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Trends in Electrical and Gas Networks

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Trends in Electrical and Gas Networks

Electricity grids

Investment needs

Networks in developed countries are old — ranging from 30 and 40 years in Europe and 40 and 50 years in the United States and Canada. These networks must be upgraded.

Energy Transition leads to a higher share of electricity in energy use as compared to fossil fuels, such as oil and gas. This means more electricity transiting in local or public grids, which calls for more network reinforcements.

It is also necessary to strengthen the grid robustness in relation to extreme climatic events which could become more frequent due to climate change. This was illustrated in February 2021 during an exceptional cold spell in Texas during which frozen wind turbines could not produce electricity despite very high consumption. Insufficient interconnections with neighbouring states meant that Texas residents had to endure power cuts for several days.

Investments in networks are also linked to the need for interconnection. Very high voltage DC cables under development in Europe are improving security of electricity supply and enabling better utilization of renewable electricity.

China is upgrading its Ultra High Voltage (UHV) electricity grid. In 2020, state-owned power transmission utilities identified many projects for development, which shall employ High Voltage Alternating Current (HVAC) and High Voltage Direct Current (HVDC) technologies. The total size of investments in these UHV projects is estimated to be $26.8 billion.

In addition, China is building and improving grids in along the route of the Belt and Road Initiative. Many of these countries are "low-income" countries; access to electricity will be a considerable improvement in their standard of living.

Investments are also necessary in both distribution networks and transmission networks to connect renewables.

Operators are also investing in networks to increase knowledge about electricity flows, improve their efficiency and better manage their stability—a concept commonly referred to as "smart grids" or "smarter grid". Operators add connected objects to a certain number of devices—for example, transformers or smart meters (which have been deployed in almost all European countries and largely in the United States). Automation in control rooms and outage detection are also possible with enhanced software.

At the same time, "softer" investments are needed in information systems to improve the processing of large amounts of data and enable analysis using artificial intelligence (AI).

FIGURE 1

AGING GRIDS, TECHNOLOGY ADVANCEMENTS AND ENERGY TRANSITION

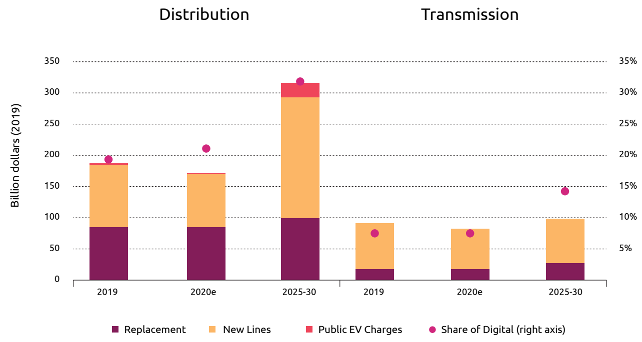
To encourage network operators to develop this type of investment, a revision of the methods for calculating network tariffs is necessary to include these "soft" investments in the "Regulated Asset Base." These soft investments could also reduce line construction, which is always a difficult issue due to local opposition.

The EU commission estimates that between now and 2030, investments in electricity grids will have to double, as compared to the last decade, reaching more than €50 billion per year.

In the US, the Department of Energy announced in June 2021, the availability of up to $8.25 billion in loans for efforts to expand and improve the nation's transmission grid.

FIGURE 2

Annual investment in electricity networks 2019-2030 in the Stated Policies Scenario



Sources: World Energy Outlook, IEA, 2019; World Energy Outlook, IEA, 2020;

The International Energy Agency states that Investment in power grids will grow up to $400 billion each year by 2025[1]:

IEA states also that 30% of this investment will be related to Smart Grid for distribution networks.

