreasing in the last decade. However, when compared to 1960, both have grown. The current share of renewable sources consists mostly of biomass and other biofuels (e.g. biodiesel and bioethanol).

Other distinctive feature of Argentina's energy mix is the link between the evolution of the Argentine energy sector and of the economy. In 1960 the TPES was 16,971 thousand tons of oil equivalent (ktoe), while in 2016 it was 80,060 ktoe, a variation that represents a compound annual growth rate (CAGR) of 2.8 %. Considering the same period, the economy grew at an average rate of 2.5 %. This link is still maintained when shorter horizons are considered.

Regarding the power sector, the installed capacity increased from 15,367 megawatts (MW) in 1990 to 33,901 MW in 2016, registering a 3.1 % CAGR. Thermal generation was the dominant technology with a share of 46 % of the energy generated in 1990 and 66 % in 2016, while hydroelectricity accounted for 38 % of the generation in 1990, falling to 26 % in 2016. Additionally, nuclear energy and unconventional renewable sources[1] registered a contribution of 16 % and 0 % to the energy generated in 1990, while in 2016 their contributions were 6 % and 2 %, respectively. It is important to note that the preponderance of thermal generation throughout the period 1990-2016 shifted its major fuel input consumption from natural gas during the 90s to liquid fuels. This, administration is working on reversing such trend.

According to the National Inventory of Greenhouse Gas Emissions (NIGHG) for 2014, presented in the Second Biennial Update Report (BUR), the energy sector emitted 193.5 million tons of CO2 equivalent (MtCO2e) in 2014, which represents approximately 53 % of the total greenhouse gas emissions at a national level[2].

1 Wind power, solar PV, small hydro, biomass, biogas, liquid biofuels.
2 The energy sector includes all GHG emissions that emanate from the combustion of fuels for energy purposes and fugitive emissions. Emissions from non-energy uses of fuels are not included in this sector, but are reported within Industrial processes and product usage.

Energy transition outlook and policies 2030/2050

Argentina is working on a cleaner deployment of its non-renewable resources. The purpose of this strategy is to ensure energy security while reducing the impact on the environment, incorporating a greater share of cleaner fuels (e.g. natural gas) and renewable technologies in the energy mix, together with active energy efficiency and social inclusion policies; while passing the appropriate regulation, and considering flexibility and competition, which are key elements in the market.

Every year, the Ministry of Energy and Mining drafts long-term energy scenarios. These prospective designs are an analytical tool for dialogue and discussion on potential paths of the Argentine energy sector towards this transition.

Based on the latest available version of the report on scenarios to 2030, we can assess the challenges involved in the transition process. Considering an articulated and ambitious set of policies on energy savings and efficiency, the final energy consumption growth rate for all the country for the period 2016-2030 will be 1.7 %., that is to say, 74 Mtoe by 2030, which accounts for a saving of 10.2 % by the same year, when compared to the scenario that does not contemplate this set of policies.

During this period, the implemented policies should result in a decoupling between the final energy consumption and the economic growth, a decoupling proven by the ratio between the expected compound annual growth rate of 1.7 % for energy consumption versus an expected CAGR of Argentina's GDP of around 3 %.

In terms of energy supply, although the aim is to further diversify the energy , this administration believes that delivering the full potential of Argentina's significant hydrocarbon resources, especially natural gas, will allow us to catalyze a process that contemplates a greater addition of low-carbon sources that will consistently reduce CO_2 emissions.

Regarding unconventional renewable sources, Argentina has a mandatory target which provides that, by December 31, 2025 at least 20 % of the total consumption of electricity must be generated from unconventional renewable sources[3], which means that installed unconventional renewable generation capacity must increase to 10,000 MW from its 1.5 % participation in 2015. In order to achieve this objective, the RenovAr Programme has been launched and included a series of tax credits and financing mechanisms. The programme has already awarded 147 projects along the country, which account for almost 4,500 MW.

The total internal energy supply in the scenario with active efficiency policies in 2030 is close to 105 MMtoe. The impact of energy savings and efficiency measures with respect to a trend scenario is approximately 12 MMtoe, when measured on the internal supply.

In relation to its potential composition, a majority share of hydrocarbons will persist due to a 52 % participation of natural gas. Nevertheless, it is estimated that the share of oil will decrease to 26 %.

In addition, the described scenario shows an increase in the share of unconventional renewable energies by 2030, which means more than doubling its relative share in 2016. The continuity of nuclear energy policies as well as the sustainable development of

3 The energy sources that can be computed for this target, according to law 27,191, are wind power, solar thermal, solar pv, geothermal, wave and tidal, small hydro (capacity < 50 MW), biomass, biogas, and other biofuels.

hydroelectric uses have allowed for an increase in the participation of these sources in the total internal energy supply throughout the last five years of this period, representing 7 % and 5 %, respectively. Hence, 22 % of the internal energy supply is covered with zero emission sources.

Towards cleaner energy systems

As previously mentioned, the diversification of the energy mix consists of a crucial strategy to achieve Argentina´s energy policy main objective, which is to ensure energy security. In other words, to have accessible energy supply from diverse sources and at reasonable prices, while mitigating the impact on the environment. Therefore, a set of measures tending to develop different energy sources in a complementary way, ranging from renewable energies to unconventional hydrocarbons has been released. This diversification includes in its genesis a policy of technological neutrality in order to make necessary adjustments according to the deployment of the different energy sources.

In this context, natural gas clearly plays a key role, not only because of its importance in the current energy mix, but also because it is considered a transitional energy resource on the way towards a cleaner and more sustainable energy mix. This insight intends to guarantee an integral and well-articulated energy sector perspective, where all the sources complement each other.

Thus, Argentina´s energy policy seeks to provide regulatory and market conditions necessary to promote the development of the hydrocarbon activity, particularly, offshore and unconventional resources, while looking at their efficient and sustainable use. The incorporation of advanced technology will allow for cost reductions that contribute to the competitiveness of the sector and the economy. Moreover, this technological improvement will facilitate the inclusion of skilled labor while respecting the best international practices that seek to mitigate the impact of the activity on the environment. In this framework, an incentive programme for the production of unconventional resources has been set up. The aim of this programme was, through a stimulus price until 2021, to enhance the learning together with the development of processing infrastructure, transportation and sufficient distribution to achieve an economic scale of production.

Furthermore, the incorporation of renewable generation, the construction of large hydroelectric dams and the continuous development of nuclear power plants will be crucial. The existence of alternative sources that complement each other will allow the electricity sector to have a resilient structure with a rapid response capacity to face temporary difficulties.

However, it is necessary to emphasise that renewable energies and energy efficiency will be priority issues to achieve the complementarity between sources that will guide the steps towards a future generation mix.

Therefore, we will continue with the incorporation of renewable generation, in compliance with the target set forth in Law 27,191, to cover 20 %[4] of the electricity demand by 2025, and with the targets committed in the framework of the SDGs (15 % of renewables in the final consumption mix by 2030). In addition to the incorporation of

[4] Energy Scenarios 2030 considers a participation of approximately 25% of the demand for the last year.

wind, solar photovoltaic, solar thermal, small hydroelectric, biogas and biomass, the incorporation of other renewable sources such as geothermal, wave and tidal, and any other source that could be competitive in the future will be also fostered.
In terms of energy efficiency, a cross-cutting issue of the energy policy, we are working to strengthen the development of information systems, which allow us to identify the savings´ potential and design specific programmes. This starting point will encourage the design of cost-effective measures that promote efficient investments by energy consumers. Furthermore, it will set the conditions for the emergence of efficiency and performance markets. A clear educational policy at all levels could also be a significant tool to promote energy savings.
Additionally, biofuels will significantly contribute to this transition. The intention is to increase the share of biofuels, not only by incorporating vehicles with Flex-Fuel technology, but also by increasing the minimum blend of biodiesel on diesel for urban and interurban passengers and heavy load transport (initially applied on captive fleets).
Finally, this transition requires an intelligent energy integration with the rest of the world, in particular, with the countries of the region. As a result, the national energy policy could take advantage not only of the potential complementarities of the systems, but also of the capitalisation of the learning process regarding the development of new technologies. Argentina will continue to enhance processes and techniques, while encouraging and allowing for innovation in all segments of the energy chain.

Trends towards flexible energy systems

In Argentina, there are several sources that give flexibility to its electricity system, either through rapid response generation machines and hydroelectric dams, or by means of the integration with neighboring countries. However, the future Argentine electricity mix will require continuous improvements in each of these aspects.
The further development of alternative energy sources that complement each other will allow the electricity sector to have a more resilient structure with a rapid response capacity to face temporary difficulties.
Regarding thermal generation, investments will be promoted in more efficient, flexible and competitive units, such as rapid response centers set forth by Resolution 21/2016, by means of which a total of 3138 MW was awarded. At the same time, this will contribute to increase the availability levels of the thermal power.
As for hydroelectric generation, the incorporation of the Cóndor Cliff, La Barrancosa, Chihuido I, Tambolar and Portezuelo del Viento power plants is planned under the portfolio of strategic projects under analysis. At the same time, necessary actions will be carried out to improve the development of binational energy exploitation, such as the expansion of Yacyretá, or other potential projects with neighboring countries.
The incorporation of thermal and hydroelectric generation mentioned above is fundamental for the installed capacity, since they represent a source of energy that complements the volatility of renewable energies, while providing security and reliability to the system. Thus, achieving an efficient and modern thermal installed capacity as well as increasing the hydroelectric reserve capacity will contribute to the reliability and safety of the system.

On the other hand, the development of interconnection infrastructure with neighboring countries, in addition to the existing one with Brazil and Uruguay, is a strategic objective when looking for an integrated and secured system. These interconnections are also important since they allow for the compensation of renewable energies, and promote exchanges between countries that have generator matrices with different structures, resulting in a complementarity of national energy resources while offering the possibility to deal with emergencies, diversifying the supply and decreasing the sector´s environmental impact.
Another point to highlight is the effort to improve the existing electric transport network, since it will require investments in the high, medium and low voltage lines. The risks will be minimized and the stability of the system will be maximised in the event of unforeseen events, such as the loss of a link or a generating unit. At the same time, the new networks must have that the capability to allow for the transmission of future generation, especially renewables, which locations are largely distant from demand points and from high-power plants (hydroelectric and nuclear). Therefore, in order to correct existing problems and strengthen the transport system, and support demand growth, 2,175 km of 500 kV lines will be bid in 2018.
The continuous promotion of the interaction and correlation of information systems and technological communication will allow the system to increase flexibility and integration of the energy system, to support the development of demand response schemes, the integration of variable renewables, distributed generation, smart meters and intelligent charging of electric vehicles, etc.

Towards transparent energy systems

Openness and transparency are key components in good governance and in the process of developing public policies. Bearing these objectives in mind, several initiatives were considered since the current administration took office in Argentina.
First, an integrated energy information system has been launched. This system seeks to become the main source of statistical information on the energy sector in the country, by providing consistent and high-quality data under the principles of impartiality, openness and transparency. The system is both fully accessible and integrated with the National Statistical System. Simultaneously, MINEM´s open data portal (datos.minem.gob.ar) was also launched, providing open access to more than 260 data sets related to energy resources, production and management through APIs and traditional downloads in open formats. This tool adds value to all the information gathered by the Ministry of Energy and Mining, within the framework of the Open Data Plan set forth by Decree 117/2016, promoted by the Ministry of Modernisation.
Also within the framework of the government´s agenda on digitalisation, the INNOVA Energy programme was launched. Some new tools were developed, such as the "Gas price at the Pump"- a mobile application that allows consumers to know in real-time, with geo-referenced locations, prices for gasoline, diesel oil and CNG throughout the country.
Within the framework of this continuous improvement and learning process, a Memorandum of Understanding with the International Energy Agency (IEA) was also signed in order to strengthen statistics and energy planning.

In the same direction, the first steps were taken for Argentina's nomination for the adoption of the EITI (Extractive Industries Transparency Initiative) Standard, which promotes the disclosure of physical and money flows from the hydrocarbon and mining industries.

Both federal level Energy Regulatory Agencies (ENRE, for electricity and ENARGAS for natural gas) were normalised in order to make public policy more transparent. A comprehensive tariff review process for utility companies in the energy sector (RTI, as per its acronym in Spanish) was carried out. According to concession contracts, such rates should be reviewed every five years. The review process was complemented by public hearings, as ordered by the Supreme Court of Justice.

The procurement processes – the selection of bidders, tendering procedures and the award of contracts – became open and transparent, as proved by the purchase tenders for liquefied natural gas (LNG) to be delivered to two import terminals and by the tenders associated with the renewable energy programme, RenovAR.

Consultations with local governments, civil society and social actors were also among the government's priorities. First, on the initiative of the Ministry of Energy and Mining (MINEM), a Federal Energy Agreement (AFE) between the national and provincial governments was signed. This agreement aims to develop and foster the implementation of energy policies at Argentina's provincial and federal levels. Second, the Platform for Energy Scenarios was launched in order to promote the development of a long-term sustainable energy vision through an open dialogue process (MINEM-ITBA-AVINA-CEARE / UBA). Scenarios use rigorous research and analysis to visualise the different options available for the energy future in this country. Finally, the initiative "Towards a 2050 Argentine energy transition" was launched. More than 30 actors representing the energy sector, academia, civil society and consumers will discuss the challenges and agreements on the Energy Transition of Argentina by 2050.

G20 actions going forward

In the recent meeting of the Energy Transitions Working Group (ETWG), a majority agreement has arisen with respect to the term "Transitions" (plural), with the aim of using terminology that could represent the non-univocal way in which each country carries out the energy transition according to its own characteristics. Nonetheless, the intention to collaborate together in order to achieve a common goal requires the setting a series of priorities. According to Argentina, the following items should be discussed in future meetings:

- Strengthening the existing bonds and creating synergies among the different countries with the purpose of sharing experiences and knowledge regarding regulation, development and implementation of new technologies;
- Discussing mechanisms in order to facilitate the financing and transfer of resources to enable projects or infrastructure that facilitate the transition process;
- Promoting regional and international integration in order to improve energy security;
- Establishing standards that allow the interoperability of energy information.

Brazil

Country:	Brazil

Evolution of energy mix

Since the 1970s, the Brazilian energy matrix underwent a significant change in its composition. At the beginning of this period, with a large part of the population living in rural areas, firewood and charcoal were the basis of our mix, with more than 40% of the domestic supply.

In the last decade, the share of sugarcane biomass and hydropower, which remained stable, jointly accounted for around 30% of the available energy. These sources are the main contributors to the high percentage of renewable energy in the Brazilian energy mix (43.5% in 2016), one of the highest renewable share in the world. Petroleum and oil products accounted for 36,5% of the total energy supply of 2016.

From 2000 to 2016, the average annual rate of CO2 emissions grew 2.5% per year. According to the International Energy Agency, Brazilians emit, on average, seven times less than Americans do and three times less than individuals in Europe or China. In 2016, the total anthropogenic emissions associated with the Brazilian energy matrix reached 429 MtCO2-eq, with the transport sector accounting for 45%.

Since 2000, there was an increase of energy intensity from 0.097 *toe / thousand 2010 USD* to 0,101 *toe / thousand 2010 USD*. In the same period, there was a more pronounced increase in *TPES / capita*, going from 1,088 to 1,394.

Energy transition outlook and policies 2030/2050

For the period from 2013 to 2050, the total Brazilian energy demand is expected to double at a rate of 2.2% per year, with a notable increase, in quantitative terms, of natural gas, electricity, oil and sugar cane derivatives. In terms of share, we expect a drop in oil products due to the penetration of biofuels in the transport sector, especially ethanol in light vehicles. In the next 10 years, electricity consumption is expected to grow twice as fast as the total energy demand.

Concerning energy use sectors, we can highlight the expected increase in participation of the commercial sector - also reflecting its increasing participation in the economy in the long term. The shares of the transport and the residential sectors in the total energy consumption are expected to decrease, due to energy efficiency gains in the former and, in the latter, the shift from firewood to natural gas, efficiency gains in lighting and the use of solar energy for thermal heating. The effects of investments and policies to increase the energy efficiency of the economy, such as the National Logistics and Transport Plan (PNLT), energy efficiency policies and the diffusion of new automotive technologies are expected to be seen after a 10-year period.

Regarding the power sector, Brazil has potential for deploying large amounts of renewables, with competitive prices, from different sources, such as wind, solar PV, biomass and hydro. Such expansion has been contracted under competitive auctions, with demand allocation being oriented by planning studies. There is increasing need for untapping flexibility from existing assets, as well as reinforcing the transmission and distribution infrastructure. Natural gas is an alternative for complementing renewable resources.

With regard to liquid fuels, we can highlight RenovaBio, a State policy that aims to draw up a joint strategy to recognize the strategic role of all types of biofuels in the Brazilian energy matrix, both for energy security and the reduction of greenhouse gases. This policy can make the country less dependent on oil and oil products.
In addition, energy efficiency is a key dimension of the energy transition. Brazil has been working on a series of policies to untap the potential for energy efficiency gains in various sectors (appliances, buildings, industry, transport), including an Action Plan with concrete measures and indicators.

Towards cleaner energy systems

The share of renewable sources in the Brazilian energy matrix was 43.5% in 2016. This is mainly due to the share of hydroelectric power and biomass from sugarcane. The expansion of hydraulics, however, increasingly faces higher economic costs and social constraints. Thus, in the power sector, Brazil faces the challenge of maintaining its high share of renewables in the mix while addressing the growth in demand necessary to support economic and social development and ensuring affordable access to energy.
The country has a portfolio of potential renewable resources to be deployed. The following key elements need to be addressed: (i) securing the investment needed in power generation and transmission; (ii) synchronizing investments in power generation and transmission; (iii) ensuring infrastructure is deployed according to the best practices in terms of environmental impact assessment and mitigation; (iv) tackling non-technical losses in the distribution level; and (iv) enabling investments in the modernisation of the distribution grid and efficient incorporation of distributed resources (such as demand response and distributed generation etc).
In expanding these renewable sources, the country faces the challenge of adapting its market design and planning tools to higher shares of variable sources and a more responsive demand.

Trends towards flexible energy systems

The Brazilian electrical matrix has been predominantly hydraulic over the past decades. Nowadays, the Brazilian Interconnected Power System has about 60% of its installed capacity coming from hydroelectric power plants. The contribution of thermal power plants represents around 15% of the Power System Capacity.
Following the main global trend, the Brazilian Power System has also progressively increased the share of variable and renewable energy into its portfolio, especially wind and solar plants, located in the Northeastern region.
As a result, the following measures of flexibility are currently under consideration to address this change in the power supply mix: (i) the reinforcement of the transmission network, with interconnection between regions with different flow regimes and basins characteristics, as well as the complementarity of wind, solar, biomass and other resources; and (ii) the incorporation of thermal plant technologies in order to complement and maintain the power system reliability and cost-effectiveness of the operation, especially during periods of limited VRE resources. Besides the hardware and infrastructure items mentioned earlier, other relevant actions focused on regulatory and market framework are being undertaken to enhance and help unlock the flexibility of

existing power supply. This approach accommodates demand response pilot projects in areas with high penetration of VRE and the implementation of hourly pricing, since changing the tariff structure can support a more efficient use of the diverse attributes associated with each generation technology.
Another flexibilization factor of our electric matrix was the National Electric Energy Agency (ANEEL) Normative Resolution 482/2012, which allows Brazilian consumers to generate their own electricity from renewable sources or qualified cogeneration and even direct the surplus to the distribution network of their locality. It is called the micro and mini distributed generation of electrical energy, an innovation that can ally financial economy, social-environmental awareness and self-sustainability.

Towards transparent energy systems

We can mention a series of improvements in terms of transparency:

- More publicity regarding the methodology and input data for the elaboration of the 10-year energy plan, followed by public consultation;
- More consistency between the energy planning studies and the energy auctions;
- Public consultations to elaborate a proposed reform of the power market legal framework, aiming to enhancing the future of the power sector, with long-term sustainability; reducing distortions in economic signals; and turning it into a more innovation-friendly environment. Market agents, financial institutions, industries as well as citizens have had the opportunity to contribute with their ideas and opinions.
- The "Gas to Grow" Initiative, by the Ministry of Mines and Energy, stimulated a long discussion process, with multiple stakeholders, on the reform of the natural gas sector market design, to increase transparency for market players.
- In relation to energy efficiency, a number of workshops and trainings have been conducted with the assiduous participation of government, universities, industry and society in general.

G20 actions going forward

G20 must ensure that countries have access to the best energy planning tools and have the chance to share experiences on implementing and monitoring policies, with a view to support the compliance of the Paris Agreement. It's also important to encourage its members to enhance their market design and enable further energy integration. Finally, the group must encourage discussions on the development of new technologies and the adoption of best practices to reach flexibility and energy security.

Chile

Country: Chile

Evolution of energy mix

The primary energy supply has doubled (and even more) in the last 25 years: in 1990 it was 140,000 [Tcal], while in 2016 was 375,000 [Tcal]. On the other hand, in 1990, the final energy consumption was 111.000 Tcal, while in 2016, it was 284.777 [Tcal], that is to say, a rise of 127%. Nevertheless, the intensity of energy (final consumption divided by GDP) has diminished in time, which is a signal that the economy is moving towards decoupling the economic activity and the use of energy[5].

Historically, hydropower has been the main resource for electricity generation, so, the availability of electricity depended, to a great extent, on the climatic conditions. As a way to improve energy security, interconnection infrastructure was developed extensively with Argentina for the importation of natural gas, directed mainly to the operation of thermoelectric plants. The primary energy matrix and the power generation matrix were changing, moving from a highly water-dependent situation to one that is more dependent on fossil fuels. While in 2006, oil and natural gas took an important part of energy supply, in 2016 their shares had been reduced significantly, and the importance of biomass and coal increased, in addition to the appearance of wind and solar energy.

Chile depends, to a large extent, on the import of energy. In 2015, the ratio of imports versus final energy consumption was 95%. According to each energy product, Chile depends, largely, on imports of oil, natural gas and coal, as opposed to renewable energy sources, such as biomass, water, solar and wind energy, which are 100% produced in our country.

As for energy consumption, in the last 10 years it has increased by 18%. On average, energy demand grew by 2% per year, between 2006 and 2016. More than half of the final consumption corresponds to petroleum derivatives, which is largely due to the consumption by the transport and mining sectors. In second place is electricity, and thirdly biomass.

In 2013, the balance of Greenhouse Gases (GHG) emissions and removals in Chile was 70,054 [Gg CO2 eq], while total GHG emissions in the country were 109,909 [Gg CO2 eq], an increase of 113% since 1990, and of 19% since 2010. The key drivers of this trend in the GHG balance were the Energy and the Agriculture, Forestry and Other Land Use (AFOLU) sectors. In 2013, the total GHG emissions were dominated by CO2, accounting for 78%, followed by CH4 (11%) and N2O (10%).

The Energy sector is the leading GHG emitter in Chile, accounting for 77% of total GHG emissions in 2013. That year, GHG emissions from the sector were 85,075 [Gg CO2 eq], an increase of 156% since 1990 and of 23% since 2010. In general, this is mainly due to the increase in energy consumption in the country, including the consumption of coal and natural gas for electricity generation and consumption of liquid fuels, mostly diesel and gasoline, for road transportation.

[5] National Energy Balance (BNE - Ministry of Energy) and International Energy Agency (IEA) database.

In the following sections Chile's actions and policies towards an energy transition are described.

Energy transition outlook and policies 2030/2050

In December 2015 the document "Energy 2050 - Chile's Energy Policy" was published, which proposes changes in the main vision of the energy sector to the year 2050, making it reliable, sustainable, inclusive and competitive. This policy was made through a participatory and transparent process, called "Energy 2050", which included the constitution of an Advisory Committee, led by the Minister of Energy, with key actors from the energy sector, as well as representatives from all of the regions coming from public institutions, private sector, social society and universities. The elaboration of this policy was supported also by products that came from the citizens:

- 130 technical workshops with over 3500 participants.
- The Advisory Committee held 30 mass meetings and 150 work focused groups meetings.
- 3 deliberative events with 217 participants.
- Regional workshops for public consultation held over 420 participants.
- The comments about the public consultation reached the number of 717, said comments were sent through the website and through letterboxes placed in the regional workshops.

It is relevant to highlight that the whole process of Energy 2050 was accompanied by a Strategic Environmental Assessment.

Within the framework of the National Energy Policy and within the energy transition that the Ministry of Energy has been promoting, a series of initiatives had been developed:

1) Políticas Energéticas para zonas extremas: Política Energética para Aysén y para Magallanes y la Antártica Chilena. (Energy Policies for extreme regions: Energy policy for Aysén and Magallanes and the Chilean Antarctic Territory)
2) Política de Desarrollo Local Sostenible y Asociativo, vinculado a proyectos de energía (Sustainable and Asociative Local Policy, linked to energy proyects).
3) Estrategia de Ciencia, Tecnología e Innovación (Strategy for Science, Technology and Innovation).
4) Estrategia de Educación Energética (Energy Education Strategy).
5) Estrategia de Electromovilidad (Electromobilty Strategy).
6) Planificación Energética de Largo Plazo. (Long Term Energy Planning)
7) Plan de Mitigación de Emisiones de GEI (Mitigation Plan for Greenhouse Gases emissions).
8) Plan de Adaptación al Cambio Climático del Sector Energía. (Climate Change Adaptation Plan for the Energy Sector)
9) Plan Estratégico Nacional para la Gestión del Riesgo de Desastres (Strategic National Plan to the Disaster Risk Management).
10) Programa Comuna Energética (Energy City Program).
11) Programa de capacitación "Mi Hogar Eficiente" (Training Program "My efficient home").
12) Programa "Más Leña Seca" ("More Dry Firewood" Program).
13) Programa Techos Solares Públicos. (Public Solar Roofs Program)

14) Política de Uso de Leña y sus Derivados para Calefacción (Policy for Firewood and its derivatives use with heating purposes).
15) Guía de Estándares de Participación (Guide for Participation Standards).
16) Ley de Transmisión Eléctrica (Electric Transmission Law).
17) Ley N° 20571 para la Generación Distribuida. (Law 20.571 for Distributed Generation)

Currently, the Ministry of Energy is carrying out a participative process for the development of the "Ruta Energética 2018-2022", road map to define the actions and goals to be achieved during the following four years. The Ruta Energética is being elaborated through a participatory process, including all sectors (public, private, academy and civil society), and 15 regions in Chile.
In view of the above, and regarding to energy projections, in the Long-term Energy Planning ("Planificación Energética de Largo Plazo PELP") process, led by Ministry of Energy between 2016 and 2017, three levels were defined for the projection of energy demand: the high level, which considers an optimistic economic growth trajectory, high penetration of electric light vehicles and buses and air conditioning in homes with high electrification; the medium level, which considers the referential economic growth trajectory and projected parameters based on current trends (energy efficiency, air conditioning, among others); and finally, the low scenario, which also considers the trajectory of referential economic growth plus a high penetration of energy efficiency measures[6].

