

SPRING TECHNICAL WORKSHOP OVERVIEW

ALBUQUERQUE, NM

Opening Plenary: Managing a High Penetration Power System

Chair: Nick Miller, Hickory Ledge Consulting

Managing a High Penetration Power System kicked off the spring ESIG session. Chair, Nick Miller, set expectations by focusing on the rapidly arriving reality that there are times and places where 100% renewables and 100% inverter-based resources are nearly today's reality. In short, the speakers covered four major points:

- Worrying about approaching or reaching 100% inverters isn't an academic exercise for the distant future, but rather is a pressing need now.
- There are fundamental shifts required to reliably, economically, and safely get "there".
- Grid-forming inverters for inverter-based resources (IBR) must be part of that shift.
- We haven't done enough homework yet to know exactly what we want or need GF inverters to do, but we've made a good start.

Jordan Bakke, MISO, showed their Renewable Energy Impact Assessment work, which includes present operation of north MISO (the size of New England) hitting 80% penetration today. MISO is developing new tools and understanding of how their limits change, with new insights into locational constraints. Then, Dennis Woodford, Electranix, took the audience through some of the basics and new realities of inverter-capabilities and grid limitations. These new realities are showing up in grids and specific projects around the world. But we aren't alone. Ralph Pfeiffer, Amprion / ENTSO-E showed how the European transmission entities are grappling with challenges on the European systems, and the emergence of new codes to help the transition. Abraham Ellis, Sandia National Laboratories, showed real field results from grid projects with grid-forming inverters, driving home the fact that many of the challenges of grid-forming inverters have already been solved on moderate scale systems. But the fact there is much to be learned was covered, in part, by Deepak Ramasubramanian, EPRI, who showed new concepts for 100% inverter-control that move beyond traditional frequency dependent control schemes. Julia Matevosyan, ERCOT, wrapped up, showing the massive progress and looming challenges that face ERCOT, now that they regularly exceed 50% instantaneous penetration with wind-rich exporting regions often approaching zero synchronous generation.



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Session 1: Improving Flexibility and Frequency Response

Chair: Bethany Frew, NREL

This session covered a diverse set of options for providing system flexibility, as well as the challenges and opportunities related to frequency response, in systems with high penetration levels of variable renewable energy (VRE) resources. A common theme among the flexibility mechanisms discussed was the need for an integrated, multi-sectoral approach, including electrification, the use of long-term storage, demand-side participation, combined heat and power with district heating systems, and market mechanisms to incentivize flexible operations of thermal units. The discussion on frequency response focused around multiple sensitivity studies of U.S.-based systems, which highlighted the need for inverter control standardization and suggested that the Eastern Interconnection may be able to withstand system disturbances with a higher VRE penetration level than previously thought.

Panelists: Danny Pudjianto (Imperial College London), Yu Jun (Northeast Branch, State Grid Corporation of China), Yilu Liu (Oak Ridge National Laboratory), and Olushola Lutalo (NERC)

Session 2: Distribution System Developments

Chair: Debbie Lew, GE

The Distribution System Developments session covered DER developments in the Western Hemisphere, starting with Colombia where Lina Ramirez of XM spoke about impacts of DERs on frequency and voltage stability. Moving north to Texas, Chase Lansdale of EPE spoke about a study to extract flexibility from residential water heaters, while Ben Sigrin of NREL showed NREL models and results of DPV forecasts. Finally, Dave Edelson of NYISO spoke about DER aggregations as participants in the NYISO wholesale market.

Session 3: Electric Transportation and Energy System Integration

Chair: Obadiah Bartholomy, SMUD

Todd Davidson from the University of Texas at Austin lead off the Electric Transportation and Energy System Integration session with a compelling set of dynamic Sankey Diagram visualizations of energy flows in the US economy under different electrified transportation futures, helping the audience see the efficiency gains possible from transitioning some of the 2/3 of our useful energy that our economy rejects as waste heat into useful energy through more efficient transportation. Following Todd, Bernie Ernst from Fraunhofer IEE discussed varying flexibility in different electric transportation futures including examining how trucks operating on catenary systems compare to the more typically modeled battery vehicles. Liz Waldren from Black & Veatch shared modeling results associated with a 100% electrification and 100% renewable future in California, showing nearly \$70B in savings in two managed EV charging scenarios vs. one where unmanaged charging substantially increased BESS investment for renewable integration. To wrap up the presentations, Pamela MacDougall from NRDC presented on results from a study with PG&E that found that most distribution system impacts could be mitigated with just 30% of the vehicles participating in Time of Day based load-shifting off of the local distribution peaks.



