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Introducing the IEEE PES Transmission Subcommittee

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SUMMARY

The IEEE PES Transmission Subcommittee is a new technical subcommittee established in 2021 by the IEEE PES Transmission & Distribution Committee to develop standards, guides, and technical presentations related to the transmission electric network reliability, generation, and energy storage integration, switching and voltage optimization. The Transmission Subcommittee's purpose is to technical promote treatment of matters related to the reliability impacts of inverter-based resources. treatment of matters relating to the integration of the generating and energy storage facilities with the transmission electric network, and treatment of matters related to the transmission power system switching as well as voltage optimization. The Transmission Subcommittee also promotes sponsorship and development of standards, recommended practices, guidelines, and policies as well as preparation of position papers and/or documents, technical conferences and/or sessions on matters related to areas identified in the scope of the subcommittee. It will liaise and cooperate with other technical committees, societies, groups, and associations concerned with various aspects of areas that are identified in the scope of this subcommittee. Initially, the IEEE PES Transmission Subcommittee has established three working groups: The Working Group on Reliability Impacts of Inverter-Based Resources, the Working Group on Generation and Energy Storage Integration, and the Working Group on Voltage Optimization.

KEYWORDS

Electric transmission systems, electric transmission reliability, inverter-based resources, voltage optimization, standards

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INTRODUCTION

This paper introduces Transmission Subcommittee of the IEEE Power & Energy Society, which is focused on the treatment, consideration and coordination of all matters related the transmission electric network reliability, generation, and energy storage integration, switching and voltage optimization.

IEEE STANDARDS ASSOCIATION

The IEEE Standards Association (IEEE-SA) is an organization within the Institute of Electrical and Electronics Engineers (IEEE) that develops global standards in a broad range of industries, including power and energy, biomedical and health care, information technology and robotics, telecommunication and home automation, transportation, nanotechnology, information assurance, and many more.

IEEE has about forty societies, which develop IEEE standards. For example, The IEEE Power & Energy Society (PES) focuses on the scientific and engineering knowledge about electric power and energy. The IEEE Industry Applications Society (IAS) is interested in electrical and electronic engineering in the development, design, manufacture and application of electrical systems, apparatus, devices and controls to the processes and equipment of industry and commerce. The IEEE Electromagnetic Compatibility Society (EMC) is focused on ensuring that the electromagnetic environmental effects of systems are compatible with themselves and their intended operational environment.

TRANSMISSION & DISTRIBUTION COMMITTEE

The IEEE PES Transmission & Distribution (T&D) Committee focuses on all matters related to the design, theoretical and experimental performance, installation, and service operation of parts of electric power systems that serve to transmit electric energy between the generating sources and substations or customer points of common coupling through AC or DC lines. See Figure 1 for an organization chart of the T&D Committee. See [1] for the committee website.

