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TECHNOLOGY INNOVATION

EPRI STRATEGIC ENGAGEMENT

EPRI's Engagement in ESIG Working Groups

The Electric Power Research Institute (EPRI) engages with a wide variety of research organizations, academic institutions, industry organizations, and other groups to coordinate research activities, support technology transfer, and work to apply research results. Collaborative engagements help enable EPRI research is at the forefront of the rapidly changing energy industry. Each engagement provides EPRI with insights into unique challenges and pathways to solutions that support EPRI's mission to benefit the public. Strategic Engagement Briefs aim to highlight the value these engagements may provide to EPRI, EPRI members, and society. EPRI does not endorse group(s) mentioned or products produced by the group.

ENERGY SYSTEMS INTEGRATION GROUP

Since its formation, initially as the Utility Wind Interest Group, the Energy Systems Integration Group (ESIG) has expanded its scope to include variable generation more broadly (e.g., including solar) and to look beyond the electricity system of yesterday. ESIG's mission is to "chart the future of energy systems integration and operations" through peer-to-peer networking and knowledge sharing. ESIG includes the following six technical working groups [1]:

- Reliability Working Group
- System Operation and Market Design Working Group
- Distributed Energy Resources (DER) Working Group
- System Planning Working Group
- Research and Education Working Group
- Wind and Solar Plant Operations and Maintenance (O&M) Users Group

EPRI has several subject matter experts (SMEs) that participate in each of these working groups, including fulfilling a leadership role in the System Operation and Market Design Working Group and serving on the ESIG Board. The EPRI team also participates in the Offerings Committee, providing guidance on ESIG conference agendas, tutorials, and other material. The EPRI team also participated in development of the ESIG strategic plan for 2021.

Reliability Working Group

The Reliability Working Group aims to facilitate and encourage discussion on topics such as load modeling, dynamic system modeling, grid codes and interconnection requirements, system disturbances, weak grids, zero inertia power systems, and electrical systems [12]. This group provides and/or participates in the following activities [12]:

- An online community forum to facilitate group discussions
- Member-led webinars, workshops, and tutorials on key discussion topics
- The High Share of Inverter-Based Generation Task Force
  This task force was established to support understanding of reliable and resilient power system operation with high penetrations of inverter-based distributed generation. It aims to establish a roadmap for inverter-based generation integration generation with input from researchers, and to create a digital repository for research and industrial projects.
- A new task force, coordinated with other working groups, on how to integrate planning processes and tools with more detailed modeling issues

Key Reports

- A Path Toward the Development and Commercialization of Grid-Forming Inverters
- Evolving Grid Codes and Standards for a Power System in Transition
- Maintaining Reliability in Power Grids with High Levels of Wind and Solar
- Grid Reliability Under High Levels of Renewables: Rethinking Protection and Control
- 10 Things You Should Know About Grid-Forming Inverters
- Additional reports on topics including dynamic modeling, testing and performance, grid codes, interconnection requirements and standards, and system control interaction, disturbances and frequency behavior are available online: https://www.esig.energy/system-reliability-library/

System Operation and Market Design Working Group

The System Operation and Market Design Working Group aims to facilitate SME discussions on topics such as system operation and operating practices, market design and operation, and operational forecasting [15]. This group is led EPRI staff from Grid Operations and Planning. This group provides and/or participates in the following activities [15]:

- An online community forum to facilitate group discussions
- Webinars, workshops, and tutorials by group members
- The Hybrids and Emerging Flexible Resources (HyFlex) Task Force
  This task force was established as a working community to support industry concepts on emerging co-located, hybrid and highly flexible resources.

- A new task force, the "Flexible Resources Task Force," that is focused on identifying the challenges and opportunities associated with integrating new sources of flexibility such as hydrogen, industrial electrification and long duration storage into power system operations and planning processes. EPRI is leading this task force.

The reports/webinars associated with this group's activity and outcomes as follows:

- Increasing the Flexibility of the Power Grid Through Sector Coupling
- The Uses of Probabilistic Forecasts in Operating a High-Renewables Grid
- Ensuring Bulk Power System Reliability with Increasing Penetration of Distributed Energy Resources [2]
- Flexibility from Energy Systems Integration [3]
- Will Grid Forming Inverters be the Key for High Renewable Penetration? [4]
- A Journey through Energy Systems Integration-Trending Grid Codes, Standards and IEC Collaboration [5]
- Secrets of Successful Integration: Operating Experience with High Levels of Variable, Inverter-based Generation [6]
- An Update on VG Integration in China [7]
- The Use of Probabilistic Forecasts in Theory and Practice [8]
- Designing Electricity Markets with Massive Amounts of Zero-Cost Variable Renewable Resources [10]
- The Future's Energy Mix: The Journey to Integration [11]

Other reports from members of this group and related to the topics discussed can be found at: https://www.esig.energy/system-operation-market-design-library

DER Working Group

The DER Working Group aims to facilitate SME discussions on topics such as distributed photovoltaics (PV), energy storage, demand management, electric transportation, distribution system design and operation, microgrids, and transactive energy [13]. This group provides and/or participates in the following activities [13]:

- An online community forum to facilitate group discussions
- Webinars, workshops, and tutorials by group members

The reports/webinars associated with this group's activity and outcomes as follows:

- Ensuring Reliability with Increasing Levels of Distributed Energy Resources

Other reports from members of this group and related to the topics discussed can be found at: www.esig.energy/der-library/.