Below, is the energy demand of each scenario by 2030:

- Low: 357,559 [Tcal] on 2030: 65% oil products; 19% electricity; 8% biofuels, and 8% others.
- Medium: 378,668 [Tcal] on 2030: 63% oil products; 20% electricity; 9% biofuels, and 8% others.
- High: 381,296 [Tcal] on 2030: 62% oil products; 21% electricity; 9% biofuels, and 8% others.

In the case of high energy demand, an average annual growth rate of 2.1% was considered, in the case of average energy demand was 2% and in the case of low demand was of 1.5%. It is important to note, that the difference between high and medium energy demand is mainly due to economic growth and consumption electrification (transport and heating), the latter being an efficient substitution of energy. The transport sector leads the expansion of demand, although, to a lesser extent in the case of the high trajectory, since this case considers high penetration of energy efficiency measures.
In terms of electricity supply, five scenarios of equal probability were built. Below, is the composition of the electrical matrix of the scenario with the lowest participation of renewable electricity generation and the scenario with the largest share by 2030:

[6] Actually, no specific energy efficiency measures have been established yet, just an overall goal in Energy 2050 policy, related to decouple energy demand from economic growth. So, in PELP, some measures, for Mining, Transport, Residential and Commercial sectors, were supposed for Low demand projection.

- The less renewable generation matrix is composed of: 35% hydroelectric (dam and run-of-river), 36% coal, 10% on-shore wind, 8% PV solar, 11% others.
- The most renewable generation matrix is composed of: 34% hydroelectric (dam and run-of-river), 29% coal, 16% PV solar, 11% on-shore wind.

Towards cleaner energy systems

In 2014, when the solar revolution in Chile was started, the situation was critical. The electricity generation mix was highly dependent on imported fossil fuels, mainly coal plants [1]. At that time, the share of solar energy in total energy production was only 1% [1]. Moreover, in 2013 the electricity supply price for householders was 161 [USD/MWh] [2], one of the highest in the Latin American region. The electricity sector was affected by a variety of internal and external factors.

The public opinion was against the development of more coal plants but there was also strong opposition to the construction of the large hydropower dams in the south of the country [4]. The solar energy produced in the Atacama Desert, was not available for consumption in the central and southern regions. There was no interconnection between the electric systems of the north (SING) and the central-south (SIC). High prices, an energy mix dominated by fossil fuels and scarce competition were a concern from the public policy point of view [3].

Nowadays the situation has changed radically, and one of the main contributors has been solar energy production. By February 2018, the installed capacity of renewable energies in Chile (including large hydro power) reached 47%[7]. Where the hydro plants represent 29%, solar power plants represent 9% (which 78% of them have been installed in the last 3 years), and wind power plants are 6%.

Besides, for final consumers in Chile, electricity had traditionally been relatively costly. The introduction of the new Tenders Law (Law 20.805) in 2016, aims to reduce electricity tariffs and encourage market competition. In recent tenders, prices have decreased, and the number of participants increased, dramatically. In the 2012 tender, there was just one participant and the price peaked at United States dollars (USD) 131 per MWh (/MWh). In 2013, two generators participated, supplying at high prices, again. Since then, many new generators have entered on the tenders: in 2014, the number of participants rose to 18, in 2015 to 38 and in 2016 it jumped to 84. In 2017, there were 24 participants. In the 2017 auction, 2.2 [TWh] per year, from 2024 to 2044, were contracted at the record-low price of USD 32.5/MWh. 46% of the supply will be from new renewable electricity projects (25% is a mixed solar/wind generation, 16% is only solar and 5% is wind) [5].

In September 2014, the Congress passed a Tax Reform Law that included three new taxes ("green taxes") on the emissions of: CO2, Sulphur Dioxide (SO2), Nitrous Oxides (NOx) and Particulate Material (PM) from power plants that add up to, at least, 50 [MW] of installed thermal capacity. This was the first green tax in, both, Chile and the whole of South America. The government considers the tax on CO2 as the first step the country has taken in putting a price on carbon. Both, the reporting and verification processes for the emissions, are being developed.

The tax level for CO2 was set at USD 5/tCO2. The level is fixed and there is no provision for a steady increase or for an adjustment mechanism, yet. The tax level on local air

[7] https://www.cne.cl/estadisticas/electricidad/

pollutants (SO2, NOx and PM) are calculated on a case-by-case basis and depend on the population affected by emitting sources and the social costs derived from these pollutants, among other factors. The green-tax revenue is estimated at USD 170 million for 2018. CO2 emissions are expected to provide around 85% of the total.

As a part of the actions needed to intensify the transition pathways to clean energies, the Chilean Government has developed a collaborative process through the Chilean Economic Development Agency CORFO to draft a 2025 Roadmap called the Strategic Solar Program[8], which included participation by over 100 government, corporate, academic and civil society representatives [6]. This Roadmap seeks to take advantage of the Atacama Desert's unique features to develop a national solar power industry with technological capabilities and that is export-oriented. To this end, an initial portfolio of 50 initiatives was identified in order to cover the gaps of the industry [7], with a total budget of US$800 million for the period 2016-2025 [6].

The main objectives of the Strategic Solar Program are to reduce the levelized cost of photovoltaic technologies for the Atacama Desert conditions, from 80 USD/MWh by 2015, to below 25 USD/MWh, add from the 3,000 local jobs to more than 40,000 new jobs in the local industry, reduce 4.5 million tons of CO2/year and insert 100 companies into the solar industry value chain by 2025 [6].

At the same time, in 2014, the Ministry of Energy, supported by German BMUB-GIZ, launched the Public Solar Roofs Programme (PSRP) to stimulate the market for rooftop PV solutions by organizing tenders to encourage demand from public buildings, and considered a public investment of USD 6.4 million, approximately. The programme is deployed mainly in the regions of Arica and Parinacota, and Maule. During the first implementation stage in 2015-16, 300 buildings in 26 municipalities were evaluated and 99 projects developed with a capacity between 5 [kW] and 100 [kW]. The tenders organized as part of this programme, have contributed to the development of technical and institutional capacities, and to disseminate best practices. The tenders have resulted in a reduction in prices of solar systems from 4.5 USD/W to 1.31 USD/W, in less than two years. The prices reached by the programme demonstrate that self-consumption projects are profitable in Chile and that profitability is likely to increase, because the cost of PV systems continues to decline.

Trends towards flexible energy systems

Today, the main sources of flexibility for Chilean power system are: hydroelectric dams and LNG Power Plants, which represent 15% and 21% of total installed power capacity[9], respectively. But, lately, hydroelectricity contribution has decreased, related with hydrological years increasingly dry, as well as LNG power plants production, due to less availability of this fuel, related with global and local market conditions.

Besides, in the ex-Northern Interconnected System (SING), 41% of total installed power capacity are coal plants, which represent a huge dispatchable power, which, while not flexible as LNG, can go through maximum and minimum operation points, so, for example, wind and solar energy can be dispatched. Also, Independent System Operator (known as

[8] http://www.programaenergiasolar.cl/english/solar-committee/atacama-desert
[9] "Energía abierta", http://energiaabierta.cl

Coordinador Eléctrico Nacional), has the faculty to take actions or give instructions to consumers to disconnect from system, in order to, for example, keep Service Quality and System Security[10]. Similarly, ISO put into operation an AGC (*Automatic Generation Control*)[11] strategy, so power plants can be managed automatically, in order to keep system frequency, improving security, efficiency and flexibility of the system.

Further, in order to increase renewables energies penetration into the system, Chile needs to improve power system flexibility with other sources, like: regional market integration, specifically with neighboring countries, where previous studies have confirmed economic, environmental and security benefits; introduction of other energy storage technologies into the power generation matrix as CSP or Batteries; and LNG swaps and importation from Argentina, in order to use existing gas infrastructure (power plants, pipelines) and construct more, if required.

In this regard, many regulations and initiatives are being discussed or implemented, among which are:

- a hydro-pump power plants regulation, which aims to establish operational criteria for them, so investors can have certainty to develop a hydro-pump project, besides regulation about operation and coordination of National Electrical System (SEN)[12], which recognize energy storage systems as an installation of the SEN.
- an Ancillary Services regulation, which is still being revised, and aims to determine remuneration of additional services in order to give incentives for flexible power plants installation, further this market was formally established by Law 20.396 (*New Transmission Law)*;
- regional electrical interconnections studies in development, specifically, one about interconnection with Argentina[13], and another with Perú[14], which aims to determine technical and economic feasibility of each project, further these interconnections were established formally as a transmission line category by Law 20.396 and, nowadays, Chile is exporting electricity to Argentina through Andes – Salta transmission line.
- a recent agreement signed by Chile and Argentina (December 2017) to intensify LNG swaps, so Argentina can now export this fuel to Chile. An additional agreement is expected to be signed in April 2018.

Towards transparent energy systems

Since the year 2011, the Chilean public administration is ruled by a law that conducts how the People can participate in the public affairs ('Ley N° 20.500 sobre Asociaciones y Participación Ciudadana en la Gestión Pública'). This act ensures for the people, certain

[10] This is called "Desconexión Manual de Carga (DMC)" and is established in a Technical Annex of the Technical Standard (NT). https://www.cne.cl/wp-content/uploads/2015/06/Anexo-NT-Desconexi%C3%B3n-Manual-de-Carga.pdf
[11] http://www.revistaei.cl/2017/08/28/coordinador-electrico-nacional-pone-servicio-plataforma-control-automatico-generacion/
[12] http://www.minenergia.cl/archivos_bajar/ucom/consulta/Reglamento-de-Coordinacion-y-Operacion-del-Sistema-Electrico-Nacional-12-octubre-2017-consulta.pdf
[13] "Estudio de beneficios, despacho económico y análisis regulatorios / alternativas interconexión Chile – Argentina" (led by Banco de Desarrollo de América Latina)
[14] "Actualización de la interconexión eléctrica Chile – Perú" (lead by Banco Interamericano de Desarrollo)

ways and instances in which every citizen can participate in deliberative or binding processes about most every matter discussed in the public administration. In the Energy sector, this Law was considered for the elaboration of different participatory process, as Energy 2050 - Chile's Energy Policy; "Política Energética para Aysén" (Aysen Region Energy Policy); "Política Energética para Magallanes y la Antártica Chilena" (Magallanes & Chilean Antartic Energy Policy); "Política de Desarrollo Local Sostenible y Asociativo" (Sustainable & Asociative Local Development Policy), related to power projects; "Plan de Mitigación de Emisiones de GEI" (Greenhouse Gases Emission Mitigation Plan); between others.

Additionally, the Law N°20.500, obliges the Public Administration to create instances in order to guarantee people's participation in deliberative processes. The main instance is the "Consejo de la Sociedad Civil" (Civil Society Council) where every citizen can be part of, assuming a main role in the Public Policy Making.

Another act, regulates the lobby and the actions that represent private interest to the authorities and public servants. This law ensures mechanisms in order to secure the correct development about how the private sector influences the public management. The law has its own bylaw, ruling the mandatory publicity of the meetings or actions.

All the actions that had been took part on the energy transition process, are under the laws mentioned before. So, the Chilean government has different mechanisms in order to secure the transparency, the dialogue and the participation of citizens and the industry.

As well, Law 20.396, which establishes a New Electric Transmission System and sets up an Independent System Operator (ISO) ('Coordinador Eléctrico Nacional) for National Electrical System (SEN), sets that the Ministry has to lead a study, called "Estudio de Franjas" (Transmission Lines Easement Area Study), looking for different location alternatives of new electric transmission lines, considering environmental, social and technical-economical issues. In the context of this study, citizens and indigenous participation instances are considered, in order to include visions and interests of this participants on the decisions related to electric transmission lines construction.

Furthermore, since 2017, a programme called "Cuentas Claras, simples y transparentes"[15] (Transparent, simple and clear bills), is running, and seeks to give better information to consumers on gas and electricity bills. The development of this initiative was a participative process, including a public consultation, national polls and spaces for dialogues (workshops, meetings), so people's perception could be collected.

Similarly, since 2015, a multifunctional web platform called "Energía Abierta"[16] (Open Energy), developed by National Energy Commission, is running, and aims to reduce information asymmetries, enhancing transparency and encouraging citizen participation. Many statistics, indicators, maps, regulations, studies and web apps of the energy sector are available on this platform, to download easily and at no cost.

G20 actions going forward

The most important priorities for Chile and for the Ministry of Energy, are defined in the National Energy Policy 2050 [2, pp. 93-124], which includes a broad set of goals for 2035 and 2050, in several energy sectors, some of those are included in the next list:

[15] https://lab.gob.cl/convocatorias/proyecto-cuentas-de-la-luz-claras-simples-y-transparentes/
[16] http://energiaabierta.cl/que-es-energia-abierta/

2035:

- Clean Energy technology:
  - At least 60% of the electricity generated in Chile comes from renewable energy sources.
  - By 2030, Chile has reduced its GHG emissions by at least 30% compared to 2007.
  - Forest biomass as a solid fuel is completely regulated.
  - At least 50% of the fuels in the energy matrix should be low in GHG emissions and atmospheric pollutants.
  - Energy projects that come into operation adopt the Zero Net Loss of Biodiversity approach.

- Flexibility:
  - Provide flexibility and security to the electricity grid through its regulatory capacity.
  - Chile's interconnection with the other SINEA (Sistema de Interconexión Eléctrica Andina) member countries, and other South American nations, especially the members of MERCOSUR, is a reality.
  - The country has the institutional framework for managing risks and emergencies affecting the energy sector.
  - Chile has adopted national, regional and local plans to manage energy risks and contingencies. These plans are regularly updated through predefined procedures.
  - The complement to this renewable energy matrix should be using the existing generation infrastructure to contribute as much as possible to the efficient performance of the system. We must focus on new developments with technologies that are low in emissions and cost-effective, such as natural gas at present and other sources that will be developed in the future.

- Transparency/energy data:
  - The electricity system is completely bidirectional, with information technology systems making it possible to produce and manage energy at all levels of the system, in ways similar to other OECD countries.
  - An institutionalized and regulated process exists to ensure that all relevant stakeholders, organizations and communities are informed, trained and empowered with regard to the energy issues that interest them, and to build their capacities for generating local energy development opportunities.
  - All energy projects under way in Chile have adopted mechanism for associativity between communities and private sector thereby promoting local development and improving implementation of the projects.
  - Ensure universal and equitable access to modern, reliable and affordable energy services for vulnerable families.
  - 100% of large companies report and manage their GHG emissions, in a manner consistent with the country's commitments.
  - 30% of buildings have control and intelligent energy management systems.
  - Everyone who is interested in energy is well informed.

2050:

- Clean Energy technology:
  - Chile has become an exporter of technology and services for specific energy innovations.
  - At least 70% of the electricity generated in Chile comes from renewable energy sources
  - At least 65% of the fuels in the energy matrix should be low in GHG emissions and atmospheric pollutants.
  - The use of collective heating using biomass with emissions exceeding 0.5 g/h under any operating arrangement is predominant in saturated or dormant areas.
  - Greenhouse gas emissions by the Chilean energy sector are consistent with the global limits defined by science and with the corresponding national reduction goals, whilst promoting cost-effective mitigation measures.

- Flexibility:
  - The energy system is robust and highly resilient to external shocks.
  - The public, commercial and residential sectors make use of the potential for distributed generation and management of electricity demand.
  - Regional energy integration has become a reality, favouring supply security and economic efficiency.
  - The complement to this renewable energy matrix should be using the existing generation infrastructure to contribute as much as possible to the efficient performance of the system. We must focus on new developments with technologies that are low in emissions and cost-effective.
  - Contribute significantly to the goal of renewable energy having a 70% share of the electricity grid.

- Transparency/energy data:
  - 100% of the population has continuous quality access to energy services.
  - An institutionalized and regulated process exists to ensure that all relevant stakeholders, organizations and communities are informed, trained and empowered with regard to the energy issues that interest them, and to build their capacities for generating local energy development opportunities.
  - All energy projects under way in Chile have adopted mechanism for associativity between communities and private sector thereby promoting local development and improving implementation of the projects.
  - Ensure universal and equitable access to modern, reliable and affordable energy services for vulnerable families
  - Regional and municipal planning and land-use instruments are consistent with Energy Policy guidelines.
  - 100% of new buildings have control systems and intelligent energy management systems.
  - Everyone who is interested in energy is well informed.

- An energy culture exists at all levels of society, including among producers, suppliers, consumers and users.

Besides of this long-term energy strategy, the Ministry of Energy is developing a participative priorities process defined as the "Ruta Energética 2018-2022", that will be released in May 2018, and is going to include the main concerns, of every region, related to the energy sectors, like:

- Modernization of the Energy Sector
- Innovation in Energy Sector
- Competitive and efficient energy markets
- Distributed generation
- Energy education and culture
- Accessible and equitable energy
- Gender equality in the Energy Sector
- Project management and social developments
- Secure and quality energy services
- Energy efficiency
- Energy systems integrations
- Territorial ordering
- Sustainable Thermo-electricity
- Firewood and heating
- Electric mobility
- Renewable generation
- Climate change
- Regulation for the future

Also, the Government is working together with the coal plants owners in order to set a "Decarbonization Work Group", which already has an agreement signed, that they compromised not to build a new power plant that does not include the carbon capture technology on them, and in the future, define a methodology to guide the decommissioning plan for the existing coal plants.
And, as a part of the modernization of the energy sector, several regulations are being defined or updated like ancillary services, energy efficiency, capacity payments, operation and coordination, among others.

China

Country:	China

Evolution of energy mix

Data:

In 2005, the total energy production in China amounted to 2.29 billion tons coal equivalent (TCE), including 1.77 billion TCE of raw coal, 260 million TCE of crude oil, 70 million TCE of natural gas, and 190 million TCE of non-fossil energy. The total energy consumption was 2.61 billion TCE. Power installed capacity was 520 GW, of which fossil fuel power accounted for 75%, hydropower 22.7%, non-hydro renewable energy less than 0.5%.

In 2016, the country's total energy production was 3.46 billion TCE, including 2.41 billion TCE of raw coal, 280 million TCE of crude oil, 180 million TCE of natural gas, and 580 million TCE of non-fossil energy. The total energy consumption was 4.36 billion TCE. Power installed capacity was 1650 GW, of which fossil fuel power took up 64%, hydropower 20.9%, and non-renewable energy 13.5%.

Comments:

Structural adjustment is accelerated: the proportion of non-fossil energy and natural gas consumption rose rapidly, while the share of coal in energy consumption declined, which shows China's energy sector is moving faster towards being cleaner. The installed capacity of hydro, wind and photovoltaic power generation all ranks first in the world. The proportion of non-fossil energy installed capacity reached 35% of world's total, and newly added non-fossil capacity accounts for about 40% of the world's total increase.

2. Significant achievements have been made in energy conservation and emission reduction: In 2010-2015, the energy consumption per unit of GDP fell by 18.4%, and the intensity of CO_2 emission dropped by more than 20%.

3. China's energy consumption continues to grow. Being green and low-carbon has been the direction of energy development. The energy system continues to improve, and the international cooperation on energy continues to intensify.

Energy transition outlook and policies 2030/2050

I. Goals

2020:

1. Demand: The total energy consumption shall be within 5 billion TCE. China will control the total coal consumption to no more than 4.1 billion tons. It will increase the proportion of non-fossil energy consumption to over 15% and that of natural gas 10%, while reducing that of coal to no more than 58%.

2. Supply: Domestic primary energy production will be about 4 billion TCE, including 3.9 billion tons of coal, 200 million tons of crude oil, 220 billion m^3 of natural gas, and 750 million TCE of non-fossil energy. The installed capacity for power generation will be about 2000 GW.

3. Efficiency: Energy consumption per unit of GDP will fall by 15% compared to the level of 2015, and CO_2 emissions per unit of GDP by 18%.

2030 :

1. Demand: The total energy consumption will be less than 6 billion TCE, of which non-fossil energy accounts for about 20%, natural gas about 15%. The new energy demand will be mainly met by clean energy.

2. Efficiency: The CO_2 emission per unit of GDP will fell by 60%-65% from the 2005 level. China's CO_2 emissions will peak around 2030 and it will strive to reach the peak as soon as possible. The energy consumption per unit of GDP (current price) is estimated to reach the current world average, and the energy efficiency of major industrial products will catch up with the advanced level in the world.

2050 :

The total energy consumption will be basically stable, making China's energy consumption more rational. China will join the advanced group of countries in terms of energy efficiency, technologies, and equipment. It will become an important player in global energy governance, and will have a modern energy system.

II. Strategies

China will continue to put promoting supply-side structural reform as a priority, meeting the needs of the economic and social development and those in the people's livelihood as the starting point, and increasing the quality and efficiency of energy development as the core. Efforts will be made in optimizing the energy system, overcoming the challenges brought about by resources and environment constraints, poor quality and low efficiency, weak infrastructure, and lack of key technologies etc. It will try its best to encourage the development of new technologies, business models and industries in the energy sector, deliver better energy service to all. By doing so, the nation will comprehensively advance the revolution in energy production and consumption, build modern, clean, safe, efficient and low-carbon energy system, which will provide a solid energy foundation for the construction of a moderately prosperous society.

III. Action Plans

1. Making the energy system more efficient and intelligent by optimization;
2. Promoting energy consumption revolution by saving energy and low-carbon growth;
3. Revolutionizing energy supply to make it diverse;
4. Promoting revolution in energy technologies through innovation;
5. Promoting revolution in energy institution to ensure equality and efficiency,;
6. Strengthening mutually beneficial and win-win international cooperation;
7. Bringing benefits to people to ensure shared development.

IV. Governance

1. To improve the system of energy laws and regulations;
2. To improve the fiscal and taxation policies for energy investment;
3. To strengthen the mechanism of implementing energy plans;

Towards cleaner energy systems

I. challenges

1. The surplus production capacity of traditional energy sources is prominent;
2. The development of renewable energy faces multiple bottlenecks;
3. The substitution of clean energy for traditional ones is arduous;
4. The institutional mechanisms for adapting to energy transformation and changes need to be improved

II. Renewable Power Sector

1. Pathways

(1) To actively and steadily develop hydropower
(2) To promote the development of wind power in a comprehensive and coordinated manner
(3) To diversify the use of solar energy
(4) To accelerate the development of biomass energy
(5) To speed up the exploration and utilization of geothermal energy
(6) To promote the demonstration and application of the power generation technologies with ocean energy
(7) To promote the demonstration and application of energy storage technologies
(8) To strengthen the international cooperation in renewable energy industry

2. Key Challenges

(1) The existing power operation mechanism doesn't fit into the need for a large-scale development of renewable energy;
(2) Renewable energy development is highly dependent on policies;
(3) Renewable energy has not been effectively used.

3. What has been done

(1) We have continued to optimize energy structure by moving towards goals.
(2) We have improved policy mechanisms to make the energy system more market orientated.
(3) We have enhanced transformation and upgrading through innovation and promotion.
(4) We have strengthened international cooperation and expanded exchanges.

Trends towards flexible energy systems

Pump storage power stations are the main source of flexibility for China's power system. As of Oct. 2017, China has operating pump storage power stations of 27.94 GW, as well as 35.46 GW under construction.

With the principle of "coordinated planning and rational distribution", China will accelerate the construction of pumped-storage power stations in accordance with the needs of various regions with nuclear and other clean energy development, the power transmission among regions, and safe and stable operation of power grids. The construction of planed projects will be accelerated and the research on pumped storage with seawater be piloted.

Towards transparent energy systems

1. To pay more attention to market rules, strengthen self-regulation of the market, and actively change the energy supply and demand model

2. To focus more on economic benefits, follow the principles of the development of energy sector, and increase the competitiveness of energy and related industries 3. To put more emphasis on mechanism innovation, give full play to the role of price signals in regulating the market, and promote fair market competition
G20 actions going forward 1. consensus building on future-oriented strategies and policies 2. collective action to address common challenges and towards common goals 3. implementation of previous action plans

Germany

Country: Germany

Evolution of energy mix

Germany's energy and electricity supplies from renewable sources are continuously growing. In 2016/2017, renewable energy already covered about 15% of final energy consumption (2016) and about 36% of gross electricity consumption (2017). The long-term target for 2050 is for renewables to provide 60% of final energy consumption and 80% of electricity consumption (until 2030, 30% and 65%, respectively), which is one of the key pillars to move to a greenhouse-gas neutral economy by mid-century.

