Island Power Systems

3 Workshops for Renewable Energy, Storage, Integration

EUCI

RENEWABLE ELECTRICITY RESOURCES, TECHNOLOGIES, & IMPLEMENTATION

DECEMBER 11-12, 2017 | MONTEGO BAY, JAMAICA

STORAGE TECHNOLOGIES AND IMPLEMENTATION

DECEMBER 12, 2017 | MONTEGO BAY, JAMAICA

MAINTAINING RELIABILITY AND SUPPORTING INTEGRATION

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Renewable Electricity Resources, Technologies, & Implementation: Island Power Systems Workshop I

DECEMBER 11-12, 2017

WORKSHOP I OVERVIEW

Renewable electricity is growing globally at an astounding pace. Rapidly declining component costs, coupled with public sentiment and policy support for cleaner energy sources, are moving these technologies into mainstream use on the electric grid. These new technologies are changing the dynamics of energy delivery and consumption at a fundamental level, requiring utilities in every region to respond to important system changes needed to enable a functional future grid.

This first of three workshops will provide utility and other power professionals essential knowledge about renewables in the context of island power systems and grid operations, exploring the opportunities these technologies offer in managing the unique island challenges and constraints. Attendees at this course will gain the ability to critically evaluate renewable technologies and obtain practical information re: real-world cost, performance, and technical characteristics. The content will also provide attendees with a fundamental understanding of wind and solar impacts to the grid, addressing the complex issues of grid integration and detailing the technical and economic challenges that variable renewables impose on electricity grid operation. And, the workshop will provide beginning considerations on how storage resources can benefit island grid operations.

WORKSHOP I LEARNING OUTCOMES

- Review a detailed rundown of the electric industry, its key concepts, and the growing role of renewable generation
- Discuss basic engineering measures and concepts related to large electricity systems
- Examine key statistics on renewable market growth and projected futures
- Evaluate renewable energy technologies cost, performance, and technical characteristics
  - Wind
  - Solar
  - Hydro power
  - Geothermal power
  - Biomass and landfill gas
- Examine wind and solar impacts on the electric grid
- Identify exposure to system integration challenges and solutions
  - Storage
  - Demand-side management
  - Others
- Assess renewable project costs and finances
- Review online tools and methods to assess renewables

WORKSHOP I AGENDA

MONDAY, DECEMBER 11, 2017

8:00 – 8:30 am **Registration and Continental Breakfast**

8:30 am – 5:00 pm **Workshop Timing**

12:00 – 1:00 pm **Group Luncheon**

I. Renewable Energy Technologies & Their Growing Role on the Electric Grid

- How the electricity utility industry began: early years and how it led to the current structure
- Dynamics of the traditional US electric power grid: generation, transmission and distribution
- Types of electric companies — IOUs, cooperatives, public power and government utilities
- The electric utility vertically integrated business model
- Drivers for change and the rise of renewables
  - Generation and consumption statistics, cost of electricity
  - How has the mix of electricity generation been changing over time?
- Big picture trends on renewable electricity
- Statistics on renewable market growth and projected future

II. Renewable Energy Technologies: Cost and Performance, Grid Impacts and Integration

- Technical characteristics, costs, and market projections
- Understanding their potentials, limitations, and promising applications
  - Wind
  - Solar
    - Photovoltaic (PV) – utility scale and distributed
    - Concentrating Solar
  - Hydro power
  - Geothermal Power
  - Burning wood and other biomass
  - Landfill gas

III. The Integration Challenge

- Solar PV and wind variability
- How much variable renewable energy can power systems handle?
  - Technological and economic limits
  - Case studies of integrating high levels of variable renewable generation: Germany, Denmark, US
- Power system planning requirements for achieving successful integration of renewables
  - Balancing and flexibility
  - Reserves
  - Transmission infrastructure and planning needs
  - Grid services from wind/solar or other equipment
- Options to increase flexibility to address grid integration challenges
  - System operation
  - Load management/DSM
  - Electricity pricing
  - Flexible generation
  - Storage
- Best planning practices to accommodate renewable integration for maintaining reliability and cost-effectiveness