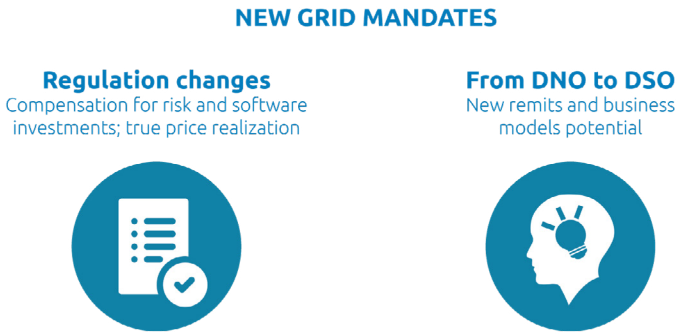
All these investment figures are consistent with the overall Transmission and Distribution announced investments and are contributing to the investment parity in renewables and grid development. Based on this model, every $1 investment in renewables leads to $1 investment in grids.

Investments are also driven by major changes brought by the addition of distributed and intermittent energy sources as well as grid digitization.

Renewables impact grid balancing and therefore security of supply as wind and solar electricity are intermittent and as electricity storage is limited today. When the renewables generation share in the electricity mix becomes significant, it may threaten the stability of the network. This was illustrated by the August 2020 blackout in California as well as in Europe, during the spring 2020 lock-down when the share of renewables in UK surpassed 50% and the dispatcher had to cut schedulable power to avoid blackouts. Multiple resources could be leveraged to manage the required flexibility ensuring the real time load-demand balance.

- **Electricity storage** is mainly provided by pumped hydro at present. However the well-suited sites are now almost all exploited in Europe.
  i. Stationary electric batteries can store a few hours of production. Their cost has dropped dramatically and their performance has increased due to advancements related to electric vehicles (EVs). These batteries are

FIGURE 3



used either in hybrid farms in association with solar or wind generation or on the grid to provide flexibility and ancillary services. Their business model is not yet satisfactory, and it is necessary to stack many usages to make them profitable.

ii. In the medium term, the electrolysis of water to produce hydrogen during periods of electricity surplus and the production of electricity using fuel cells, should make it possible to store large quantities of electricity.

- As the 2020 blackout in California demonstrated, in the absence of massive storage capacity, **it is necessary to maintain schedulable generation** on the power grid.

- Beyond the issues of supply-demand balancing, **the grid design** is impacted by the arrival of solar and wind farms, requiring important development and moving from a one-way to a two-way flow, with Distributed Resources.

On the one hand, these renewables farms must be connected to the grid. This connection can take several years due to local opposition, further delaying the arrival of this carbon-free energy on the grid.
On the other hand, the massive arrival of renewables associated with the closure of large-capacity power plants such as nuclear reactors or coal-fired power stations, is leading to an overhaul of the network. This is the case in Germany where network managers, who must wheel North Sea wind electricity to consumption centres in the southern part of the country, are building very HVDC underground lines. It is technically complex and costly.

- Network balancing must also consider the **new habits of consumers** who are becoming “prosumers.” This is characterized by the development of self-consumption or communities almost self-sufficient in electricity. In the latter case, the network has an “insurance” role and the remuneration for its use should take this into account.

- **Demand response.** On one hand, the aim is to give the right economic signals to customers to push them to use electricity when supply of renewable electricity exceeds demand and when prices are low. On the other hand, the objective is to encourage customers to postpone or cancel their demand during peak times. These demand response policies have been implemented for years on both sides of the Atlantic with limited success. Because of increasing renewables connected to the grids, Europe, which seeks to amplify demand response attitudes, adopted a directive on dynamic tariffs in June 2019. It applies from 2021 and onwards. All suppliers with more than 200,000 customers are required to offer this type of tariff which reflects spot market prices, which itself is a good indicator of periods of excess or lack of production. These dynamic tariffs are better suited to businesses than individuals as the latter may have difficulty understanding highly variable electricity bills from month to month.

- Finally, curtailment, which consists of cutting production of excess renewables, is possible in some countries. For example, in 2018, the wind power curtailment rate in China reached 7% on a national average. This loss of electricity is a waste of the investments made in wind farms both for the government, which has subsidized them and the end consumers who helped fund them through income taxes and/or electricity prices increase.