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Session 4: Preparing for Future Energy Systems

Chair: Charlton Clark, DOE

This session centered on highlighting some of the tools under development and in use to better prepare for the future energy transition. Pablo Ruiz and Jay Caspary, from Brattle and Southwest Power Pool (SPP), respectively, presented on how SPP has been utilizing NewGrid's transmission switching optimization software to address congestion in the SPP footprint. Rebecca O'Neil from PNNL presented on efforts within DOE's Water Power Technologies Office to better understand the value of pumped storage hydro and the technical capabilities of hydropower in general. Next, Jingwei Yang, presented on a research project from Tsinghua University related to the development of an energy flow matrix to help optimize the development of combined heat and power systems with renewable deployment. Next, Guohui Yuan, from the DOE Solar Energy Technologies Office (SETO) presented an overview of SETO's Grid Integration research activities. Finally, Andrew Mills from LBNL presented on analysis related to understanding how variable generation has impacted average prices within ISO wholesale markets.

Session 5: High Penetration and Weak Grid Issues

Chair: Jason MacDowell, GE

The High Penetration and Weak Grid Issues session kicked off the second day of the conference with enthusiastic comments by the General Electric session chair, Jason MacDowell, about the plethora of international work occurring in this space. First up was Vahan Gevorgian, a NREL researcher in the Power Systems Engineering Center, who spoke about the black start of wind and solar plants with battery grid forming inverters.

Second up was Grégoire Prime, from EDF in France, who presented a first methodology to assess the economic cost related to the challenges of a low inertia system (e.g. larger rate of change of frequency following large generation/load imbalances, lower first swing/nadirs, rotor angle stability issues, etc). Shail Shah, of NREL, then spoke on system dynamic interactions with wind plants, focusing on frequency domain analysis of power electronics, making the point that a primary characteristic for distinguishing the difference between grid following (i.e. current injecting), and grid forming (voltage source) is the output impedance.

From SGERI in China, Caixia Wang presented a Qinghai high penetration case study regarding the 100% operation of this region (Qinghai) at two different times, concluding that interconnection, a flexible generation structure, advanced operation technology, and thermal compensation methods were necessary for the path forward to longer periods of 100% renewable generation.

Finally, Yongning Chi from CEPRI in China, spoke on a weak grid case study, recognizing that weaker grids may have smaller voltage stability margins due to the larger voltage swings for a set amount of power differentials, and that series compensation can sometimes lead to sub synchronous resonance.



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Session 6: Energy Storage Developments

Chair: Russ Philbrick, Polaris Optimization

Storage technology is evolving rapidly, and is seen by some as a panacea to solve challenges of renewable integration and to reach 100% renewables. However, there are still significant limitations on deployment due to costs, regulatory barriers, and business models. This panel presented both a broad and deep perspective on these issues.

The first two speakers -- Jason Burwen and Mak Nagle -- discussed existing barriers and opportunities for viable business models. One noteworthy topic was benefits of connected storage to the AC or DC side of inverters. Ongoing barriers to system deployment combined with decreasing PV panel prices and increasing automation (i.e., allowing direct use by DC loads through “smart” devices) suggest that system costs will drive connections to the DC side of inverters. Unfortunately, current engineering of distributed PV has gone in the other direction, such as with development of string inverters attached directly to PV panels.

The second group of speakers -- Yingchen Zhang, Vahan Gevorgian, and Lynn Trahey -- discussed ongoing development of storage technologies to address short-term and long-term variability in system operations. At one end, the quick and flexible response of many storage technologies can be used to provide synthetic inertia to respond to system contingencies. At the other end, development of new storage chemistry offers opportunities for significant cost reductions needed for long-term energy storage (i.e., hours or days into future). Of particular note are promising but early results from sulfur-based technologies.

Closing Plenary – Long-term Planning Considerations

Chair: Mark O'Malley, NREL

The final plenary session of the ESIG Spring 2019 meeting was on the topic of long term planning considerations. It ended with the conclusion that what was needed is for a philosopher and an electrical power engineer to get together over a drink (nonalcoholic) and solve all the challenges. While this is something of an exaggeration and slightly light hearted, it did summarize the session which covered an extremely wide range of topics from decarbonization, human behavior, regulatory, political and social issues, to the engineering of electricity, gas, heat, transport and fuel systems. These are all important topics and all in one way or another have an impact on the long-term trajectory of the integrated energy system. Therefore, as a community we must be aware of all of them and understand how they can shape our own personal work and endeavors, which is what ESIG is all about.



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