The Renewable Energy Sources Act (EEG), which entered into force in 2000, is a key driving force for the expansion of renewable energy in the electricity sector in Germany. The 2014 and 2017 revisions of the Renewable Energy Sources Act were important steps towards ensuring continued expansion according on the one hand and further reducing costs and making renewables market-ready on the other hand, while maintaining stakeholder diversity and dovetailing deployment with grid expansion. The reforms included among others changes from a feed-in-tariff to a feed-in-premium system that requires generators to directly sell their electricity in the market, and the introduction of competitive auctions in 2015-2016, which helped to further reduce technology costs.

Wind and solar energy are the most important forms of renewables in Germany. Biomass and hydropower are also valuable building blocks of our energy system. At the end of 2015, more than 1.5 million photovoltaic installations with a total capacity of 40 gigawatts (GW) accounted for the second largest amount of electricity generation capacity in Germany, behind approx. 26,000 wind energy turbines with a total capacity of 45 GW.

Between 2000 and 2015, the share of renewables in the heating sector tripled, rising from 4.4 per cent to 13.2 per cent. Within the heat market, the use of renewable energies is regulated by the Renewable Energies Heat Act. Under this law, builders of new buildings are required to generate a percentage of their heating requirements from renewable sources of energy, to undertake certain compensatory measures such as installing additional insulation, or to use combined heat and power systems or district heating. In addition to the Renewable Energies Heat Act, the Federal Government uses the Market Incentive Programme (MAP) to increase the proportion of heat generated from renewable sources. Under this programme, assistance is provided primarily for existing buildings to promote the use of renewable energy technology in the heat market, such as solar thermal installations, wood pellet heating systems and efficient heat pumps.

In the transport sector, biofuels like bioethanol, biodiesel and biogas accounted for 5.3 per cent of the fuel used in the German transport sector in 2015. The renewables in question consisted almost entirely of biofuels for cars, trucks, trains, ships and aircraft. But renewables are also becoming ever more important when it comes to powering more electric vehicles. Electric mobility is low-carbon mobility and helps to bring electricity from renewable sources, such as solar and wind energy, into the transport sector.

The price of electricity is a major factor in the level of competitiveness of energy-intensive industries facing international competition. These companies are covered by the special equalisation scheme, which in certain circumstances provides for a reduced EEG surcharge. Also, the Renewable Energy Sources Act grants self-suppliers and self-generators certain privileges under certain conditions.

Energy transition outlook and policies 2030/2050

By pursuing the energy transition, Germany is heading towards a future with a secure, economic and environmentally friendly energy supply. The orientation for the energy transition – and thus the basis for its monitoring – is provided by the Federal Government's Energy Concept, further decisions by the Bundestag, and European rules. The triple objective of security of supply, affordability and environmental compatibility remains the guiding principle for Germany's energy policy.

In recent years, the various strands of the energy transition, renewable energy, the electricity market, energy efficiency, the grids and digitalisation, have been brought together into a consistent overall framework. We are continuing to integrate renewable energy into the electricity market, are creating the electricity market 2.0 – a market fit for integrating a growing share of renewables – and are enabling the development of a digital infrastructure that is capable of connecting more than 1.5 million electricity producers and large-scale consumers. Moving forward together at European level is more efficient than pursuing national strategies unilaterally. This is why our reforms are anchored in the European internal market.

There are clear goals for all the areas of the energy transition – electricity, heat and transport. The concept behind this is: Firstly, using energy more and more efficiently. Secondly, directly using renewable energy in end-use sectors. Thirdly, using increasingly renewables-based electricity in end-use sectors (sector coupling).

Monitoring the progress towards the targets of the energy transition – and deriving specific measures from this: That is the task of the target architecture for the energy transition. It prioritises the various quantitative goals of the Federal Government's Energy Concept and imposes a clear structure on them. In the target architecture of the energy transition and the specific measures, the Federal Government is aiming to deploy low-cost solutions and optimal system integration for renewables. This will put the conditions in place to ensure that energy remains affordable for consumers.

Germany also supports the global energy transition. Access to sustainable, reliable and affordable energy is a prerequisite for both development and a decarbonization of the economy. This is why the energy sector is one of the largest funding areas of the German development cooperation. In 2017 alone the German development cooperation commitments amounted to more than EUR 2 billion.

To achieve universal access by 2030, the share of decentralized renewable energy solutions will need to increase significantly. Even beyond rural areas, decentralized renewables can complement grid services by providing back-up options and cheaper, more sustainable alternatives. This is why the deployment of decentralized renewables for energy access is one of the key focal areas for the German development cooperation.

Towards cleaner energy systems / Trends towards flexible energy systems

Supply is secured in the electricity market when supply and demand can be balanced at any time. Studies conducted in 2015 for the study period 2015–2025 reveal that the electricity market in Germany and neighbouring countries can – with reference to Germany – consistently balance demand and generation with a very high probability of almost 100%. Germany also has a very high level of supply security when compared with other countries, making the German power supply system one of the most secure systems in the world. Despite growing demands on the grids, grid quality in Germany continues to remain very high – another factor contributing to security of supply. Many indicators are used to rate grid quality. Each year, the Federal Network Agency publishes the "System Average Interruption Duration Index" (SAIDI), which is representative of the average outage duration per connected final consumer. The SAIDI value includes all interruptions lasting longer than three minutes. It stood at 12.70 minutes in 2015, so that Germany ranks among the best in this regard.

However, additional effort is needed on the part of the grid operators to also ensure this high level of grid stability in the future.

Security of supply is also considered and established in a European context. The German electricity market is closely connected to the electricity markets of its "electricity neighbours", by which is meant its geographical neighbors as well as Norway and Sweden. By taking advantage of smoothing effects across a large area, particularly in the event of peak loads and the feed-in of renewable energy, security of supply can be achieved at a lower cost in the European internal market than in a single country.
The new Electricity Market Act, which the Bundestag and Bundesrat adopted on 8 July 2016, makes the electricity market ready for renewable energy. Germany must continue to have a low-cost and reliable supply of electricity even if wind and solar power increasingly dictate market activity. The Electricity Market Act plots the course for competition between flexible generation, flexible demand and storage. It also takes electricity traders to task: anyone selling electricity to customers must purchase an identical volume and feed it into the grid at the same time. This ensures that supply remains secure. Free price formation on the electricity wholesale market ensures that investment is made in the necessary capacities. The capacities maintained are precisely the capacities that are demanded by customers. A capacity reserve additionally safeguards the electricity supply. These power stations are established separately from the electricity market and are only dispatched if, despite free price formation on the electricity market, supply does not cover demand. Power stations that are part of the capacity reserve cannot participate in the electricity market and so cannot distort competition or pricing. Further to this, a security standby reserve with lignite-fired power plants will also be established. The electricity market will become more transparent. To this end, the Federal Network Agency has set up an Internet-based electricity market information platform which is open to anyone (www.smard.de). It is geared both toward interested members of the public and informed experts in the field. The platform went live in 2017 and provides information on the electricity market in layman's terms with data, graphics and background articles.

Towards transparent energy systems

The monitoring process for the energy transition in Germany is based on publicly available, verifiable data. It is undertaken using selected indicators which visualise progress made in the energy transition over time. They are informed, wherever possible, by official and publicly accessible data. The Energy Statistics Act is the national legal basis for official energy statistics. In September 2016 the Federal Cabinet adopted a bill to amend the Energy Statistics Act to adapt it to current circumstances.
A points system is used to assess the progress made in terms of the quantitative targets of the energy transition. This evaluation scheme cannot replace complex, model-based forecasts. But this system offers the advantage of a comparatively simple and comprehensible depiction of the current status of key energy transition indicators at a glance.
For further information, also please refer to https://www.bmwi.de/Navigation/EN.

G20 actions going forward

Germany supports G20 collaboration for ambitious energy systems transformations in G20 member countries and beyond in line with the priorities of the G20 Hamburg Climate and Energy Action Plan for Growth of 2017, which states that "G20 members should lead the transition to sustainable and low greenhouse gas emission energy systems [… and] stress the importance of increased investment in sustainable and clean energy technologies, energy efficiency, energy infrastructure and energy projects".

Further information

Please refer to:

Bi-weekly English-language newsletter on current energy policy developments by the German Federal Ministry for Economic Affairs and Energy at: https://www.bmwi.de/Navigation/EN/Service/Abo-Service/Newsletter-Energiewende-direkt/newsletter-energiewende-direkt.html

Monitoring and Progress Reports of the Energiewende, available for download at: http://www.bmwi.de/Redaktion/EN/Artikel/Energy/monitoring-implementation-of-the-energy-reforms.html

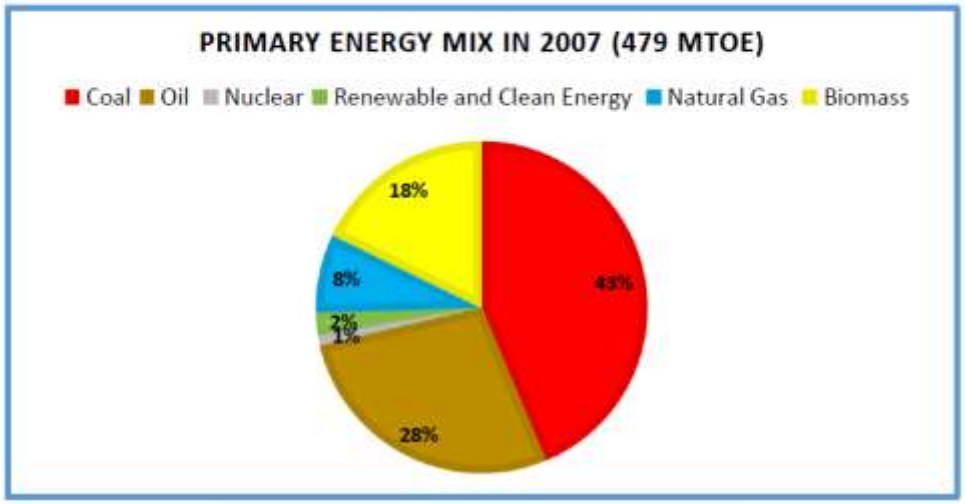
Green Paper on Energy Efficiency; Discussion Paper Electricity 2030; and further documents available for download at: http://www.bmwi.de/Redaktion/EN/Dossier/energy-transition.html

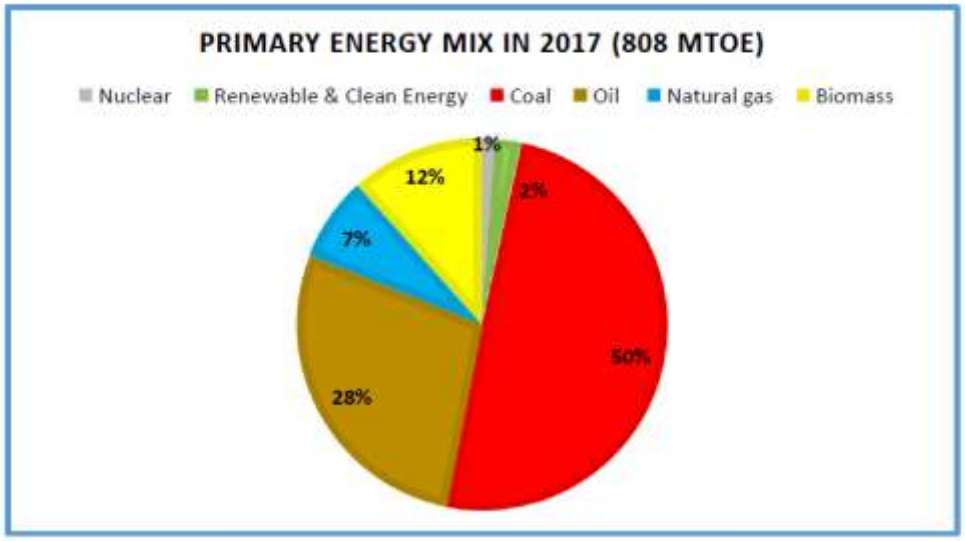
India

Country: **India**

Evolution of energy mix:

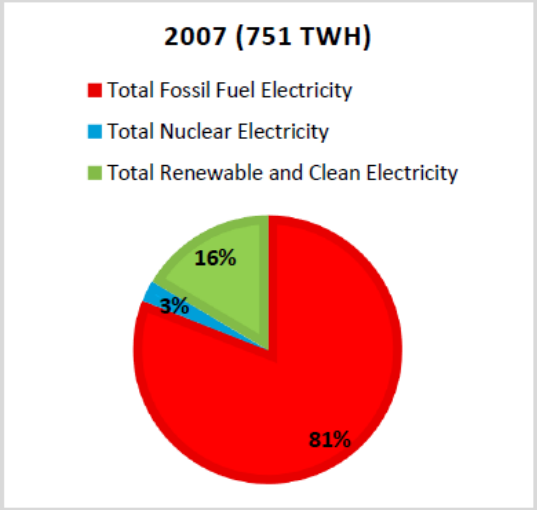
The primary energy supply in India was about 479 million ton of oil equivalent (mtoe) in 2007 which attained the level of 808 mtoe in 2017. The share of coal, oil, nuclear, renewable, natural gas and biomass in primary energy mix in 2007 and 2017 is given below:

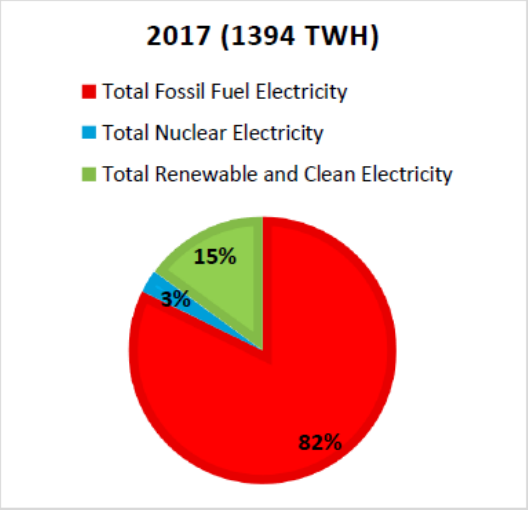




- Share of coal has increased from 43% in 2007 to 50% in 2017. This has happened due to massive expansion in electricity sector because of increasing electricity access to citizens of the country.
- Share of biomass has come down due to increasing access of cleaner cooking fuels. Penetration of LPG has increased at a fast rate in both rural and urban areas due to implementation of various LPG focused scheme.
- Renewable and clean energy (Large Hydro combined) has stayed at same level.
- Share of Natural Gas has remained at almost same level, however, it is likely to increase in future due to increasing measures to boost natural gas consumption in the country.

The electricity generation in India was about 751 tera watt hour (TWH) in 2007 which attained the level of about 1394 TWH in 2017. The share of fossil fuel, nuclear and renewable energy in electricity generation in 2007 and 2017 is given below:

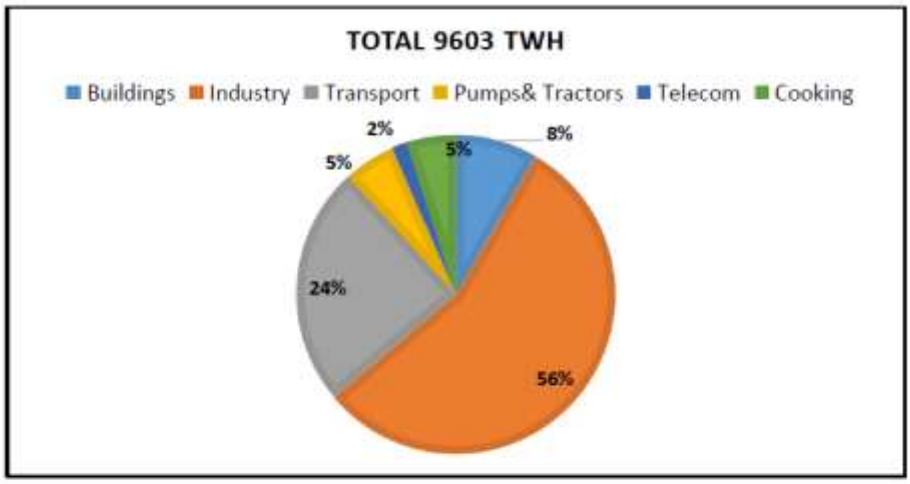




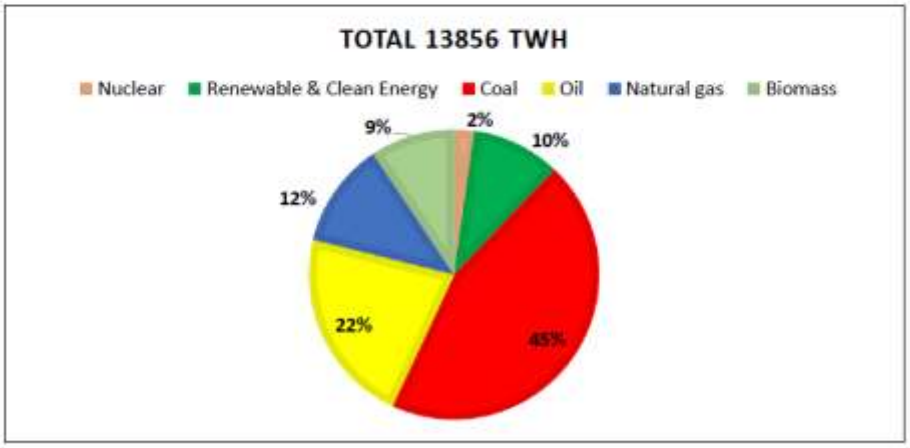
- The electricity generation mix in the country has almost remained constant between 2007 and 2017.

Energy transition outlook and policies 2030:

Likely energy demand in India by 2030 would be 9603 TWH. The breakup of likely energy demand of building, industry, transport, pump & tractor, telecom and cooking sector is given below:



Considering the likely energy demand, the energy supply requirement in India by 2030 would be 13856 TWH. The breakup of likely energy supply from nuclear, renewable, coal, oil, natural gas and biomass is given below:



- In 2030, the energy system of the country would favour renewables and it share in primary energy supply is likely to increase to 10%. Additionally, biomass is likely to

have a major contribution of about 9% which prominently will be used for biomass to power and biofuel production.

- Share of coal and oil is likely to go down to 45% and 22% respectively.

India is committed to its Nationally Determined Contribution (NDCs) targets. The key elements are:

- To achieve about 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030.
- To reduce the emissions intensity of its GDP by 33% to 35 % by 2030 from 2005 level.

Projected Achievements of NDCs – Power Sector

India has set a target of 175 GW of installed capacity from Renewable Energy Sources (RES) by March 2022. The percentage of non-fossil fuel in installed capacity is likely to increase to 49.31% in March 2022 and 57.37 % in March 2027, if India could meet its target of 175 GW of installed capacity from RES. On achieving the said RES targets the estimated reduction in emission intensity (base 2005) would be 40.51 % and 53.65 % by 2022 and 2027 respectively for power sector.

In order to achieve NDCs, emphasis is being given to the development of more efficient supercritical technologies for coal based power plants in addition to exploitation to renewable energy sources. Ultra-supercritical technology is also being adopted for coal based thermal power plants. The improvement in design efficiency of Ultra Supercritical technology (USC) is around 1.5% over supercritical units. Many units with conventional supercritical parameters are already operational while number of USC units are under construction.

In automobile sector, efforts are being made for faster penetration of electric and LNG based vehicles such that faster decarbonisation transport sector becomes possible. Various schemes such as Standard and Labelling program for appliances, PAT scheme for industries, fuel standard norms for ICE vehicles (BS-IV) etc. are being run to build higher efficiency in all the energy sectors. Energy efficiency measures are likely to reduce the energy demand by 11% in 2030.

Towards cleaner energy systems

Energy access is central to policy of India. In order to reap the benefits of development by all citizens, it is important that everyone has access to electricity and clean cooking fuels. Schemes based on massive penetration of LPG have been launched in successive years. Pradhan Mantri Ujjwala Yojana was launched in 2016 to provide free LPG connection of rural BPL households. Around 30 million connections have been distributed till now. Under this scheme it is targeted to provide around 80 million connections by 2019. This will effectively boost the penetration of clean cooking fuels in the country. Additionally, India has been striving hard to provide electricity access to all citizens and Saubhagya Scheme which has been launched recently will increase the electricity access to all citizens by 2019. It is envisaged, with universal penetration and better quality of electricity provided, might also be used for cooking. For the houses which are still dependent on biomass, Unnat Chulha Abhiyan has been running to provide efficient cook stove to households. In recent years,

there has been increasing focus on city gas distribution and PNG network which has been functioning in around 30 cities in the country. In future, the network is going to cover almost all the Tier-1, Tier-2 and Tier-3 cities.

Trends towards flexible energy systems

Studies were undertaken under the project "Greening the Grid". The studies were aimed to understand the impact of 175 GW of Renewable Energy (RE) by 2022. Some of the key findings of the National Study are as follows:

- Based on existing plans of transmission and Generation, power system balancing with 175 GW RE can be achieved at 15-minute operational timescales with minimal RE curtailment.
- The interstate transmission as planned under Green Energy Corridor is sufficient for meeting demand requirements as analyzed in this study, but additional intrastate transmission planning should consider project locations of new RE development.
- The existing flexibility in the coal-dominated power system can handle RE forecast errors, net load changes, and exchanges of energy between regions. System ramps can be met if all generating stations exploit their inherent ramping capability. The ramp rates assumed were a conservative 1% for coal and 3% for gas fired stations.
- The latent flexibility in hydroelectric generation helps to maintain the system balance.
- Reducing minimum generation levels of large thermal plants is the biggest driver to reducing RE curtailment. Meeting CERC regulations that require plants to operate at a minimum of 55% rated capacity reduces RE curtailment from 3.5% to 1.4%.
- Balancing at 15 minute intervals with the coal and gas fleet expected to be in place by 2022.

Towards transparent energy systems

There is increasing numbers of reforms in recent years to bring transparency and rationalization in the energy system. One example: A new bidding mechanism OALP (Open Acreage Licensing policy) has been launched by Ministry of Petroleum and Natural gas to bring efficiency in oil and gas exploration. Petrol and Diesel prices have been completely de-regulated and almost all petroleum products other than petrol and diesel has been brought now under single uniform tax regime called GST (Goods and Services Tax). Under the OALP regime, operators will complete freedom for marketing of oil and gas.

G20 actions going forward

Deployment of high renewable energy requires balancing solutions which requires high capital. Further, introduction of new technologies like Advanced Ultra Supercritical technology, HELE, battery storage, electric vehicles etc will play a major role in addressing environmental concerns but they are technology driven and capital intensive. Thus technology transfer from Developed nations and low cost financing becomes imperative from international financial institutions.

Indonesia

Country: Indonesia
Energy mix In Indonesia's National energy mix 2016, oil accounted for 36.98%, while others were 33.38% coal, 21.21% natural gas and 8.43% renewables. The energy mix figure has not significantly changed yet since past 10 years, while greenhouse gasses from energy sector contributed around 1.9 Ton CO2e per capita. The emissions prevalently originate from coal use in power sector that accounted to around 46% of the total power mix, while Indonesia's annual GDP per capita in 2016 was 3,570 USD.
Energy transition outlook and policies 2030/2050 The National Energy Policy has set forth the target for 2025/2050 with the major focus on reducing oil share well below 25%/20% in the primary energy mix as well as enhancing share of renewable energy 23%/31%, natural gas 22%/24% and coal 20%/25% within the national energy mix. The main policies consist of providing energy for domestic energy supply, focusing on renewable energy and clean fossil energy, developing energy for sustainable development, and preparing the energy reserves. In addition, the other supporting policies comprises energy conservation and diversification, environmental and safety management, energy price and subsidy, access and infrastructure improvement for private and public sector, research and development, and funding mechanism.
Towards cleaner energy systems In order to promote the renewable energy in supply side as well as the energy efficiency in demand side, funding mechanism and access to finance are the major challenges. The Government of Indonesia (GoI) has performed the pricing restructuration so that renewable energy can compete with fossil energy. The volatile energy price, especially oil, has become the main driver to improve energy conservation in demand side, despite promoting multiple benefits from implementing energy efficiency.
Towards transparent energy systems GoI has done a series of major restructuration on energy price in order to reflect the actual generation costs. Moreover, GoI has also diminished the investment barrier through restructuring and simplifying the permit/non-permit process on investment. By the end of 2017, 68 Power Purchase Agreement (PPA) on renewable energy development projects has been signed between PT PLN (Indonesian National State-Owned Utility) with national/international private investors with the total capacity of 1,214 MW.

Trends towards flexible energy systems
Indonesia is aiming to integrate the electricity transmission to increase the power reliability particularly with the growing demand between large energy consumers (for example in Java) and rich-energy-producer regions (for example in Sumatera). Considering the archipelagic landscapes, PLN has also developed the regional electricity market for remote or grid-unconnected islands, which do not have any power transmission into the Indonesian main islands. Following growing number of power plants, particularly from renewables, we require to improve the existing power system both in grid coverage and power flexibility. Despite technological constraints, GoI urges to develop a set of new supporting policies in shaping flexible market and facilitating business venture in energy-related sectors.
G20 actions going forward
G20 multilateral cooperation can promote market integration to support more reliable, transparent and flexible energy system in the national and regional level. It shall include the sharing and encouragement in policy framework and technology transfer as well as in providing financial access and creating business-friendly mechanism in energy investment.

Italy

Country:	Italy

Energy mix

In 2016, Italian TPES amounted to 167.6 million tonnes of oil-equivalent (Mtoe), down by 13.5% compared with 2007. In the 2007-2016 period the most relevant change in the energy landscape has been the increasing relevance of renewable energy (mainly deployed in the power and heating sector): in 2016 renewable represented 19.1% of TPES compared with 7.4% in 2007 (almost 12 percentage points in just a decade).

