

Electric Power Distribution in the World: Today and Tomorrow

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Electric power systems have been going through a radical transformation due to renewable energy sources, distributed generation, demand-driven planning ambitions, smart grids and smart energy technologies, climate change related pressures and shifting consumer preferences. It is often argued that yesterday's power systems paradigm might not meet the demands of the future. Traditional design of the power systems which puts distinct (and varying across countries) boundaries between generation (G), transmission (T), distribution (D) and retail (R) might be regarded as inefficient and incapable of meeting the challenges of the transition to a low carbon electricity system transformation. In the past electricity systems have been built around moving power from large central power plants directly connected to the transmission system to passive loads connected to the distribution system. Increasingly, across the OECD, the system has shifted to a world where most new generation is connected directly to the distribution system and loads are becoming more active in both importing and exporting power and maintaining power quality. In such a world, distribution systems move from being passive networks, often quietly integrated with transmission or retail to being active networks whose role in shaping the system is the subject of increased commercial and regulatory interest.

This review paper compiles some of the significant information about the distribution systems in 175 countries worldwide in order to characterise the current situation of the distribution system as we move to a world where these entities are a focus of interest. The findings for each country include the number, legal structure and ownership of distribution system operators, the access to electricity they provide, distribution level voltages, electric power frequency and the significance of renewable electricity generation. This study covers 99.4% of the world's population. As of June 2018, there

are around 7600 distribution system operators in these 175 countries. After reviewing the status of today's distribution system, we also review the various discussions and proposals for tomorrow's electric power distribution. We also highlight the concept of Distribution System Platforms (DSPs) which are proposed to be a better option in terms of facilitating the shift from passive to active distribution network operation.

In this paper, we highlight those grey areas that raise new subjects for discussion about the distribution/retail and distribution/transmission relationships. The relationship between transmission system operators (TSOs) and distribution system operators (DSOs) will likely to be a hot discussion topic as concerns over distributed generation, demand response and data management increase. TSOs will likely seek to extend their system operation (SO) function to lower voltages while DSOs will likely seek to provide opportunities for distributed energy resources (DERs) to provide system services traditionally procured by the TSO. In addition to the network operation duties, DSOs should also become neutral facilitators of open and accessible markets so that they will enable competitive access to markets and the optimal use of both traditional generations and DERs. Hence, in addition to network provision, the main core functions of the future DSOs will likely be providing:

- system operation,
- market platforms,
- data management through data hubs.

We discuss each of these core functions illustrated by various examples from around the world.

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