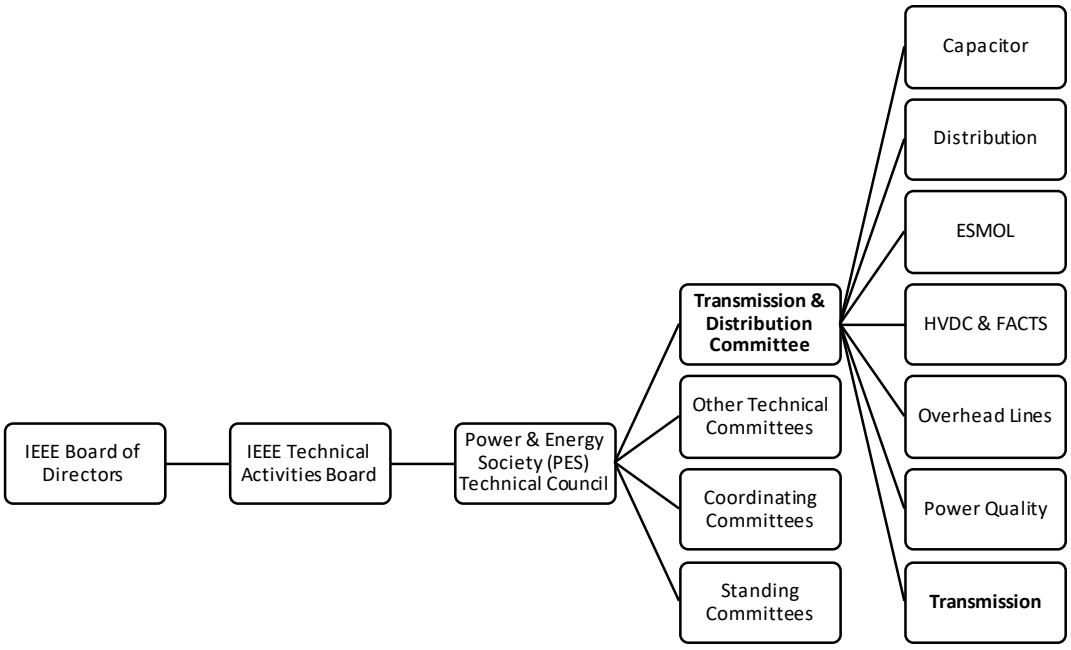

Figure 1: Organization Chart of the IEEE PES Transmission & Distribution Committee

The T&D Committee has seven responsible subcommittees. A "responsible subcommittee" is delegated responsibility for approving the submission of PARs and sponsor ballots. Responsible subcommittees assist the T&D Committee in the control and management of its large scope by creating working groups.

1. **Capacitor Subcommittee**: Treatment of all shunt and series capacitor matters related to economics, technical design, theoretical and experimental performance, installation, application, and service operation for use in power circuits of 60 Hertz and below for the purpose of affecting performance or operating characteristics of these circuits.

2. **Distribution Subcommittee**: Treatment, consideration and coordination of the economic and technical factors that influence the analysis, design, construction, operation, planning, standardization of components and environmental compatibility of overhead and underground electric distribution systems.

3. **Engineering in the Safety, Maintenance and Operation of Lines (ESMOL) Subcommittee**: The treatment of all matters related to the engineering in maintenance of lines and associated devices. Research, development, testing, acceptance of various techniques, practices, and procedures (involving the physical effects and other considerations) as they relate to safety and maintenance of lines and associated devices. Development of work methods to provide safe work areas while taking into consideration grounding, bonding, induction effects, equipment characteristics and testing techniques.

4. **HVDC & FACTS Subcommittee:** Treatment of technology related to direct current and flexible alternating current transmission systems. Applications of power electronic switching equipment and ancillary components to AC and DC transmission systems. Coordination of these systems at the interface between transmission and generation and the over-all studies of their parameters and performance.

5. **Overhead Lines Subcommittee:** Treatment of all matters of economic and technical design, theoretical and experimental performance, installation, and service operation of transmission and distribution conductors and overhead ground wires, their supporting structures, associated splicing and hardware components, and counterpoise and structure grounding. Design, application, and standards for all types of overhead line insulators including attachments to minimize arc damage and control of the electrostatic fields.

6. **Power Quality Subcommittee**: Treatment of all matters of definitions, monitoring, benchmarking, assessment, indices, and solutions to power quality phenomena in transmission and distribution systems. Treatment of harmonic distortion in transmission and distribution systems including limits, modeling, probabilistic aspects, interharmonics, and waveform distortion. Treatment of voltage quality issues including assessment of voltage fluctuation monitoring and limits and definition of voltage sag indices. Treatment of power quality solutions including custom power equipment applications and evaluation of power system compatibility with end-use equipment. See [2] for a more in-depth overview.

7. **Transmission Subcommittee**: Treatment, consideration and coordination of all matters related the transmission electric network reliability, generation and energy storage integration, switching and voltage optimization.

In addition to developing IEEE standards, subcommittees of the T&D Committee focus on conference planning and organization, such as the ESMO Conference [3], completing conference paper reviews and organizing panel sessions for the annual IEEE PES General Meeting [4] and the biennial IEEE PES Transmission & Distribution Conference & Exposition [5], publishing reports to the IEEE PES Resource Center [7], and writing/reviewing papers for IEEE Transactions on Power Delivery [8].

Types of IEEE Standards

IEEE Committees such as the T&D Committee develops IEEE standards, which are classified into three different types:

- **Standards**: Documents with mandatory requirements
- **Recommended Practices**: Documents in which procedures and positions preferred by the IEEE are presented
- **Guides**: Documents in which alternative approaches to good practice are suggested but no clear-cut recommendations are made

IEEE-SA standards projects are authorized by IEEE-SA New Standards (NesCom) Committee via a Project Authorization Request (PAR). The PAR is approved with an expiration date, which is the final date for the standard to be drafted, completed, and balloted by the working group. Successfully balloted standards are submitted to IEEE-SA Review Committee (RevCom), which makes recommendations on final approval of standards to the IEEE-SA Standards Board itself.