Since 2007, Italy's domestic GHG emissions have declined. Several factors such as greater use of renewable energy in the power sector and improvements in energy efficiency have contributed to this decline. Overall, GHG emissions declined by almost 23% from 2007 to 2015 (last official statistic available), with a slight increase (+2.3%) in 2015 after the constant decline registered since 2004. In the considered period GHG emissions' reduction came mostly from the Industrial sector (-28%), followed by Energy (-24%) and Waste (-20%) while Agriculture emissions decreased less (-9%).

The electricity mix has evolved since 2007. In that year, natural gas, coal and oil represented 80% of total generation, including 48% gas, 20% coal and 12% oil. Renewables (mostly hydro) accounted for the remainder. Over the last ten years, solar, wind, and biofuels and waste have boomed, growing steeply. Solar PV energy has experienced the highest level of growth since 2010 as a result of favourable government incentives. In 2016, the share of renewables in domestic generation reached almost 40% and half of their contribution came from solar PV, wind and bioenergies.

Energy transition outlook and policies 2030/2050

In November 2017, the Italian Government released its National Energy Strategy (NES), a document looking beyond 2030. Some of the main targets of the NES are: 1) reducing final energy
consumption by a total of 10 Mtoe by 2030; 2) reaching a 28% share of renewables in total energy consumption by 2030, and a 55% share of renewables in electricity consumption by 2030; 3) strengthening supply security; 4) narrowing the energy price gap with the EU; 5) supporting sustainable public mobility and eco-friendly fuels; 5) phasing out the use of coal in electricity generation by 2025; 6) Increasing public resources allocated for research and development of clean-energy technologies. More details are available here: http://www.sviluppoeconomico.gov.it/images/stories/documenti/BROCHURE_ENG_SEN.PDF.

Towards cleaner energy systems

Italy has a long-lasting tradition in the use of natural gas for heating and power production and also in the transport sector. With the growth of RES, natural gas will continue to play a key role in the energy transition, as it will represent a back-up resource for the power system. However, the gas market will be more uncertain and volatile. Therefore, the NES foresees to: diversify supply sources, by optimising the use of the existing infrastructures, and develop new connection infrastructures; improve the flexibility of supply sources, by strengthening gas pipelines and the peak-demand security margin; and coordinate national contingency plans, including mutual support between EU countries.

Moreover, Italy is among the promoters of Mission Innovation (MI) - a global initiative resulting from COP21 to launch leading-edge clean-technology (clean-tech) projects - and committed to doubling the value of public resources allocated for investments in clean-

energy research and development by 2021. The progressive transition towards low-emission models requires substantial efforts in supporting technological evolution, as well as research and development of new technologies. The Strategy aims to strengthen public support and create conditions to attract private investments, with the goal of contributing to developing technological concepts that can sustain the energy transition at reasonable costs, and offer business and employment opportunities. For this reason the Italian Government took action in order to double investments in clean-energy research and development: from € 222 million in 2013 to € 444 million in 2021, with specific investments on energy efficiency, biofuels, renewables, materials and smart grids. In fact, Italy has joined all the 7 Innovation Challenges of MI, as we consider these exercises extremely relevant and unique. Concerning Challenge 1 on Smart Grids, Italy is Co-leader with China and India; the Italian leadership in Smart Grids is renowned worldwide being Italy one of the most advanced countries around the world in the development and implementation of smart grid solutions and technologies. Moreover, there is a strong commitment among the others Innovation Challenges: in Challenge 4 – Sustainable Biofuels, in Challenge 6 - Clean Energy Materials and in Challenge 7 - Affordable Heating and Cooling of Buildings.

Towards transparent energy systems

In terms of Governance, because energy is a cross-cutting issue, energy policies in the energy sector should be integrated with those in other sectors, so as to take a consistent approach, capture possible synergies, and offer new business opportunities.

For this reason the NES foresees the setting-up of a special Steering Committee. The members of the Committee, coordinated by the Ministries of Economic Development and of the Environment, are representatives from the Ministries of Economy, Transport, and Cultural Heritage, as well as from the Regions; periodical consultations with local governments are also planned.

Additionally, to ensure transparency in monitoring the implementation of the NES, the Government will have to present a yearly report to the Parliament on the status of its implementation, and on the actions taken to achieve its targets, as well as to undertake a participative process of revision of the NES every three years.

The NES also sets forth actions to streamline and rationalise the energy system, with a view to obtaining significant reductions in the costs of RES technologies, while limiting their environmental impact.

Trends towards flexible energy systems

In a context of increasing complexity, the power system should not only be flexible, but also and above all reliable in terms of: 1) adequacy in order to cover electricity demand security in order to respond to changes in its status of operation, without violating its operation limits; 2) resilience in order to predict, accommodate, adapt to and/or rapidly recover from extreme events.

The NES has set the target of providing the power system with innovative instruments and infrastructures, in order to: a) guarantee its adequacy and capability of meeting security standards; b) guarantee its flexibility, thanks also to technological breakthroughs, in a context of growing penetration of RES; c) promote its resilience to extreme weather events and contingencies; and shorten the timescales of and streamline the permitting process and the implementation of projects.

The main actions to achieve these objectives are: 1) launching the capacity market in 2018 to guarantee system adequacy, maintaining the still necessary gas-fired capacity (with priority to flexible capacity); 2) integrating new resources into the market (cross-border renewable-energy power-generating units, storage systems, active demand side); 3)

further strengthening interconnections with neighbouring countries; 4) increasing the capacity of storage systems and implementing grid projects to integrate renewables, and increase the resilience of the system.
G20 actions going forward We believe that a collaboration on R&D&D in clean tech technologies among G20 countries could be a good strategy in order to better afford energy transition and contributing to decarbonisation, in line with the long-term targets of the Paris Agreement on Climate Change.

Japan

Country: Japan

Evolution of energy mix

TPES and Power mix

Since the late 1970s until 2011, Japan's energy supply was dominated by fossil fuels and nuclear energy. However, the proportion of nuclear decreased due to the successive suspension of nuclear power plants after the Great East Japan Earthquake. This mainly raised the proportion of coal and natural gas, making the FY2016 TPES mix: coal (25%), oil (40%), natural gas (24%), nuclear (1%), and renewable energy (10%).

Regarding power generation, before 2011, installed generating capacity was well diversified, as no single source of electricity accounted for more than 30% of the country's total generating capacity. However the supply gap left by nuclear power shutdown was initially bridged by additional gas- and oil-fired power and energy efficiency measures, later also by coal and renewables. FY2016 power mix was coal (32%), oil (9%), natural gas (42%), nuclear (2%), and renewable energy (15%).

CO2 emissions from fuel combustion

Japan's CO_2 emissions from fuel combustion are estimated at 1,128 million tonnes (Mt) in 2016, 5.9% more than in 1990. Emissions increased steadily for decades to reach 1,213 Mt in 2007, before a 10.5% decline during 2008-09.

Population and GDP

Japan has a population of 127 million and its nominal GDP was USD 4.1 trillion in 2015.

Energy transition outlook and policies 2030/2050

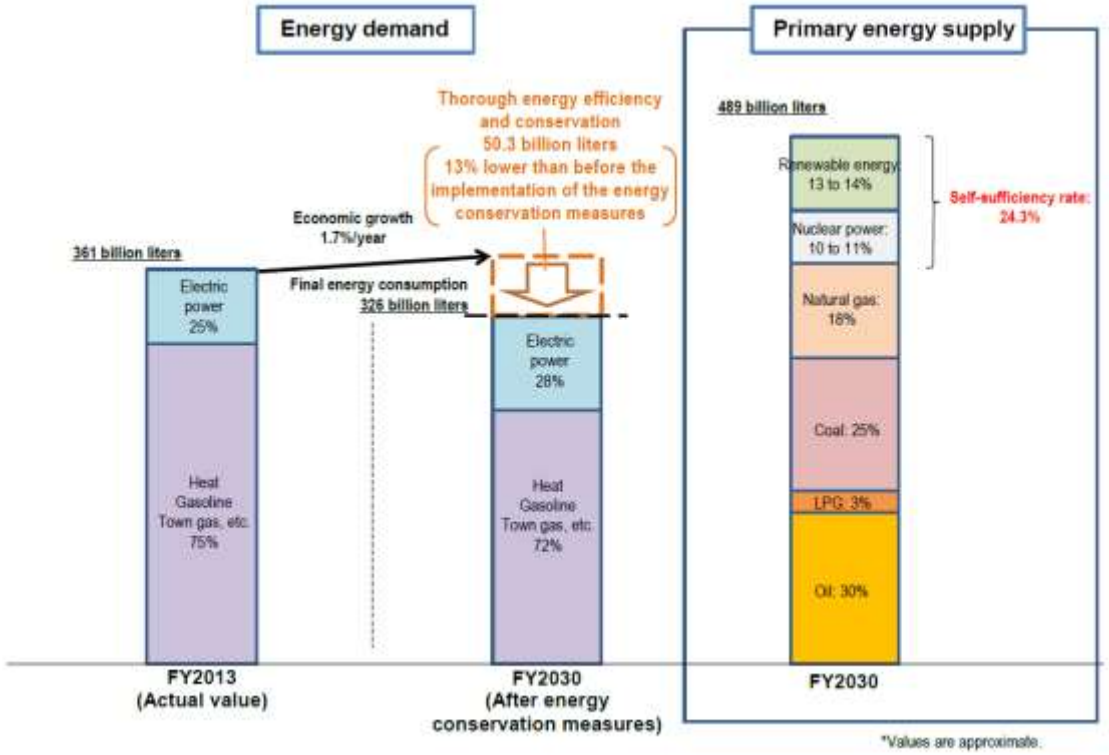
Japan sets an energy target for FY2030 in Long-term Energy Supply and Demand Outlook approved in July 2015. Based on the Strategic Energy Plan compiled in 2014, the Long-term Energy Supply and Demand Outlook presents an ideal structure of energy supply and demand that can be realized if appropriate measures are taken based on the fundamental direction of energy policies by envisioning policy objectives to be achieved on safety, energy security, economic efficiency, and environment, which are the basic ideas of the policies.

Demand Outlook for 2030

While expecting an increase in energy demand due to economic growth, etc., significant improvement of energy efficiency, comparable to the situation after the oil shock in 1970s, is expected. Reduction of total energy demand is achieved by promoting thorough energy efficiency and conservation.

Supply Outlook for 2030

Japan aims to reducing dependence on nuclear power generation as much as possible by promoting thorough energy efficiency and conservation, introduction of renewable energy, and introduction of efficient thermal power plants. The primary energy supply structure in FY2030 will be as follows.



Initiative for long-term energy transitions

Initiative for long-term energy transitions according to the policy recommendation from the advisory board of Minister of Economy, Trade and Industry issued in April 2018, it is essential to establish ambitious scenario for energy transitions and decarbonization, but the scenario should be on multiple tracks and energy policy should seek possibility in all choices of technologies to be applied to energy system.

- Renewable Energy: Development of hydrogen, electricity storage and digital technologies, as well as the enhancement of power grids is necessary.
- Nuclear energy: An option for decarbonization in the phase of practical use. Efforts for seeking safe and advanced reactors are necessary.
- Fossil fuels: Major power source in the transitional period; Shift to gas thermal, fading out of inefficient coal-fired power generation and, concentrating high efficient coal-fired power generation

Towards cleaner energy systems

While Japan's renewable capacity has grown rapidly thanks to the feed-in tariff system introduced in 2012, its generation cost of renewables is relatively high compared with international level. Furthermore, the technical and regulatory structure of Japan's electricity system where main electricity grid is divided, makes integration of variable renewable energy challenging. To this end, Japan is seeking to promote cost reduction, expansion of the grid and ensuring flexibility through improvement of power grid

management, dispatchable generation, innovation of battery and hydrogen storage, and demand side management.
In addition, Japan is promoting utilization of hydrogen energy as it will be a key technology to solve the issues of energy security and global warming through innovation. In December 2017, the Ministerial Council on Renewable Energy, Hydrogen and Related Issues formulated the "Basic Hydrogen Strategy", the world's first national strategy of hydrogen, demonstrating the direction or vision for realizing a hydrogen-based society with an eye on 2050 and provides an action plan for its realization. In order to make hydrogen to be a new energy alternative, the strategy aims for making hydrogen affordable and cost-competitive as much as conventional energy sources such as natural gas.
For further details of the Basic Hydrogen Strategy:
http://www.meti.go.jp/english/press/2017/1226_003.html

Trends towards flexible energy systems

In order to realize stable energy supply structure, the Japanese government has been taking many measures. Representative examples are mentioned below.
1) Establishment of The Organization for Cross-regional Coordination of Transmission Operators (OCCTO), which manages Cross Regional Interconnecting Lines and arranges Supply and Demand Balance especially in cases of emergency.
2) Establishment of a verification process which affirms that each local area maintain an adequate reserve margin, which is 3% or more under severe conditions. If necessary, the government announces the need for energy-saving.
In case of a supply shortage or instability in a particular area, the OCCTO enhances cross-regional electricity use and gives orders for electric utilities including power producers, TSOs and retail electric operators to supply more electricity in order to maintain stable electricity supply.

Towards transparent energy systems

Good practice : "The Fukushima Plan for a New Energy Society"
Objective : Aiming to turn the whole of Fukushima Prefecture into a base for the creation of a pioneering model of a future new energy oriented society in order to further strengthen support for Fukushima's reconstruction.
Brief summary : The three main components of the plan are: Expanded introduction of renewable energy; Model construction for realizing a hydrogen-based society; and building smart communities. In the "Fukushima prefecture Vision for Promoting Renewable Energy" of March 2012, the goal was set of supplying 100% of primary energy demand in Fukushima Prefecture from renewable energy by around 2040.To accelerate these efforts, and further strengthen support for energy industry recovery in Fukushima, the government, prefecture, private industry, and other stakeholders work as a team. It is expected that the dialogues within the team will contribute to increasing transparency of the energy system.
For further details:
http://www.enecho.meti.go.jp/category/saving_and_new/fukushima_vision/pdf/fukushima_vision_en.pdf

G20 actions going forward
Japan emphasize the importance of the G20 role and its capacity to send strong signals for energy policy, share best practices and strengthen collaboration for all member countries. Japan will chair G20 in 2019 and send a strong message for energy transitions for sustainable growth cooperating with Argentina and other member countries.

Mexico

Country:	Mexico

Energy transition outlook and policies 2030/2050

One of the premises of the Energy Reform was to revolutionize the sector with the adoption of international best practices and transit to an open market model allowing private investment that stimulates competitiveness and incorporates sustainability across the entire value chain.

Today, planning in the sector is done through wide and public participation in which industry, civil society and government define policies, programs, and metrics to advance towards the development of a greener and more sustainable energy economy.

In December 2015 we enacted the Energy Transition Act, which was mandated by the Consultative Council for Energy Transition, conformed by civil society, private sector, academia and the legislative and executive powers with the purpose of designing planning instruments to transit towards a sustainable energy future. This Council launched the *Transition Strategy to promote the use of Cleaner Fuels and Technologies* in order to have a road map that allows for the sustainable use of natural resources, promoting the development of new markets, promoting efficiency and consolidating the competitiveness of the energy system.

To take advantage of the country´s natural capital, the Strategy reaffirms the mandate of the Energy Transition Act: to have at least 35% of clean generation by 2024, and 50% by 2050. The main features to achieve those goals, are:

- Wholesale electricity market.
- Long-term clean power auctions.
- Clean energy certificates.
- Independent system operator.
- Strengthening of the regulatory body
- We implemented the platforms to identify the availability of renewable resources in the country, through the National Inventory of Renewable Energies and the Atlas of Renewable Energies.
- Public policy consolidation.

Promoting clean power generation is a fundamental pillar of the energy reform yet we must complement these efforts in order to achieve an energy transition by addressing strategies to make for a more sustainable use of energy. In this sense, energy efficiency is the second pillar of the energy transition policy.

We established a nationwide energy efficiency goal (Transition Strategy) to reduce the use of energy per unit of Gross Domestic Product: the target is to reduce 1.9% energy intensity per year from now up to 2030, and 3.7% from 2031 up to 2050. With these goals we are reducing the energy intensity of all products and services developed in the country. To work towards this goal, we are implementing the following actions established too in the *National Program for Sustainable Use of Energy 2014-2018*:

- Strengthening of the regulatory system. There are thirty-one Mexican Official Energy Efficiency Standards (NOMs by its Spanish acronym) or mandatory standards in force, a conformity assessment system in charge of compliance,

eight certification bodies, seventy-one test laboratories and two hundred and five verification units.

- Implementation of energy management systems. To promote the sustainable use of energy across all consumers, we are promoting in high energy users or industry users, the adoption of the ISO-50001.
- Accelerated adoption of efficient technologies. To foster the use of lower energy consumption appliances, we designed innovative financial instruments and energy incentives tailor-made for:
  - *Cities and Residential Sector*: Replacement National Program of Incandescent Lamps National Energy Efficiency in Municipal Public Lighting Project and Municipalities Energy Efficiency and Sustainability Project.
  - *Energy efficiency by sectors:* National awareness campaign on energy efficiency in Cinemas; Appliances Replacement Project (PSEE); and Eco-credit program to boost energy efficiency in the enterprises operations.
  - *Buildings:* Support to the development and the implementation of the International Code Council (ICC) International Energy Conservation Code (IECC) for Mexico and Sustainable Housing Programme.

In this sense, Mexico has carried out actions that promote the efficient use of energy in various sectors to contribute to the energetic and economic security.

Trends towards flexible energy systems

The Mexican electricity market operates under security, reliability, continuity and opportunity principles in order to satisfy the final demand at competitive prices. Based on this, CENACE executes all the procedures considered in the Electricity Market Rules. In other words, the MEM operates upon different components: the Short-Term Electricity Market (real time, one-day ahead), Power Capacity Balance Market, Financial Transmission Rights and Clean Energy Certificates. So, the electricity dispatch is carried out on an economical merit basis, evaluating at each moment all the available power generation units and their corresponding generation costs as well as the transmission grid's conditions like congestion, availability, etc.

As was explained above the regulatory framework already considers the transparent and appropriate mechanisms to allow to the authorities and market agents to propose changes or improvements in the rules.

Towards transparent energy systems

Regarding the Long-Term clean energy auctions, all the processes are conducted by the Mexican authorities (SENER, CRE) and the National Energy Control Center (CENACE) under procedures strictly transparent. The regulatory framework's origin is established in the Electricity Market Rules (Bases del Mercado Eléctrico, in Spanish) which contains the principles and procedures that the authorities and Market Participants must carry out to maintain an adequate administration, operation and planning in the Wholesale Electricity Market (MEM). This framework also considers the transparent and appropriate mechanisms to allow to the market agents to propose changes or improvements in the rules.

In terms of transparency for the auctions' results, the CENACE operates the Market Information System where all the steps developed during the competitive processes are published and opportunely updated for open access.

G20 actions going forward

The most important priorities for future G20 collaboration on Efficiency and Energy Sustainability should be: Strengthen technical cooperation to share experiences with G20 members and non G20 members, to play a leading role in long-term energy efficiency improvement.

In Energy Efficiency, we have to strengthen the gathering, dissemination and analysis of knowledge and information for G20 members, and identifying potential trilateral activities to have better data collection for building energy efficiency indicators and policies in order to achieve further climate change adaptation and resilience.

Thus revealing its information to interested in general and, in particular, to G20 members, which facilitates the monitoring of their international commitments. Mexico shares data on energy through:

Energy Information System,

International Energy Agency,

Web application of the North American Energy Information Cooperation (www.nacei.org)

Netherlands

Country:	The Netherlands

Evolution of the energy mix

Between 2005 and 2016 the final energy use decreased. The share of renewables increased to 6% in 2016. In 2015 three new coal power plants increased (1/3) the use of coal. Five coal power plants, from the 1980s, will be closed in the upcoming years however. Oil remains important, while the use of natural gas slowly decreases (47% of the total energy mix in 2000 to 38% in 2015).

Energy transition outlook and policies 2030/2050

The share of renewables in the total energy mix will increase from 6% in 2016 (1,6% in 2000) to 12,4% in 2020 and 16,7 in 2023. Until 2030 the share will be 24%. For electricity a scenario of 50% share of renewables in 2025 in not unlikely. Aside from (offshore) wind, solar grows as well. The increase in renewable heath sources and biofuels takes place in a much slower pace. The Netherlands will close its coal power plants by 2030 and introduce a minimum CO2-price for the electricity sector. In 2030 11,5 GW should be realised in offshore wind. The country will become a net-importer of gas and a net-exporter of electricity by 2025
Currently the negotiations for achieving a national Climate Agreement are ongoing. The government and stakeholders from all societal sectors, divided over 5 sectors, aim to decide on ways to achieve the goals set by the government coalition:

Top priorities Coalition Agreement

- 49% reduction of greenhouse gas emissions in 2030 compared to 1990 levels
- Cost-efficiency is the guiding principle for choices made. This means a future-oriented cost perspective, based on minimising marginal abatement costs towards the 2030-goal but also taking into account necessary steps towards 2050.
- The agreement must ensure an affordable, reliable and safe energy supply.
- The agreement must be in line with the international context and the regulatory framework in Europe.
- Integrated approach is necessary, since the issues and solutions are cross-cutting and cannot be limited to one sector or table. This is especially relevant for measures relating to innovation, spatial planning, the labour market and finance.
- Keep carbon leakage to a minimum.

Table-specific priorities:

Built Environment

- An average of 200,000 homes and other buildings per annum will need to be rendered natural gas-free until 2050. As a starting point, 30,000-50,0000 homes

per year should be made natural gas-free or natural gas-free-ready by the end of the government's term in office.
- Introduce new financial mechanism to support investments in energy-efficiency and alternative heating solutions, such as building-based loans.
- Market models for collective heating systems, including ownership/investments in infrastructure.

Transport/Mobility
- Need for short-term measures.
- Remove barriers to large scale implementation of innovation.
- Pilot projects and green deals to stimulate innovation and regional/local initiatives.
- Ambition to ensure all new sold cars in 2030 are zero-emission.

Agriculture and land-use
- Additional energy efficiency horticulture sector (greenhouses)
- Reduce methane emissions through processing en fermentation
- Sector will be called upon to offer land space and to supply raw materials to achieve emission reduction in other sectors.
- Incentivise measures for storing of emissions in soils and vegetation.

Electricity
- Coal-fired power plants are to be phased out by 2030 at the latest.
- Introduction of a national CO2 minimum price in electricity generation.
- Mechanisms for further flexibility in electricity system, in order to integrate CO2-free electricity production
- Development of various CO2-free electricity production techniques (role SDE+ incentive scheme, extra sites designated for off-shore wind farms, on shore wind and solar).
- Arrangements for appropriate proper spatial integration to facilitate the extra capacity needed to produce CO2 free electricity.

Industry
- Off-shore CCS and CCU should be developed.
- 75% of the emissions come from 12 different companies within five regional clusters, targeted approach needed.
- Investments in process efficiency and recycling need to be combined with a renewal of production processes and application of other non-fossil, raw materials.
- The industry sector can play a useful role by offering flexibility for the electricity system and provide residual heat.
- New arrangements needed for infrastructural projects (CCS/CCU, hydrogen and heat supply).

Table: Estimated share in the 49% reduction target for 2030		
Industry	1	Recycling
	3	Process efficiency
	18	Capture and Storage CO2
Transport	1,5	Efficient tyres, European standards, EV
	2	Biofuels and measures cities
Built environment	3	Optimisation energy use offices
	2	Isolation, heat pumps and heat infrastructure
	2	More energy efficient new buildings
Electricity	1	More energy efficient lighting
	12	Closing of coal plants
	2	Capture and storage CO2 in waste incineration plants
	4	Extra offshore wind
	1	Extra solar
Land use and agriculture	1,5	Smarter land-use
	1	Less methane
	1	Glasshouses

Towards cleaner energy systems

Key challenges in the Dutch transition are the downscaling of our dependence on natural gas and the lack of public support for generating wind energy on land. Other challenges have to do with the integration of renewables in the national grid. Opportunities arise with regard to offshore wind and innovation.

Trends towards flexible energy systems

The Netherlands Environmental Assessment Agency (PBL) monitors the progress made on the current Agreement on Energy for Sustainable Growth and the future National Climate Agreement. The institution publicises a yearly overview of their monitoring results.

Towards transparent energy systems

Currently fossil fuel powered power stations are the source of flexibility for our power system. In the future regional integration, and possibly hydrogen or battery storage are seen as essential for a flexible energy system. Especially the integration of offshore wind will constitute a major challenge to the national power grid.

G20 actions going forward

Republic of Korea

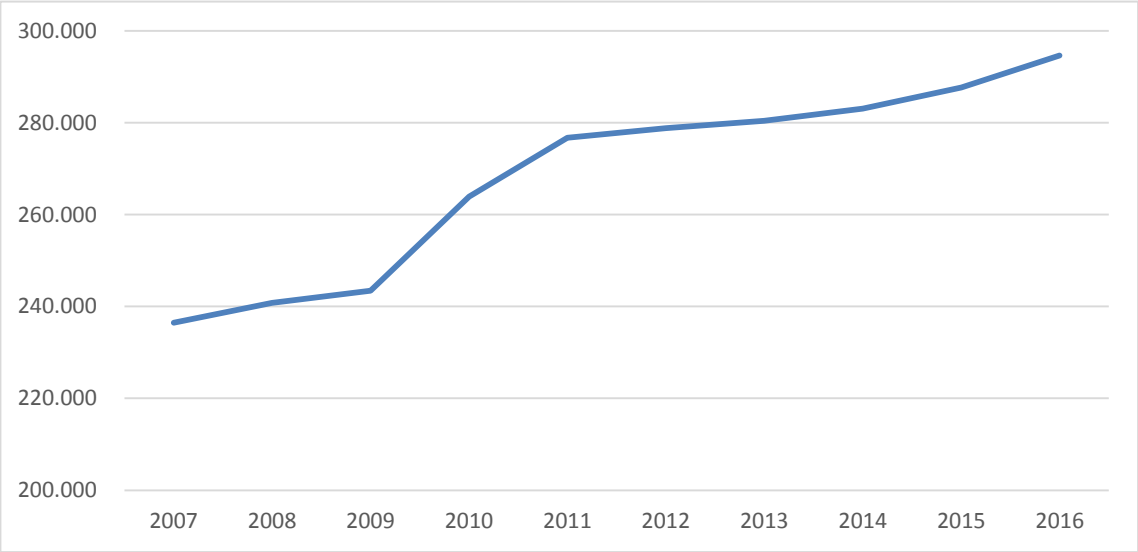
Country	Republic of Korea

Evolution of energy mix

The Total Primary Energy Supply (TPES) of Korea increased from 236 million toe in 2007 to 295 million toe in 2016. After the global financial crisis in 2008-2009, TPES temporarily declined. However, as the global economy recovers, the TPES increased again by 8.4% and 4.9% each in 2010 and 2011.

