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Thoughts on an Electricity System and Grid Paradigm Shift in Response to the EU Energy Transition and the Clean Energy Package

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Highlights

- The EU Clean Energy Package aims to facilitate the transition to low-carbon energy system based largely on renewable energy sources, while furthering the completion of the internal energy market. The achievement of such "double goal" implies a profound paradigm shift in the way the electricity system is developed and operated.
- The growth of distributed energy resources, on both the generation and demand side, cannot be neglected anymore. On the contrary, such resources connected to the distribution grids must be fully integrated and subject to grid codes that ensure a level playing field.
- The operation of transmission and distribution grids must change and adapt to the new dynamics introduced by the growth of distributed energy resources. Transmission and distribution system operators must develop new coordination mechanisms to ensure an efficient balancing and preserve the security and continuity of electricity supply. Such coordination must not stop to real-time system operation but extend to grid planning and expansion.
- More sophisticated network tariffs and new market players enabled by digital technologies are crucial to improve the active management of demand and simplify the balancing of the system.
- These significant changes in system and market operation and in system development question the share of tasks and responsibilities between the different system levels (local, regional, national, European). In this respect, the creation of multinational control areas operated by actors that go beyond the remit of the single national companies has the potential simplify the coordination challenge and improve market functioning.

1. Introduction

The EU Clean Energy Package aims to deepen and promote the enlargement of a common energy market in Europe, and, at the same time, facilitate a clean energy transition based largely on renewable and intermittent energies (mainly wind and solar energy). This transition, which has been gradually occurring in European countries over the past few years, entails paradigm shifts in the European electricity system that will affect all market players, including those involved in generation, transmission, distribution, as well as consumers.

Roughly since the end of the Second World War, electrical systems have been characterised by the development of robust centralised generation capacity (i.e., large hydraulic plants, fossil fuel thermal power stations and, since the late 1970s, nuclear power plants). The operation of electrical systems is, therefore, based on the management of generation spillage from high voltage to medium and low voltage grids to supply end-consumers, which are now at the centre of the Clean Energy Package debate. Accordingly, European countries have been organised in balancing areas in which an operator ensures the physical balance between generation and demand within the territory.

In recent years, the energy sector has experienced the development of distributed generation, mainly linked to renewable energies, which are mostly intermittent. Going forward, the development of distributed generation, as well as local loops and microgrids, including storage facilities, will dramatically change the management of grids. Such paradigm shifts require the adaptation of grid codes, for instance, for connection or balancing. Moreover, they will transform the role, responsibilities and business models of DSOs and TSOs.

2. Connections

The role of distributed generation and microgrids in supplying ancillary services would be a key part of future connection grid codes. In this respect, reserves (in particular primary reserve) are essential, not only for grid operators but also for generators and traders. More in general, reserves are essential for all market actors, who could not carry out their business without them. It was for this reason that prior laws and grid codes imposed design specifications on generation plants, authorising them to produce electricity only if able to provide certain ancillary services.

Remuneration should be linked to economic cost, instead of market prices, and should be paid, on the basis of mid or long-term contracts, to generators as well as consumersor aggregators, all able to provide system services. Currently, the supply of these services is paid for by consumers through the grid access tariff.

Among ancillary service providers, generators must be able to provide their services similarly, regardless of the generation technology, to ensure a level playing field. Therefore, grid codes should require that all types of generation provide the same services through design specifications imposed ex-ante. If certain generation means do not meet these standards, system service providers should be compensated for their inadequacy.

Micro-grids connected to the public grid will continue to benefit from their connection to the larger electric system, both in terms of supply insurance, and ancillary services (e.g., voltage support). Hence, they will have to continue financing a part of the upstream grid, both transmission and distribution.

3. Balancing and Congestion Management

Compared to centralised systems connecting means of huge capacities, it is clear that the development of decentralised generation connected to the distribution grids, as well as storage means of lower capacities, will lead to significant changes in network management (mainly balancing). Decentralisation of generation at the level of distribution grids, which could be substantial in the coming years, will change the role of distribution and transmission operators and could even allow the emergence of new players to be able to balance the electrical system.

Currently, the development of distributed generation is leading to significant changes at the border between distribution grids and transmission grids. This is causing energy flows to go from distribution grids to transmission grids. Moreover, it is triggering the need for adjustment through demand reductions at the level of the distribution grids to facilitate the management of the supply-demand balance at the level of the transmission grids. This raises questions concerning distribution and transmission operators' coordination when optimising the balancing of grids, and especially the modalities relating to the relationship betweenthe electrical system's different voltage levels.

Too often, only real-time congestion is considered, as if only balancing actions were needed to solve potential bottlenecks between the distribution and transmission grids. However, the essential point in terms of coordination between grids operators is to define common rules for the development of grids. In this respect, it should be recalled that the profitability of the development of new grid elements is generally based on the costs of congestion and losses avoided. Besides, given the development of generation connected to distribution grids, it is essential to develop transmission grids to evacuate surplus generation, otherwise, curtailment policies of distributed generation will have to be strongly applied.

Regarding congestion management between TSOs and DSOs, as far as local loops are concerned, demand control methods have already been put in place in some countries based on tariffs (high prices when demand is high, water heaters tariffs, etc.) thanks to the price signals sent to the consumers through electricity distribution grids in particular. It is now necessary that these demand management tools are based on market mechanisms, provided that the decrease in demand is well-regulated and does not rest solely on the declaration. The development of smart meters and specific digital applications should thus facilitate the development of these mechanisms. In this framework, microgrids have the possibility of pre-balancing if they have designated a real-time balancing manager between generation and demand, using storage available and optimizing the supply from the distribution grid to which the microgrid is connected. At the local level, the distribution networks will have to provide balancing for the local loops to which consumers are currently connected or to microgridsthat ensure pre-balancing.

It is then necessary to return to technical data and grid design. Distribution grids are generally radial, but balancing requires looped grids. Consequently, balancing operations at local distribution loops will only be valid if the distribution grids manage parts of the high voltage networks (at least up to 110/130 kV), which is not yet the case in all European Union countries.

4. A New Organisation?

It is clear that issues raised by these changes are not only a question of coordination between DSOs and TSOs (knowing that the organizational, technical, legal and economic structures of distribution vary from one country to another, often significantly), but rather a share of responsibilities at different levels of electricity grids (local, regional, national, European) and between different actors. Depending on the technical conditions for the operation of meshed grids in Europe, several levels of infrastructure and balancing could be seen:

- Local, with microgrid connections and direct consumers,
- Regional power supply for local loops and regional balancing,
- National, which ensures the final loop of the remaining regional differences,
- Potentially European, which would constitute a backbone of very high voltage (essentially 400kV) to which significant generation means are connected, the electricity-intensive sites or industrial platforms.

In this context, the national level corresponds to a market node, but its existence could be questioned by the creation of multinational control areas and one single market node. Even if it required legal adjustments on liability (mainly in case of a blackout), the creation of multinational control areas would simplify complex mechanisms ability to move from one control area to another, making markets more fluid by internalising congestions at borders in the grid access tariff.

Eventually, the energy transition could lead to a profound change in the organisation of the electrical systems:

- It would affect DSOs and TSOs, specifically in their role as infrastructure operators or balancing flow operators, and would lead to the emergence of new actors such as ISOs, RTOs, balancing actors, and aggregators and more.
- It would require a radical change in the remuneration methods of the various infrastructure operators, on the one hand, and of system operators on the other hand, dramatically changing their business models.

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