TRANSMISSION SUBCOMMITTEE

The IEEE PES Transmission Subcommittee is a technical subcommittee established in 2021 by the IEEE PES Transmission & Distribution Committee to develop standards, guides, and technical presentations related to the transmission electric network reliability, generation, and energy storage integration, switching and voltage optimization.

The Transmission Subcommittee's purpose is to technically promote:

- Treatment of matters related to the reliability impacts of inverter-based resources. This task will closely be coordinated with NERC and other reliability councils.
- Treatment of matters relating to the integration of the generating and energy storage facilities with the transmission electric network. The scope of this task includes but not limited to the control of the facilities and impacts on the transmission system.
- Treatment of matters related to the transmission power system switching as well as voltage optimization.
- Sponsorship and development (either alone or jointly with other technical committees and/or organizations) of standards, recommended practices, guidelines, and policies as well as preparation of position papers and/or documents, technical conferences and/or sessions on matters related to areas identified in the scope of the subcommittee.
- Liaison and cooperation with other technical committees, societies, groups, and associations concerned with various aspects of areas that are identified in the scope of this subcommittee.

Initially, the IEEE PES Transmission Subcommittee has established three working groups:

- Working Group on Reliability Impacts of Inverter-Based Resources
- Working Group on Generation and Energy Storage Integration
- Working Group on Voltage Optimization

The organization of the IEEE PES Transmission Subcommittee is shown in Figure 2.

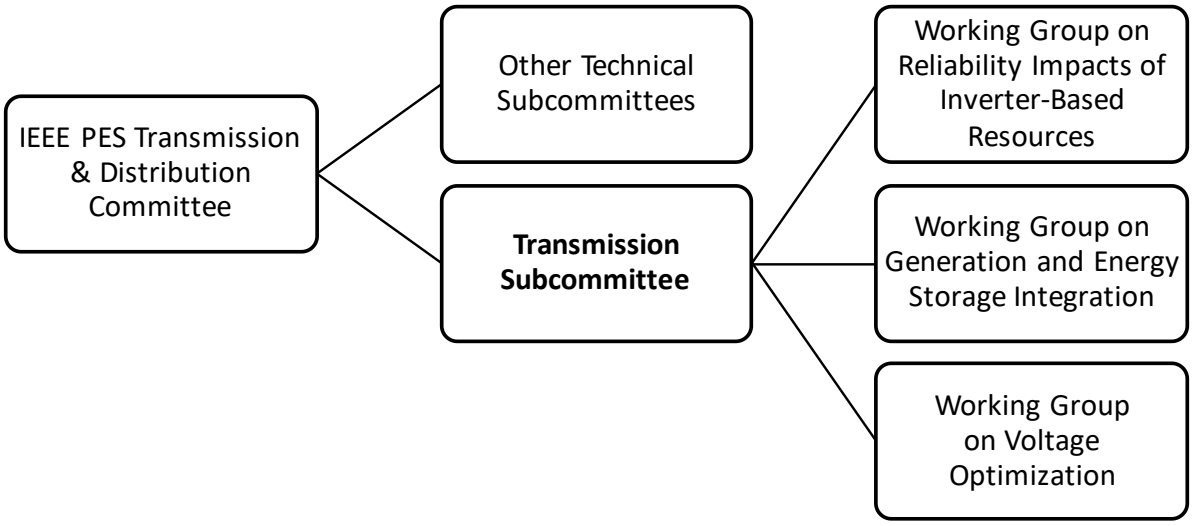

Figure 2: Organization Chart of the IEEE PES Transmission Subcommittee

Reliability Impacts of Inverter-Based Resources Working Group

This working group will investigate the challenges to reliability on the Bulk Electric System (BES) posed by the introduction of Inverter-Based Resources (IBR). IBRs have gained in scope and scale and their impacts as resources on the transmission grid are increasingly becoming critical to comprehend to ensure that the electric grid can be operated reliably. IBRs may include solar and wind renewable resources, energy storage devices, and other power sources such as fuel cell generators, and their increased penetration poses a challenge to bulk electric system reliability. These challenges arise from limitations in modeling tools of such IBRs and unfamiliarity (given the comparatively short operating history) with the operating characteristics and failure modes of such resources and technologies. As such, non-traditional resources, technologies, and operating procedures increasing in the extent to which they are deployed in the system pose challenges that may lead to gaps in the reliability assessment of the BES and operating states that are not fully understood. The working group is tasked with the identification of such reliability challenges, the quantification of the impact of such adverse impacts on various reliability metrics, and the exploration of potential solutions that may mitigate or otherwise alleviate such reliability constraints.