Cybersecurity. The growth of the Internet of Things (IoT) and related on network equipment has led to a proliferation of sensitive data that is managed in a decentralized manner. This increases the risk of cyberattacks. Cybersecurity is a crucial component of any grid development (hardware or software) and must be integrated by design.

In April 2021, the US Department of Energy launched an initiative (the 100-day plan) to improve the cybersecurity of Industrial Control Systems for electric utilities and secure the energy supply. This plan was in response to the “Colonial Pipeline” cyberattack and other attacks on sensitive infrastructure. The US President declared a state of emergency and also warned his Russian counterpart that attacks on facilities in 16 sensitive sectors, including energy, were "off limits."

Gas networks

Investment needs. The challenges for gas networks are different from those for electricity networks. Unlike electricity:

- Gas is easily stored; gas networks therefore do not have the same balancing problems as electricity networks.
- While electricity generation is local, gas must be transported from the gas fields to the point of consumption. This transport takes place either in liquid form (LNG is transported by ship) or in gaseous form by gas pipelines.

LNG represents a growing but limited share of global gas exchanges market representing around 12%.

The transport pipelines are often very long. For example, "Power of Siberia" runs 4000 kilometers between Russia and China, costing about €50 billion.

Other pipelines may be controversial for geopolitical reasons. For example, NordStream 2, which is 1200 km long, would supply Russian gas to Germany without going through Ukraine. A political agreement has been reached between Germany and the US in July 2021 about Nordstream 2. The pipeline construction will come to an end and the pipeline will become operational.

Gas networks management

a. **The correlation between electricity and gas networks management.** With growing high intermittency of renewable power generation, there is an increased need for flexibility in the electricity system. In addition to other technologies such as battery storage, natural gas fired power plants can provide such flexibility2. This will require an increasingly flexible management of the gas networks and better cooperation between the managers of these two types of networks. In the middle term future, Power to Gas and Gas to Power could also provide solutions for storing electricity.

b. **Greening of networks.** In some European countries, energy transition plans provide for reductions in gas consumption in the medium term. Gas networks could eventually become stranded assets. Several operators are therefore seeking to "green" their network either by increasing the share of bio methane or by planning to mix hydrogen with natural gas (methane). The permitted hydrogen mixing rate varies depending on the country. For example, it is 6% in France and 10% in Germany. There are plans to reuse old pipelines to transport hydrogen, provided they are hydrogen tight and sufficiently clean. Nevertheless, additional dedicated pipelines will probably need to be built. In Europe, 11 gas Transport System Operators (TSOs) are planning to have 22900 kilometers of pipeline for hydrogen (or converted gas pipelines or new ones).

c. **Hydrogen Generation impact on electricity grids** will depend on electricity feed system and will follow one of two main options:
   i. *Small electrolysers collocated with renewables. In this case there is a need to store hydrogen and then transport it by pipelines. Investment in dedicated pipelines will be necessary.*

   ii. *Locate electrolyser's near usages (steel plants or refineries) and use green electricity to feed them, notably with excess renewable generation. In this scenario, new electricity grid investments will be needed.*

Conclusion:

Networks are impacted by the transformation of the economy towards sustainability.

Electricity is the preferred vector for the energy transition and its consumption growth over the coming years is expected to surpass that of energy.

Significant investments in power lines are needed to improve the robustness of networks and ensure the transit of increasing amounts of electricity. In addition to line construction, system operators must increase soft (digital) investments. Indeed, thanks to artificial intelligence, it will be possible to improve the grid balance and sometimes even avoid planning new lines with long construction times.

In Europe, gas networks are not likely to develop. To match its "Green deal" objectives, the European Commission proposed to end its funding for natural gas (and oil) pipelines and instead funnel cash into electricity and low-carbon energy networks to meet climate goals.

Indeed, strengthening and increasing the performance of electricity grids is crucial for the success of energy transition. Electricity grids are the backbone of energy transition.

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