5:00 pm **Workshop Adjourns for Day**

WORKSHOP I AGENDA (CONTINUED)

TUESDAY, DECEMBER 12, 2017

8:00 – 8:30 am **Continental Breakfast**

8:30 am – 11:45 am **Workshop Timing**

IV. Renewable Energy Business Cases in Island Power Systems

- Key elements for renewable projects
  - Levelized cost of electricity (LCOE) and other metrics for cost analysis
  - Technology selection considerations – quality, equipment warranties, and performance guarantees
  - Balance of system costs
  - "Soft" costs
  - Acquisition and siting elements
  - O&M costs
  - Project financing costs

11:45 am **Workshop Concludes**

WORKSHOP I INSTRUCTOR

Paul Komor

Paul Komor is the founder of the Energy Education programs at the Renewable and Sustainable Energy Institute (RASEI) and a lecturer in the Environmental Studies Program at the University of Colorado-Boulder. As RASEI's first Education Director, Dr. Komor worked to establish CU-Boulder as a leader in energy education. He currently teaches graduate courses in energy technology and policy at CU-Boulder, and is an Advisor to the UNFCCC, IRENA, and UTP (Malaysia). Prior to joining the University of Colorado faculty, Paul was a Project Director at the U.S. Congress' Office of Technology Assessment (OTA), where he worked with House and Senate Congressional Committees in preparing and evaluating energy legislation. Prior to joining OTA, he taught at Princeton University. He has published numerous refereed articles, reports, and other papers on renewable energy. His book, Renewable Energy Policy, was required or recommended reading for courses at University of California, Santa Barbara (UCSB), University of Denver (DU), University of Utah, Robert Gordon University (UK), and elsewhere. In 2005, Paul was selected as the 2006 MAP/Ming Visiting Professor of Energy and the Environment by Stanford University, where he spent a sabbatical year researching and teaching on renewable energy policy and technology. In 2007, Paul shared in the Nobel Peace Prize awarded to Al Gore and the Intergovernmental Panel on Climate Change (IPCC) "for their efforts to build up and disseminate greater knowledge about man-made climate change". For his work with the IPCC, Paul was named a contributor to the Nobel Peace Prize. Paul holds a BS in Engineering from Cornell University, and MS and PhD degrees in Engineering from Stanford University.

Storage Technologies and Implementation: Island Power Systems Workshop II

DECEMBER 12, 2017

OVERVIEW

Energy Storage is emerging as a key facilitator of the future electricity system. Storage installations are multi-value resources, improving the efficiency of existing system operations and meeting the emerging demands of an evolving electricity grid and changing supply mix. The myriad storage technologies available — from conventional and advanced battery storage to flywheels and compressed-air or thermal storage — have wide-ranging capabilities and use cases. They can fill the roles of both generators and wires resources to efficiently meet power system reliability and policy objectives. These attributes, in combination with rapidly falling technology costs, supportive policies, and the growing need for flexible resources, are contributing to strong demand for grid-scale and distributed energy storage. Cumulative global capacity is expected to reach 45,000 MW by 2024. Virtually nowhere are the potential benefits from energy storage deployment higher than in island power systems, which confront these challenges:

- Maximizing operating efficiency with relatively higher costs of fuel
- Managing variability and uncertainty associated with integrating renewables
- Deploying a limited fleet of resources
- Confronting disproportionate climate-related impacts

This second of three workshops will dig into the key aspects of storage integration and operation in island power systems. It will discuss the various technical and economic challenges faced by island utilities seeking to plan for and integrate energy storage at the transmission and distribution level. Additionally, it will consider the impacts of storage ownership/operating models and utility rate designs on the incentives for energy storage investment, and on the ability of utilities to maximize the captured benefits of installed storage. Finally, the workshop will address storage integration in the context of optimizing the integration of renewable resources.

