***System costs of European Electricity Transmission System Operators – A Benchmark***

Sandra Torras Ortiz, Trading Department, TransnetBW GmbH, +4971121858 3059, s.torras@transnetbw.de

Andreas Semmig, Trading Department, TransnetBW GmbH, +4971121858 3059, a.semmig@transnetbw.de

## Overview

With the implementation of several Directives, the European Commission drives the full integration of the internal electricity market. The European target model for power markets provides a clear outlook of the power system in the future, integrating cleaner resources efficiently to achieve decarbonisation targets in all sectors. In this context, increasing efficiency in the operation of the electrical systems is particularly important for maximizing the net economic and environmental value of electricity. Nevertheless, the perceived unused potential for improvement in market integration has fostered an ongoing debate among different market actors. Concerns about the efficient use of interconnectors and the volume of loop flows affecting several countries in Central Europe are some of the critical issues to be addressed by the transmission system operators (TSOs). As a result, the adaptation of the current market design has been brought up as one of the options for reducing system inefficiencies. Accordingly, the requirement to review the configuration of the bidding zones was integrated into the European legislation (EU Regulations 2015/1222 and 2019/927). Some academics even propose more fundamental changes in the market design, such as the introduction of locational pricing signals. Against this background, the increasing congestion management costs in Germany have been the subject of many discussions, from economical, technical, and political perspectives. However, when trying to assess the efficiency regarding the costs incurred in relevant system services, it seems intuitive not only to look at the economic aspect but also at fundamental features of the systems. The rationale appears straightforward: specific characteristics of the electricity system determine its complexity widely and, therefore, the monetary efforts required to provide reliable system operation could be expected to be correlated to said complexity. For instance, the challenges faced by systems with a high penetration level of renewable energy sources (RES) may differ from a system where this is not the case. The operational efforts may even be exacerbated by a large share of weather-dependent RES, such as wind and photovoltaic generation units.

Regulatory authorities publish regularly detailed data concerning the electricity generation mix and installed capacity. Similarly, official data sources provide valuable information about the system costs arising from the core activities of the TSOs. However, this information is mostly neither harmonized nor centrally published, which hampers an objective comparison between electricity systems with different features and challenges. Since transparency is a critical element of the internal Europe-an electricity market, we explore in this paper available public information concerning relevant sys-tem costs, such as congestion management, balancing, and other ancillary services. An additional dimension is then considered for capturing specific features of the electricity systems for which the following fundamental indicators are assessed: the electricity generated, the penetration of weather-dependent RES in the system, and the CO2 emissions level. Thus, by including fundamental system features to a discussion based solely on system costs, we provide an assessment framework for a more balanced discussion about the efficiency of European TSOs.

## Methods

We analyse and compare costs for relevant activities of electricity transmission system operators in six European countries: Austria, Germany, Spain, France, Great Britain, and Italy. These six countries accounted for around two-thirds of the total EU electricity generation in 2018. The assessment is based on available public information on congestion management, balancing, and other ancillary services. Additional dimensions of power system are taken into account, such as the amount of electricity being fed into the grid and managed by the system operator, the penetration of weather-dependent renewable energy sources (RES) and the CO2 intensity.

Given the data presented above, we build a benchmarking chart with the system costs on the x-axis and the relevant system characteristic in the y-axis. The metrics are then plotted in such a way that the upper left quadrant represents a higher efficiency than the lower right quadrant. The advantages of using this benchmarking approach are twofold: It allows us to identify the outliers and role models, and on the other hand, to explain the cost differences across countries to some extent. It is worth to note, that a detailed financial analysis for assessing the overall competitiveness of the TSOs is out of the scope of this study.

## Results

## Data presented in this study suggest that the specific costs correlate directly with the share of wind and solar penetration in the system. However, when a system has a large share of nuclear or hydro resources available, the relationship mentioned above is weaker, making that system an outlier in our benchmark. Given that many countries have no potential to increase their hydropower capacity significantly and nuclear power is socially and politically accepted in only some European countries, the deployment of wind and solar will continue to be a crucial element to achieve decarbonisation targets. The increasing operational challenges faced by systems with high shares of wind and solar generation have been discussed at length in the literature. Against this background, the German system provides some interesting features: Despite the integration of the highest share of wind and solar capacity, the specific system costs derived are comparable to those of countries with significantly lower shares of those resources, and therefore, less volatility.

## Moreover, the lumpiness of transmission grid development has not hampered the integration of wind and solar capacity. In fact, the installed wind and solar capacity accounted for almost the same amount of conventional capacity. One reason to explain the efficiency savings may be found in the high system flexibility and coordination across processes. The coordinated processes may be suitable for other electricity systems that have similar characteristics and market designs since they will probably face increasing internal grid congestions due to an increasing share of wind and solar in their system.

## Conclusions

This paper provides insight into the costs incurred by TSOs for some of their core activities in six countries, including additional dimensions concerning fundamental system characteristics. The authors believe that such inclusion is essential for allowing a more balanced discussion on the efficiency of TSOs. Further, the results identify systems with a large share of wind and solar resources paired with specific system costs comparable to those of systems with a lower share. A more in-depth analysis of the reasons behind this development could be the subject of future research. Considering the operational challenges posed to the system with high penetration of weather-dependent RES will most probably be faced by a large number of systems in the near future. Thus, closer collaboration and sharing of best practices may prove to be a crucial element for reaching the ambitious European decarbonisation targets in an efficient manner. It is recognized that more sophisticated methodologies may provide additional conclusions. For instance, relevant environmental factors could be included for taking into account heterogeneous operating conditions. Finally, a higher harmonization in the publication of relevant TSOs information will undoubtedly contribute to more transparency in the assessment of electricity systems.

## References

To be included in final paper