After the sharp increase, primary energy consumption increased by less than 1% in 2012-2014, partly because of a slowdown in the domestic industrial sector's energy consumption. The growth rate has remained relatively low since 2011.

[Total Primary Energy Supply]

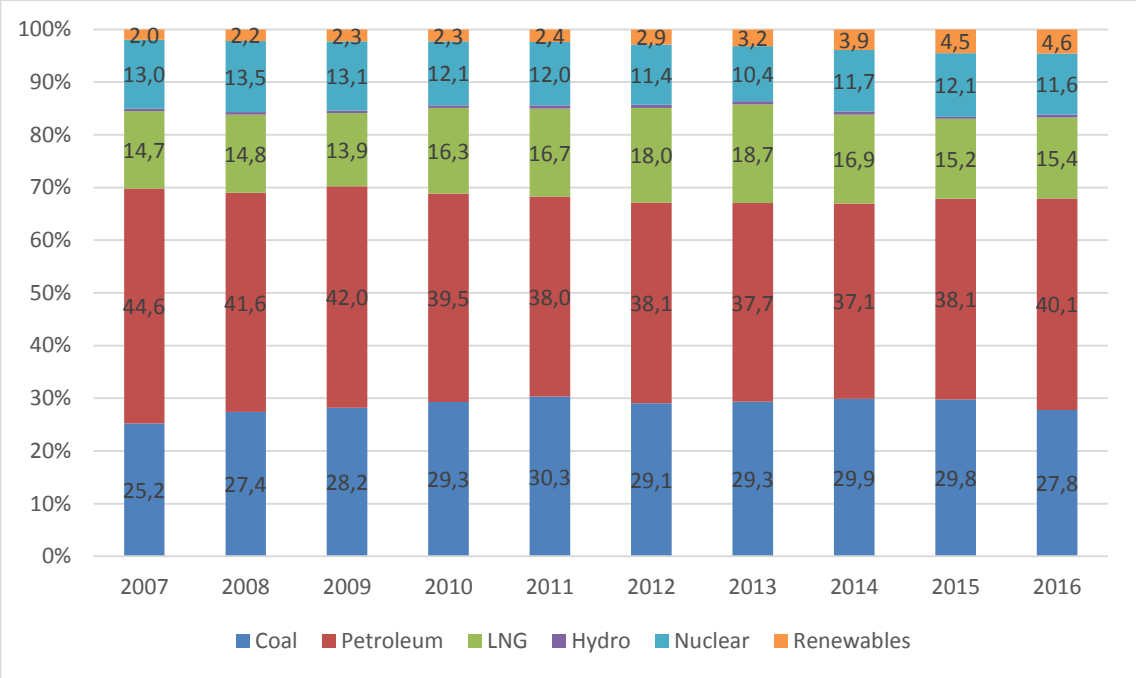


Source: MOTIE, KEEI. Yearbook of Energy Statistics 2017

The share of petroleum in the primary energy mix decreased from 44.5% in 2007 to 37.1 % in 2014. However, it has increased again to 40.1% in 2016 because of the low-oil price trend and a gradual proliferation of naphtha. The share of coal has grown from 2006 to 2011, with the annual growth rate of 8.3% on average. However, after 2011, the stagnating steel industry and the declining coal power has led the share of coal to decrease.

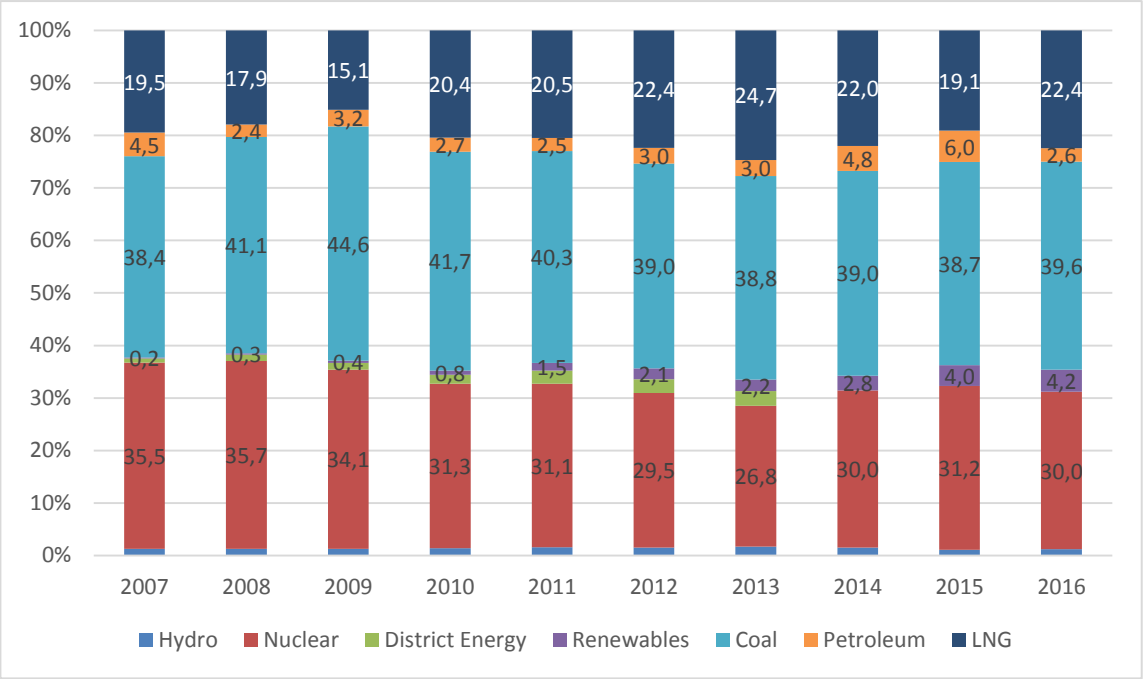
While the share of LNG went up to 18.7% in 2013, the direction went into reverse as a result of a fall in LNG demand for power generation and city gas manufacturing. The establishment of new nuclear power plants increased its share slightly, with the annual growth rate of 0.9% on average between 2011 and 2016. The share of renewables has gradually increased from 2.0% in 2007 to 4.6% in 2016.

[Primary Energy Share by Sources]



Source: MOTIE, KEEI. Yearbook of Energy Statistics 2017

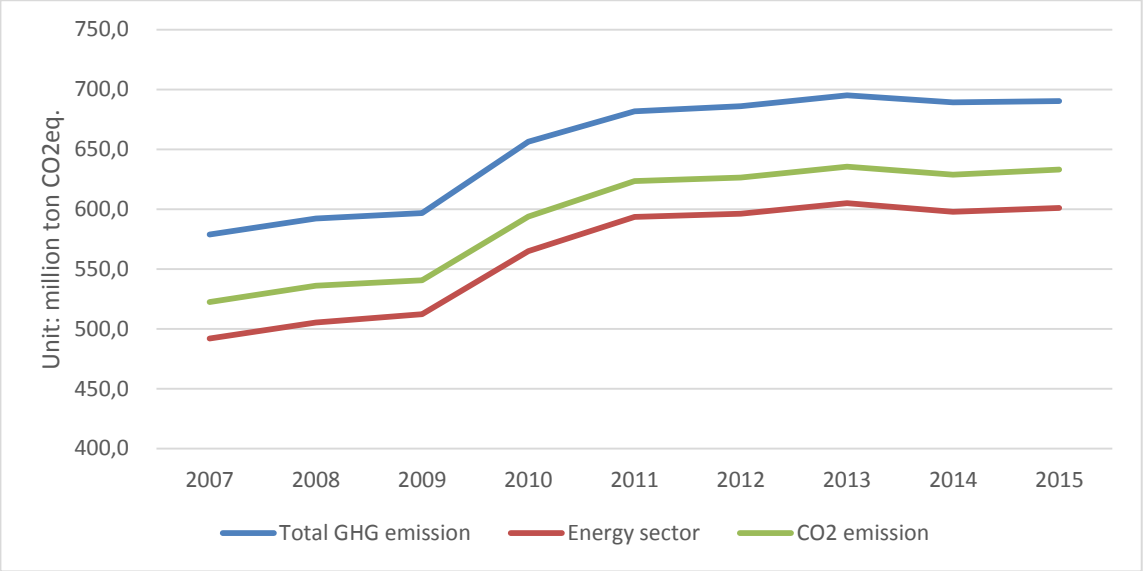
[Electricity Generation Share by Sources]



Source: MOTIE, KEEI. Yearbook of Energy Statistics 2017

The energy sector holds the largest share in the national greenhouse gas (GHG) emission, approximately 87% (in 2015). National GHG emission rose sharply during between 2009 and 2011 as the TPES had sharply increased. Since 2012, it has been modestly consistent, approximately 690 million ton Co2eq. emission in 2015.

[National GHG Emission]



Note: "Land use, land-use change, and forestry" is not included

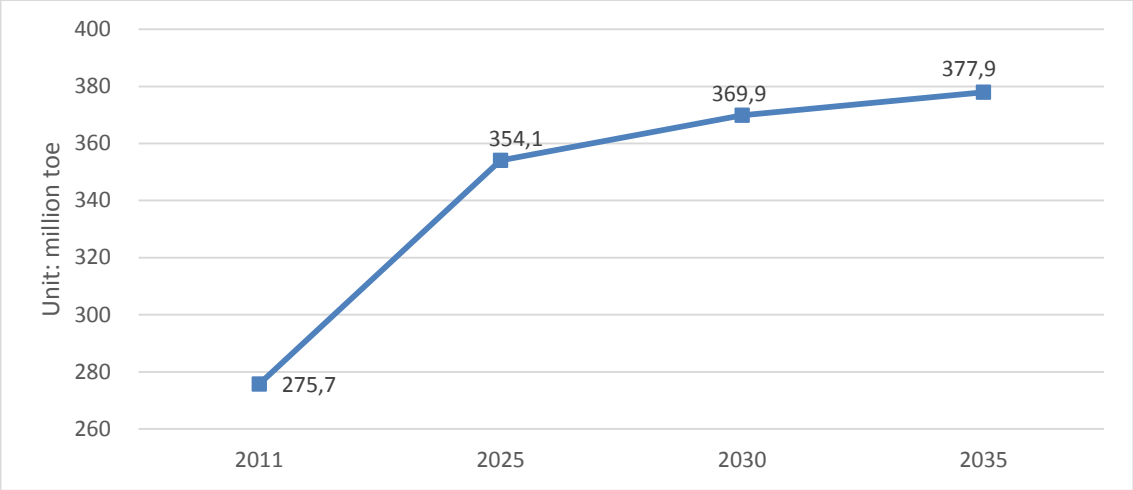
Source: Greenhouse Gas Inventory and Research Center. 2017 National Greenhouse Gas Inventory Report of Korea

Energy transition outlook and policies 2030/2050

According to Korea 2nd Energy Master Plan (2014, "2nd Plan"), the total energy demand will increase by 1.3% annually on average from 2011 to 2035. The growth rate is expected to decrease due to slower economic and population growth. With the inauguration of President Moon in 2017, directions and objectives in the energy plan has been revised. The 3rd Energy Master Plan reflecting this revision is supposed to be released at the end of 2018.

Renewable energy sources and natural gas are expected to increase their portions instead of fossil fuels and nuclear power.

[Outlook of Total Energy Demand]

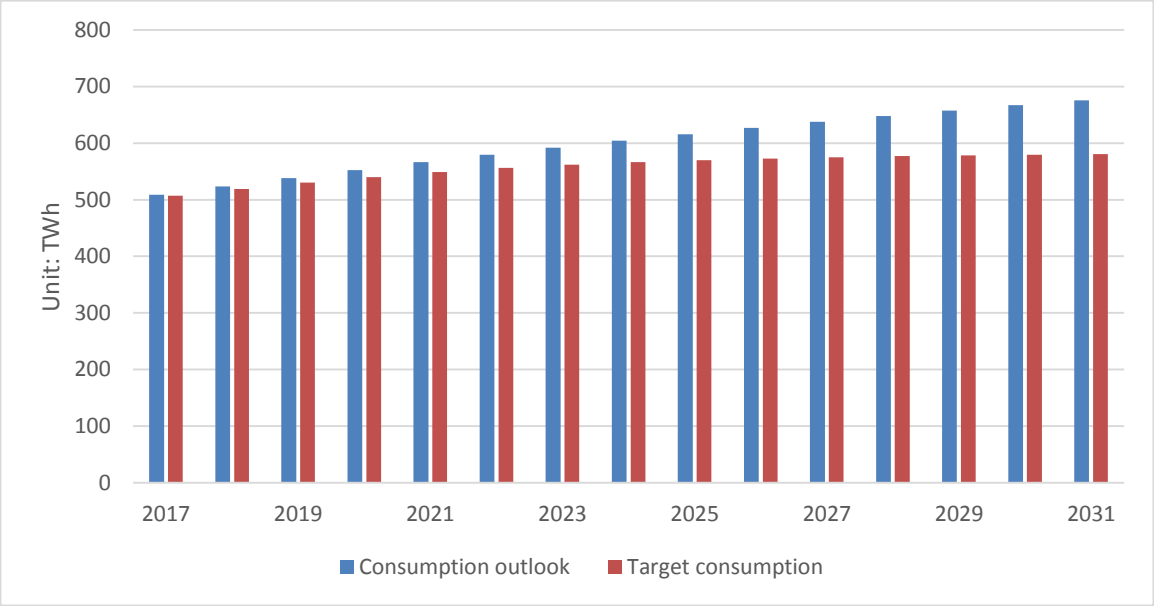


Source: Korea 2nd Energy Master Plan

According to the 2016 long-term energy outlook by Korea Energy Economics Institute, the demand will be accelerated by an economic rally and additional installation of petrochemical facilities until 2019. However, after 2020, the growth rate will decrease as the economy is stabilized. In the long-term, the total energy demand will grow annually on average less than 1%, reaching 363 million toe in 2040.

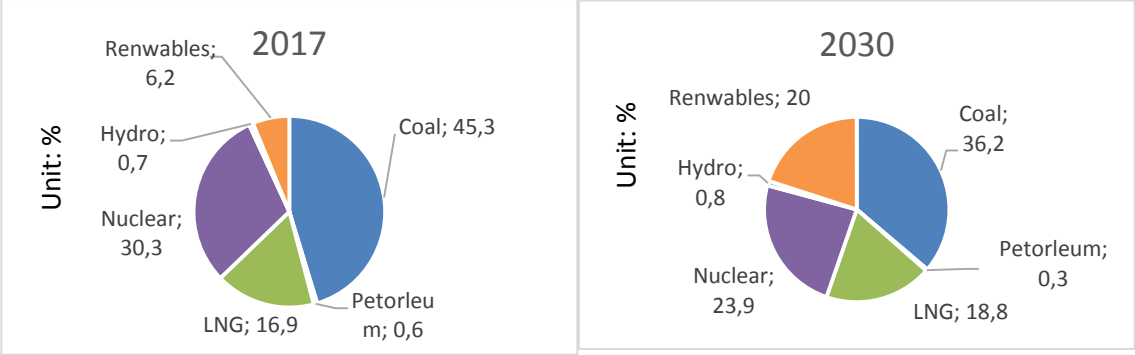
The government released the 8th Basic Plan for Long-term Electricity Supply and Demand (8th Electricity Plan) in December 2017, which expects that the electricity consumption will grow annually on average 2.1% between 2017 and 2031. The government has a plan to manage electricity consumption with measures such as an expansion of solar power deployment, an application of the Energy Efficiency Resource Standards, and electricity price adjustment. The plan will reduce the average annual growth rate into 1.0%. As a result, the total capacity installed in 2030 is expected to reach around 100.5GW.

[Outlook of Electricity Consumption]



Source: 8th Basic Plan for Long-term Electricity Supply and Demand

[Outlook of Electricity Generation Mix (Objective Scenario)]



Source: 8th Basic Plan for Long-term Electricity Supply and Demand

The Ministry of Trade, Industry and Energy (MOTIE) announced the Implementation Plan for Renewable Energy 3020 (Renewable Plan 3020) in December 2017, as the strategy to achieve the objective share of renewables. This plan aims to raise the share of renewable in power generation from 7.0% in 2016 to 10.5% in 2020, 20% in 2030, and the renewable power generation capacity will increase from 13.3GW in 2016 to 27.5GW in 2020 and 63.8GW in 2030, most of which will be installed as solar PV and wind power capacity.

Towards cleaner energy systems

As the new administration sets a goal to have 20 % of power generation with renewables by 2030, there will be substantial changes in directions of energy policy. According to the Renewable Plan 3020, approximately 50 GW of renewable power generation capacity, will be installed until 2030. The Ministry expects that investment for renewable capacity will cost about 100 trillion Won (94 billion USD), including 51 trillion Won (48 billion USD) from the public and 41 trillion Won (39 billion USD) from the private sector. 18 trillion won (17 billion US) by the government is planned to be invested until 2030.

Investment outlook for renewables capacity

Unit: trillion Won

2018	2019	2020	2021	2022	2023	2024
2.8	4.9	4.9	5.1	5.8	6.5	7.8
2025	**2026**	**2027**	**2028**	**2029**	**2030**	**Total**
8.4	8.2	8.5	9.8	9.6	9.9	92.4

Note 1: The budget of government R&D is excluded.

Note 2: 1 trillion Won can be exchanged with about 0.94 billion USD.

Source: Implementation Plan for Renewable Energy 3020

The Renewable Plan 3020 sets a strategy to proliferate personal solar panels in building, of which total capacity is expected to reach 140MW in 2020. The plan designed some incentives such as a cash reimbursement for leftover electricity and the Zero Energy Building Certification System which evaluate a building's degree of self-sustainability. The system requires a higher energy efficiency and more use of renewable energy in buildings, and it will be applied to all public buildings in 2020 and expanded to all kinds of buildings by 2030. In addition, Feed-in Tariff (FIT) will be temporarily implemented to cover the generation cost partly for personal or small-scaled renewable capacity.

Capacity of renewables by 2030

Unit: MW

	Solar PV	Wind	Hydro	Waste	Ocean	Bio/LFG	By-product gas	Fuel cell	IGCC	Total
Rated capacity	33,530	17,674	2,105	323	255	1,705	1,377	746	746	58,461
Peak load	15.6%	1.9%	28.1%	24.2%	1.1%	29.2%	75.5%	73.5%	60.0%	-
Effective capacity	5,231	336	591	78	3	498	1,040	548	448	8,772

Source: 8th Basic Plan for Long-term Electricity Supply and Demand

The government encourages solar panels to be installed in rural areas, and local governments will identify a site for renewable projects. As large-scaled projects, a

capacity of 5GW will be installed until 2022 and a capacity of 23.8GW, including floating photovoltaic systems and wind power plants, will be added by 2030. The government will lift restrictions to encourage these renewable projects to be successfully conduced.

As these large renewable projects are planned, there are concerns about the intermittency and the variability. The 8th Electricity Plan suggested ways to manage the variability of renewables. For example, back-up capacity whose power output is adjusted up and down quickly is considered, which include Energy Storage System (ESS), pumping-up power plant (2GW) and LNG combined power plant (3.2GW). In addition, a comprehensive monitoring system for renewable power generation will be developed to predict and to gauge its output in real-time, and to respond to its sudden change. The pilot system is to be established in 2018 and the complete system is planned in operation in 2020. In the electricity market, further incentives will be provided for suppliers of back-up renewables and a standard of resilient renewable sources to producers will be prepared. More details will be included in the "3rd Energy Master Plan" which is released at the end of 2018.

Trends towards flexible energy systems

As mentioned in the part of trends towards cleaner energy systems, challenges regarding intermittency problem are considered as critical. To solve the problem, 1,560km power lines, 89 transformers and 43 substations are to be installed additionally. Moreover, a new technology, "Flexible AC Transmission System", which controls electric current and voltage in grid, will be introduced and the comprehensive monitoring system will improve the security of grid. All these efforts are examples of moving towards more flexible energy systems.

Trends towards transparent energy systems

One of the most important benefits a transparent system provides is a more public acceptance. The Korean government considers public acceptance regarding energy transitions quite serious. To improve public acceptance for new energy facility, the 3020 Plan encourages residents to participate in the businesses of renewable projects. Establishing a small-scaled cooperative union, residents can fund the project and share its profit, which means a local ownership of renewable facilities.

Furthermore, regarding projects of transmission & distribution facility, it is difficult to obtain public acceptance in local communities. To solve this problem, the 8th Electricity Plan plans to apply a new transmission technology of High Voltage Direct Current (HVDC). This technology is efficient in long-distance transmission while requiring a smaller-scaled pylon and emits less electromagnetic wave. These plans are included as the efforts to move towards a more transparent energy systems.

G20 actions going forward

First, it is important to have direction of cooperation in the ministers' communique and concrete plans in the deliverables. These two level documents, which have to be appropriately developed, will guide the G20 members into required actions for energy transitions.

Second, checking what have been done by members is also essential. Without follow-up monitoring, a number of actions which were planned would not be implemented. The G20 presidency has to put more efforts in this follow-up monitoring as well as planning.

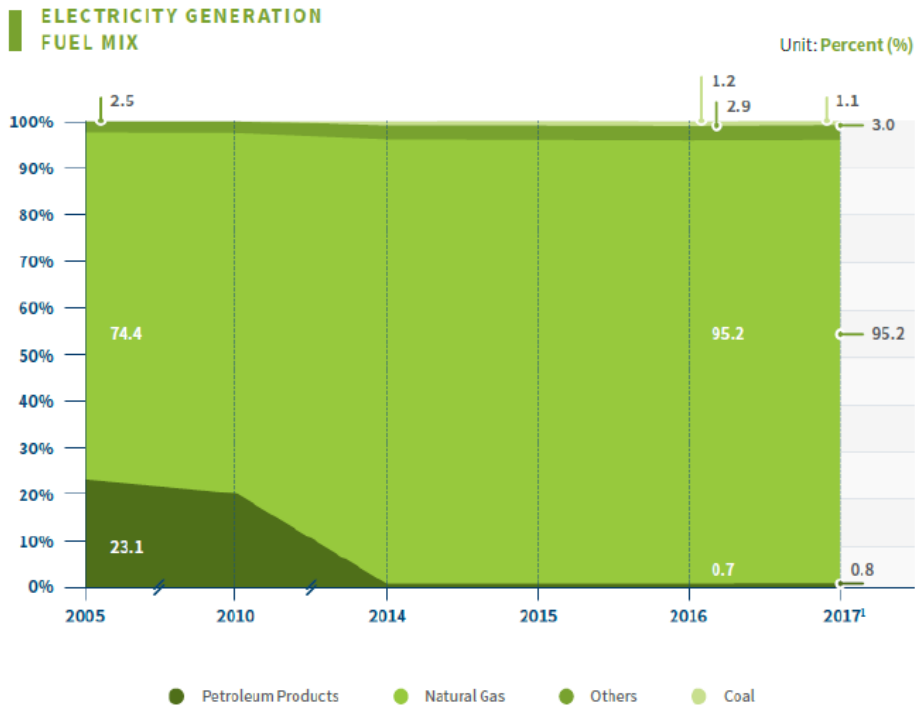
Third, the G20 should increase collaboration with organizations which actually implement projects in the field. Not only international organizations and governments, but also domestic organizations are in charge of specific projects for diverse energy transitions. It is important to hear what is going on and what are challenges in the field. So, the G20 needs to strengthen interactions and collaborations with various organizations for accomplishing the goals it has for energy transitions.

Singapore

Country	Singapore

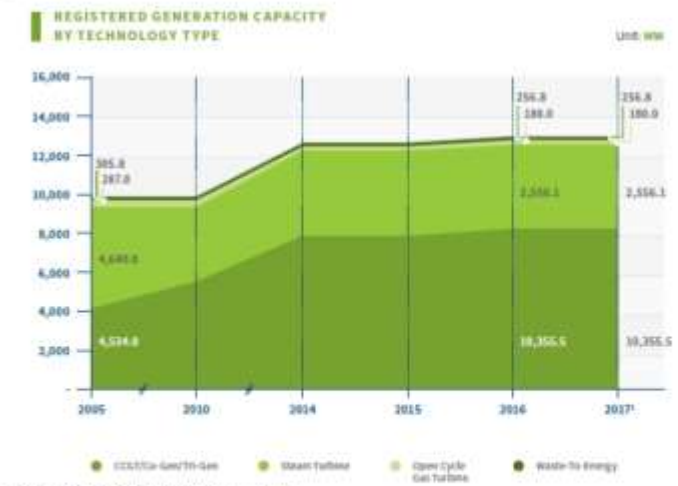
Evolution of Energy Mix

In 2005, around 75 percent of our electricity was generated by natural gas and 23 percent by petroleum products. Today, about 95 percent of our electricity is generated using natural gas, the cleanest form of fossil fuels, and the share of petroleum products stands at less than 1 percent. The figure below illustrates our electricity generation fuel mix from 2005 to 2017.



