Evolving Grid Codes and Standards for a Power System in Transition

A BRIEF FROM ESIG

Interconnection requirements, grid codes, and technology standards exert a great deal of influence over how the power system is built, how it operates, and how it performs. These requirements drove the development of electricity systems we know today, and they play an important role in these systems' transformation now, as increasing amounts of variable renewable energy and battery storage are integrated into the grid. The development of grid codes—system-level integration standards—must balance the needs of grid operators for reliable service, the needs of customers for affordability, and the needs of society for a sustainable future. Experiences around the world have shown that retroactive changes to installed energy resources can be costly and complicated. Standards development should be proactive, giving developers and equipment manufacturers clear guidelines that are implemented consistently across geographies.

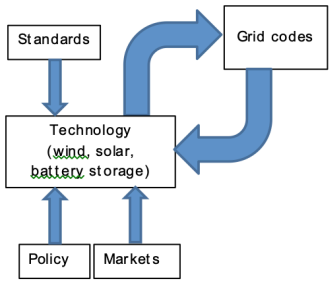
Requirements should be no more specific than necessary to avoid over-designed equipment and reduced efficiency, but specific enough to maintain system reliability. The International Electrotechnical Commission has suggested that the time is right to develop an international framework document to assist in the creation of more consistent grid codes globally.

Standardization Challenges

All connected components, from large power plants to smaller devices, can impact the grid in various ways. With increasing levels of distributed energy resources (DERs), the aggregate behaviors of these resources become as relevant as large power plants. Therefore, evolving requirements for DERs need to address not only their local effects but system-wide responsibilities. As technology develops, standards may serve as an enabler, unlocking the best available performance of certain functions contributing to reliability. Conversely, if requirements are overprescribed or disregard the costs of implementation, they can inhibit the very functions they aim to enable. Standardization and regulation need to strike a balance between ensuring a minimum level of performance and reliability while not being overly prescriptive.

Standards are often written as technology agnostic. However, this has led to requirements that lack the clarity required for newer technologies. More work is needed to ensure that codes and requirements balance the competing needs of technological neutrality with clarity and consistency regarding specific technologies.

The role of grid codes and standards in maintaining reliability requires wind and solar generation to tolerate small variations in grid frequency or voltage, to be able to provide voltage and frequency support, and to remain connected to the grid during large disturbances, such as the unexpected loss of a large power plant.



Institute of Electrical and Electronics Engineers (IEEE)

Through IEEE Standard 1547, Interconnecting Inverter-based Resources with the Distribution System, the Institute of Electrical and Electronics Engineers (IEEE) aims to achieve some uniformity in DERs' settings that impact the bulk power system by fostering collaboration among utilities, state regulatory entities, reliability coordinators, independent system operators, transmission operators and planners, and planning coordinators.

Originally approved in 2003, IEEE 1547 establishes criteria and requirements for the interconnection of relatively small DERs to the distribution system. The first version of the standard, IEEE 1547-2003, considered the main contribution of distributed energy resources to be the energy provided. Solar and wind generation were required to disconnect from the grid upon sensing a disturbance and were not allowed to regulate grid voltage. By 2018, DERs were being utilized not only for energy but also for reliability. Modifications to this standard in 2014 *allowed* distributed solar and wind to assist with voltage and frequency support, and further modifications in 2018 *required* such capabilities.

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A full revision of IEEE 1547 in 2018 further addressed DER expansion and interoperability as related to the development of the smart grid. The revised standard provides guidance on secure communication between DERs and utilities, DERs' grid support during disturbances, and DERs' support for microgrid islanding during grid disturbances (disconnecting from the grid and serving smaller local loads).

A newer IEEE effort, P2800, is developing a standard for interconnection and interoperability of inverter-based resources that interconnect with transmission systems. P2800's approval and adoption are estimated for 2021.

NERC Industry Stakeholder Groups

The North American Electric Reliability Corporation (NERC) is charged with ensuring the reliability of the North American bulk power system and has two industry stakeholder groups which are helping to drive reliability improvements and advanced capabilities for inverter-based resources. In 2018 the Inverter-based Resource Performance Task Force (IRPTF) produced the "NERC Reliability Guideline: BPS-connected Inverter-based Resource Performance," and the group is actively working on several additional guidelines. Its initial guideline specifies the recommended behavior and performance of inverter-based resources, covering the ability of these resources' power electronics to help maintain as well as improve the stability and performance of the bulk power system. The NERC System Planning Impacts of Distributed Energy Resources Working Group (SPIDERWG) examines DERs from the perspective of transmission planning and system analysis. This working group is developing guidelines to help transmission entities ensure that they have the tools and capabilities to understand the impacts of DERs on the bulk power system.

International Electrotechnical Commission

The International Electrotechnical Commission (IEC) publishes standards for all electrical and electronic technologies—including those used in power generation, transmission and distribution, and wind and solar energy—to support the harmonization of technical requirements around the globe.

The Technical Committee on System Aspects of Electrical Energy Supply (TC8) develops standards pertaining to grid integration and end-user connection. The Grid Integration of Renewable Energy Generation Subcommittee (SC8A), established in 2013, focuses on the system-wide effect of a high percentage of renewables, including interconnection requirements for renewable energy and related grid compliance tests. The subcommittee shares best practices for planning, modeling, forecasting, scheduling, and dispatching of renewables. A second subcommittee (SC8B) is focused on decentralized electrical energy systems, preparing standards to enable the development of secure, reliable, cost-effective systems with decentralized management, including microgrids. A third subcommittee (SC8C) deals with standardization in the field of network management in interconnected power systems ranging across time horizons from system planning to system control.

The Technical Committee on Wind Energy Generation Systems (TC88) covers wind turbines, land-based and offshore wind power plants, and their interaction with the grid. The first TC88 standards addressed mechanical parts and performance of wind turbines, followed by IEC 61400-21 in 2001 addressing the grid connection of wind turbines with a focus on power quality. The second and third editions (in 2008 and 2019) include the test and measurement of fault-ride-through capability and control performance of wind turbines. Standards are under development pertaining to the testing of wind power plants (IEC 61400-21-2) and electrical components and subsystems (IEC 61400-21-4).

TC88 also publishes standards covering wind turbine modeling (IEC 61400-27-1 and IEC 61400-27-2). The IEC 61400-27-1 models are included in IEC 61970-302 specifying how to exchange data for dynamic power system simulations using generic models.

The Path to International Harmonization

National as well as international organizations are active in creating and updating technical guidelines, grid codes, and interconnection requirements. Harmonization between them is important to avoid unnecessary cost in the development and deployment of equipment, which in turn affects system reliability. Poorly harmonized or conflicting requirements cause very costly equipment development and deployment.

There are many possible paths to ensuring reliability in a new era of rising levels of renewable generation and steady technological advances, and the development of standards needs subject-matter experts to participate and collaborate to get it right. Technology development is an iterative process between new requirements pushing the envelope and the cost of implementation. Grid planners and operators, manufacturers, generation owners, regulating bodies, public commissions, and universities all have a unique perspective and a critical role to play.

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