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Integrated Deployment and the Energy Systems Integration Facility

Workshop Proceedings

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Andrea Spikes, and Connie Komomua
National Renewable Energy Laboratory

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Technical Report
NREL/TP-6A00-56322
January 2013

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1 Introduction

The United States and its territories are integrating renewable energy sources at an increasing rate each year. At the same time, utilities and other electricity industry stakeholders are facing integration challenges that slow the progress of integration.

The National Renewable Energy Laboratory (NREL) is positioned to help industry meet and solve these challenges. With the opening of the Energy Systems Integration Facility (ESIF) in late 2012, NREL has the ability to test renewable energy technology in a utility-scale grid environment. This capability allows industry to partner with NREL to test, optimize, and visualize integration projects long before they are deployed to the grid, saving time and resources while minimizing integration issues.

1.1 Workshop Motivation

In anticipation of the opening of the ESIF, NREL held a three-day Integrated Deployment workshop August 21-23, 2012 and invited participants from utilities, government, industry, and academia to discuss renewable integration challenges and discover new ways to meet them by taking advantage of the ESIF's capabilities. The workshop was broken up into three days, with a different topic of emphasis for each day.

1.2 Workshop Objectives

NREL had three primary objectives to the Integrated Deployment workshop:

- Gain an understanding of the challenges faced by industry stakeholders in integrating renewables into the grid
- Determine what participants' top priorities are for solving these challenges
- Develop an action plan for addressing the challenges, particularly by partnering with industry and taking advantage of the ESIF's capabilities.

To achieve these objectives, NREL developed the workshop agenda around four key steps:

1. List the challenges in these areas.
2. Prioritize a list of critical challenges.
3. Create research questions that could help address these challenges.
4. Develop potential partnerships and next steps to address targeted research questions.

1.3 Participants

Participant	Affiliation
Colton Ching	HECO
Marc Matsuura	HECO
Mark Glick	DBEDT
Traci Ho Kim	DBEDT
Mike Champley	HI PUC
Leon Roose	UH HNEI
Emura Fumitoshi	Hitachi
Takahiro Tsukishima	Hitachi
Osamu Onodera	NEDO
Darren Scott	Kodiak Electric
Rich Weis	UAF - ACEP
Marc Mueller_Stoffel	UAF - ACEP
Ethan Schutt	Fire Island IPP rep - Alaska Native Corporation
Dennis Meiners	Intelligent Energy Systems - AK
John Lyons	Marsh Creek
Hugo Hodge	WAPA
Jeff Ottaviano	Toshiba
Dan Ryan	SunEdison
David Walker	SunEdison
Elaine Sison-Lebrilla	SMUD
Laura Rip	Lockheed Martin
Tracy Dahl	CH2M Hill / Tracy@Polarfield.com / Judson.Joyner@CH2M.com
Judson Joyner	
Geroge Roe	Boeing
Kat Keith	WHPacific
Gary Jackson	Carilec
Tom Siegel w cc: Kelly O'Brien	First Wind
Josue Colon	PREPA
Ricardo Fabre	PRIDCO
George Blaisdell / Brian W. Stone	NSF
Steve Meder w cc Dan Ishi and MRC Greenwood	UH
Brad Evans (CEA)/or Gene Therriault (GVEA)	Chugach Elec Assoc or Golden Valley Elec Assoc
David Bissell	KIUC

2 Day 1: Utility-Scale Renewable Integration

The first day of the Integrated Deployment workshop was held on the NREL campus in Golden, Colorado on August 21, 2012.

2.1 Agenda

8:30 a.m. Welcome, Introductions, and Objectives
- Brief introductions
- Meeting objectives

9:15 a.m. Overview Presentations
- ESIF (Energy System Integration Facility) Ben Kroposki
- ID (Integrated Deployment) Mary Werner

10:15 a.m. Around the Room
- 5 minutes each on challenges as they relate to the discussion topics

12:00 p.m. Lunch & Networking

1:00 p.m. Open Discussion on Challenges

3:00 p.m. Summarize and Prioritize Key Issues
- Develop up to six research questions
- Next Steps

4:00 p.m. Partnering Overview: Brent Rice

4:30 p.m. ESIF Tour: Ben Kroposki

5:30 p.m. Adjourn

6:30 p.m. Dinner and recap

The workshop agenda featured introductory presentations by Ben Kroposki, NREL, on the Energy Systems Integration Facility at NREL and Mary Werner, NREL, on Integrated Deployment. Brent Rice, NREL, gave a presentation on partnering with NREL. The presentations were followed by a group discussion on the workshop objectives. At the end of the workshop, Ben Kroposki led a tour of the ESIF. Ben Kroposki and Mary Werner joined several participants at dinner, where they discussed the outcomes of today's workshop.