Source: Singapore Energy Statistics, 2017

Since 2005, Singapore has also transitioned from steam turbine power plants towards more efficient CCGT and co-generation options. The figure below illustrates the change of our generation capacity by technology type.



Source: Singapore Energy Statistics, 2017

Energy transition outlook and policies 2030/2050

As part of our energy transition, Singapore has embarked on a series of initiatives and policies to reduce our emissions intensity. Singapore aims to (i) reduce greenhouse gas emissions by 16 percent below BAU levels by 2020 and (ii) reduce emissions intensity by 36 percent from 2005 levels, and stabilise our emissions with the aim of peaking around 2030.

Singapore has taken a Whole-of-Government approach to achieve these goals and adopted a mix of regulations, incentives, and capability building measures to encourage energy efficiency improvements in the industrial, building and household sectors. For example, the Ministry of the Environment and Water Resources (MEWR) recently enhanced our Energy Conservation Act to strengthen energy efficiency practices among companies, and plans to implement Minimum Energy Performance Standards (MEPS) for common industrial equipment.

The Buildings and Construction Authority (BCA) requires buildings to submit annual energy consumption data to ensure our Green Mark Standards[1] are maintained. The National Environment Agency (NEA) has also introduced the Mandatory energy Labelling (MELS) to raise the average energy efficiency of regulated goods[2] in the market.

Singapore will implement a carbon tax at S$5 per tonne of greenhouse gas emissions from 2019 to 2023, with the intention to increase it to a rate between S$10 and S$15 per tonne of emissions by 2030. The carbon tax will apply uniformly to all sectors, without exemption.

[1] The Green Mark is a green building rating system to evaluate a building for its environmental impact and performance. It provides a comprehensive framework for assessing the overall environmental performance of buildings to promote sustainable design, construction and operations practices.
[2] Goods include refrigerators, air conditions, televisions and lighting.

This would send a transparent, fair and consistent price signal across the economy. It would also incentivise the adoption of more energy efficient practices by the industry sector as well as the rest of the economy.

Towards cleaner energy systems

Singapore is a small island city-state with relatively flat terrain, low wind speeds and low tidal range which limit our renewable energy options. While Singapore is "alternative energy disadvantaged", we have been working to facilitate the introduction of solar PV, as it is currently the most technically and economically viable renewable energy option for Singapore.

We aim to achieve this through enhancing our regulatory framework to create an enabling environment for all solar adopters and industry stakeholders. For example, we streamlined connection requirements by offering consumers the option to leverage on solar profiling to measure solar output, thereby removing the need for them to install physical meters. In addition to regulatory reform, the government also supports continued investment in research, development, and demonstration (RD&D) to improve the supporting infrastructure and capabilities to enable wider deployment of solar PV. We have embarked on research projects aimed at reducing the cost of solar PV modules and improving their efficiency.

Our efforts have succeeded in cultivating strong market interest in solar. Even without financial support, our solar capacity has grown tremendously, almost doubling year-on-year since 2008. Looking beyond 2020, we plan to further raise the adoption of solar power in our system to 1 gigawatt peak.

Trends towards flexible energy systems

Singapore today enjoys a 100 percent electrification rate and our grid remains one of the most reliable in the world with an average electricity interruption time of less than 1 minute per customer per year. This milestone was achieved by the government's willingness to view electricity as an investment for its people and consistently upgrading itself to be more efficient. To support greater renewables deployment, Singapore has invested in system-level solutions such as solar forecasting and energy storage technologies to manage intermittency. In 2017, the Energy Market Authority (EMA) and Singapore Power (SP) awarded S$17.8 million to two Singapore-led Consortiums, CW Group and Red Dot Power, to implement Singapore's first utility-scale Energy Storage System (ESS). This project aims to evaluate the performance of different ESS technologies under Singapore's operating environment which would contribute to the establishment of clear technical guidelines for ESS deployment in Singapore.

Singapore has also been taking proactive steps to enhance the regulatory framework for solar generation, so as to ensure the stability and reliability of the national grid while facilitating market interest and maximising the amount of solar generation capacity that can be deployed. These include reviewing the solar value chain to facilitate solar deployment through (i) streamlining our infrastructure connection process and requirements, (ii)

simplifying the registration processes and licensing requirements for solar PV adopters, and (iii) simplifying the payment models for selling excess solar electricity back to the grid.

On the other side of the spectrum, EMA has also introduced a Demand Response (DR) programme, which enables contestable consumers to reduce their electricity demand voluntarily to enhance competition in our electricity market. DR helps consumers better manage usage and realise cost savings, while improving system reliability and generation capacity planning. To supplement this, EMA launched the Project Optiwatt programme to demonstrate the viability of Demand-Side Management (DSM) initiatives with 16 partners from Institutes of Higher Learning, companies, electricity retailers, research institutions and grid operator.

Towards transparent energy systems

Singapore is supportive of greater data transparency and accuracy. To support this effort, Singapore contributes regularly to the Joint Organisations Data Initiative (JODI) as a member of the International Energy Forum (IEF). EMA also publishes the annual Singapore Energy Statistics (SES) which aims to provide readers with a comprehensive understanding of the Singapore energy landscape through a detailed coverage of various energy related topics. The SES is accompanied by a micro-site to facilitate easier access to our energy data.

G20 actions going forward

Greater cooperation amongst the international community in sharing its experience and know-how plays an important role in our collective efforts towards a sustainable energy future. As such, the G20 could play an active role in the exchange of best practices in the areas of energy policy reform, infrastructure financing and technology exchange amongst and beyond the G20.

In particular, the G20 has identified natural gas as an integral piece of the global energy supply and highlighted its important role in our global energy transition. In that regard, the G20 is well positioned to strengthen energy security and facilitate cooperative mechanisms that enhance global gas value chains, diversify LNG contract terms and promote gas trade, including small scale LNG and bunkering.

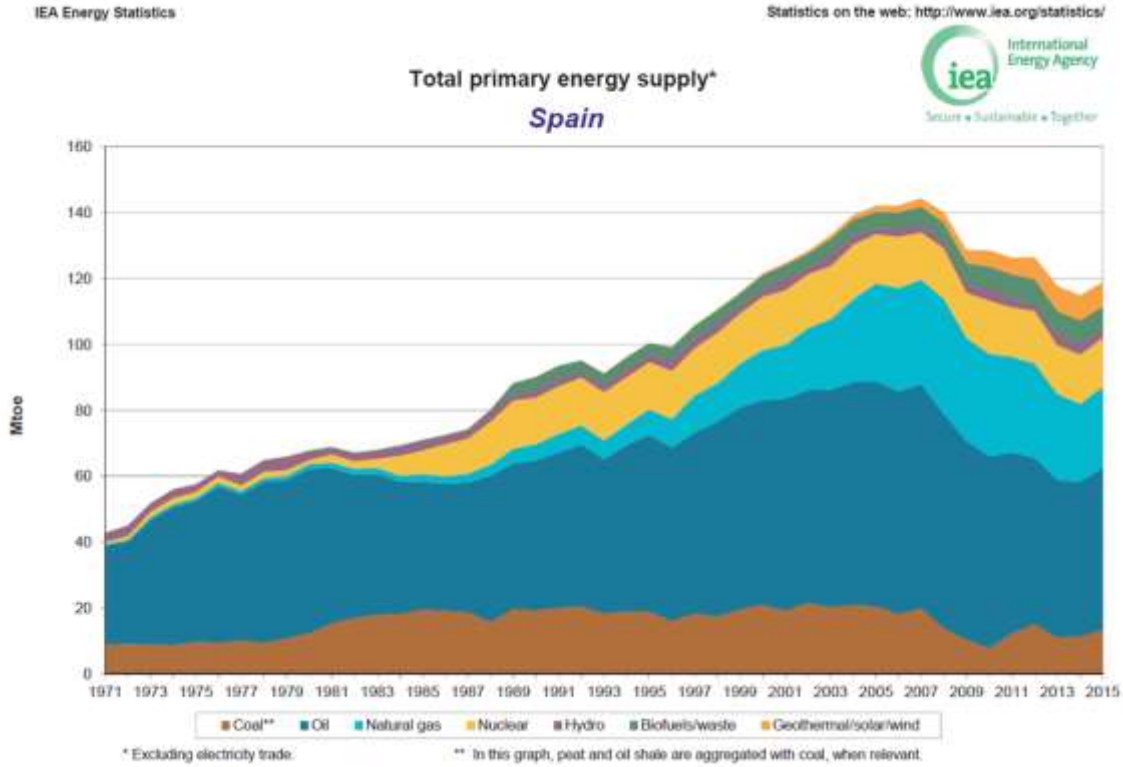
Capital costs remains a key factor in the deployment of natural gas. In view of this, the G20 could work with global financial institutions to facilitate innovative financial and investment models for infrastructure projects and further expand the use of natural gas beyond power generation, including in the transportation and commercial sectors.

Spain

Country:	Spain

Evolution of the energy mix

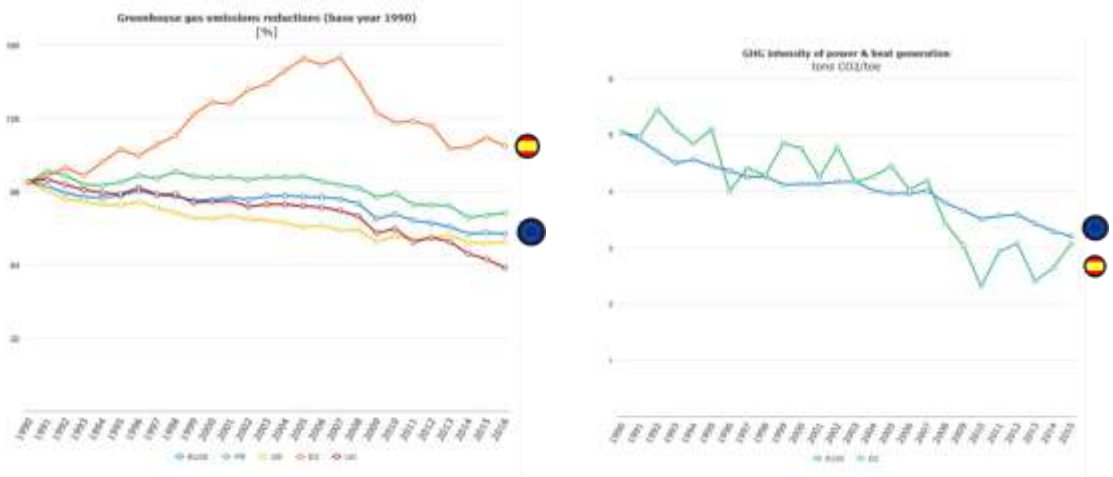
In the past few decades, the trend towards energy diversification has been consolidated and, as a result, the significance of energy sources with greater impact on greenhouse gas emissions, like coal and oil, has declined. Conversely, renewables and natural gas have increased their weight in the Spanish energy mix. It has to be pointed out though that an important dependence of oil still remains and, as regards natural gas, since 2011 there has been a slight decrease in its contribution to the mix with a share stabilized at about 20%. The contribution of nuclear energy remains essentially unaltered



Evolucition of the Spanish primary energy mix (1971-1915) Source: International Energy Agency

MAJOR CHANGES IN THE COUNTRY'S TOTAL PRIMARY ENERGY MIX (TPES), GREENHOUSE GAS EMISSIONS/ENERGY-RELATED CO2 EMISSIONS, THE POWER MIX AND POPULATION/GROSS DOMESTIC PRODUCT (GDP)

GHG Emissions: From 1900 to 2008, gross greenhouse gas emissions followed a general upward trend in line with the expansion experienced by the economy. With the start of the economic crisis, since 2008, a path of decreasing emissions began with slight upticks associated with the variation in the availability of renewable energies for electricity generation.



Source: European Commission. Indicators for monitoring progress towards Energy Union objectives[17].

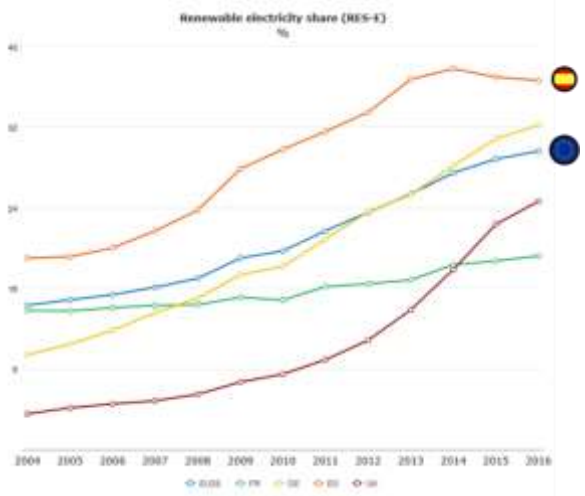
Electricity mix: The most noteworthy fact is the share of renewable energy production, where the ratio is much higher than the European average and that of countries such as Germany, France or United Kingdom. Hydro and wind energy facilities amount to 83% of the renewable power capacity.

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
EU28	**EU28**	**15,4%**	**16,1%**	**17,0%**	**19,0%**	**19,7%**	**21,7%**	**23,5%**	**25,4%**	**27,4%**	**28,8%**	**29,6%**
BE	Belgium	3,1%	3,6%	4,6%	6,2%	7,1%	9,1%	11,3%	12,5%	13,4%	15,5%	15,8%
BG	Bulgaria	9,3%	9,4%	10,0%	11,3%	12,7%	12,9%	16,1%	18,9%	18,9%	19,1%	19,2%
CZ	Czech Rep.	4,0%	4,6%	5,2%	6,4%	7,5%	10,6%	11,7%	12,8%	13,9%	14,1%	13,6%
DK	Denmark	24,0%	25,0%	25,9%	28,3%	32,7%	35,9%	38,7%	43,1%	48,5%	51,3%	53,7%
DE	Germany	11,8%	13,6%	15,0%	17,3%	18,2%	20,9%	23,6%	25,3%	28,1%	30,8%	32,2%
EE	Estonia	1,5%	1,5%	2,1%	6,1%	10,4%	12,3%	15,8%	13,0%	14,1%	15,1%	15,5%
IE	Ireland	8,7%	10,4%	11,2%	13,4%	14,6%	17,4%	19,7%	21,0%	22,9%	25,2%	27,2%
EL	Greece	8,9%	9,3%	9,6%	11,0%	12,3%	13,8%	16,4%	21,2%	21,9%	22,1%	23,8%
ES	**Spain**	**20,0%**	**21,7%**	**23,7%**	**27,8%**	**29,8%**	**31,6%**	**33,5%**	**36,7%**	**37,8%**	**37,0%**	**36,6%**
FR	France	14,1%	14,3%	14,4%	15,1%	14,8%	16,2%	16,4%	16,8%	18,3%	18,7%	19,2%
HR	Croatia	35,0%	34,0%	33,9%	35,9%	37,6%	37,6%	38,8%	42,1%	45,3%	45,4%	46,7%
IT	Italy	15,9%	16,0%	16,6%	18,8%	20,1%	23,5%	27,4%	31,3%	33,4%	33,5%	34,0%
CY	Cyprus	0,0%	0,1%	0,3%	0,6%	1,4%	3,4%	4,9%	6,6%	7,4%	8,4%	8,6%
LV	Latvia	40,4%	38,6%	38,7%	41,9%	42,1%	44,7%	44,9%	48,8%	51,1%	52,2%	51,3%
LT	Lithuania	4,0%	4,7%	4,9%	5,9%	7,4%	9,0%	10,9%	13,1%	13,7%	15,5%	16,8%
LU	Luxembourg	3,2%	3,3%	3,6%	4,1%	3,8%	4,1%	4,6%	5,3%	5,9%	6,2%	6,7%
HU	Hungary	3,5%	4,2%	5,3%	7,0%	7,1%	6,4%	6,1%	6,6%	7,3%	7,3%	7,2%
MT	Malta	0,0%	0,0%	0,0%	0,0%	0,0%	0,5%	1,1%	1,6%	3,3%	4,2%	5,6%
NL	Netherlands	6,5%	6,0%	7,5%	9,1%	9,6%	9,8%	10,4%	10,0%	10,0%	11,1%	12,5%
AT	Austria	62,0%	64,0%	65,1%	67,8%	65,7%	66,0%	66,5%	68,0%	70,1%	70,3%	72,6%
PL	Poland	3,0%	3,5%	4,4%	5,8%	6,6%	8,2%	10,7%	10,7%	12,4%	13,4%	13,4%
PT	Portugal	29,3%	32,3%	34,1%	37,6%	40,7%	45,9%	47,6%	49,1%	52,1%	52,6%	54,1%

[17] https://ec.europa.eu/energy/en/atico_countrysheets/scoreboard

RO	Romania	28,1%	28,1%	28,1%	30,9%	30,4%	31,1%	33,6%	37,5%	41,7%	43,2%	42,7%
SI	Slovenia	28,2%	27,7%	30,0%	33,8%	32,2%	31,0%	31,6%	33,1%	33,9%	32,7%	32,1%
SK	Slovak Rep.	16,6%	16,5%	17,0%	17,8%	17,8%	19,3%	20,1%	20,8%	22,9%	22,7%	22,5%
FI	Finland	26,4%	25,5%	27,3%	27,3%	27,7%	29,4%	29,5%	30,9%	31,4%	32,5%	32,9%
SE	Sweden	51,8%	53,2%	53,6%	58,3%	56,0%	59,9%	60,0%	61,8%	63,2%	65,8%	64,9%
UK	Unit.Kingdom	4,5%	4,8%	5,5%	6,7%	7,5%	8,9%	10,8%	13,8%	17,8%	22,3%	24,6%

Share of energy from renewable sources for electricity (RES-E). Source: http://ec.europa.eu/eurostat/web/energy/data/shares



Source: European Commission. Indicators for monitoring progress towards Energy Union objectives

Population: The Spanish population has grown at a constant pace over the last four decades, with growth intensifying in the period 2000-2010, probably driven by migratory movements. Since 2010, the pace of growth has moderated, with a downward trend linked to population ageing, birth rate drop and migratory balance.

GDP: The Spanish economy grew at an average annual rate of 2.7% from 1990 to 2008. From that year onwards, the GDP decreased with an annual rate of 1.8% up to 2014, the year in which the economy began to show signs of recovery. In 2016, GDP grew by 3.2% and in 2017 stood at 3.1 %

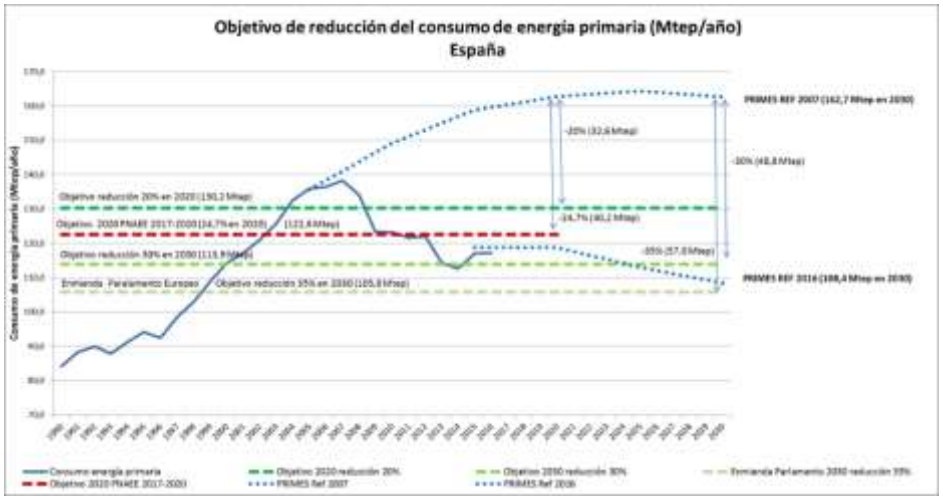
Energy transition outlook and policies 2030/2050

It's foreseen that the current trend (lower share of energy sources with greater impact on greenhouse gas emissions and greater weight of clean technologies) will consolidate. There is actually every indication that the Spanish energy supply will evolve towards a significant increase in the weight of renewables and natural gas while reducing the role

of oil. In any case, the future demand for final energy will be defined by an increase of electrification, as well as a greater presence of electricity in the transport and household sectors.

Official quantitative projections for 2030 and 2050 are not yet available. Nevertheless, Spain is working together with the rest of EU member States to agree on a common 2030 framework for climate and energy to be stablished by the European Regulation on the Governance of the Energy Union. The future Governance Regulation will include, among other aspects, the obligation to produce national integrated energy and climate plans, covering ten-year periods and starting from 2021 to 2030.

Indicatively, the following graph shows the impact of the objectives in terms of energy efficiency, according to scenarios developed by PRIMES.[18]



The three shades of green show the targets of Directive 2012/27/EU on energy efficiency (currently under discussion in the overarching framework of the EU Winter Package "Clean energy for all Europeans") and their implications as regards the primary energy consumption in Spain. Dark green marks the collective primary energy consumption reduction-goal of 20% by 2020 while lighter greens show the proposed targets by 2030 (more specifically, 30 % proposed by the Energy Council and 35% proposed by the European Parliament)

The red line shows the Spanish target as contained in the National Action Plan on Energy Efficiency 2017-2020 currently in force. It should be mentioned that this target is more ambitious than the one agreed at European level (20% on average for the EU as a whole as mentioned in the previous paragraph) .It's also worth mentioning that the energy efficiency target is set with regard to a defined "business as usual" scenario which is used as a base for the analysis of the scenario in 2007 (PRIMES Ref 2007, blue line).

[18] The PRIMES model is an EU energy system model which simulates energy consumption and the energy supply system. It is a partial equilibrium modelling system that simulates an energy market equilibrium in the European Union and each of its Member States.

POLICIES, STRATEGIES, ACTION PLANS, AND INSTITUTIONAL AND GOVERNANCE FRAMEWORKS.

European Regulation on the Governance of the Energy Union

At European level, and as mentioned in the previous section, the future European Regulation on the Governance of the Energy Union is currently under discussion both in the Council and in the Parliament. This regulation aims to ensure that policies and measures at different levels are coherent, complementary and sufficiently ambitious to deliver the targets of the Energy Union.

The European Energy Union covers five key dimensions: energy security, internal energy market, energy efficiency, decarbonisation, and research, innovation and competitiveness.

The cornerstone of this legislative proposal is the establishment of a new UE Governance system based on national integrated energy and climate plans, covering ten-year periods and starting from 2021 to 2030. These plans will follow a common EU approach in order to provide certainty to investors as well as transparency and policy coherence across the EU.

To this end, the new regulation will bring together existing planning and reporting obligations from the main pieces of the EU legislation across energy, climate and other Energy Union related policy areas, which should contribute to achieve a major streamlined political Governance process.

The future EU energy governance system foresees that Member States produce biennial progress reports on the implementation of the plans from 2021 onwards across the five dimensions of the Energy Union to track progress. In these progress reports, Member States will also be required to report biennially on their national climate change adaptation planning and strategies, aligning the timeline with the Paris Agreement.

Thus, the new Governance regulation facilitates mechanisms for Member States to be able to comment on other Member States' plans to avoid inconsistencies, potential negative impacts and to ensure that common objectives are met collectively.

Additionally, the second pillar of the regulatory framework for the Governance of the Energy Union is to establish a robust political process between Member States and the European Commission, with close involvement of other EU institutions, in view of the achievement of the Energy Union objectives, in particular its 2030 targets for energy and climate:

- 40% cut in greenhouse gas emissions compared to 1990 levels
- at least a 27% share of renewable energy consumption
- at least 27% energy savings compared with the business-as-usual scenario

In this framework, the European Commission will be able to make recommendations regarding the level of ambition of objectives, targets and contributions in every Member State, as well as on specific policies and measures included in the respective plan.

In sum, the new Regulation on the Governance of the European Union will be the main instrument to rule the energy and climate transition process of the EU towards 2030 and beyond.

REPORT OF THE COMMITTEE OF EXPERTS ON ENERGY TRANSITION

Decarbonisation strategies entail public administration leading the way in some specific areas to develop effective governance that fosters efficiency and social welfare. In this vein, the Council of Ministers approved on 7 July 2017 the creation of a Committee of Experts in order to prepare a report on different scenarios for energy transition, ensuring the competitiveness of the economy, economic growth, job creation and environmental sustainability. The report, that was delivered on 2 April 2018 to the Ministry of Energy of Spain, is intended to help frame the future discussion on the Climate Change and Energy Transition Law.

The report analyses a series of scenarios and shows several options (each of which presents a different energy mix encompassing nuclear, hydropower, coal-fired and combined cycle power plants, and renewables) whose objective is to move towards a sustainable, efficient and low-carbon energy transition. Thus, the report analyses the objective concerning the market penetration of renewables based on different levels of interconnection between Spain and the rest of Europe, as well as the impact of mobility and energy efficiency policies.

The report indicates that the degree of renewable energy penetration and interconnection level with Europe are highly correlated, in order to properly incorporate renewable energy into the electricity system, avoid massive renewable energy spill and excessive volatility in price formation and guarantee that the TSO is able to securely operate the electricity system.

It also highlights that, regarding greenhouse gas (GHG) Emissions, Spain is in a favourable position in order to comply with the Paris Agreement. This should be valued, as it allows addressing the energy transition with a wider scope to follow a step-wise policy and avoid and undue rush.

As for the energy mix, all scenarios show a very high renewable energy (RES) penetration, especially in the power sector. In this regard it is instrumental to keep working to achieve greater level of power interconnection with France.

