Demand Response - Innovation for Renewable Support

Transmission Research – Paving the Way for Renewables

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Presentation Outline

- Automation of Demand Response
- Statewide and National Progress
- Linking Demand Response and Renewables
- Future Directions
Motivation for Automating Demand Response

- **Automated DR** developed to meet goals from 2002
  - **Cost** - Develop low-cost, automation infrastructure
  - **Technology** - Evaluate “readiness” for common signals
  - **Capability** - Evaluate control strategies to modify electric loads

- **Open Automated Demand Response (OpenADR)** is a public domain specification to communicate price and reliability signals

- **Automated DR programs**, offered by utilities or ISOs, automate DR using OpenADR. Programs in 4 states.
OpenADR Technology Concepts

- **2002** - Initial Research Concept
- **April 2009** – OpenADR Spec Published
- **May 2009** - one of 1\textsuperscript{st} 16 NIST Smart Grid Standards
- **2010** – OpenADR in over 250 facilities in California, over 150 MW planned

**Elements** -
1. **Utility System**
2. **DR Automation Server**
3. **Two Way Signals to Facility**
4. **Facility Controls**
5. **Client Acknowledges Signal**

**Graphical Diagram**

- **Pricing Data Models**
- **Physical Communications**
- **Control Strategies**

- **Price Signal** \( \$/kWh \)
- **Data Model** OpenADR
- **Comms** Internet
- **Auto-DR** Client Server
- **End-Use Controls** Building Action
Historic focus on Seasonal Grid Stress

OpenADR PG&E Demand Bid Test Day

OpenADR Northwest Test on Cold Morning

OpenADR Cumulative Shed in July 2008
What Combination of DR Resources Needed?

- Daily Peak Management
- Ramp Smoothing
- Shift Load to Night - Regulation Down
Demand Response for Variable Generation

DR has value in many other hours than 2PM to 6 PM. The “ramping” hours will be increasingly important in future years as intermittent renewables increase.
Linking Efficiency and Demand Response

- Daily Energy Efficiency
- Time-Of-Use Energy
- Daily Peak Load Managed
- Day-Ahead (slow) DR
- Real-Time DR
- Spinning Reserve (fast) DR

- Service Levels Optimized
- Time of Use Optimized
- Service Levels Temporarily Reduced

- Increasing Levels of Granularity of Controls
- Increasing Speed of Telemetry

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Linking Efficiency, DR and Renewables

1. Shift load to maximize use of wind
2. Facilitate smoother ramp
3. Provide reserves to manage forecast error and intra-hour variability

Explore best demand side end-uses to store, shift and shed load
## Facilities Type and Key End Uses for DR

<table>
<thead>
<tr>
<th>End Use</th>
<th>Type of Response</th>
<th>Response Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scaling Down</td>
<td>Switching Off</td>
</tr>
<tr>
<td><strong>HVAC</strong></td>
<td>Global temperature adjustment, Decreasing duct static pressure, etc.</td>
<td>Turning off compressor(s), chiller(s), etc.</td>
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<tr>
<td><strong>Lighting</strong></td>
<td>Dimming down lights</td>
<td>Turning off lights</td>
</tr>
<tr>
<td><strong>Plug Loads</strong></td>
<td>N/A</td>
<td>Turning off equipment</td>
</tr>
<tr>
<td><strong>Miscellaneous Electric Loads</strong></td>
<td>Turning off power</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DR Strategy*</th>
<th>Very Fast (Same hour)</th>
<th>Fast (Same Day)</th>
<th>Slow (Day Ahead)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Refrigerated Warehouse</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precooling</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Short term shutdown</td>
<td>3</td>
<td></td>
<td></td>
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<tr>
<td><strong>Water Pumping</strong></td>
<td></td>
<td></td>
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<tr>
<td>Municipal Water Pumping</td>
<td>2 (w/ storage)</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Agricultural Pumping</td>
<td>1</td>
<td></td>
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<tr>
<td><strong>Wastewater Treatment</strong></td>
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<tr>
<td>Storage</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Over oxygenation</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scheduling</td>
<td>1</td>
<td></td>
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</tr>
</tbody>
</table>

(*Number indicates priority)
Preliminary Concepts for Continuously Dispatchable Demand Response Resources

Demand Response Potential - Typical Winter Day

- Wastewater
- Data Centers
- Ag Pumping
- Refrigerated Warehouses - Chilled Storage
- Refrigerated Warehouses - Frozen Storage
- Lights - Offices & Refrigerated Warehouses
- HVAC - Offices & Refrigerated Warehouses

GW Reduction Potential

Hour
Future Directions

- Develop framework for DR resources to continuously link with grid: market prices, renewable integration, ancillary services
  - Design communications and control infrastructure
  - Evaluate technical and market potential, predictability of DR
  - Ensure linkage to daily energy efficiency
- Conduct demonstrations and field trials
- Link with Building Codes, require interoperable controls, minimize deployment costs