2.2 Workshop Objectives: Group Discussion

After the welcome and overview presentations, workshop participants were asked to share insight about the challenges they face in integrating renewable energy at the utility scale. Participants were given five minutes to share their perspectives in the following discussion topics:

- Utility-scale renewable generation: Grid electronics, forecasting, controlling, curtailing
- Grid challenges such as frequency controls, voltage regulation, and grid stability
- Transmission: What are the limitations or needed improvements
- Grid operations such as simulator training and visualization applications.
- Storage: When, where, how much, what type

2.3 Workshop Questions: Prioritizing the Issues

To frame the group discussion, participants were asked to provide input based on the following questions:

1. What are the challenges faced by utilities, industry, government, and academia in integrating renewables at the utility scale?
2. Which challenges are critical to achieving aggressive progress in renewable integration?
3. Which critical challenges could this group address? Which critical challenges can the ESIF help support?

The participants' answers were written down and grouped by industry focus. The following is a summary of participant challenges and how NREL can address them with the capabilities of the ESIF.

- Combining old infrastructure with new technologies
    - High priority, consistent with ESIF capability
    - NREL can investigate limits of how much power electronics the grid can handle
- Grid operations
    - Validate equipment relative to performance standards and advertised specs, including different vendors
    - Ensure data capture – related to data needs
    - NREL can build in grid performance envelopes, not just single points, and build this into new technology integration
- System optimization
    - Large potential in this area
    - Control as a means of optimization: NREL can evaluate the balance of centralized vs. distributed control, and study cost effectiveness and how to value infrastructure
- Data
    - Gaps in modeling issues, accessing, best locations for adding renewables, non-secure data
    - NREL has resource maps for the country: combine with grid info, creating renewable energy points that show optimal resource and grid combinations
        - Could create a tool and make it available on the Web
        - Must address questions of funding and maintenance
    - Data architecture: many fluctuation points, massive amounts of data; NREL could possibly create a data architecture and recommend standards to industry.
- Controls
    - Common need for greater control, system-wide management, location (central, decentralized, local, etc.)
    - NREL can test voltage and other control points, determine optimal locations for controls, and make recommendations.
- Storage
    - Cost vs. optimization

- Grid ramp rate requirements primarily drive the need for storage: NREL could test technology configurations and functions within the grid system and see which perform better under varying conditions; need to determine what kind of test this would be.

2.4 NREL Workshop Results: Top 6 Actionable Priorities

After sorting the key issues, participants voted on which issues they determined were the most important, and that NREL has the capability to address. The results are as follows:

1. NREL can investigate limits of how much power electronics-based technology the grid can handle.
2. Control as a means of optimization: NREL can evaluate the balance of centralized vs. distributed control.
    a. Study cost effectiveness and how to value infrastructure.
    b. Discover where it is best to deal with intermittency.
3. Validate equipment, components and subsystems including different vendors relative to performance standards and advertised specs (this is related to, or feeds, data needs).
4. Perform technology validation for storage: Test different configurations and functions within a system.
5. Create a GIS-based national model: REZ, resource maps, and grid information.
6. Study strategies to reduce costs to install and operate undersea cables.

3 Day 2: Distribution-Level Integration

The second day of the Integrated Deployment workshop was held on the NREL campus in Golden, Colorado on August 22, 2012.

3.1 Agenda

8:30 a.m. Welcome, Introductions, and Objectives
- Brief introductions
- Meeting objectives

9:15 a.m. Overview Presentations
- ESIF, Ben Kroposki
- ID, Mary Werner

10:15 a.m. Around the Room
- 5 minutes each on challenges as they relate to the discussion topics

12:00 p.m. Lunch & Networking

1:00 p.m. Open Discussion on Challenges

3:00 p.m. Summarize and Prioritize Key Issues
- Develop up to six research questions
- Next Steps

4:00 p.m. Partnering Overview, Brent Rice
4:30 p.m. ESIF Tour, Ben Kroposki
5:30 p.m. Adjourn
6:30 p.m. Dinner and recap

The workshop agenda featured introductory presentations by Ben Kroposki, NREL, on the Energy Systems Integration Facility at NREL and Mary Werner, NREL, on Integrated Deployment. Brent Rice, NREL, gave a presentation on partnering with NREL. The presentations were followed by a group discussion on the workshop objectives. At the end of the workshop, Ben Kroposki led a tour of the ESIF. Ben Kroposki and Mary Werner joined several participants at dinner, where they discussed the outcomes of today's workshop.

