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RESEARCH BRIEF

TSO/DSO Coordination In A Context of Distributed Energy Resource Penetration

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With respect to electrical grids and power systems there is a trend towards a greater penetration and subsequent utilization of distributed energy resources ("DERs"). DERs can provide services to both Distribution System Operators ("DSOs") and Transmission System Operators ("TSOs"). Distributed energy resources are typically installed and interconnected to electricity networks that may or may not be completely controlled, monitored or analyzed by the power system operators themselves. If and when DERs are operated to provide system services and/or market actions, this may lead to system benefits and grid efficiency improvements, but can come with technical, economic, and jurisdictional challenges.

Distributed Energy Resources typically are defined as technologies that can be installed "behind the meter" on consumer premises connected to on-site loads or remote premises without on-site load. DERs are typically interconnected on distribution and lower voltage networks, and are smaller in installed capacity; ranging in the order of a few kilowatts (kW) to a few megawatts (MW) in rated nameplate capacity. A multitude of governments, transmission system or regional operators, public utility commissions and regulators, utility companies or distribution system operators, and researchers at think tanks, research laboratories, and universities have come up with slightly different definitions of DERs, covering a diversity of energy resource types, capacity, and where on the power system the resources are interconnected.

Recent technological advances and cost declines in distributed energy resources and information and communication technologies (ICT) as well as specific regional and state policies, mandates, and incentives, regulatory paradigms, and consumer trends have been major driving forces behind the increasing penetration of DERs. DERs can and do provide many services to the electric grid, and this trend will only increase as the ubiquity and ability to control these assets, for instance through management systems and smart inverters, continues to increase. However, current market designs and operational practices do not provide a level playing field for DERs to deliver services. Existing markets need to evolve, new markets need to be created, and new roles and coordination functions need to be established between distribution and transmission system operators.

A new MIT CEEPR Working Paper offers an exploration into the services that DERs can provide, market structures observed in the European Union and United States, the interaction between distribution and transmission system operators, the new roles that DSOs would need to perform to unlock the most value from DERs, and certain market barriers for DERs at the transmission level. Coordinating and co-optimizing distributed, typically low-voltage assets, across jurisdictions and levels of the power system are still quite nascent. Future roles of utilities and distribution system operators, new planning and interconnection methodologies, and new wholesale market designs for DERs have been researched in theory, but not yet extensively adopted in industry. The Working Paper highlights and advocates for not only a level-playing field for DERs where their services can be valued in markets, but also for managing the complexities associated with communication, coordination, and interactions between grid operators to coordinate the services provided by DERs.

Overall, the energy sector is in a period of rapid growth and transformation unlike anything seen in the past century. Decentralization and decarbonization are driving greater penetration of distributed and renewable energy systems, and with them the subsequent need for greater system awareness, forecasting, and intelligence. Distributed energy resources can provide system services, which may enable even greater penetration of these resources. Specific responsibilities of operators, including coordination and information exchange between the operators, are of utmost importance. The European and the U.S. electricity sectors are taking positive steps towards a decentralized paradigm for enhancing network operations as well as new tariff and market designs.

The Working Paper highlights phases of DER penetration on electric grids in the U.S. and Europe and the interactions between the transmission and distribution system operators. At present, the penetration of DERs is still relatively small, although in many regions the yearly installed capacities are growing rapidly. In initial phases of DER integration, distribution networks are expected to be able to manage the presence of small amounts of DERs. The challenge in this initial phase is to be able to have visibility and monitor the assets on the distribution network.

In a subsequent phase, the Working Paper concludes that there could be significantly higher penetration levels of DERs in the system that provide services to the transmission and distribution system. In this subsequent phase, energy and load forecasting, scheduling, activation of resources and procedures to manage emergency situations will need to be defined and implemented. Under these conditions, the DSOs will likely need to perform new functions, such as determining prices for local constraints and coordinating those prices with those of the transmission system operator or wholesale market operator. New market rules and requirements, tariff designs, and price signals could mitigate many of the potential conflicts between services.

New wholesale market rules, requirements, and mechanisms for distributed resources to provide services should be codified, as DERs are able to provide system services. Today, there exists a lack of proper market structures, rules, and access as well as compensation mechanisms for DERs to actively provide services across the power system. Coordination between DSOs and TSOs will become increasingly salient as more and more distributed resources interconnect to the grid and provide system services.

References

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Michael Birk holds a Master’s degree from the Technology and Policy Program in the MIT Institute for Data, Systems, and Society. Michael was a Statoil-MIT Energy Fellow at the MIT Energy Initiative and contributed to the Utility of the Future Report. Michael has twice been an Invited Student to the Instituto de Investigación Technológica (IIT) at the Engineering School (ICAI) of the Comillas Pontifical University in Madrid, Spain. His areas of research include the interaction between distributed energy resources and wholesale electricity markets as well as the computation of locational marginal prices in transmission and distribution networks.

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