Various parts of the US, especially in the Western Electricity Coordinating Council (WECC), and the world, have already experienced a high degree of penetration of renewable, intermittent resources that incorporate an inverter to produce AC. The operating experience and impacts to reliability in these areas have provided valuable insights into the operational characteristics, the variability in the power production, the fault ride-through capabilities, the impact on reactive power management and, indeed, the ramifications on reliability of the transmission system. The working group intends to build upon the work already done by academia, NERC working groups, utility transmission planning groups, IEEE Standards working groups, and other interested parties in order to contribute meaningful, original discourse to the impacts of IBRs on transmission reliability.

As mentioned, this working group will focus on the reliability impact of IBRs. IBRs are defined as any source of electric power that is connected to the transmission system via power electronic interface, and that consists of one or more IBRs capable of exporting active power from a primary energy source or energy storage system to the transmission system. Any collector systems or supplemental device that enable the operation of the IBR is also considered part of an IBR.

While it is probable that scope of resources that the working group will investigate reliability impacts for will evolve, the group expects to begin working on the impacts to transmission reliability resulting from the operations of the following types of resources:

1. Photovoltaic resources
2. Photovoltaic resources with DC-coupled batteries
3. Energy storage devices
4. Wind turbine resources
5. HVDC transmission lines

The reliability analysis in focus by this working group will include these topics and more:

1. Analyze impact of IBRs on steady-state voltage and thermal loading on the transmission system: The working group will look at steady-state impacts using both frequency-domain and time-domain models, including the manner in which ride-through capabilities of IBRs impact reliability.

2. Analyze impact of IBRs on system inertial response: This reliability impact will be a particular focus for this working group. The working group will study similar efforts at ERCOT and apply similar principles to critical system inertial response levels and rate of change of frequency for the other Interconnections.

3. Analyze impact of IBR on transient stability of the transmission system: The working group will study first-swing stability and dynamic stability using time-domain models, including the manner in which ride-through capabilities of IBRs impact reliability.

4. Analyze impact of IBR on electromagnetic transients on the transmission system: The working group will analyze the impact of IBRs on electromagnetic transients on the transmission system. This effort will also include an assessment of the time-domain IBR models, including those that are provided in response to MOD-32 requirements, and the impact on transient over-voltages and other transient phenomena.

5. Consider impact of electrification and load growth, in conjunction with IBRs: Electrification of various industrial processes and the transportation sector have the potential of drastically changing the pattern of demand on the electric system, including significant amounts of inverter-based loads (in electric vehicle charging stations, for instance) or IBLs. The working group will investigate the impact of changing load growth patterns and the changing composition of load, particularly IBLs, on the reliability of the transmission system, and the manner in which IBL models impact the ability to analyze the impact of IBLs on transmission reliability.

The working group will seek to collaborate with other working groups, review the work that has already been done and identify new areas that the working group can contribute to. While the exact scope of this collaboration and the original work will largely be determined during the course of this outreach, the tentative plan for teaming up with other working groups consists of the following activities:

- IEE P2800 drafting task force: this task force with collaborate with the IEEE PES Energy Development & Power Generation (EDPG) Committee and will focus on system analysis, modeling, and review of inverter behavior under normal and abnormal system conditions to

understand the impact on transmissions reliability of performance. The technical analyses resulting from this collaboration may include outreach to utility transmission planning groups, Generator Owners with inverter-based resources, and IBR OEM manufacturers to inform analyses that will help further the understanding of the impact of IBRs on transmission reliability.

- NERC Inverter-Based Resource Performance Task Force: this collaboration will focus on ways to further explore the manner in which IBR performance characteristics can influence transmission system reliability and analyze means of improving transmission reliability through the addition of supplemental devices and operational practices [9].

- NERC Distributed Energy Resources Working Group (SPIDERWG): this collaboration will focus on ways to merge the analysis of transmission and distribution systems into single models and explore means of assessing the mutual impacts that the transmission and distribution models have on each other [10].

The working group will publish a white paper or a report to document and memorialize the findings of working group. In addition, it is likely that the working group will present progress updates to its work at various PES working sessions and provide periodic updates during the course of its work to PES sub-committees.

