***Evaluation FRAMEWORK FOR THE ASSESSMENT OF DIFFERENT TSO-DSO COORDINATION SCHEMES***

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## Overview

Power systems worldwide are experiencing important changes. Decarbonization, digitalization, and decentralization are changing the way electricity is produced, transported and consumed. These changes can also be extended to the way that system operators will operate their networks. Both transmission system operators (TSO) and distribution system operators (DSO) are facing challenges and observing opportunities coming from the new paradigm at power systems.

For the TSO, distributed energy resources (DER) may be an additional agent participating in ancillary service markets and helping to keep the cost of the system’s flexibility down. For the DSO, the opportunity to procure flexibility from DER, which now is digitalized and more flexible (batteries, EV charging stations, etc) offers the opportunity for a complete change in the distribution management paradigm. The DSO will be able to move from the “fit-and-forget” approach into an “active system management” position. By procuring DER’s flexibility, the DSO may be able to defer investments and consequently be more efficient.

Once TSOs and DSOs start procuring DER flexibility, enhanced coordination between these two system operators will be needed. Several situations will require coordination actions so that one system operator’s action does not create a problem for the operation of the other network. The enhanced cooperation will take place at the different phases of power systems planning and operation, namely network expansion planning, operational planning, and real-time operation. Nevertheless, this enhanced cooperation will happen gradually. The first situation in which TSOs and DSOs will have to cooperate more actively seems to be when the TSO procures DER flexibility for balancing and congestion management purposes, and the DSO procures DER flexibility for local congestion management (CEDEC et al., 2019).

To provide answers on how TSOs and DSOs can use DER’s flexibility in an efficient way, the academic literature has proposed several “Coordination Schemes”.

Coordination schemes can be defined as arrangements for the **procurement** and **activation** of DER’s flexibility. Therefore, they may take place both at the operational planning and at the real-time phases. Several different academic papers and research projects have proposed different coordination schemes (Tohidi et al., 2018). Considering that this research field is rather recent, academic contributions have focused on conceptual schemes. These schemes are usually tested in small test cases, under simplified assumptions. The evaluation of these coordination schemes is simplified. The literature published so far focuses on the short-term cost of activation as a means of evaluating the efficiency of a coordination scheme, eventually discussing other aspects such as regulation and information exchange needs in a qualitative and unstructured way.

This paper aims at providing a comprehensive framework for the evaluation of different coordination schemes. This framework goes beyond the typical economic short-term evaluation and considers different aspects in three main categories, namely **technical**, **economic** and **regulatory**.

## Methods

The framework for the evaluation of coordination schemes is based on three pillars, namely technical, economic and regulatory.

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| --- | --- | --- |
| Pillar | Criteria | Type |
| Technical | Scalability of Coordination Algorithm | Quantitative |
| ICT complexity | Quantitative |
| Economic | Short-term cost of activation | Quantitative |
| Long-term economic benefit | Quantitative |
| Regulatory | Fitness to national/regional regulation | Qualitative |
| Fitness to national/regional TSO-DSO landscape | Qualitative |

The technical pillar is composed of two criteria, namely the scalability of the coordination algorithm and the ICT complexity related to it. The scalability of the algorithm is related to the time the algorithm takes to find an optimal solution, while the ICT complexity criterium captures the difficulties in information exchange associated with the coordination scheme.

For the economic pillar, two criteria are proposed, namely the short-term cost of flexibility activation, and the long-term economic benefits. The former criterium is already used by the literature, but the latter is usually neglected. At the center of the idea of the DSO becoming an active system operators is the expectation of long-term benefits such as investment deferrals. Therefore, one coordination scheme may be more expensive in the short-term but allow for a more efficient distribution grid in the long run. The economic pillar aims at capturing the overall economic benefit of the coordination scheme.

Finally, the regulatory pillar is focused on assessing two different aspects of the TSO-DSO regulation. On one hand, the national and regional regulatory frameworks are considered to assess the compatibility of a certain TSO-DSO coordination scheme for a given regulatory reality. A coordination scheme may be possible in Europe, but not the United States, for instance. Additionally, the national and regional TSO-DSO landscape is also considered, taking into account that even in Europe, several different realities exist in terms of DSO landscape. Germany, for instance, is known for having more than 800 DSOs, while in Sweden a “two-level” DSO is in place, with a regional and a local DSO operate the distribution network.

For each of the criteria, specific KPIs are defined and applied to a small test case, demonstrating the applicability of the evaluation framework. The test case is modeled through a DC OPF containing a transmission network of five nodes and two distribution networks of 18 nodes. Both imbalances and congestions at the distribution level are considered. The network used is based on the work by Savvopoulos et al. (2019).

## Results

The results are expected to demonstrate the applicability of the proposed evaluation framework for TSO-DSO coordination schemes. So far, this is a work in progress, and numerical results, as well as the final definition of KPIs, are under development.

## Conclusions

## This paper aims at providing a comprehensive and robust framework for the evaluation of TSO-DSO coordination schemes, advocating for the need of considering aspects that go beyond the current comparison of short-term cost of DER flexibility activation.

## References

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