WORKSHOP II LEARNING OUTCOMES

- Identify primary use cases for storage in island systems
- Assess the ability of storage to support different island supply mixes
- Analyze system integration considerations for distribution/transmission-connected storage
- Evaluate technical performance expectations
- Indicate the ways in which storage can providing ancillary services such as frequency regulation, spinning reserve, reactive support
- Examine storage's role in managing the supply/demand balance
- Discuss how to estimate the value of storage in supporting decarbonization efforts/targets

WORKSHOP II AGENDA

TUESDAY, DECEMBER 12, 2017

12:00 – 1:00 pm **Registration**

1:00 – 4:45 pm **Workshop Timing**

I. Storage Interconnection and Operations in the Context of Island Power Systems:
- Primary use cases for storage in island systems
  - Storage technologies and capabilities
  - Comparison of capabilities with island power system needs
  - Examples of existing installations/use cases
- Storage to support different island supply mixes
  - Diesel-based and other hydrocarbon fuel island systems
  - High renewables island systems
- System integration considerations for distribution/transmission-connected storage
  - Power quality
  - Line thermal loading/capacity impacts
  - Variability and intermittency (utility-scale vs distributed resources)
  - Over-generation conditions
  - Load compatibility
- Technical performance expectations
  - Operating and maintenance costs
  - Cycling degradation

II. Optimizing Grid-Connected Battery Storage to Enhance Renewable Energy Performance:
- Aiding the integration of renewables
  - Balancing variability and intermittency
  - Maximizing resource potential
- Providing ancillary services—frequency regulation, spinning reserve, reactive support
- Managing the supply/demand balance
- Supporting decarbonization efforts/targets

4:45 pm **Workshop Concludes**

WORKSHOP II INSTRUCTOR

Dr. Kai Van Horn

Dr. Kai Van Horn is a power systems engineer and Associate at the Brattle Group specializing in the analysis and modeling of power systems and electric markets. He has supported clients from across the electricity sector and world on a wide variety of consulting engagements, including renewable integration (in both mainland and island power systems), storage analysis and valuation, transmission planning, electric sector policy design, and utility business model development. Prior to joining The Brattle Group, he held a position as an agricultural engineering consultant at Waterborne Environmental, Inc., worked as an intern in short-term planning at Southern California Edison, and served as a U.S. Peace Corps volunteer in an environmental program in northern Zambia. Dr. Van Horn earned a Ph.D. and M.S. in electrical and computer engineering from the University of Illinois at Urbana-Champaign, and a B.S. in multi-disciplinary engineering from Purdue University.

Maintaining Reliability and Supporting Integration: Island Power Systems Workshop III

DECEMBER 13, 2017

WORKSHOP III OVERVIEW

The power grids on most islands present special challenges that do not confront larger, more integrated systems. Worldwide, there are many thousands of similar "low-inertia" electric power systems in operation, supplying remote communities, islands, military installations, industrial campuses, or critical loads. Some systems have the capability to operate in a grid-parallel mode, in which case they are called "microgrids". Other systems have unique economic and technical characteristics, and thus many of the operating assumptions often made on large-scale grid systems do not work well in the planning, design and operation of island systems.

Many customers of these island and low-inertia systems wish to deploy distributed, variable renewable energy plants. Their reasons typically include offsetting high electricity costs, reducing fuel usage, increasing off-grid autonomous run time and reducing emissions. Whatever the reason, such deployment decisions are driving the need to integrate these distributed variable renewable energy plants without disrupting the operation of the larger power system or grid; if this is not done, several aspects of system performance may be degraded. The system integration requirements, in turn, are compelling utilities, system operators and third-party providers to examine the operational measures more diligently and ensure their successful implementation. This third of three technical workshops will provide a "deep dive" into the integration requirements and measures, exploring the unique challenges of island power systems, raising awareness of the problems (and benefits) that can arise when integrating renewables into these systems, and discussing solutions as well as mitigating strategies. Being aware of these issues and how to address them will be particularly important for grid and power system operators in the islands' push to maintain reliability on the current system, while transitioning to much higher penetrations of renewable energy resources in the years to come.