Generation and Energy Storage Integration Working Group

Advancements in generation technologies and energy storage facilities play a critical role in the zero-emission framework for future power systems. Each of these technologies have unique attributes that introduce challenges during integration with the transmission electric network. The currently changing generation mix with significantly more variable renewables resources require expansion and adaptation of the transmission system. On the other hand, advances in power electronics bring about opportunities to enhance power system flexibility through technologies like inverter-based generation, energy storage, and controllable transmission (HVDC, FACTS, low-frequency high-voltage AC). The scope of this working group is to:

1. Gather Industrial perspectives on the network integration challenges associated with different technologies and characterize their impacts on the transmission system.

2. Identify the best practices that facilitate modelling of each technology.

3. Understand the flexibility and control paradigms offered by each technology. Investigate new industry opportunities for transmission system controllability through power electronics-based solutions (HVDC, FACTS, low-frequency high-voltage AC), energy storage, and inverter-based generation as the power grid evolves.

4. Understand the regulatory barriers and challenges associated with wide scale integration of these technologies. Investigate engineering methods to support regulatory aspects of transmission expansion to support the evolving power system; methods could include identification of market beneficiaries and public interest for transmission projects.

5. Provide solutions and recommendations to support integration of new inverter-based generation and energy storage. Serve as a forum for industry and researchers to discuss transmission and sub-transmission adaptation and expansion needed to accommodate the upcoming changes in generation mix towards zero-emission future.

6. Complement the development of technical standards and technical reports by coordinating research objectives with P2800 and other relevant working groups.

Voltage Optimization Working Group

Voltage and reactive power control are essential for securing the proper operation of a power system during both normal and emergency conditions. Volt/var control in large power networks has become very challenging due to significant changes in system generation mix, proliferation of inverter-based generation resources, and changes to how the system must be planned based on regulatory and environmental constraints These new characteristics have a noticeable impact on the way the system is to be controlled to maintain satisfactory steady-state and dynamic voltage profiles and secure operation.

While current processes and methods for volt/var control have been successfully used for many years, transmission system operators have recognized their major limitations to properly coordinate and implement Volt/var control under the more stringent operating conditions imposed by large integration of variable generation and other system changes. This drives the need for major adaptations of voltage control approaches that require more complex coordination and interactions among controllers.

Advanced voltage control schemes have long been implemented in some systems, like the centralized hierarchical automatic voltage control used in Europe and Asia, and large-scale security-constrained optimal power flow for online applications. Even though these developments represent significant advances in bolt/var control technology, they are not widely used in transmission systems, and may not be the most adequate approaches to face the challenges and highly demanding standards of future power grid. As the changes in power system structure and operations are expected to become even more pronounced in the upcoming years, it is critical to revise the adequacy of current voltage control approaches and promote the development of more advance methods.

The purpose of this working group is to provide a forum to review the major volt/var control challenges for transmission systems, evaluate the different voltage control methods that have been proposed to address these needs, identify gaps, and propose potential research and development directions.

The scope of this working group includes all existing, emerging, and under research technologies and methods for improving voltage control and reactive power management in transmission networks. These technologies include but are not limited to the following:

- Traditional voltage control approach
- Wide area centralized voltage control
- Coordinated control of various reactive power devices
- Adaptive zone division method
- Autonomous decentralized control
- Large-scale security-constrained optimal power for online applications
- Day-ahead reactive power scheduling tools
- Supervisory voltage control strategy for renewable generation

The working group plans to complete the following activities:

1. Plan, coordinate, develop, and sponsor technical panel sessions pertaining to the Voltage Optimization working group scope.

2. Coordinate joined activities with other subcommittees, working groups, and task forces

3. Promote the preparation and publishing of technical papers, special feature articles, and special reports relating to the voltage control and reactive power management in transmission systems.

4. Act as a liaison to international bodies, technical committees, societies, groups, and individuals that have an interest in the scope of this working group.

CONCLUSIONS

The IEEE PES Transmission Subcommittee and its working groups will meet in person at least twice per year. The first in-person meeting each year is during the IEEE PES Joint Technical Committee Meeting, which typically meets in early January [6]. The second meeting is with the IEEE PES General Meeting, which typically meets in July or August [4]. Many of the Transmission Subcommittee working groups will meet in between the in-person meetings via online collaboration tools. In general, all Transmission Subcommittee meetings are open but voting on an IEEE standard requires membership in the IEEE Standards Association. For more information, see the IEEE Transmission & Distribution Committee website [1].

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