System Planning Working Group

The System Planning Working Group aims to facilitate discussion from SMEs on topics such as generation and transmission planning, technical and economic aspects of electrical, thermal, gas and transportation systems integration, capacity adequacy and flexibility, and alternative sources of system flexibility services [16].

This group provides and/or participates in the following activities [16]:

- An online community forum to facilitate group discussions
- Webinars, workshops, and tutorials by group members
- The Redefining Resource Adequacy Task Force:
  This task force was established to support understanding of resource adequacy challenges and opportunities for modern power systems with the guidance of the System Planning Working Group. This task force conducts reviews of recent methodologies analyzing power system resource adequacy.
- The Macrogrid Transmission Overlay Task Force:
  This task force was established to provide technical support to the U.S. macrogrid initiative efforts to accelerate the transition to clean energy. The task force seeks to aid in removing transmission constraints on the renewable energy integration.

The reports/webinars associated with this group's activity and outcomes as follows:

- Planning for Ultra-High Levels of Renewables

Other reports from members of this group and related to the topics discussed can be found at: https://www.esig.energy/system-planning-resource-library/

Research and Education Working Group

The Research and Education Working Group aims to facilitate discussion from SMEs on studies of high integration of renewables into future power systems, as well as analysis and concepts on renewable energy integration effects on current energy systems and associated services and utility, such as transportation, water, communication and data systems [14].

This group provides and/or participates in the following activities [14]:

- An online community forum to facilitate group discussions
- Webinars and workshops by group members

Wind and Solar Plant O&M Users Group

The ESIG Wind and Solar Plant O&M Users Group strives to "[facilitate] an open and candid discussion on the care and operation of generation equipment" [17]. The group is comprised of owners and operators of wind and solar assets and divides the discussion into 26 sub-groups to support open technical exchange of experience among its participants. In 2020, EPRI launched the Solar Owners League (SOL) and Wind Innovators Network (WIN) user groups that similarly pertain to O&M issues, but

which are more research-focused to identify subtopics that require further attention through scientific research, hardware development, data gathering, analysis and benchmarking or other technical solutions [17].

Reports associated with this group and detailing some outcomes of the group can be found at https://www.esig.energy/operations-maintenance-resource-library/.

Towards 100% Renewables Roadmap Workshop

ESIG held a workshop in May 2019 with experts from around the world from industry and the research community. The goal of this workshop was to develop a coordinated international research roadmap to address the technical challenges associated with incorporating large amounts of variable generation into the energy supply mix. The group recognized that all deep decarbonization scenarios involved increased utilization of renewable resources, further integration of sectors (electrical, thermal, transportation), increasing electrification, and a social science dimension. The group focused on the challenges of operating a power system with 100% power instantaneously provided by inverter-based renewable resources in a reliable and economic manner, while keeping in mind the additional challenges of the bookend scenarios of 100% annual energy from renewables, such as voltage and frequency regulation. The group recognized that, although all regions will not follow the same pathway at the same time, those paths may still require a common destination. The aim is also to identify which major technology development gaps exist, and which parties need to be involved to address those gaps [9].

EPRI SMEs facilitated two of the five breakout groups that met across the day and a half meeting. The groups included:

1. Planning and Adequacy
2. Voltage and Frequency Control and Dynamics
3. Distribution, Microgrid, and Customer Impacts
4. Flexibility, Operations, and Balancing
5. Market Designs

Each group began with laying out the key gaps in their areas, and then potential pathways for addressing the gaps. Key common gaps and findings were identified. The level of demand-side participation required significant changes to address challenges, with digitization and automation being key. Innovative technologies may be necessary to provide the reliability needs, including long-duration, seasonal storage of emissions-free resources that act similar to thermal gas generators of today. Some potential major changes to operations and markets structures may also be on the horizon, including how a more decentralized paradigm is expected to impact operating and planning the power system.

The report associated with this meeting is located at:

- Toward 100% Renewable Energy Pathways: Key Research Needs [9]

The roadmap was published, and industry and research groups are working to address these further. EPRI research has referenced this resource to help evaluate which areas of research are needed going forward. Further workshops with ESIG have since focused on some of the key areas that found common mitigation strategies. This roadmap also formed the basis of the re-

cently established Global Power Systems Transformation Initiative (G-PST), of which EPRI and ESIG are both founding members [18].

G-PST is a consortium that aims to bring together key energy system actors in accelerating decarbonization and transition to affordable, secure, and reliable energy systems. The consortium coordinates through activities in [18]:

- System operator research and peer learning
- System operator technical support
- Foundational workforce development
- Localized technology adoption support
- Open data and tools

In January 2021, ESIG and G-PST hosted a webinar that covered the current and still needed research related to frequency response with increase in inverter-based resources (IBRs), and during which an EPRI SME relayed the change in frequency control needed when transitioning to IBRs. The webinar recording and related materials can be found at: https://www.esig.energy/event/webinar-frequency-control-in-a-100-inverter-based-grid/ [18].

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EPRI RESOURCES

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About EPRI

Founded in 1972, EPRI is the world's preeminent independent, non-profit energy research and development organization, with offices around the world. EPRI's trusted experts collaborate with more than 450 companies in 45 countries, driving innovation to ensure the public has clean, safe, reliable, affordable, and equitable access to electricity across the globe. Together, we are shaping the future of energy.

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