

# Supersession

## Grid Edge

Devices, Control, Applications, and System Operation  
July 28, 8am-12 noon

Co-chairs:

Federico Milano, UCD, Ireland, [federico.Milano@ucd.ie](mailto:federico.Milano@ucd.ie)

Andrey Bernstein, NREL, US, [andrey.bernstein@nrel.gov](mailto:andrey.bernstein@nrel.gov)

Part I	Panelists	Presentation
8:00 – 8:05	F. Milano & A. Bernstein	<i>Opening statement</i>
8:05 – 8:25	<b>Babak Enayati</b> , National Grid, US	<i>Distributed energy resources and energy storage are paving the way to grid modernization</i>
8:25 – 8:45	<b>Jacob Østergaard and Charalampos Ziras</b> , DTU, Denmark	<i>Flexibility from distributed resources</i>
8:45 – 9:05	<b>Ehsan Nasr</b> , Microsoft, US	<i>Hydrogen and smart energy storage in data centers</i>
9:05 – 9:25	<b>Steven Low and Fengyu Zhou</b> , CalTech, US	<i>Grid Edge AC OPF applications</i>
9:25 – 9:55	F. Milano (moderator)	<i>Q&amp;A</i>
9:55 – 10:05	All	<i>Break</i>

# Break

Part II	Panelists	Presentation
10.05 – 10:25	<b>Randy Boys</b> , Oncor, US	<i>Grid modernization and DER: Resilient, complex, and affordable, pick any three</i>
10:25 – 10:45	<b>Yingchen Zhang</b> , NREL, US	<i>Understanding the behind-the-meter resources</i>
10:45 – 11:05	<b>Emiliano Dall'Anese</b> , University of Colorado, Boulder, US	<i>Learning to optimize grid-edge devices in real time</i>
11:05 – 11:25	<b>Johanna Mathieu</b> , University of Michigan, US	<i>Establishing credibility for load coordination at scale</i>
11:25 – 11:55	A. Bernstein (moderator)	Q&A
11:05 – 12:00	F. Milano & A. Bernstein	Final Statement

# Panelists



## Co-Chair: Federico Milano

Professor of Power System Control and Protections, UCD

**Bio:** Federico Milano received from the University of Genoa, Italy, the Ph.D. in Electrical Engineering in June 2003. He worked at the Electrical & Computer Engineering Department of the University of Waterloo, Canada, as a Visiting Scholar between 2001 and 2002. He was with the Department of Electrical Engineering of University of Castilla-La Mancha, Spain, from 2003 to 2013. In 2013, he joined the UCD School of Electrical and Electronic Engineering, where he is currently Professor of Power Systems Control and Protections. In 2016, he was elevated to IEEE Fellow for his contributions to power system modelling and simulation. In 2017, he was elevated to IET Fellow. In 2020, he joined the IEEE PES Distinguished Lecturer Program.



## Co-Chair: Andrey Bernstein

Senior Researcher and Group Manager, Energy Systems Control and Optimization, NREL

**Bio:** Andrey Bernstein received his B.Sc., M.Sc., and PhD degrees in Electrical Engineering from the Technion - Israel Institute of Technology. Between 2010 and 2011, he was a visiting researcher at Columbia University. During 2011-2012, he was a visiting Assistant Professor at the Stony Brook University. From 2013 to 2016, he was a postdoctoral researcher at the Laboratory for Communications and Applications of Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland. Since October 2016 he has been a Senior Researcher and Group Manager at the National Renewable Energy Laboratory, Golden, CO, USA. His research interests are in the decision and control problems in complex environments and related optimization and machine learning methods, with application to power and energy systems.

## Babak Enayati

Manager, Distributed Generation Standards and New Technology,  
National Grid



**Bio:** Babak Enayati received his PhD in Electrical Engineering from Clarkson University, USA in 2009. He joined National Grid, USA in 2009 and is currently the Manager of the Distributed Generation Standards and New Technology team, which is responsible for the implementation of the new technologies to meet National Grid's Intelligent Electric Network objectives. Since Babak joined National Grid, he has held engineering positions in the Protection Engineering, Retail Connections Engineering, and New Energy Solutions departments. He joined Institute of Electrical and Electronics Engineers (IEEE) in 2006 and currently is a Senior IEEE Member. Babak currently serves as the Vice President of Education on the IEEE Power and Energy Society (PES) Governing Board. Babak serves as the Vice Chair of the IEEE 1547-Standard for Interconnecting Distributed Energy Resources with Electric Power Systems, and IEEE P2800- Standard for Interconnection and Interoperability of Inverter-Based Resources Interconnecting with Associated Transmission Electric Power Systems. Babak is a registered Professional Engineer (PE) in the state of Massachusetts.