3.2 Workshop Objectives: Group Discussion

After the welcome and overview presentations, workshop participants were asked to share insight about the challenges they face in integrating renewable energy at the distribution level. Participants were given five minutes to share their perspectives in the following discussion topics:

- Smart Grid: "smart" communications and controls, smart meters, demand response
- Distributed Generation such as distribution system, feeder impacts, analysis, and controls
- Building load, building integrated renewable generation, net zero energy buildings, and communities: How to plan for, model within a grid system, control, etc.
- Electric vehicle integration such as interaction with grid, storage, and load control
- Grid interactions with vehicles, buildings, and grid interactions: How to model, analyze, optimize, and control
- Controls, simulations, modeling, visualization, and data: What exists, and what's needed.

3.3 Workshop Questions: Prioritizing the Issues

To frame the group discussion, participants were asked to provide input based on the following questions:

1. What are the challenges faced by utilities, industry, government, and academia in integrating renewables at the distribution level?
2. Which challenges are critical to achieving aggressive progress in renewable integration?
3. Which critical challenges could this group address?
4. Which critical challenges can the ESIF help support?

The participants' answers were written down and grouped by industry focus. The following is a summary of participant challenges and how NREL can address them with the capabilities of the ESIF.

- Developing a validated, highly DG-penetrated circuit model
    - Leverage info and data
    - Ability to evaluate many variations with architecture and technology levels
    - Can ESIF replicate a distribution circuit with PV to verify confirm model outputs?
        - Yes, supplement models of systems.

- Efficient Vehicles (EV): testing possible impacts, especially on battery life
    - Evaluate EV cycle and requirements to mitigate specific grid impacts

- Building: How can building/home EMS enable high penetration DG by mitigating negative grid effects?
    - Opportunity to link to actual data being generated in Maui Smart Grid or other high pen grids
    - Evaluate consumer vs. utility benefits of building EMS strategy of kW vs. kWh
    - Integrating with the grid model

- Modeling of distribution feeder
    - High pen PV & EV (Hawaii, USVI)
    - Wind/diesel hybrid (Alaska, USVI)
    - Data requirement

- Testing of components (PV, EV, wind)
    - Hardware testing
    - Model validation
    - Interoperability and communications (open protocol)

- Control testing (repeats)
    - Centralized
    - Decentralized

- Distribution-level storage / DSM
    - Location
    - Charge status and planning

- Distribution-level grid control room
    - Data, modeling, visualization
    - Analysis and control

- Value of forecasting
    - Wind/solar prediction for operations
    - What is value of x-minute forecast/reduced storage/DSM/advanced control
    - Visualization

3.4 NREL Workshop Results: Top 6 Actionable Priorities

After sorting the key issues, participants voted on which issues they determined were the most important, and that NREL has the capability to address. The results are as follows:

1. Develop a validated, highly DG-penetrated circuit model: Test and evaluate a variety of scenarios.
2. Test components (PV, EV, wind): Validate performance of new and existing functionality-develop validated models of components.
3. Value of forecasting: Understand uncertainties and link them to operations.
4. Buildings: Determine how building and home EMS can enable high penetration DG by mitigating negative grid effects.
5. Evaluate distribution-level storage and DSM.
6. Evaluate EV cycle and requirements to mitigate specific grid impacts.

4 Day 3: Isolated and Islanded Grid Systems

The third day of the Integrated Deployment workshop was held on the NREL campus in Golden, Colorado on August 22, 2012.

4.1 Agenda

8:30 a.m. Welcome, Introductions, and Objectives
- Brief introductions
- Meeting objectives

9:15 a.m. Overview Presentations
- ESIF, Ben Kroposki
- Integrated Deployment, Mary Werner

10:15 a.m. Around the Room
- 5 minutes each on challenges as they relate to the discussion topics

12:00 p.m. Lunch & Networking

1:00 p.m. Open Discussion on Challenges

3:00 p.m. Summarize and Prioritize Key Issues
- Develop up to six research questions
- Next Steps

4:00 p.m. Partnering Overview, Brent Rice

4:30 p.m. ESIF Tour, Ben Kroposki

5:30 p.m. Adjourn

6:30 p.m. Dinner and recap

The workshop agenda featured introductory presentations by Ben Kroposki, NREL, on the Energy Systems Integration Facility at NREL and Mary Werner, NREL, on Integrated Deployment. Brent Rice, NREL, gave a presentation on partnering with NREL and Vahan Gevorgian, NREL, gave a presentation on

the National Wind Technology Center's new grid integration testing capabilities. The presentations were followed by a group discussion on the workshop objectives. At the end of the workshop, Ben Kroposki led a tour of the ESIF building. Ben Kroposki and Mary Werner joined several participants at dinner, where they discussed the outcomes of today's workshop.

