Handling of the TSO-DSO interface: An assessment of global trends and a taxonomy for systematic treatment initiatives

Nina Hubner Goldenzweig, PSR, +55 21 3906 2100, ninahubner@psr-inc.com
Gabriel Rocha de Almeida Cunha, PSR, +55 21 3906 2100, gabriel@psr-inc.com
Luiz Augusto Barroso, PSR, +55 21 3906 2100, luiz@psr-inc.com
José Pablo Chavez Ávila, IIT Comillas, +55 21 3906 2100, Jose.Chaves@comillas.edu

Overview

A common trend in many electricity sectors worldwide is the increasing role played by distributed energy resources, which have started to reach levels in which they may affect not only the operations of the distribution-level system but also system operations at the transmission level. This is particularly true for countries that have offered at some point generous subsidies for distribution generation, which has often led to extreme amounts of small-scale solar projects being built and requiring accommodation from the system operator and generators (California, Australia, and Brazil being prominent examples).

An immediate reaction to these transformations would be to require the transmission system operator (TSO) to have at least some level of presence in the distribution-level systems, for monitoring and dispatch of the most relevant distribution-level units at minimum. On the other hand, the pulverized nature of these resources implies that the number of individual assets that would need to have an operational relationship with the TSO could be very extreme, imposing a severe burden on telecommunications and computational infrastructure. For this reason, it makes sense instead to focus on initiatives that could empower the distribution system operators (DSO) – these are the main focus of this paper.

Methods

We structure a taxonomy of interventions for improving the management of the TSO-DSO relationship around four main macro-initiatives: (i) quality of the information transmitted at the TSO-DSO interface, (ii) introduction of market mechanisms (including but not limited to markets for flexibility services), (iii) systematization of the DSO activity as part of the regulated services supplied by the distribution company, (iv) interface with other market activities such as retailer and aggregator (particularly in countries where the distribution company can currently participate in these areas).

For each of these macro-initiatives, we discuss how particular initiatives could be characterized and offer some examples. We take care to describe these initiatives in a way that could be applied to countries at different stages of development – noting that, while advanced economies can generally rely on sophisticated and mature electricity market mechanisms for handling the TSO-DSO interface, developing economies will also face similar challenges in terms of high levels of penetration of distributed energy resources and will benefit from a "roadmap" for prioritizing implementing improvements to their regulations, operational procedures, and technical infrastructure.

Results

An analysis of current practices in international electricity systems reveals some interesting trends – in particular, virtually all developed economies already implement mechanisms for distributed energy resources to access the electricity spot market, and therefore be subject to the efficient real-time market signals of the transmission-level price (with adequate time and space granularity). This is in contrast with previous designs of incentives for distributed energy resources, which commonly awarded a flat benefit (or tariff reduction) disassociated from the spot price.

Even in case it is not possible to implement a market-based incentive to the distributed energy resources (for example due to regulatory or political constraints), we demonstrate there is much that can be done to improve TSO-DSO interoperability. In particular, we discuss mechanisms focused on detailing protocols and requirements for the information that needs to be passed from the DSO to the TSO and vice versa – which can be understood as a sort of "proto-market" but which might face fewer obstacles to implementation in practice.

Conclusions

The need to properly incorporate distributed energy resources to electricity systems in the context of the energy transition is already a reality in several countries, if not most of them. Most likely, this evolution will require the tranmission system operator to rely more on the distribution system operator for some operational activities – including providing information for dispatch models and maintaining a communication link with distributed energy resources. In this context, it is imperative to establish regulations explicitly addressing the role of the DSO and responsibilities expected from the DSO and from the distributed energy resources (and potentially of intermediates such as aggregators). Explicit initiatives for improving the management of the TSO-DSO interface can also lead to very positive benefits – whether market-based mechanisms or initiatives involving the implementation of standardized protocols based on mandatory requirements from the DSO and distributed energy resources, improving the flow of information and interoperability between these entities is an important first principle.

References

- N. R. Pérez, J. M. Domingo, G. L. López, J. P. Chaves Ávila, F. Bosco, V. Croce, K. Kukk, M. Uslar, C. Madina, M. Santos-Mugica, 2023. ICT Architectures for TSO-DSO Coordination and Data Exchange: A European Perspective. IEEE Transactions on Smart Grid, vol. 14.

- S.P. Menci, O. Valarezo, 2024.. Decoding design characteristics of local flexibility markets for congestion management with a multi-layered taxonomy. Applied Energy 357 (2024) 122203

- G. Elizondo, R.Poudineh, 2023. "Harnessing the Power of Distributed Energy Resources in Developing Countries: What Can Be Learned from the Experiences of Global Leaders?" OIES Paper: EL49

- E. Beckstedde, L. Meeus, E. Delarue, 2023. "A Bilevel Model to Study Inc-Dec Games at the TSO-DSO Interface". IEEE Transactions on Energy Markets, Policy and Regulation, vol. 1.