## Jacob Østergaard

Professor, Head of the Center for Electricity and Energy, DTU

**Bio:** Jacob Østergaard has been head of DTU's Center for Electricity and Energy, Copenhagen, Denmark, since 2005, when he founded the center. He has published a large number of papers on intelligent energy systems based on renewable energy. He contributes to a large number of boards and committees at European and national level, including the former Danish government's energy commission, which has laid the foundation for the current ambitious Danish energy policy.

## Johanna Mathieu

Associate Professor, Department of Electrical Engineering and Computer Science, University of Michigan



**Bio:** Johanna Mathieu is an associate professor of Electrical Engineering and Computer Science at the University of Michigan, Ann Arbor. Prior to joining Michigan, she was a postdoctoral researcher at ETH Zurich, Switzerland. She completed her PhD at the University of California at Berkeley in 2012 and her SB at the Massachusetts Institute of Technology in 2004. She is the recipient of an NSF CAREER Award and the Ernest and Bettine Kuh Distinguished Faculty Award. Her research focuses on ways to reduce the environmental impact, cost, and inefficiency of electric power systems via new operational and control strategies. She is particularly interested in developing new methods to actively engage distributed flexible resources such as energy storage, electric loads, and distributed renewable resources in power system operation, which are especially important in power systems with high penetrations of intermittent renewable energy resources such as wind and solar. Professor Mathieu serves as Vice Chair of the IEEE Power and Energy Society Technical Committee on Smart Buildings, Loads, and Customer Systems.



## Ehsan Nasr

### Senior Electrical Engineer, Microsoft

**Bio:** Ehsan Nasr, PhD, SMIEEE, is a senior infrastructure engineer and technical lead at the Datacenter Advanced Development, Cloud Operation & Innovation, at Microsoft Corp, USA, leading advanced energy storage and grid interactive data center, and artificial intelligence in data center programs. Ehsan has worked at various research and engineering institutes with +15 years of experience, leading various hybrid renewable energy solutions, energy storage, and microgrid projects. Ehsan received a Ph.D. from the University of Waterloo, Canada, 2014. He has received several awards in power and energy society and active in various IEEE working groups, task forces, and standard developments and served as the technical committee program chair of Power System Dynamic Performance, IEEE (2018-2020), and a senior member of IEEE. Ehsan has published several technical journal and conference papers.



## Mark Manore

### Principle Engineer, Microsoft

**Bio:** Mark Monroe is a Principal Engineer in Microsoft's Datacenter Advanced Development group working on future systems for energy, water conservation, and automation. He is a Six Sigma Master Black Belt, with a focus on change acceleration in corporate settings. Mark led industry consortium including Infrastructure Masons and The Green Grid, and served on the board of directors for the Center for ReSource Conservation in Boulder, CO. He has a Master of Science in Mechanical Engineering from Virginia Tech.



## Randy Boys

### Strategy & Technology Manager, Oncor Electric Delivery



**Bio:** Randy has been with Oncor Electric Delivery for four years, supporting a number of initiatives in the Strategy and Technology organization, also as the Lancaster SOSF microgrid operations manager. Randy is a Systems Engineer with 35 years electronics R&D experience, and 5 years in health sciences R&D before that. Randy's personal interests in environmental stewardship and the mechanics of societal and cultural change align well with his 'ancillary' assignments within Oncor, such as running their annual EarthX event and other Oncor engagements in public-facing new energy forums. As often as possible, two themes steer his assignment interests: (a) transportation electrification (e.g., EVs, public charging, V2X functions and Standards, EPA non-attainment region mitigation and health impacts, industry-wide TCO) and (b) active consumer/prosumer participation in Grid operations (e.g., IoT-enabled consuming devices, demand management, vehicle-to-grid functions, future compensatory markets)

## Yingchen “YC” Zhang

Research Group Manager, Sensing and Predictive Analytics, NREL



**Bio:** Dr. Yingchen Zhang is chief scientist and manager of the Sensing and Predictive Analytics group at the National Renewable Energy Laboratory. He is also a visiting research assistant professor at the University of Denver and an adjunct faculty at Colorado State University. His key areas of expertise lie in sensing and measurement for power systems, artificial intelligence, predictive analytics, advanced energy management system for future grids, the impact of large-scale integration of renewable energies on power system operations. He has led the early development of machine learning applications to power systems, including resource forecasting, state estimation, behind meter disaggregation and autonomous decision making. Dr. Zhang previously worked for the California ISO developing and implementing State Estimator and Network Applications. He was also responsible for ISO’s full network models and SCADA databases development. He was a key member to develop and implement Synchrophasor technology into ISO’s operation system. Dr. Zhang received his B.S. degree from Tianjin University, China in 2003 and his Ph.D. degree from Virginia Polytechnic Institute and State University in 2010.