Energy saving and energy efficiency, according to the report will play a vital role in the process of decarbonisation of the economy and in the energy transition, as well as in the progressive reduction of dependence on foreign energy resources and price volatility.

Towards cleaner energy systems

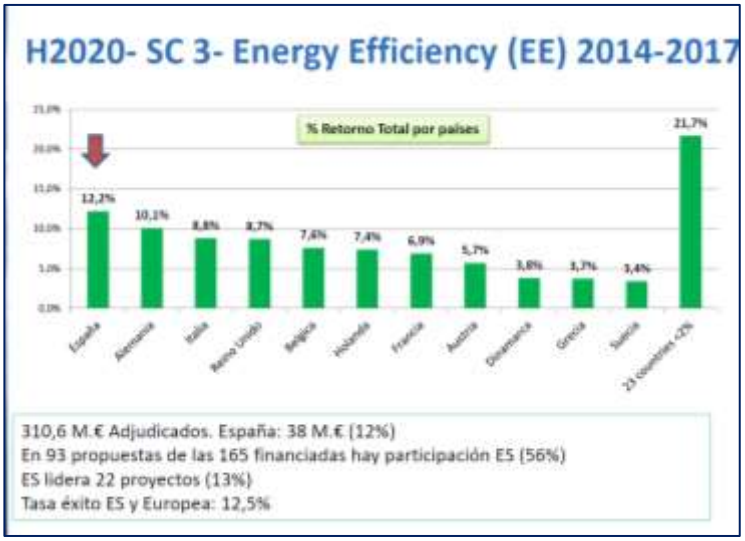
CHALLENGES AND OPPORTUNITIES ARISING FROM THE TRANSITION TOWARDS CLEANER ENERGY SYSTEMS IN SPAIN

The energy transition towards a low carbon economy is one of the main challenges that all countries must face nowadays, since this transition implies changes with great impact on the economy as a whole and in particular on the industrial sector, the sector of transport, the residential sector and, of course, on the electricity generation.

Aiming at making progress on decarbonisation strategies, in 2007 the European institutions approved specific objectives for the development of renewable energy and energy efficiency that every EU Member State has to meet by 2020. All the efforts made by Spain in recent years in this field have concentrated on achieving these objectives.

In October 2014, the European Council agreed on the 2030 climate and energy policy framework for the EU which entails an ambitious economy-wide domestic target for 2030. Currently, the European institutions are discussing the new legislative package

whereby the EU should be in a position as to lead, at a global level, the clean energy transition based on a greater integration of energy markets at European level.
This legislative package includes, among other issues and as already mentioned in the previous section, the obligation for the Member States to prepare Integrated National Energy and Climate Plans.
The integrated national energy and climate plans shall include a description of the national objectives, targets and contributions for each of the five dimensions of the Energy Union as well as a description of the policies and measures foreseen to meet those objectives, targets and contributions. While responding to such obligation, the Spanish Government is drafting a Law on Climate Change and Energy Transition that will allow an integrated response to European objectives.
As regards the opportunities related to the transition, a clear example is the energy efficiency sector. Opting on energy efficiency can boost growth in the EU's economy as well as business opportunities, investments and job creation. In fact, some Spanish companies have already shown a clear interest in this matter. It is also worth mentioning that Spain is the EU country that obtains higher returns from the Framework Program for Research and Innovation Horizon 2020, in the area of energy efficiency (see graph below). It demonstrates the interest that energy efficiency generates while at the same time constitutes a strategic decision for the future.



Returns from the Framework Program for Research and Innovation Horizon 2020. Source: CDTI

SECTORS CONSIDERED CENTRAL TO THE SPANISH ENERGY TRANSITION
There are several sectors which are called to play a key role in the framework of the Spanish energy transition. Two of these relevant sectors are energy efficiency and transport.

Energy efficiency: building renovation
The building sector, which accounts for approximately 25 M houses, is the largest single energy consumer in Europe, absorbing 31% of final energy and producing 11% of direct

CO_2 emissions. Almost two-thirds of buildings were built before 1990, which means that more than 85% of the current stock has a deficient energy rating, type E or lower.

In order to address the improvement of efficiency in buildings, various aid schemes have been implemented, i.a:

- IDAE [19], "Aid program for energy renovation of existing buildings PAREER-CRECE", Budget: 200 M€
- State housing plan 2018-2021 (Ministerio de Fomento, approved on 09/03/2018), that includes a work stream on Promotion of the improvement in energy efficiency and sustainability in housings.

In addition, also related to energy efficiency in buildings:

- Royal Decree 616/2017, of June 16, which regulates direct subsidies devoted to unique projects of Local Entities, Budget: 336 M €.
- IDAE, Call for energy renovation of existing buildings and infrastructures in the framework of the Central State Administration. Budget: 95 M €.

Transport

Transport is nearly 80% of the total consumption of oil products. Spain imports 99% of these products, which implies an energy dependence of 73.3% that seriously affects security of supply. In addition, the increase in GHG emissions between 1990 and 2015 was mainly the consequence of transport-related activities. Therefore, one of the pillars of our energy policy, especially in the context of a successful transition, is the reform of the transport sector.

In this regard, a significant number of actions and assistance programs that aim at improving the efficiency of the sector have been implemented in recent years, with particular focus on road transport (i.e. the PIVE Program and the PIMA Air Plans for the acquisition of efficient vehicles, endowed with € 1,115 million and € 53.1 million respectively)

On the other hand, electric mobility has also received great boost thank to programs such as the 2014 MOVELE Program, approved within the framework of the "Integral Strategy for the Electric Vehicle in Spain 2010-2014", and further expanded by the MOVELE Program 2015. Both programs were replaced by the Mobility Plan with Alternative Energies Vehicles (MOVEA) 2016- 2017, which also included vehicles powered by LPG, natural gas and electric motorcycles, as well as points of recharging for electric vehicles in areas of public access.

In parallel, the Royal Decree 639/2016 on alternative fuels infrastructure and the associated National Action Framework (MAN) transposed the European Directive 2014/94/EU on the deployment of alternative fuels infrastructure. These regulatory measures provide incentives for the decarbonisation of transports, in line with international policies (Paris Agreement, EU Winter Package, etc.). In order to reinforce progress towards those objectives the MOVALT Plan on Alternative Vehicles and Infrastructure has recently been launched.

[19] IDAE: Institute for Diversification and Energy Saving

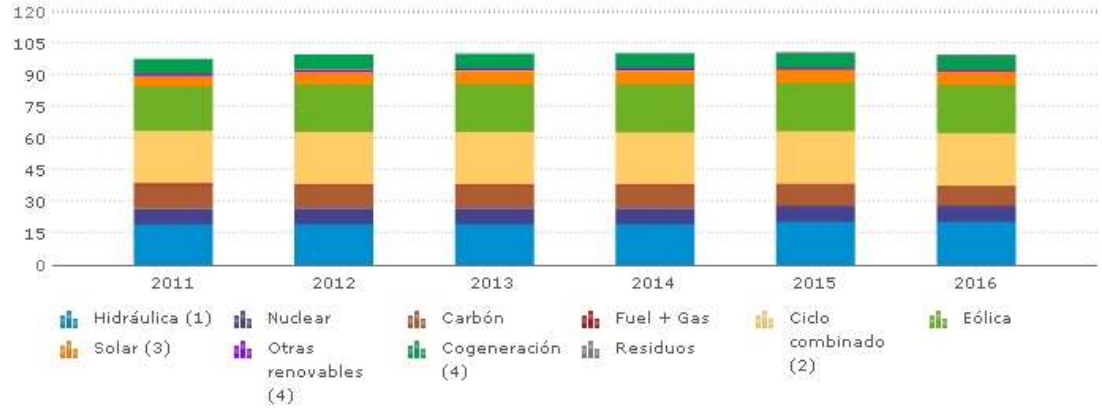
Finally, the National Energy Saving and Efficiency Action Plan 2014-2020 (updated in 2017 as Action Plan 2017-2020) included additional aid programs financed by the National Energy Efficiency Fund. These programs focused on modal shift and efficient driving (€ 11.7 million) and improvement of rail transport efficiency (€ 13 million). Besides, in the framework of the Operational Program for Sustainable Growth 2014-2020 (both within the "Low Carbon Economy" and the "Integrated and Sustainable Urban Development" work streams) specific aids devoted to promote sustainable urban mobility are being granted. Tax incentives for new cars based on CO_2 emissions is also an important measure.

Trends towards flexible energy systems

MAIN SOURCES OF FLEXIBILITY FOR THE SPANISH POWER SYSTEM

1. Manageable power plants

Evolution of the installed capacity [GW] in mainland Spain (Spanish part of the Iberian Peninsula):



Bars indicating installed capacity in the graph above refer to: blue-Hydropower, orange-Solar, purple-Nuclear, maroon-Other renewables sources, brown-Coal, dark green-Cogeneration, red- Oil and Gas, grey-Wastes, yellow-Combined cycle and light green-Wind.

Manageable technologies (including hydro, pumping and combustion power plants) accounted for 62% of the installed capacity in mainland Spain in 2017. Forty four per cent of the installed power of these facilities corresponds to power plants whose primary energy source is non-fossil.

2. Regional market integration

Since 2007, buyers and sellers of electricity in Spain and Portugal acquire their energy in a single market, the Iberian Market (MIBEL[20]), and their purchase and sale offers are

[20] MIBEL: *Mercado Ibérico de la Electricidad*

accepted according to their economic merit order (until the interconnection between Spain and Portugal is congested, which happens in just a few hours).

Likewise, Spain, together with its European partners, is working on the appropriate regulatory and technical measures so that the internal electricity market becomes a reality. Thus, Spain is carrying out a huge effort to develop the necessary interconnections with France which would allow increasing the power exchange capacity between the Iberian Peninsula and the rest of Europe, an essential requirement towards the completion of a real internal market.

In this area, a market coupling system has already been implemented at European level, the Price Coupling of Regions (PCR), which allows calculating transmission capacities and electricity prices using the same methodology in seven electricity markets that encompass 23 European countries. This is true despite the fact that the lack of sufficient cross-border interconnection capacity with France very often causes different price setting on both sides of the border.

Furthermore, Spain participates actively in the pioneering project of the European Cross-Border Intraday Market (XBID Project) so that market players can adjust their energy by presenting purchase and sale offers. In this project, market operators, together with the transmission system operators from 12 countries, will be launching in the coming months an integrated Cross-Border Intraday European market on a continuous basis, which will significantly improve the efficiency of transactions and the integration of renewables. This system is based on a common computer system, to which local intraday markets are linked, as well as on the availability of all commercial capacity of cross-border interconnections. Energy offers and demands introduced in one country may be matched by market participants in any other country, provided that there is cross-border transmission capacity available between the zones.

3. Demand response

The Spanish Electricity Sector Law 24/2013, of December 26 envisages the possibility of active demand-side participation in those services that are part of the generation market, either directly or through suppliers.
This possibility is already a reality for major consumers through the service of interruptibility demand management, whereby the system operator, responding to the operational needs and, according to the criteria of safety, security and lowest possible cost, may request these consumers a temporary power reduction.
Concerning household consumers, one of the main tools for the promotion of demand response is the Voluntary Price for the Small Consumer (PVPC, in its Spanish acronym) to which all consumers whose supplies are made in low voltage and have a contracted power equal to or less than 10 kW are entitled. The PVPC is an essential step for the active demand response since it transfers directly the hourly price signal of the electricity market to the final consumer.
The methodology includes daily and intraday market price, the costs of the ancillary services and, where applicable, other supply-associated cost, for each hour. Therefore, consumers receive a real price signal, which allows them to adopt more efficient consumption behaviors. Thus, consumers with the appropriate measuring and control

equipment are billed according to real hourly readings (as the system charges the energy consumed in each period at the price set in the market) The market price information is available and accessible via internet one day in advance.
The combination of PVPC and smart meters contributes significantly to a better demand management as consumers can have precise information about prices and consumption almost in real time.
Finally, a greater development of the demand response is foreseen when the European platforms of balancing services, in which the Spanish system operator participates, are implemented. The necessary regulatory framework to deploy those platforms is currently being undertaken.

4. Energy storage

Hydropower plants
Pumped-storage power plants are essential for the integration of renewables. There are several pumped-storage power plants in operation in the Peninsula, of which, by their power, it is worth mentioning: La Muela (1,511 MW), Estany Gento-Sallent (439 MW among the four groups), Tajo de la Encantada and Aguayo (376 and 360 MW respectively)

Others:

- Control centers: in order to allow the integration of non-manageable technologies in a safe manner for all facilities above 1 MW (including renewable technologies) telemetry is sent in real time to the System Operator. Additionally, all facilities above 5 MW are connected to a control center.
  The Electric Control Center of Red Eléctrica (CECOEL), for which the Spanish system operator is responsible, centralizes the information in real time concerning the production and transport facilities of the national electricity system. CECOEL performs its functions 24 hours a day, 365 days a year.
  In order to cope with variations in demand, possible unavailability of the generating units and to control that variables remain within the established margins, CECOEL issues the necessary operating instructions that guarantee the proper programming of electricity generation and international exchanges. More specifically, the Electricity Control Center (CECRE, by its Spanish acronym) is an operational unit integrated into CECOEL from which the production of renewable generation facilities or groups above 5 MW is supervised and specifically controlled. This allows a high integration of renewable energy, without compromising safety and quality of supply.
  Through telemetering CECRE receives information every 12 seconds real-time of each facility in relation to the connection status, the production of both active and reactive power and the voltage at the connection point. All this information allows real-time analysis of the current scenario, provides the necessary operation measures for the system to be kept in a safe state and issues, in case of detecting unacceptable situations in the system, production restriction orders.
- Participation of renewable technologies in balance markets: since 2015, facilities for the production of electricity from renewable energy sources, cogeneration and waste can participate, along with conventional technologies, in balance

services of the Spanish electricity system. Eligibility criteria are objective, transparent and non-discriminatory, being able to reach the minimum offer value in aggregate form.

At the beginning of 2018, facilities of different technologies, such as hydro, wind, solar thermal and biomass/biogas, have already been empowered to participate in ancillary services. Among them, hydro and wind facilities stand out with 87% and 46% that are entitled to participate in the deviation management services and tertiary regulation, with regard to the total amount of each technology. Concerning the allocated power those facilities represent as a whole 22.6% of the total energy allocated in the deviation management services and tertiary regulation, and 25% of the secondary regulation services. Quite significant advances have been made in the participation of renewable technologies in the ancillary services.

- Smart Meters: with a view to replace conventional electricity meters by smart meters Spain is undertaken the Smart Meter Deployment Plant to guarantee that, by 31 December 2018, almost all household consumers have a meter with telemanagement and hourly discrimination telemetering. Such meters allows, among other functionalities, reading of energy, power and quality standard records, remotely parameterization of the measurement equipment and remote power control. Likewise, they have the capacity of load management, in order to reduce demand at critical moments.

  According to the Report on compliance (CNMC Meter Replacement Plan [21]) at the end of 2016 the main distribution companies had replaced more than 81% of the total meter pool while distribution companies with less than 100,000 customers had replaced on average about 82%. Last data (January 2018) show that more than 94% of meters have been replaced.

REGULATORY FRAMEWORK

Spain, as a Member State of the European Union, in currently involved in the process of completing the legislative package "Clean Energy for All Europeans" which includes, as regards the electricity sector, a comprehensive overhaul of the regulatory framework to advance in the achievement of the internal electricity market and comply with the climate commitments made in the framework of the Paris Agreement.

On the other hand, at a national level, a Committee of Experts to assess different scenarios for the energy transition was set (as mentioned before). To the extent possible and together with other relevant inputs its conclusions will contribute to the discussion on the future Climate Change and Energy Transition Law.

Furthermore, within the upcoming reform of the current capacity mechanisms, the framework that regulates the interruptibility service is also being adapted, fulfilling European Commission's requirements. Hence, in 2018, some modifications have already been introduced in order to provide greater flexibility to the service and increase the competition of the auctions whereby the interruptibility potential is allocated to the consumers who are service providers.

[21] https://www.cnmc.es/records/infde06317

Towards transparent energy systems

In recent years, a far-reaching reform of the energy sector has been carried out.
In the field of electricity, this reform involved the adoption of a new Electricity Sector Law in 2014 that lays the foundations of the regulation of the sector. The main objective of the law is to secure the power supply and to match it to the consumer needs in terms of safety, quality, efficiency, objectivity, transparency and minimum cost. This reform, which provides more legal certainty for entities carrying out activities in the electricity sector, was conducted through the due public participation and consultation processes with stakeholders. This reform has brought economical and financial stability back to the electricity system, finishing the tariff deficit that was becoming a structural problem for Spain.
Besides, a reform of the gas market is being undertaken over the last years. This reform provides for, among other provisions, measures to promote competition and the reduction of obstacles in the hydrocarbons sector (i. e. via the regulatory development of the Organized Natural Gas Market - MIBGAS by its Spanish acronym - which entered into operation in December 2015).
It should also be noted that maximum transparency is expected as regards the activity of the energy markets, so all the necessary information as well as periodic reports are available on the websites of market operators, and electricity and gas system operators. Similarly, the supervising body, the National Commission for Markets and Competition, publishes on its website regular information about the monitoring operation and the level of competition on the electricity market (both in the wholesale market and in the retail market) and about the system operation. [22]
Regarding the nuclear field it should be mentioned the role of the Nuclear Safety Council (CSN by its Spanish acronym), the sole competent authority concerning nuclear safety and radiation protection. The CSN is responsible for monitoring the safe operation of nuclear and radioactive facilities by the respective license holders and establishing the necessary preventive and corrective measures in the event of radiological emergencies, irrespective of their origin.
Other mechanisms that help improving the transparency of the energy transition process and that encourage social dialogue whilst ensuring an active involvement of civil society and industry are:

- Specific Commission focused on Climate Change: set by the Congress.
- Committee on Energy Transition, whose experts were appointed in close consultation with the parliamentary groups and social agents.
- Inter-ministerial Working Group that brings together representatives of the Ministerial departments with competences in the fields of energy and climate. The purpose of the group is to ensure adequate coordination among all departments in order to develop the future Climate Change and Energy Transition Law and the Integrated Energy and Climate National Plan.
- Public consultation processes: prior to the drafting of the Law on Climate Change and Energy Transition, citizens' contributions will be collected through the website made available for this purpose.

[22] https://www.cnmc.es/ambitos-de-actuacion/energia/mercado-electrico

- Discussion sessions at the Parliament to prepare the Draft Law on Climate Change and Energy Transition.
- A number of discussion fora, events, conferences and seminars with the participation of authorities from the Spanish Ministries of Energy and Environment (MINETAD and MAPAMA by their Spanish acronyms, respectively).

G20 actions going forward

In the framework of the G20 discussions it has been repeatedly stressed that over the next decades, the world needs to expand energy services to meet growing demand but, at the same time, it's necessary to cope with the fact that reducing energy related CO2 emissions rapidly has become crucial to ensure an environmental, social and economically sustainable future.

The G20 members are in a privileged position to show leadership in this transition exercise which is different from previous transitional periods. This time it is not about improving our well-being by producing and consuming more energy but doing it producing the same and consuming less energy while reducing the carbon footprint.

Leading the path towards the decarbonisation of the economy entails strong political messages as well as realistic and implementation-oriented analysis and proposals.

Political messages such as underlining that it is possible to grow the global economy while limiting global warming if the key actions to achieve these goals are clear and strengthened international cooperation is encouraged to guarantee that energy transitions can be successfully addressed. That involves flexibility and willingness to find common grounds for understanding between decision-makers across the world, companies, organizations and institutions, even if they have different and legitimate perspectives and interests as regards the future of the energy systems.

Concerning specific actions and proposals, there is a huge variety of options both at political and technical level that could be explored and potentially undertaken in the framework of G20. Nevertheless, it is also important to avoid overlaps with the work being already carried out by other international organizations and institutions. Instead, the G20 members should take advantage of the valuable platform that provides their capacity to pave the way for further developments in each specific area.

Building on this premises some priorities for future G20 collaboration on energy transitions are suggested:

1. IMPROVING ENERGY PRODUCTIVITY

G20 members share a broad vision that the transition to a low-carbon energy system is technically feasible. In fact, the instrumental and increasing role of technology is one of the pillars on which all the energy transition scenarios are based. Such scenarios show that decarbonising the power sector is essential, and decarbonized power can be used in a significant range of economic activities. However, it is also needed to decarbonise other sectors and value chains which would require reshaping transport systems, building and urban design, industrial processes as well as other activities to enable either cost-effective zero emissions electrification or a zero-carbon non-power energy supply. In both cases, substantial improvements in energy productivity will be required.

Aiming at making rapid but achievable progress in energy productivity G20 may foster technological innovation which is focus on four dimensions:

- Decarbonisation of power combined with extended electrification
- Decarbonisation of activities which cannot be cost-effectively electrified
- Acceleration in the pace of energy productivity improvement
- Optimization of fossil fuels use (cleaner) within overall carbon budget constraints.

2. TECHNOLOGICAL DEVELOPMENT AND FINANCING

In parallel, G20 collaboration should also be conductive to boost a major shift in the mix and financing of energy system investment as well as a coherent and predictable policy frameworks.

Furthermore, any measure should be defined considering its potential economic impact and the cost and benefits of various alternatives so that an ever-growing technological environment does not harm competitiveness and employment but drives the economy forward.

Therefore, a comprehensive analysis that assess opportunities but also risks deriving from the unstoppable technological development would be a valuable instrument for both G20 members and non-G20 members to address their own decision-making processes.

Such analysis should also address the fact that technology is expensive and therefore unaffordable for many developing economies. Over the last years, one of the pillars around which G20 initiatives has turned is universal access to, among other features, affordable energy. In this context, concrete proposals on how to implement new business models that not only allow affordable technological development for all countries but that can be adapted to the needs and circumstances of different countries and regions would be of great value.

On the other hand, clean energy investments with predictable long-term returns could be attractive to a range of institutional investors. However, it will not be easy to mobilise the required scale of finance even if it seems unquestionable that securing finance in an appropriate form at reasonable prices across the multitude of new business models and technologies will be essential to delivering the energy systems we need. So new policies and regulations are needed to allocate transition costs fairly, send the right market signals and create a more predictable environment for long-term investors. Thus, G20 needs to keep the financing of the energy transitions as one of its main priorities. In this regard, stabilising appropriate channels to facilitate regular dialogue and collaboration between the G20-ETWG and international financial institutions is instrumental to identify possible areas for G20 action. Besides, strengthening the relationship between the G20 Energy and Finance working groups might facilitate discussions on the development of proposals in both sides.

3. INTEGRATION OF RENEWABLES IN ELECTRICITY SYSTEMS

It is clear that successfully completing the energy transition towards a low carbon economy entails, among other requirements, the need to integrate greater shares of renewables in our energy mix without compromising the financial and economic sustainability of the electricity systems. Nevertheless, given the particular nature of renewables together with different national circumstances, this undeniable fact is

proving to be a big challenge, not only from the technical and/or regulatory point of view but also because of its cross-cutting effects that have an impact beyond the energy field.
In this light, a possible key G20 action must be to develop a vision-roadmap that includes market design options that can provide some useful guidance to adapt our electricity markets so that they are able to integrate higher shares of renewables. Those options must in addition incorporate not only the energy but also the economic and social perspective.

4. DIGITALIZATION

Regarding digitalization Spain, who is determined to make tangible progress in this field, firmly believes that the G20 could play a key role in promoting digital solutions. Pervasive digitization has the potential to have a very positive impact on multiple sectors of the economy, and is likely to do so at exponentially increasing rates given the growing "digital mind-set" among consumers and the rise in digital business models.
Moreover, today's capital markets have immense capacity to direct financial resources towards future opportunities despite the fact that risks exist, both globally and locally.
In this vein, a priority for G20 analysis and action would be boosting the rate at which policy innovations and effective policy practices focused on digitalization spread internationally.

Turkey

Country:	Turkey

Evolution of Energy Mix:

Share of Resources in TPES (%)						
Years	**Coal**	**Oil**	**Natural Gas**	**Hydro**	**Other Renewables**	**TPES**
2007	28	32	29	3	6	104067
2008	28	31	30	3	6	102825
2009	30	29	29	3	7	100739
2010	29	28	30	4	7	105888
2011	29	27	33	4	6	113371
2012	29	26	32	4	6	117312
2013	26	28	32	4	6	116314
2014	28	26	33	3	7	120747
2015	27	30	31	4	7	129138
2016	28	31	28	4	8	136229

For the year 2016, regarding total primary energy supply of the country, oil products, natural gas and coal are by far the predominant energy forms (31%, 28% and 28% respectively).
Turkey has managed a significant energy transition, which is still ongoing. Since 90s, largescale deployment of gas has been accomplished, i.e. gasification of Turkish Economy has been managed. The key trend has been gasification of Turkish Economy since 90's. Turkish gas consumption reached 37.9 Mtoe in 2016. In last years, Turkey suffers from lack of flexibility in gas demand especially in peak demand seasons. Therefore, Turkey took FSRU and LNG facilities into operation to meet growing energy demand.
Turkey's CO2 emissions from energy sector in 2015 was 130,28 Mtoe CO2 and share of energy sector in total CO2 emissions was 27%.

