Load Participation in Ancillary Services

DOE Framing Workshop

October 25-26, 2011
Proposed Agenda

• EnerNOC Overview
  • Who, Where, How and What we do

• Demand Response for Ancillary Services
  • Wholesale Markets
  • Bilateral Programs
  • Lessons Learned

• Program Development Challenges
  • NYISO Experience
EnerNOC Overview

Market Leader in Demand Response
- Largest C&I DR provider in the world
- Over 6.6 GW from more than 10,700 sites
- 100+ utility and grid operator customers

Innovative Suite of Applications

Strong Financial Track Record
- Publicly traded on NASDAQ (ENOC)
- 2010 Revenue of ~$280M
- ~600 full-time employees
EnerNOC’s Demand Response Footprint

- United Kingdom
- Australia and New Zealand

EnerNOC Demand Response
EnerNOC Office

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Technology Platform

EnerNOC’s highly-scalable technology platform provides a foundation for consistent and reliable DR dispatch performance, real-time performance measurement, and verification.

**EnerNOC Site Server (ESS)**
- Gateway device that establishes communication with EnerNOC’s network
- Provides near-real time visibility into end-user energy usage
- Allows the NOC to remotely curtail loads

**Network Operations Center**
- 2 NOCs (3 with M2M)
- Staffed 24x7x365
- Advanced technology, specialized staff
- NOC (and ESS) are OpenADR compliant

**DemandSMART**
- Proprietary web-based energy management platform
- Monitors energy consumption and enables end-user load control
- Provides utilities and end-users with a web portal for monitoring (and dispatch)
A multi-purpose resource

Capacity
- Peak Management / CT Alternative
- Emergency / Reliability
- Network Support

Energy
- Direct participation wholesale energy markets
- Price response programs

Ancillary Services
- Load-Following/Wind integration (bi-directional)
- Spinning and non-spinning reserves
- Regulation
- Frequency responsive reserves
DR for A/S

Wind Integration
Demand Response Provides A/S Around the Globe

**UNITED KINGDOM**
National Grid Short Term Operating Reserves (STOR)
Response time: < 20 minutes

**NORDPOOL**
Multinational power exchange provides Regulation and Spinning Reserves

**GERMANY**
The country’s four TSO jointly operate three A/S markets including “negative” secondary and tertiary reserves

**CANADA**
Atlantic Provinces (Planned):
Fast-acting DR to balance intermittent wind
AESO LssI: Frequency responsive instantaneous DR resources

**USA: ERCOT**
LaaR program for both responsive reserve and non-spinning reserves. Instantaneous and 10 minute response.

**USA: PJM**
Synchronized Reserves and Regulation programs require 10 minute and 4 second response, respectively

**AUSTRALIA, NEW ZEALAND**
Both the NEM and NZEM feature frequency response markets open to DR (e.g. FIR/SIR; FCAS)
# EnerNOC DR in Wholesale Markets

<table>
<thead>
<tr>
<th>ISO/RTO</th>
<th>Wholesale Market</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Reliability Council of Texas (ERCOT)</td>
<td>Emergency Interruptible Load Service</td>
<td>Capacity</td>
</tr>
<tr>
<td>ISO New England</td>
<td>Forward Capacity Market</td>
<td>Capacity</td>
</tr>
<tr>
<td></td>
<td>Day Ahead Load Response</td>
<td>Day-ahead</td>
</tr>
<tr>
<td></td>
<td>Demand Response Reserves Pilot</td>
<td>Ancillary Services</td>
</tr>
<tr>
<td>New York ISO</td>
<td>Special Case Resources</td>
<td>Capacity</td>
</tr>
<tr>
<td></td>
<td>Con Edison Distributed Load Relief Program</td>
<td>Capacity</td>
</tr>
<tr>
<td>Ontario Power Authority</td>
<td>Demand Response 3 Program</td>
<td>Capacity</td>
</tr>
<tr>
<td>PJM Interconnection</td>
<td>Emergency Load Response Program</td>
<td>Capacity</td>
</tr>
<tr>
<td></td>
<td>Economic Load Response Program</td>
<td>Energy</td>
</tr>
<tr>
<td></td>
<td>Synchronized Reserves Market</td>
<td>Ancillary Services</td>
</tr>
<tr>
<td>National Grid UK</td>
<td>Short Term Operating Reserve (STOR) Market</td>
<td>Ancillary Services</td>
</tr>
<tr>
<td>Independent Market Operator (Western Australia)</td>
<td>Wholesale Electricity Market (WEM)</td>
<td>Capacity</td>
</tr>
<tr>
<td>Transpower (New Zealand)</td>
<td>Instantaneous Reserves</td>
<td>Ancillary Services</td>
</tr>
<tr>
<td>Australia Electricity Market Operator (AEMO)</td>
<td>National Electricity Market (NEM)</td>
<td>Energy</td>
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## Example A/S Markets for DR

