POWER SECTOR CRUCIAL FOR GLOBAL DECARBONISATION

Accelerated deployment of renewable power generation will drive total renewables growth.

Today, around a quarter of all electricity is generated from renewables. The share of renewables in power generation could reach over 80% by 2050. This implies that the share of renewable power in total final renewable energy use would grow from about 20% in 2015 to 40% in 2050, with the remaining renewable energy directly used for heating, cooling and transport. Such a high share of renewable power would create substantial, but manageable, challenges that must be tackled during the transition.

Electrification of end-use sectors will continue to grow, coupled with renewable power.

The share of electricity use in the global final energy mix was just below 20% in 2015, used mainly for lighting and appliance use in buildings and for motor systems in industry. Within transport, railways are the largest users of electricity. Electrifying end-use energy applications (e.g. electric instead of combustion engine vehicles; heat pumps instead of thermal boilers) has multiple benefits to both society and to the overall economy, since renewable electricity is a clean energy source and does not produce emissions at the point of use (reducing local pollution), and the efficiency of use is often much higher than for thermal systems. The share of all these existing electricity-based energy applications can grow, enabling services that are currently provided by thermal energy systems to switch to electricity-based systems whilst achieving the decarbonisation goals. Examples increasingly seen in modern life are heat pumps and electric vehicles (EVs). With accelerated electrification of the energy system, electricity's share is projected to rise to 30% of total final energy consumption in 2050. Electrification should be complemented by direct use of other forms of renewable energy such as solar, bioenergy and geothermal for heating purposes.

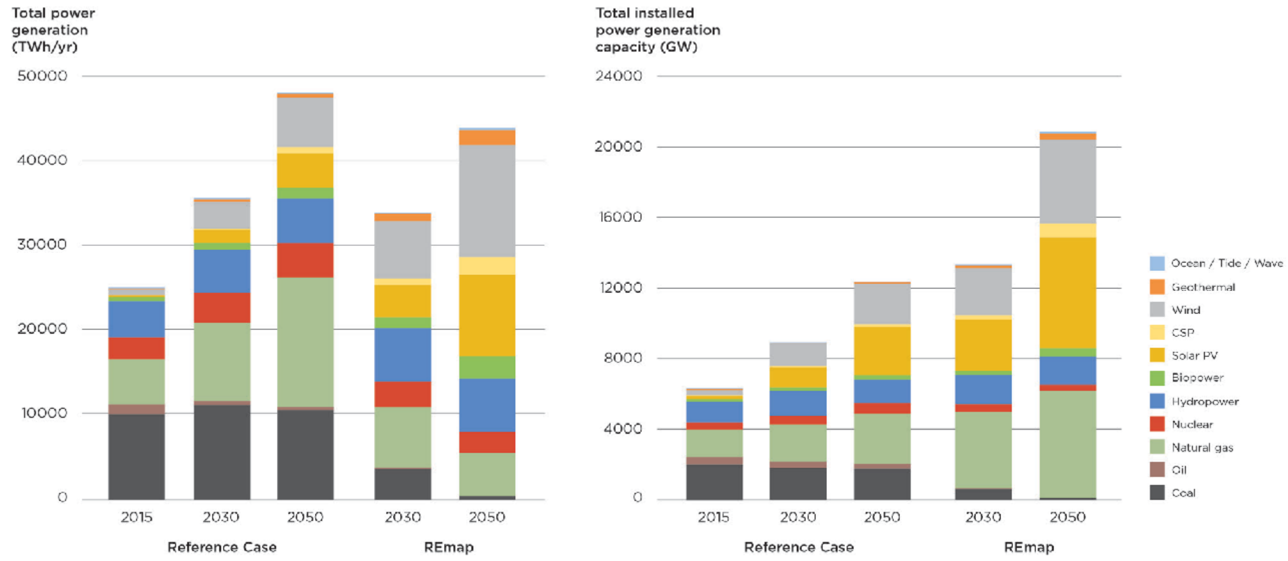
Renewable power can cover up to four-fifths of global electricity supply by 2050.

Due to economic and population growth coupled with accelerated electrification of the heating, cooling and transport sectors, demand for electricity is expected double by 2050, compared to 2015 levels. This growth in electricity demand presents a substantial opportunity for decarbonisation. Driven by policy incentives and rapidly falling costs, renewables have accounted for the majority of global power generation capacity additions over the past five years. The global share of renewables in power generation reached 23% in 2015. International Renewable Energy Agency (IRENA) REmap analysis shows that this can increase to over 80% by 2050, which implies a growth rate of 2% per year between 2015 and 2030, and 1% per year between 2030 and 2050.[1]

In capacity terms, renewable power would increase from around 2 000 gigawatts (GW) today to 14 000 GW in 2050, a sevenfold increase. To put this in perspective, the world has around 6 000 GW of power generation capacity in place today, as shown in Figure 1.

[1] The Reference Case is the most likely case based on current and planned policies and expected market developments. The REmap case is a low-carbon technology pathway that goes beyond the Reference Case for an energy transition to decarbonise the energy system in line with the goal in the Paris Agreement of limiting global temperature rise to less than 2°C above pre-industrial levels with a 66% probability.

Figure 1: Power generation capacity and total electricity generation by technology, 2015-2050, based on today's policies and with more renewables



Notes: CSP = concentrated solar power; TWh/yr = terawatt hours per year.

Accelerated renewable power deployment

The power sector will see the highest share of renewables. With accelerated deployment, a diverse mix of renewables could provide more than 80% of electricity by 2050, with wind and solar providing the largest shares. Coal and oil would be virtually eliminated from power generation.