WORKSHOP III LEARNING OUTCOMES

Workshop attendees will:

- Recognize the definition and unique characteristics of island (a.ka., "low-inertia" power systems
- Distinguish how to quantify the renewable energy hosting capacity of island systems
- Identify key problems arising from high penetrations of renewables in island systems
- Assess mitigation strategies, including energy storage, demand response and smart devices
- Examine new technologies that will facilitate higher renewable hosting capacities in island systems
- Apply the modeling and simulation tools appropriate for island power systems work, and be able to select the correct modeling tool for a specific job

WORKSHOP III AGENDA

WEDNESDAY, DECEMBER 13, 2017

8:00 – 8:30 am **Registration & Continental Breakfast**

8:30 am – 4:45 pm **Workshop Timing**

12:00 – 1:00 pm **Group Luncheon**

I. Integration Considerations with Existing Island Power System Fuels and Technologies

- Fuel types
  - Fuel oil
  - Gas
  - Diesel
- Technologies
  - Steam
  - Reciprocating engines
  - Combustion turbines

II. Small Systems (< 20 MW)

- Dynamics and transient stability with increasing penetrations of renewables
- How to set up interconnection and technical requirements for distributed generators—what can be adapted from existing standards, and where all-new requirements are needed
- Control and dispatch when distributed generation rivals central generation in size
- Options for better dispatch—modular generation, variable-frequency diesels
- Protection, especially when dominated by inverter-based sources
- Maintenance of proper arc-flash safety, especially when dominated by inverter-based sources
- Role, sizing, design, operation and performance of storage
- Reliability and customer expectations

III. Medium-sized Systems (20-200 MW)

- Dynamics and transient stability—at what level do distributed renewables make a serious difference?
- The critical importance of demand management
- How to set up interconnection and technical requirements for distributed generators — adapting codes and standards to local needs
- Avoiding the pitfalls of "large-system" thinking where it doesn't apply
- Scalable tools that work in systems of this size
- Reliability — its definition, importance, measurement, customer expectations, and how to improve it

IV. Large Systems (> 200 MW)

- When do the traditional assumptions break down? When they do, then what?
- How changes in codes and standards should benefit large systems
- Reliability again

4:45 pm **Workshop Concludes**

WORKSHOP III INSTRUCTOR

Dr. Michael Ropp

President and Principal Engineer, Northern Plains Power Technology

Michael Ropp is President and Principal Engineer of Northern Plains Power Technologies. Dr. Ropp has nearly 20 years of experience in power engineering, power electronics, and photovoltaics. His experience encompasses computer modeling of power systems; grid integration of distributed energy resources (DERs); design, modeling, fabrication and testing of power electronic converters (DC-DC and DC-AC); modeling, control, and monitoring of energy storage systems; and the design, system integration, control and dynamics, protection, and seamless grid integration of low-inertia systems (microgrids). He has especially deep expertise in: detection and prevention of unintentional islanding; temporary and transient over-voltages in distribution systems, especially those associated with DERs; integration of DERs into high-reliability zones and FLISR/ASR schemes; calculation of and issues associated with ground return current; effective protection techniques for power systems with current-limited sources; and planning, design, commissioning/testing, dynamics and control of smaller (< 20 MW) power systems with rotating and inverter-based sources, with and without storage, including microgrids. Dr. Ropp has worked in nearly every aspect of photovoltaics, from solar cell fabrication through on- and off-grid system design. Recent work has also included modeling and protection of AC and DC railway electric traction power supply systems. He has authored over fifty technical publications and presently holds two patents. He is a Senior Member of the IEEE and is active in standards creation, and is a registered Professional Engineer in South Dakota and Hawaii. Dr. Ropp received the Bachelor's degree in Music from the University of Nebraska-Lincoln in 1991, and the Masters and Ph.D. in Electrical Engineering in 1996 and 1998, respectively, from the Georgia Institute of Technology.

INSTRUCTIONAL METHODS

PowerPoint presentations and case studies will be used in program.

REQUIREMENTS FOR SUCCESSFUL COMPLETION

Participants must sign in/out each day and be in attendance for the entirety of the conference to be eligible for any continuing education credit.

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