<table>
<thead>
<tr>
<th></th>
<th>National Grid STOR Programme (UK)</th>
<th>PJM Synchronized Reserves Program (USA)</th>
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<tr>
<td>Demand Response Types</td>
<td>Load curtailment and generation</td>
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</tr>
<tr>
<td>Expected Event Frequency</td>
<td>Weekly</td>
<td>Bi-weekly</td>
</tr>
<tr>
<td>Event Notification</td>
<td>20 minutes</td>
<td>10 minutes</td>
</tr>
<tr>
<td>Program Period</td>
<td>Year Round</td>
<td>Year Round</td>
</tr>
<tr>
<td>Program Hours</td>
<td>Program Hours vary slightly by season, generally:</td>
<td>24/7</td>
</tr>
<tr>
<td></td>
<td>• First Window: 07:30 to 14:00</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Second Window: 16:00 to 21:30</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bank holidays not included 6 or 7 day/week availability</td>
<td></td>
</tr>
<tr>
<td>Maximum Events</td>
<td>At aggregator’s discretion</td>
<td>At customer’s discretion</td>
</tr>
<tr>
<td>Response Duration</td>
<td>15 minutes to 4 hours</td>
<td>Up to 30 minutes. Average of ~12 minutes.</td>
</tr>
<tr>
<td>Technology Requirement</td>
<td>1 minute interval metering Required integration with National Grid (SRD)</td>
<td>1-minute interval metering SCADA response at gen or meter (RTU)</td>
</tr>
<tr>
<td>Capacity Payments</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Event Payment</td>
<td>Yes</td>
<td>No</td>
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• First Window: 07:30 to 14:00  
• Second Window: 16:00 to 21:30  
Bank holidays not included  
6 or 7 day/week availability | SCADA response at gen or meter (RTU) |
| **Maximum Events**                | At aggregator’s discretion             | At customer’s discretion          |
| **Response Duration**             | 15 minutes                             | Up to 30 minutes. Average of ~12 minutes. |
| **Technology Requirement**        | 1 minute interval metering  
Required integration with National Grid (SRD) | SCADA response at gen or meter (RTU) |
| **Capacity Payments**             | Yes                                    | Yes                               |
| **Event Payment**                 | Yes                                    | No                                |

Wind capacity on the National Grid UK system is expected to grow from 3.8 GW today to more than 26 GW in 2020. As a result, National Grid plans to double the Short Term Operating Reserves Requirement from 4GW to 8 GW.
Increasingly Fast Response Times
Case Study: ERCOT Interruptible Load Response (ILR)

Demand Response as Responsive Reserves

Technology Requirements
• Under frequency relay (UFR)
• Real-time telemetry

Event Triggers
• Grid frequency drops below 59.7 Hz
• ERCOT operator discretion

Advance Notice
• Instantaneous when tripped by UFR
• 10 minute when dispatch by phone

Event Details
• 24/7/365 resource availability
• No minimum or maximum event duration
• Performance must be maintained, on a second-by-second basis, throughout the entire duration of the event

DR can provide cost-effective and reliable Responsive Reserve Services (RRS) and Non-spinning Responsive Reserve Services (NSRS); DR can provide up to a 1,150 MW cap and there is ~2,100 MW of registered LR capacity
Wind Integration Challenges Around the World