## Emiliano Dall'Anese

Assistant Professor, Department of Electrical, Computer, and Energy Engineering, University of Colorado Boulder



**Bio:** Emiliano Dall'Anese is an Assistant Professor in the Department of Electrical, Computer, and Energy Engineering at the University of Colorado Boulder, and an affiliate Faculty with the Department of Applied Mathematics. He received the Ph.D. in Information Engineering from the Department of Information Engineering, University of Padova, Italy, in 2011. From January 2011 to November 2014, he was a Postdoctoral Associate at the Department of Electrical and Computer Engineering of the University of Minnesota, and from December 2014 to July 2018 he was a Senior Researcher at the National Renewable Energy Laboratory, within the Power Systems Engineering Center. His research interests span the areas of optimization, control, and learning, with current emphasis on online optimization and data-driven control. Applications span the areas of to power and energy systems, (electrified) transportation, and health. He received the National Science Foundation CAREER Award in 2020. He is currently an Associate Editor for IEEE Control Systems Letters.

## Steven Low



F. J. Gilloon Professor of Electrical Engineering Department and Computing and Mathematical Sciences Department, Caltech

**Bio:** Steven Low is the F. J. Gilloon Professor of the Department of Computing & Mathematical Sciences and the Department of Electrical Engineering at Caltech. Before that, he was with AT&T Bell Laboratories, Murray Hill, NJ, and the University of Melbourne, Australia. He has held honorary/chaired professorship in Australia, China and Taiwan. He was a co-recipient of IEEE best paper awards, an awardee of the IEEE INFOCOM Achievement Award, and is a Fellow of both IEEE (2008) and ACM (2020). He was well-known for pioneering a mathematical theory of Internet congestion control and semidefinite relaxation of optimal power flow problems in smart grid. His research on networks has been accelerating more than 1TB of Internet traffic every second since 2014. His research on smart grid is providing large scale EV charging to workplaces, from K-12 and universities to municipalities to Fortune Global 50 companies. He received his B.S. from Cornell and PhD from Berkeley, both in EE.



# Concluding Remarks (I)

What is your definition/understanding of Grid Edge?

- Grid Edge is the **decentralization of energy generation and storage system** (Nasr).
- Distributed energy resources such as PV, EV, storage devices, smart buildings, smart appliances, smart power electronics. The key difference between behind the meter appliances and those on the distribution grid is the **ownership and privacy** (Low, Matthieu, Dall'Anese).
- Behind-the-meter assets and associated functions that interact either explicitly **across the meter**, or with **awareness of front-of-meter** operations and grid/market conditions (Boys).
- Grid Edge is when system operators starts to **lose visibility and controllability** over connected devices/systems, thus edge is where things are too far to reach (Zhang).
- Grid Edge technologies provide the customers with the **choice** to decide how and when to consume and generate energy. They also help improve the grid **resiliency and reliability** (Enayati).

# Concluding Remarks (II)

What is the most important feature of the Grid Edge?

- **Diversity** of the technologies (Nasr).
- Grid Edge is **intelligent**, i.e, capable of real-time sensing, communication, computing and control (Low).
- Grid Edge is **provides services** to the distribution network and **ancillary services** to the bulk system (Matthieu).
- Grid Edge ncludes a **sheer number of devices** that are interacting with the grid (Zhang YC).
- Grid Edge requires **coordinated control** (Dall'Anese).
- Grid Edge is delivers **clean and affordable energy** to the customers (Babak Enayati)
- Grid Edge is a **growing corpus of utility-problematic concerns** that are accelerating grid evolution (Randy Boys).

# Concluding Remarks (III)

What do you think will be the key enabler of the Grid Edge?

- The drive to decarbonize power grid will need an **intelligent** Grid Edge (Low, Zhang).
- The development of **better mechanisms** for the grid to compensate participants **for services** (Matthieu).
- **Control and optimization methods** based on well-principled methods; no heuristics (Dall'Anese).
- **Communication systems** (Enayati, Nasr)
- **Clean energy** (Nasr)
- **Market factors** are the key enabler (Boys).

Thank you all!