The Role of AMI and DR in Enabling Island Renewable Integration

Smart Metering Caribbean
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Matt Lecar, Principal
Lavelle Freeman, Principal
GE Energy Consulting
Outline

• Unique Challenges of Island Systems
• Benefits of AMI and DR
• Renewable Integration
Since the early 1900’s our team has provided industry expertise on:

- Understanding and study of the financial and physical operation of electric power systems including generation and grid planning, system optimization, asset valuation, competitive power markets, and energy policy implications
- Thermo-mechanical and electrical power systems engineering solutions, spanning the entire equipment life-cycle with understanding of customer needs
- Software tools for assessing the economics, performance, and reliability of integrated electric power systems
Unique Challenges of Island Systems

- High cost of energy - conventional fossil fuel sources expensive
- Storm vulnerability
- Fresh water scarcity
- Rich in renewable resources (solar, wind, hydro, biomass, geothermal, wave)
- Smaller and more granular systems means renewable variability more problematic
- Self-contained … limited or no ties to neighbors
- **Value of flexible demand resources should be high**
AMI and Demand Response

- AMI-enabled DR makes economic sense today
- The cost-effectiveness of DR is demonstrated for C&I customers
AMI and DR in Island Systems

- Renewable integration in island system requires localized, fast response resources (<10 minute)
- Automated Demand Response (ADR) for C&I customers is an excellent candidate
  - Large point loads accessible through a single point of control (with active participation of customer)
  - Sophisticated on-site energy/facility manager
  - Incentivizes customer-owned DER by passing on ancillary services value
- AMI is a pre-requisite for ADR to participate more actively in providing ancillary services for accurate monitoring and verification of interval load relief
GE’s Renewables Integration Experience

Studies commissioned by utilities, commissions, ISOs...
- Examine feasibility of 100+ GW of new renewables
- Consider operability, costs, emissions, transmission

- 2004 New York
  - 3 GW Wind
  - 10% Peak Load
  - 4% Energy
- 2005 Ontario
  - 15 GW Wind
  - 50% Peak Load
  - 30% Energy
- 2006 California
  - 13 GW Wind
  - 3 GW Solar
  - 26% Peak Load
  - 15% Energy
- 2007 Texas
  - 15 GW Wind
  - 25% Peak Load
  - 17% Energy
- 2008 Maui
  - 70 MW Wind
  - 39% Peak Load
  - 25% Energy
- 2010 Oahu
  - 500 MW Wind
  - 100 MW Solar
  - 55% Peak Load
  - 25% Energy
- PJM Study (underway)
  - 96 GW Wind
  - 22 GW Solar
  - 30% Energy
- 2009 Western U.S.
  - 72 GW Wind
  - 15 GW Solar
  - 50% Peak Load
  - 27% Energy
- 2010 New England
  - 12 GW Wind
  - 39% Peak Load
  - 24% Energy

Need for fleet flexibility, new operating strategies and markets, transmission reinforcement, grid friendly renewables

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Example: NREL Western Wind and Solar Integration Study

Monthly Energy for Three Years (30% Scenario)

- To achieve 30% RPS on annual basis, monthly contribution ranges from <20% (Summer Peak) to >50% (Spring)

- Year-to-year variations for same calendar month are of a similar magnitude, due to weather and load variations

Source: NREL Western Wind & Solar Integration Study
Operation During Selected Weeks
30% Wind Penetration Scenario

No Wind or Solar

30% Wind & Solar

Source: NREL Western Wind & Solar Integration Study
Distribution of Extreme Hourly Net Load Deltas

30%

For baseline, 9 up-ramps of 3400 MW/hr or more

For 30% penetration, 108 up-ramps of 3400 MW/hr or more.

For baseline, 3 down-ramps of 4200 MW/hr or more

For 30% penetration, 5 down-ramps of 4200 MW/hr or more.