"Texas Wind Farms Paying People to Take Power"

"Wind Farm Owners Face Negative Electricity Prices"

"Problem of Too Much Power From Renewables"

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Controlling Loads Both Up and Down

Case Study: Bonneville Power Administration Pilots

Demand Response to Balance Wind

Technology Requirements
- Automated remote load control
- Real-time interval metering

Resource Details
- Capability to provide both INCs (load decreases) and DECs (load increases)
- Sub 10-minute notice
- 24/7/365 resource availability

Pilot Projects
- Refrigerated Warehouses
- Residential Hot Water Heaters
- Municipal Water Pumps
- Industrial Processes
- Irrigation Pumps

Pace of wind power development in the Pacific Northwest is dramatically exceeding expectations, with 3,000 MW online today and another 6,000 MW ‘in-process’.
DR Strategies for Wind Balancing

Only a subset of traditional DR strategies will also work for wind balancing. DR plans in red below represent candidates for bi-directional load control.

<table>
<thead>
<tr>
<th>Industry Vertical</th>
<th>Example Demand Response Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>Control central pivot irrigation pumps</td>
</tr>
<tr>
<td>Asphalt, Concrete, Gravel</td>
<td>Curtail kilns, crushers, washers, and screening load centers. Shut off water pumps</td>
</tr>
<tr>
<td>Commercial Property/Office</td>
<td>Remotely curtail 1/3 of lighting. Shut off chillers and AHUs. Remotely raise chilled water temperature points several degrees</td>
</tr>
<tr>
<td>College/Univ.</td>
<td>Shut off 600 ton chiller. 300 kW from spare capacity on 6 CHP Units</td>
</tr>
<tr>
<td>Foil Processing Plant</td>
<td>Shut down etching machines and rectifier lines</td>
</tr>
<tr>
<td>Food Processing</td>
<td>Control of spiral chillers, compressors, refrigeration motors, and HVAC. Switch off refrigeration plant and butter mixer plant</td>
</tr>
<tr>
<td>Hospital</td>
<td>Transfer load to back-up generator</td>
</tr>
<tr>
<td>Lumber/Forestry</td>
<td>Curtail pole line, log sorting line, debarker, sawline, planing and grading</td>
</tr>
<tr>
<td>Printing</td>
<td>Shut down printing presses, binding equipment, compressors</td>
</tr>
<tr>
<td>Recycling</td>
<td>Curtail shredder, compactor and conveyor. Shut down shredder and balers</td>
</tr>
<tr>
<td>Refrigerated Warehouse</td>
<td>Remote control of refrigeration equipment</td>
</tr>
<tr>
<td>Water/Wastewater</td>
<td>Control booster pumps</td>
</tr>
</tbody>
</table>
Lessons Learned From Ancillary Service DR

- Ancillary services require a more technical sales and enablement process than emergency DR resources
  - Resource requirements are more demanding, so need to set customer expectations through education
  - Seek highly-repeatable curtailment strategies
  - Enable remotely-controlled curtailment
  - Ensure expected curtailment through rigorous acceptance testing

- Rapid notification and initiation of curtailment protocols are crucial
  - Manage the resource with a sophisticated software platform, that can automatically receive and act on dispatch signals from utilities and grid operators
  - Facilities must allow full access to directly curtail loads
  - Schedule auto-curtailment protocols to begin 0-5 minutes from notification

- Continuously monitor each site to ensure connectivity and performance
  - Utilize a 24/7/365 Network Operating Center, in order to provide real-time visibility into resource availability and performance
  - Leverage very granular interval meter data (1 min intervals with short latency)
Program Development

Getting the details right is a time-consuming process
NYISO Demand-Side Ancillary Services Program (DSASP)

- Current DSASP rules in place since 2008
  - All Ancillary Services open to DR
  - Minimum requirement: 1 MW sustainable for 1 hr (Reserves)
  - Communication: Leased line
  - Telemetry: Real-time ICCP to NYISO and utility, regulation must respond to 6 second AGC signals
  - Currently no active participants