Energy Transition Outlook and Policies 2030/2050

The general strategic framework document of Turkey is the 10th Development Plan (2014-2018). The Plan sets the main objective of the energy policy as to meet the energy needs of economic and social development in a continuous, qualified, secure and sustainable manner through a free competitive market. The preparatory studies for the 11th Development Plan (2019-2023) are ongoing.
By increasing the share of renewables, it is also aimed to reduce the share of natural gas in electricity generation to a level below 30%. The strategy aims to support the liberalization of a well-functioning energy market. The main strategy document regarding the sector is Energy and Natural Resources Strategic Plan (2015-2019), published by Ministry of Energy and Natural Resources (MENR) on 4 December 2014. The plan aims to improve security of energy supply through building powerful and

reliable energy infrastructure, diversifying the sources of supply and developing an efficient demand management structure.
Turkey's goal is to develop 10 MW of additional capacity in solar and wind energy each by 2026 compared to 2016 and increase the share of the domestic and renewable energy up to two thirds of the electricity production by 2023.
Turkey plans to include nuclear energy to its primary energy supply starting from 2023 and increasing gradually until 2030. Two nuclear power plant (NPP) projects are on-going and a third project is under preparation. Turkey is conducting NPP projects under Build-Own-Operate agreements with foreign vendors. MENR is responsible for representing the government's role in agreements with vendor countries and TAEK is responsible for nuclear safety and radiation protection in Turkey.
In April 2017, the MENR announced "the National Energy and Mining Policy of Turkey". The main pillars of this policy are security of supply, localization, and predictable market conditions. The strategies for security of energy supply are particularly emphasized in this policy with projects such as pipelines, both under construction and existing ones; LNG investments and storage facilities. Utilization of domestic energy resources policy is main driver for this policy including investments in renewable energy, the introduction of nuclear energy to the economy as soon as possible; and the localization of mining technologies. The predictability objective is based on the development of energy markets and the restructuring of institutions in the energy sector.

Towards Cleaner Energy Systems

As a giant step of our targets regarding increasing the share of domestic and renewable energy sources, in March and August 2017, competitive auctions regarding 1000 MW mega projects for each solar PV and wind energy generation plants and equipment manufacturing were successfully organized, receiving great investor interest and record-low prices. Likewise, we will implement a similar model for clean coal technologies in the near future to benefit from vast coal reserves of the country. In this regard, the auction process for one coal site was completed and operation rights were transferred. Accordingly, the auction for the privatization of another coal site through establishment of power plants and transfer of operation rights is announced.
In addition, improving energy efficiency is also determined as one of the vital policy issues towards transition to a cleaner energy system. New action plan, legislative regulations, investment financing are the efforts to boost energy efficiency which will rebound as a reduction in imported energy bill. In the National Energy Efficiency Action Plan adopted in January 2018, it is stated that Turkish primary energy consumption will be reduced by 14% by 2023 through 55 actions defined in 6 categories, namely buildings and services, energy, transport, industry and technology, agriculture and cross-cutting (horizontal) areas. It is also projected that we will achieve 23.9 mtoe of savings cumulatively by 2023.
10.9 billion dollars of investment is envisaged until 2023. Until 2023, 20.000 jobs will be created. The aim is to achieve 30.2 billion dollars of savings until 2033.Through the energy efficiency studies, it was aimed to be reduced energy density of Turkey as 20% until 2023 compared to 2011.

Trends Towards Transparent Energy Systems

The electricity market in Turkey is quite advanced and the Electricity Market Law No. 6446 published in the Official Gazette No: 28603 of 30 March 2013 is largely compliant with the EU's third energy package. Energy Markets Operation Joint Stock Company (EPİAŞ, or Turkish Energy Exchange) was established on March 2015 and it carries out organized wholesale operations in the market. Electricity distribution is fully privatized.
While the electricity trading market includes bilateral contracts, financial market run by Borsa Istanbul, the day-ahead and intra-day markets run by EPİAŞ and the balancing market run by TEİAŞ.

By-law regarding Organizational Structure and Operation Principles of EPİAŞ was published in Official Gazette No. 29313 of 1 April 2015. EPİAŞ took over operations of day ahead and intra-day markets from TEİAŞ as of 1 September 2015. At first, EPİAŞ has been responsible for power purchase and sale. It is aimed that natural gas, oil and derivatives are also traded.

In 2018, it is envisaged that natural gas will be traded.

The eligible consumer limit for 2018 is 2000 kWh/year. The corresponding theoretical degree of market opening on demand side is calculated as 90%. In 2016, the number of eligible consumers switched their suppliers was 304.654.

According to the Article 8 of the Natural Gas Market Law, "The Energy Market Regulatory Authority (EMRA) Board shall determine the limits for being an eligible consumer in the natural gas market every year until all consumers become eligible consumers". In this framework, all end users except household customers were rendered eligible to choose their supplier by the EMRA Board decision dated December 2012, which also defines the rules for customer switching in the market. In December 2014, the eligibility threshold for the household customers was determined by EMRA as 75.000 m3/year by another Board decision, which is the current eligibility limit for household customers. In 2014, the competition in distribution zones was reinforced by the model agreements published by EMRA for natural gas transportation and delivery services for distribution regions. This development provided transparency to supplier switching process and better functioning of the retail market.

The competences of EMRA include the power to fix and approve distribution and transmission tariffs for access and use of the electricity and natural gas systems. Tariffs are set taking into account the methodologies, the investment plans and their fulfilment by the system operator and distribution companies. EMRA also has the competences to determine the methodologies of cross-border capacity allocation and balancing regimes in line with the relevant secondary legislation.

The Law No. 6719 Amending the Electricity Market Law and Certain Other Laws (Official Gazette No. 29745 of 17 June 2016) introduced certain amendments to various laws related to the Turkish energy market legislation. These laws are Electricity Market Law No. 6446, the Natural Gas Market Law No. 4646, the Law on Use of Renewable Energy Resources for
Generating Electricity Energy Law (the "RER Law") No. 5346, the Mining Law No. 3213 and the Petroleum Law No. 6491.

In accordance with provisions newly added to the Electricity Market Law, it will be possible for certain areas to be designated as renewable energy resource zones by the MENR. With respect to these zones:

- If they are on private property then accelerated expropriation, which is a shorter expropriation procedure, shall be applied for investment or generation licence applications, in accordance with the Expropriation Law No: 2942.
- Zoning plans affecting the productivity and utilisation of these areas as renewable energy resource zones cannot be issued.
- The equipment that is used in the generation facilities to be established on these sites must be locally manufactured.
- The measurement data which is usually required when acquiring preliminary licenses for wind and solar energy plants shall not be required for those generation facilities which are to be established on these sites.
- The tender for the system connection shall, for those facilities to be established on each renewable energy resource site, be capped to the sum of the prices calculated according to Annexes (I) and (II) of the RES Law.

Other details such as the designation of renewable energy sites, the requirements for the legal entities which will use these sites, the issuance of connection evaluations by the Turkish Electricity Transmission Company (TEİAŞ) and the allocation of capacity will be governed by a regulation to be issued by MENR.

Trends Towards Flexible Energy Systems

Towards a flexible energy system, the interconnections between neighbour countries are an important issue. For this purpose, synchronous connection to the ENTSO-E network has been an important target for TEİAŞ.

The principles and procedures pertaining to the activities of import and/or export of electricity and principles pertaining to allocation and use of interconnection capacity for cross border trade are carried out according to the Electricity Market Import and Export Regulation.

In line with the developments in neighbouring countries, participation shall be provided to the regional electricity markets to be established through coupling and duties shall be undertaken in the organizations regarding the functioning of regional markets.

The installed capacity is dominated by hydro and natural gas fired power plants followed by coal and other renewable sources. Hydro and natural gas power plants provide a significant contribution to the flexibility of the power system.

According to a statement in MENR Strategic Plan (2015-2019), implementation of existing electricity transmission investments provided with taking into consideration technological advances such as smart grid and storage in electricity are being considered.

Also, regarding the Pumped HEP; a series of studies on optimal power generation for peak demand have been ongoing.

According to the National Energy Efficiency Plan (2017-2023), market based demand side participation mechanism will be implemented in order to reduce the rate of peak demand to average demand in electricity market.

G-20 Actions Going Forward

In the context of Turkish energy policies and strategies the following issues are among our priorities:

- Energy security

- Domestic and renewable energy development
- Energy technology transfer
- Energy efficiency

Taking into consideration that energy transition policies depend on the national circumstances, need and priorities of the countries, G20 can be used as a platform for sharing of best practices regarding the related fields among its members.

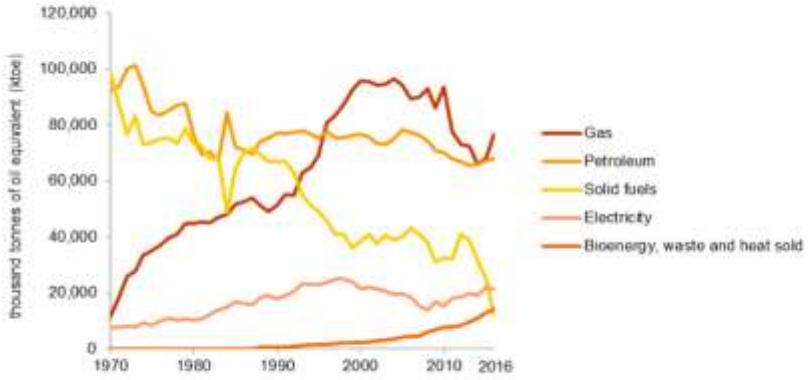
United Kingdom

Country:	United Kingdom

Evolution of the energy mix

In 1970, solid fuels and petroleum dominated the UK fuel mix, accounting for 47% and 44% respectively. As the share of solid fuels decreased sharply in 1984 during the miners' strike, the use of petroleum spiked due to substitution for low coal production. Solid fuels' share recovered up to 1987 before steadily declining to a 16% share in 1999. During this period, North Sea gas increased its share from just 5% in 1970 to a maximum of 43% in 2010. Electricity's share also increased during this period, and more recently, the share of renewables has increased from 1% in 1999 to 7.4% in 2016 as a result of various drives to reduce reliance on fossil fuels, and the subsequent production of greenhouse gasses.

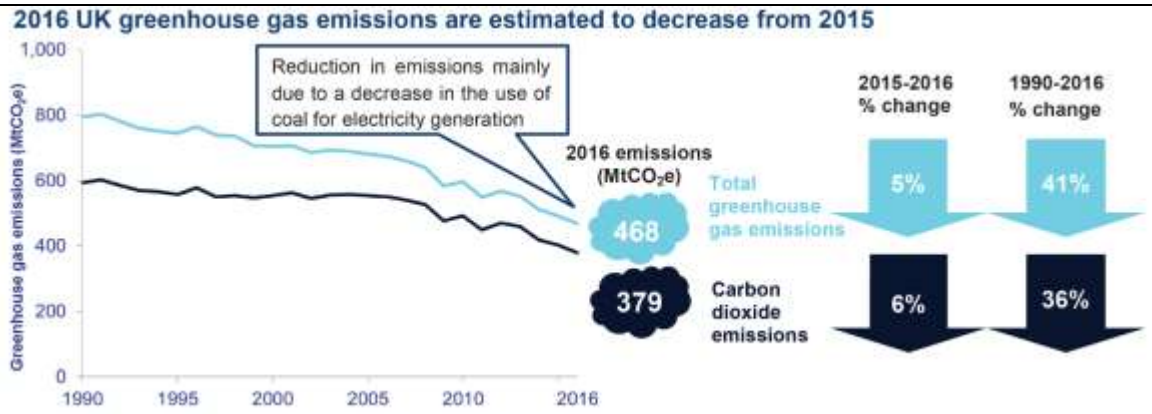
Chart 1.06: Final energy consumption in primary energy equivalents by fuel type



Source; BEIS ECUK Table 1.10

Source: Department for Business, Energy and Industrial Strategy

The UK's final energy consumption in 2016 was 140,668 ktoe, an increase of 1.6% on the year before. Most of the increase was due to gas, which increased by 1,356 kteo. On a temperature corrected basis, consumption increased by 1,330 kteo (0.9%), with transport being the primary driver behind this increase.



Source: Department for Business, Energy and Industrial Strategy

The energy supply sector consists of emissions from fuel combustion for electricity generation, and other energy production sources. It was responsible for 25% of UK greenhouse gas emissions in 2016, with carbon dioxide being by far the most prominent gas emitted at 95%. The main source of emissions from this sector is the use of natural gas and coal in electricity generation from power stations.
Between 1990 and 2016, there was a 57% reduction in greenhouse gas emissions from the energy supply sector. This decrease mainly resulted from changes in the mix of fuels being used for electricity generation, including the growth of renewables, and greater efficiency resulting from improvements in technology. The energy supply sector has historically been the largest emissions sector, but these reductions meant that it became the second largest sector in 2016, with transport being the largest.

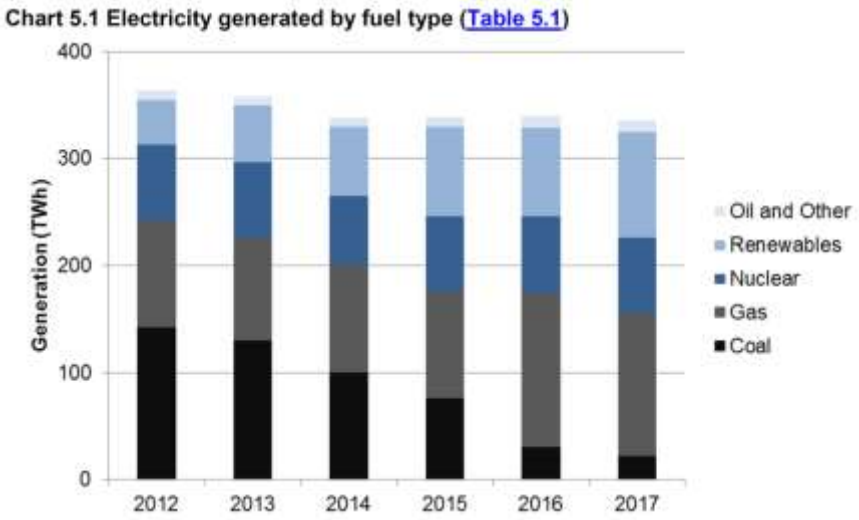
Table 4: Sources of greenhouse gas emissions
UK, 1990-2016

	1990	1995	2000	2005	2010	2015	2016
							$MtCO_2e$
Energy supply	277.9	237.8	221.0	231.3	207.2	144.4	120.2

Source: Department for Business, Energy and Industrial Strategy

In 2017, total electricity generation continued the gradual declining trend seen in recent years, falling 1% from 339 TWh in 2016 to 336 TWh. This was largely due to warmer weather, with the daily average temperature in 2017 being 0.3 degrees warmer than 2016, as well as improved energy efficiency measures.
Over the past five years, the generation mix has shifted further away from fossil fuels. Coal-fired generation fell by 84% compared to 2012, from 143 TWh to 22.6 TWh, its lowest level in this time series as coal plants closed or were converted to high-range co-firing plants (85-100% biomass). Some of the drop in coal-powered generation was replaced by gas-fired generation, which increased from 100 TWh in 2012 to 143 TWh in 2016 as production costs favoured supply from gas. The increase in carbon price in April 2016 meant that the carbon

price per GWh was lower for gas than for coal. Gas fired-generation fell back to 133 TWh in 2017 (-7% compared to 2016), with an increase in generation from renewable sources. Nuclear generation fell by 1.9% from 71.7 TWh to 70.3 TWh, the same as in 2015.
Generation from renewables such as hydro, wind, solar, and bioenergy increased by 19% from 83.2 TWh in 2016 to a record high of 98.9 TWh in 2017. This rise was driven by capacity increases in recent years as weather conditions for both wind and solar generation were both slightly below the ten-year UK average. Average wind speeds were 4.8% higher at 8.8 knots in 2017 compared to 2016, but still 0.1 knots below the ten year mean. Average daily sun hours were stable at 4.2 hours in 2017 compared to 2016, 0.2 hours below the ten year mean. Hydro generation rose 10%, from 5.4 TWh to 5.9 TWh, but this was still below the 2015 record of 6.3 TWh.
The generation mix in 2017 was 6.7% from coal (-2.3 pp on 2016), 40% gas (-2.5 pp), 21% nuclear (stable), 29% renewables (+4.9 pp) and 3.2% from other sources (stable).



Source: Department for Business, Energy and Industrial Strategy

In 2017 the UK population was 66,051,000. Gross Domestic product was £1,959,707 million. Gross domestic product per head of £29,670.[23]

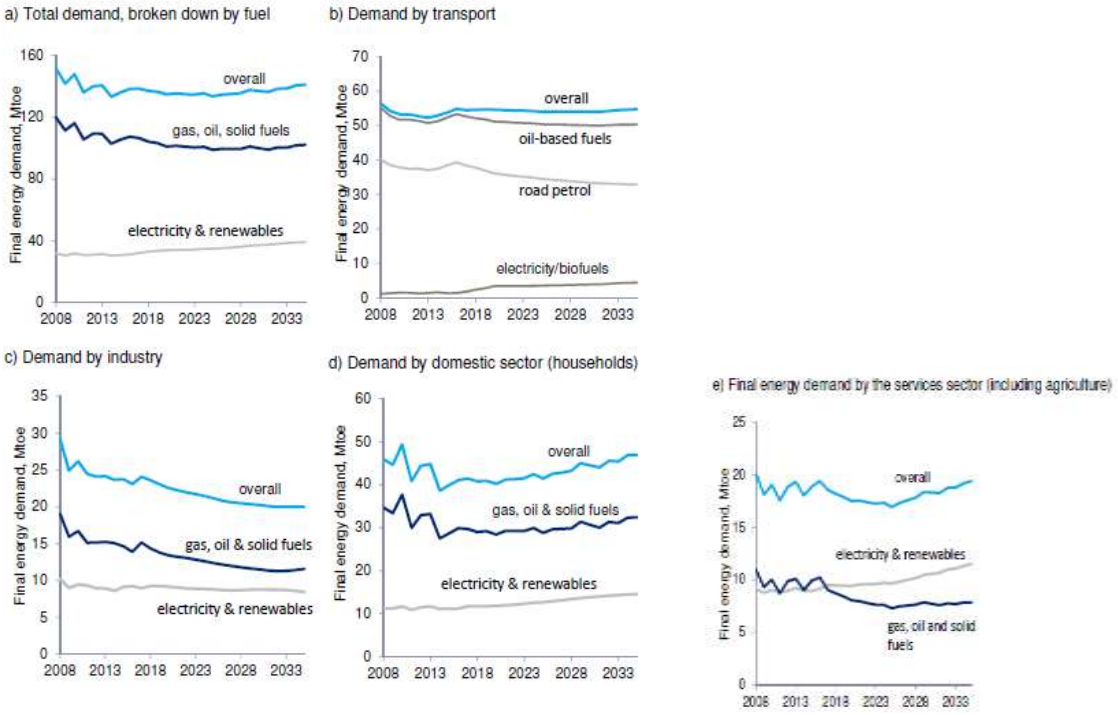
Energy transition outlook and policies 2030/2050

The Department for Business, Energy, and Industrial Strategy produces estimates of energy demand and emissions under existing policies[24] to give an assessment of the expected impacts of the Government's policies, and any further effort required to meet targets.
The final energy demand is projected to be 134 Mtoe in 2025, 3% lower than in 2016. It is then projected to increase again after 2025, as the effects of included policies diminish, and macroeconomic drivers continue to increase demand. Projected final energy demand is

[23] Figures in Great British Pound. Source: Office for National Statistics, https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/gdpperheadtablep
[24] https://www.gov.uk/government/collections/energy-and-emissions-projections

forecasted to increase by 2% in 2035 compared to 2016. The shape of this trend reflects the combined demand across the four major energy consuming sectors: transport (Figure 4.2b), domestic (Figure 4.2d), industry (Figure 4.2c), and services (Figure 4.2e).

The Climate Change Act of 2008 committed the UK to reducing greenhouse gas emissions by at least 80% by 2050 when compared to 1990 levels, through a process of setting five-year caps on greenhouse gas emissions termed 'Carbon Budgets'. This means greenhouse gas emissions falling from around 14 tonnes per person in 1990 to approximately 2 tonnes per person in 2050. Five carbon budgets have been set to date, putting in place caps on greenhouse gas emissions from 2008 to 2032. In July 2016, the fifth carbon budget was set, which requires a 57% average reduction in emissions over 2028-32 across the UK compared to a 1990 baseline.



The UK government recently published its Clean Growth Strategy,[25] which aims to achieve increased economic growth and decreased emissions whilst ensuring affordable energy supply for businesses and consumers. Its purpose is to increase the country's productivity, create jobs, boost people's earning power, and help protect the climate and environment. The strategy sets out proposals for decarbonising all sectors of the economy whilst fulfilling security of supply as well as the objectives of the UK's industrial strategy. The strategy sets out three illustrative ways of meeting the UK's 2050 target, reflecting different possible technology outcomes. These give an indication of the range of how the energy and technology mix could vary in 2050, depending on how technologies develop, and the policy choices that are made going forward.

[25] https://www.gov.uk/government/publications/clean-growth-strategy

Characteristics of the 2050 pathways

		Pathway 1: Electricity	Pathway 2: Hydrogen	Pathway 3: Emissions removal
Non-industrial business and public sector	Emissions ($MtCO_2e$)	3	1	1
	Share of district heat use in heating (per cent)	17%	24%	18%
	Share of electricity use heating (per cent)	83%	13%	80%
	Share of hydrogen use in heating (per cent)	0%	56%	0%
Industrial business	Emissions ($MtCO_2e$)	58	59	48
	Share of electricity use (per cent)	33%	23%	30%
	Share of hydrogen use (per cent)	0%	32%	28%
	Share of bioenergy use (per cent)	20%	15%	9%
	Captured emissions from industrial businesses ($MtCO_2e$)	0	165	37
Homes	Emissions ($MtCO_2e$)	8	6	19
	Share of district heat use in heating (per cent)	17%	17%	17%
	Share of electricity use in heating (per cent)	76%	14%	60%
	Share of hydrogen use in heating (per cent)	0%	62%	0%
Transport	Emissions ($MtCO_2e$)	3	5	15
	Share of car and van km in battery electric vehicles (per cent)	100%	0%	85%
	Share of car and van km in hydrogen fuel cell electric vehicles (per cent)	0%	100%	0%

	Share of HGV km in zero emission vehicles (per cent)	55%	19%	93%
Power	Emissions ($MtCO_2e$)	4	3	-22
	Electricity generation (TWh)	647	339	572
	Share of clean electricity generation (per cent)	99%	99%	99%
Natural resources	Emissions ($MtCO_2e$)	46	46	60
Aviation and shipping[26]	Emissions ($MtCO_2e$)	44	44	44
Total	**Emissions ($MtCO_2e$)**	**165**	**165**	**165**

Towards cleaner energy systems

Clean growth can make a real difference to people's lives, from reducing energy bills and improving air quality, to supporting new technologies and boosting earning power in high-quality jobs. The global transition to a low carbon economy offers huge growth opportunities, which the UK is well placed to take advantage of as a core element of our Industrial Strategy.

While the UK has performed strongly to date, the task ahead is significant. The Clean Growth Strategy, published on 12 October 2017, sets out policies and proposals across the whole of the economy and the country, including business, housing, transport, power, the natural environment, and the public sector.

Low carbon innovation is at the heart of this approach, with over £2.5 billion of government investment from 2015 to 2021. This forms part of the largest increase in public spending on UK science, research, and innovation in almost 40 years.

In the power sector, for example, the key plans and policies included in the Clean Growth Strategy to achieve clean, affordable energy are:

- Phasing out the use of unabated coal to produce electricity by 2025.
- Providing up to half a billion pounds for further Contract for Difference auctions for less established technologies, such as offshore wind, with the next one planned for 2019.
- Working with industry as they develop an ambitious Sector Deal for offshore wind, which could result in 10 GW of new capacity, with the opportunity for additional deployment if this is cost-effective, to be built in the 2020s.
- Delivering new nuclear power through Hinkley Point C and progressing discussions with developers to secure a competitive price for future projects in the pipeline.

[26] Includes domestic and international aviation and shipping, in line with advice from the Committee on Climate Change CCC (2015) Sectoral scenarios for the fifth carbon budget https://www.theccc.org.uk/publication/sectoral-scenarios-for-the-fifth-carbon-budget-technical-report/

Trends towards flexible energy systems

In 2017, the UK launched an Industrial Strategy that aims to provide a major upgrade to infrastructure, including improvement to people's lives through clean and affordable energy. Alongside this, in July 2017, the government and Ofgem published the Smart Systems and Flexibility Plan, outlining 29 actions that the government, Ofgem, and industry will take to remove barriers to smart technologies, enable smart homes and businesses, and improve access to energy markets for new technologies and business models.

The GB electricity system operator, National Grid, also facilitates a stakeholder-led programme called 'Power Responsive' to stimulate increased participation of industry and other large energy users in different forms of flexible technology, including demand side response (DSR) and storage. This integration and optimisation of a customer's energy assets is often supported by innovative IT platforms or aggregation intermediaries that also seek to unlock value for customers by aggregating their energy flexibility into a range of markets and revenue streams.

Towards transparent energy systems

The Government has commissioned an independent review of the cost of energy by Professor Dieter Helm. We are now carefully considering his findings, and have asked for views from businesses, consumer groups, academics, and other stakeholders on how we can reduce the cost of energy in the longer term, and will set out our next steps after considering those responses.

The Government has already taken action that has reduced costs, and helped consumers manage their bills. This includes the cost of offshore wind, which has halved in the last two years. We have provided over £570 million in relief from the costs of renewable generation to eligible businesses since 2013, and are supporting around £3.6 billion of investment to upgrade approximately one million homes through the Energy Company Obligation. The cost of policies for delivering clean growth on bills are more than offset by savings from improvements to energy efficiency, saving bill payers £14 on average in 2016, and we have published for scrutiny draft legislation to introduce a price cap on household energy tariffs. Ofgem are also working to extend the safeguarding tariff for prepayment consumers to 1 million more households this winter to protect vulnerable consumers from overpaying. These households will save around £120 per year on average.