Curtail wind
To increase reserves

Curtail load
To reduce need for additional resources

Demand-side participation could alleviate need for additional resources to cover large infrequent events
Grid challenges with integration of local energy and load resources

- Frequency performance under large generation/load swings
- Integration of renewables can impact grid stability
- Distribution protection and controls often inadequate for distributed generation
- Supervisory level controls needed to realize full operating potential
Example: Hawaii; High Penetration Renewables Issues

System Impact

- Uncontrolled ramp-down impacting system frequency
- Potential for triggering under-frequency load shedding
- Wear and tear on thermal assets
- Heatrate concerns due to spinning reserve

Constrained Systems More Susceptible to Penetration Issues
Example: Oahu Wind Integration Study

- State of Hawaii has
  - Ambitious renewable energy targets
  - Relatively high cost of energy
  - About 1200MW peak load on Oahu
- Study examined the integration of
  - 500MW of wind + 100MW solar

<table>
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<th>Scenario</th>
<th>Title</th>
<th>Wind Oahu</th>
<th>Wind Lanai</th>
<th>Wind Molokai</th>
<th>Solar PV Oahu</th>
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<td>2014 Baseline</td>
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<td>100MW</td>
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These four tools can be used together to quantify the impacts of wind power on the power system.

1 sec 1 min 10 min 1 hr 1 day 1 wk

Voltage Support  Inertia  Governor Response  AGC Regulation  Economic Dispatch  Planning

GE Power Systems Analysis Tools

Positive Sequence Load Flow (GE PSLF™)

Long-term Dynamic Simulations (GE PSLF™)

Multi-Area Production Simulation (GE MAPSTM)

GE Interhour Screening Tool™

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Power Systems Modeling for Maui

**GE MAPS™ Production Cost**
8 typical days of production

Historical

Less than 2% error by fuel type for 2007

**GE PSLF™ AGC Model**
Wind event from Feb 11, 2008

Excellent comparison to historical data
Oahu System Baseline (No Wind or Solar)

Typical week of operation

MW

7 days

Annual Energy Production, by type

Peaking
- Biodiesel CT (1)
- Diesel CT (2)
- Diesel Recip (4)

Cycling
- Oil Steam Turbine (6)

Baseload
- Oil Steam (8)
- Coal (1)
- Oil Combined Cycle (1)
- Other (3)
Different “Events” Challenge the System

1. Sustained wind power drops over an hour ...  
   Potentially challenge the system’s up reserve

2. Sustained wind power drops within an hour ...  
   Potentially challenge up ramp rate capability of thermal units

3. Volatile wind power changes ...  
   Potentially challenge maneuvering capability of thermal units

4. Undersea cable trip contingency event ...  
   Potentially cause large under-frequency events

5. Load rejection contingency event ...  
   Potentially cause large over-frequency events
Transitioning to 25% energy from Renewables

Baseline
No Wind or Solar

High Renewables
600MW Wind & Solar

Week of Dec 19
Highest Curtailment

Week of Oct 10
Largest Wind Drop

Thermal units are backed down, wind energy is *sometimes* curtailed at light load, and wind power changes are managed by ramping the thermal units.
Lessons Learned from Wind Studies

System Cost
- Unserved Energy
- Missing Wind/Solar Target
- Higher Cost of Electricity

Impediments
- Lack of transmission
- Lack of control area cooperation
- Market rules / contracts constraints
- Unobservable DG – “behind the fence”
- Inflexible operation strategies during light load & high risk periods

Success Factors
- Wind Forecasting
- Flexible Thermal fleet
  - Faster quick starts
  - Deeper turn-down
  - Faster ramps
- More spatial diversity of wind/solar
- Grid-friendly wind and solar
- Demand response ancillary services

Policy and load participation… key to successful integration of wind and other renewables
Lessons Learned from Island Systems

- Island Power Systems can accommodate high levels of wind penetration
- Wind generation can...
  - Greatly reduce variable cost of generation
  - Greatly reduce fossil fuel consumption and GHG emissions
- Regulation and spinning reserve requirements may need to be more conservative than with large interconnected systems
  - Careful definition of reserve requirements can greatly improve the economy of operation with wind
  - Flexibility and dynamic performance of both wind plants and other generation is critical
- Advanced active and reactive control functionality in wind plants is essential
- Investment in thermal plant flexibility can be extremely valuable
- Demand response can enable economic and reliable operation
Thank you!