Most growth potential is related to variable renewables.

The most rapid growth would be in renewable sources of energy other than hydropower and bioenergy, particularly wind, solar photovoltaic (PV) and concentrated solar power. Collectively, they increase by a factor of 15 between 2015 and 2050, and just before 2050 become the largest component of total primary energy supply, overtaking bioenergy. Annual increases in electricity generation from wind would be more than 12% over the next 15 years, with a further 18% from solar; together, they would account for the largest source of electricity by 2030.

Grid integration of variable renewables is a priority.

This ongoing transition of the power sector will continue in the decades to come and significantly affect the operation of future power systems, as well as the required business models. Innovation is needed to rapidly integrate new technologies, such as variable renewables, in a highly dynamic power sector. As the share of variable renewables grows substantially, so the importance of deploying measures to integrate them in power systems emerges. These measures include additional interconnectors, demand-side management, sector coupling, storage and curtailment. This will require major power infrastructure investment, long-term and stable technical plans and political commitment, and close co ordination between all stakeholders involved in the energy sector. With low load hours in fossil plants, highly variable supply and growing investment challenges, current power market structures need to undergo fundamental changes.

Strategies are needed for effective integration of variable renewables.

Power system analysis and practical experience in countries such as Brazil, Denmark, Germany, Italy, Ireland and Spain suggest that operating grids with high shares of variable renewable power is feasible. It is critical, however, to plan ahead and ensure adequacy of supply (power availability at all times) and sufficient flexibility in the power system (to deal with abundance and fluctuations in supply). Various operational grid services must also be ensured.

Different options can be considered to accommodate higher shares of variable renewables depending on national circumstances. These options generally fall into the following categories: supply side, demand side, transmission and distribution network, market design, and system operation and management. Power markets must properly reflect the scarcity and price of services to ensure smooth grid operation. New regulatory frameworks must also allow for new power market entrants and reflect the evolving roles of generation companies, distribution companies and consumers. In certain situations, it is cheaper to curtail renewable production than to deploy other flexibility measures.

Markets must be designed to allow for sufficient dispatchable electricity generation capacity in order to ensure adequacy of supply.

Around half of the 20 000 GW of power generation capacity forecast in 2050 under REmap will be dispatchable (see Figure 1). This includes hydropower, biomass, solar CSP and geothermal as well as flexible fossil fuel and nuclear power generation. Flexible natural gas generation, with a capacity of around 5 000 GW by 2050, will play a special role. Average capacity factors for dispatchable power would be lower than today, requiring a market model that properly values their role in providing adequacy and reserves to the system.

Demand-side management is an important type of low-cost flexibility.

Demand-side management, or demand-side response, can increase the power system's ability to deal with supply-side fluctuations. Certain consumers have the ability to adjust their electricity demand, increasing or decreasing their consumption accordingly. For example, when wind and solar PV are producing at their peak on windy or sunny days, consumers may choose to consume more, taking advantage of lower electricity prices. Electrification of end uses will allow for increased flexibility on the demand side. EVs, for example, can allow for additional flexibility through smart charging, based on supply/pricing signals. Demand response also can occur through electrification of the heating sector, for example, by shifting the supply of heat in the buildings sector to account for peaks in electricity supply (within certain comfort constraints). A common method of implementing such sectoral linkages is to use heat pumps that can operate on a flexible schedule to supply heating or cooling services. Important potential also exists in industry where aluminium smelters or chemical plants, among others, can adjust the production rate of electricity-intensive processes if they add a product storage buffer. Moreover, smart thermal grids (district heating and cooling) can effectively connect the electricity and heating sectors, adding flexibility through thermal storage.

Electricity storage is another key option for introducing greater flexibility into energy systems and integrating higher shares of variable renewables.

By 2030, electricity storage capacity will reach over 1 000 GW, with 600 GW available through the active stock of EVs used worldwide and 300 GW from pumped hydropower. Around 150 GW of additional storage would also become available from discarded EV batteries in 2030. Under REmap, electricity storage from two-, three- and four-wheel EV batteries reaches nearly 3 000 gigawatt hours (GWh) in 2030 and 10 500 GWh in 2050. This is against total solar and wind generation of over 11 000 terawatt hours (TWh) in 2030 and nearly 25 000 TWh in 2050. Clearly, electric mobility can play an important role for countries in coping with higher shares of VRE. This will require smart charging facilities.

Information technology is essential for the successful integration of renewable energy, and the full scope of complementarities is still being developed.

The evolving link between information and communication technology and the power sector will be a defining feature of the energy transition, enabling for the first time a more integrated approach to power supply and demand, more sophisticated energy management systems, and the addition of the flexibility needed to incorporate variable renewables. Important questions remain regarding the optimal functionality and integration strategies for smart meters and smart appliances. New challenges, such as cybersecurity and privacy, must be resolved for a successful uptake.

Governments must ensure enabling grid infrastructure for accelerated renewable power uptake.

Electricity grids will continue to play an important role for decades to come, but their function will change as high-voltage transmission plays a greater role, interconnection is strengthened and so-called smart grids are rolled out. Important investments will be needed. Governments have a key role to play by providing a credible long-term outlook, by facilitating and streamlining planning and by ensuring proper incentives are put in place. Increased long-distance transmission capacity within countries (in particular for countries with large territories) and between countries will also be important to integrate power sectors, as interconnectors offer an important means of system flexibility by allowing power trade and enhancing the security of electricity supply. The REmap 2050 case includes 2 000 GW of new long-distance transmission capacity.

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