4.2 Workshop Objectives: Group Discussion

After the welcome and overview presentations, workshop participants were asked to share insight about the challenges they face in integrating renewable energy on islands or islanded locations. Participants were given five minutes to share their perspectives in the following discussion topics:

- Islanded and isolated systems: Unique challenges, limitations, needs
- Remote locations: Unique challenges, limitations, needs
- Combining multiple small grid systems: Grid system needs, controls, hardware
- Distributed generation, storage, and combination systems (i.e. wind/diesel systems)
- Microgrid systems: Connect to a bigger grid and be able to isolate – what's needed
- Controls, simulations, modeling, visualization, and data: What exists and what's needed

4.3 Workshop Questions: Prioritizing the Issues

To frame the group discussion, participants were asked to provide input based on the following questions:

1. What are the challenges faced by utilities, industry, government, and academia in integrating renewables with isolated and islanded grid systems?
2. Which challenges are critical to achieving aggressive progress in renewable integration?
3. Which critical challenges could this group address?
4. Which critical challenges can the ESIF help support?

The participants' answers were written down and grouped by industry focus. Afterward, the participants separated into two groups to determine their most significant challenges. The following is a summary of participant challenges and how NREL can address them with the capabilities of the ESIF.

Group 1 Topics of Discussion

- Standards and design
- Reliability and resilience
- Optimization
- Costs and scale in islanded systems

Group 1 Results

- Development of a decision tree for the development of the projects with RE technologies
    - What to deploy
    - Where to deploy
    - What are the benefits of that
- Information about what works – who is doing it – with dates to demonstrate and learn from

- How to develop systems that are very simple, east to use
- Politics – PEIS Model
- Fast tools for integration models to assess different options that come back from RDP's to project development.
- Wedge analysis validation
- Management of isolated microgrids in utility systems
- Full microgrid optimization tool
- Cyber security or energy security
- Development of the criteria of the backbone/smart backbone platform
- Optimization model to look at real costs to understand long-term cost impacts

Group 2 Topics of Discussion

- Weak grids
- Combining microgrids
- Direct current connectivity
- Understand reliability, power quality, and low-voltage-ride-through
- Demand-side questions

Group 2 Results

- Dynamic interconnection of microgrid with larger grid
    - How does a microgrid disconnect and reconnect to larger grid on the fly? (isochronous control AGC)
    - How does microgrid disconnect and reconnect RE power source?
    - Is seamless operation needed? What is the cost?
    - How do re-balance the individual systems (load, renewables)?
- How large can the grid be without rotating equipment? How much can we do with only power electronics?
    - What are the power conditioning equipment currently available and what are the limits, effects of interaction, etc.?
    - What are the role, limits, and cost of synchronous condensers and power conditioning equipment?
- What are the ancillary services that can be provided by wind, PV, and storage and how to manage?
    - Active and reactive power
    - Voltage control
    - Primary and secondary frequency control
    - Black start capability
- Development of grid code and interconnection standards for high-penetration renewable energy (RE)
    - Performance vs. cost

    - What is the expectation of reliability in small islanded systems? How expensive is it to meet this expectation?
- Integration of RE in microgrids under varying control strategies (isochronous control vs. AGC)
- With high-penetration DG, how does this affect load shedding scheme? Demand response? Storage?
- How do we plan for and create systems that can handle a rapidly-expanding amount of RE? (quickly expanding DG installation in a given feeder)
    - Dynamic system controls and protection

4.4 NREL Workshop Results: Top 6 Actionable Priorities

After sorting the key issues, participants voted on which issues they determined were the most important, and that NREL has the capability to address. The results are as follows:

1. Determine how large the grid can be without rotating equipment, and how much we can do with only power electronics.
2. Test the dynamic interconnection of a microgrid with a larger grid.
3. Research what ancillary services can be provided by wind, PV, and storage, and how to manage them.
4. Develop a full microgrid optimization tool.
5. Test integration of renewables in microgrids under varying control strategies.
6. Develop criteria standards of the grid backbone – smart backbone or platform.