Electric Power Distribution in the World

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Summary

In the light of the increasing importance of distributed energy resources (DERs) in the electricity system, there is an ongoing need to understand the current status of electric power distribution across the world. This review paper compiles some of the significant information about the distribution systems in 175 countries worldwide. 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 today's distribution system status, this paper also reviews the various discussions and proposals for tomorrow's electric power distribution. The discussion covers both system operation and market platform roles as well as data management options for DSOs in the near future.

Context

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. For each 175 countries, the paper provides information about; number of Distribution System Operators (DSOs), Legal Structure and Ownership of these DSOs, Access to electricity (%), Population (thousand), Population without electricity connection (thousand), Connected Population per DSO (thousand), distribution voltages (kV), supply voltage (V), lowest transmission voltage (kV), highest distribution voltage (kV), frequency (Hz), Electricity generation (GWh), Renewable electricity generation (GWh), Renewable electricity output (% of total electricity output) After reviewing today's distribution system status, this paper also reviews the various discussions and proposals for tomorrow's electric power distribution.

Electric Power Distribution of Today

To better present the results of this comprehensive review, we would like to illustrate some of the findings as maps. Figure 1 shows the electric power frequencies used in countries. Figure 2 presents the access to electricity worldwide (World Bank, 2014 and International Energy Agency, 2017). Figure 3 summarizes the renewable electricity generation as a share of the renewable electricity output in the total electricity generation output (EIA, 2015; IRENA, 2015). Figure 4 is about the DSO intensity by simply showing number of connected people served by one DSO in each country (World Bank, 2016). Figure 5 presents the ownership of the DSOs worldwide. In addition to distinguishing public and private ownership, we defined a third classification as mixed ownership. Mixed ownership covers DSOs that have public and private shareholders. Table 1 shows the details of DSO ownership in the US, Australia, Canada, Brazil, India and New Zealand. Finally, Table 2 and Table 3 include all the distribution system information that we gathered for this paper. The DSO structure information per each country is presented with four functions of electricity system, where;

- G: Generation
- T: Transmission
- D: Distribution
- R: Retail

The ownership/legal structure of DSOs is a challenging subject on which to make decisive conclusions (e.g. knowing all the shareholders and ultimate parent companies of a given distribution entity is difficult to trace and present, especially when there might be foreign owners). We therefore focus on legal structure of DSOs within the country of interest. Unbundling of the power sector is a grey area for many countries we reviewed. In addition, due to privatization, renationalization, company splits or due to company mergers, the number of DSOs may vary as well . For example, there were 8 DSOs in the Netherlands in 2015, however in 2018, this number is 7. Similarly, number of German DSOs dropped from 884 to 875 in these years.

Electric Power Distribution of Tomorrow

According to a recent extensive DSO survey conducted with 108 executives from 24 countries in Europe, 72% of the respondents think that DSOs will become more service-focused than asset-oriented. For the future role of the DSOs, 89% mention being data hubs to facilitate market access, 82% report actively controlling distributed generation and being responsible for demand response and balancing at the distribution level (Outlook on the European DSO landscape 2020, 2016). Nevertheless, the transition from network-ownership to system operation and hence being service-based companies will not be an easy task. The MIT Utility of the Future report (Utility of the Future, 2016) argued that the degree of complexity is quite high for the distribution networks to decouple network planning from network operation. Therefore, the economies of scope between distribution network ownership and distribution system operation will be higher than for the transmission system. The report suggests three possible future DSO designs;

- Distribution network owner and operator
- Independent distribution system operator and separate network owner
- Closely regulated, vertically integrated utility

Being a distribution network owner and operator or an Independent distribution system operator is discussed in the context of the EU as well. However, we should remember that vertically integrated utilities or VIUs are not allowed in EU since these are against the unbundling rules of EC which are specified in the third energy package in Directive 2009/72.

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