- Current DSASP Barriers
  - Burdensome and expensive metering and communication requirements ($50-100k/site)
  - Aggregations not yet permitted
  - Full integration with energy market means A/S dispatches are economic, not event-based
  - No energy payment until new real-time economic program implemented
NYISO Demand-Side Ancillary Services Program (DSASP)

Current Communications Configuration

Sample Communication Path Through Transmission Owner

1. NYISO (1) to TO (3) via ICCP
2. TO ICCP (3) to TO EMS (4)
3. TO EMS (4) to TO CATEWAY (5) and DSASP RTU (6)
4. METERS (8) TO TOTALIZER (7) TO DSASP RTU (6)

5. TO GATEWAY
6. DSASP RTU
7. TOTALIZER

1. NYISO SCAN (6-second update and read)
2. TO SCAN (Up to 10 seconds update and read)
3. TO SCAN (Up to 10 seconds TO EMS TO DSASP RTU update and read)
4. TO SCAN (7 Seconds update and read)
NYISO Demand-Side Ancillary Services Program (DSASP)

- DSASP Aggregation rules first proposed discussed in 2009, no rules in place
  - Minimum requirement: 1 MW sustainable for 1 hr (Reserves)
  - Communication: Leased line to aggregator
  - Telemetry: Real-time from aggregator ICCP to NYISO, regulation must respond to 6 second AGC signals
  - Program not yet implemented

- DSASP Aggregations
  - Mandated by Order 719
  - Initial discussions began in 2009 but details remain undeveloped
  - Premise: Aggregators communicate aggregate data to NYISO (and utility?) using ICCP over leased line. Aggregators communicate with resources using internet-based protocols

- Outstanding Concerns
  - Full integration with energy market means A/S dispatches are economic, not event-based
  - No energy payment until new real-time economic program implemented
  - Network latency may preclude aggregations participating in regulation markets if resource to aggregator to NYISO data must comply with 6 second AGC scan rates
NYISO Demand-Side Ancillary Services Program (DSASP)

Current Communications Configuration

Sample Direct Communication Path for DSASP Aggregation

Communication Requirements for Direct Communication for DSASP

Market Rules
New to DSASP
NYISO Demand-Side Ancillary Services Program (DSASP)
Competing Priorities and Tie to Real-Time Economic Program have Delayed Initiative

Schedule Prioritization with other Demand Response Initiatives

<table>
<thead>
<tr>
<th>Q2 2010</th>
<th>Q3 2010</th>
<th>Q4 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>May</td>
<td>Jun</td>
<td>Jul</td>
</tr>
<tr>
<td>DRIS Training and Market Trials</td>
<td>DRIS Deployment</td>
<td>DRIS Training and Market Trials</td>
</tr>
<tr>
<td>Jul</td>
<td>Aug</td>
<td>Sep</td>
</tr>
<tr>
<td>DRIS Training and Market Trials</td>
<td>DRIS Deployment</td>
<td>DRIS Training and Market Trials</td>
</tr>
<tr>
<td>Aug</td>
<td>Sep</td>
<td>Oct</td>
</tr>
<tr>
<td>SCR BASELINE ANALYSIS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline Analysis Processing</td>
<td>Results of SCR Baseline Analysis</td>
<td>Procedures, Tariff and/or Manual Changes resulting from SCR Baseline Analysis and Aggregations</td>
</tr>
<tr>
<td>Oct</td>
<td>Nov</td>
<td>Dec</td>
</tr>
<tr>
<td>DRIS Training and Market Trials</td>
<td>DRIS Training and Market Trials</td>
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</tr>
</tbody>
</table>

DSASP
- DSASP Workshop
- NYISO Internal Procedures, Tariff and Manual Changes for Direct Communication for DSASP
- Tariff Filings, including DSASP Aggregations

REAL-TIME DEMAND RESPONSE (ENERGY)
- Preliminary Market Design: Real-Time Energy for Demand Response

2011 Project Prioritization

Schedule prioritization subject to change as necessary to comply with regulatory orders