Demand Response

NARUC Webinar

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Webinar Objectives

1. Provide an overview of evolving smart grid demand response requirements.
2. Identify demand response regulatory and policy issues.
3. Examine the status and implications of demand response standards development.

Note: This presentation addresses demand response principles and concepts, not specific retail or wholesale programs.
The Smart Grid is a system of information and communication applications integrated with electric generation, transmission, distribution, and end use technologies which will:

1. **Enable Consumers** to manage their usage and choose the most economically efficient offerings.

2. Use **automation** and alternative resources to maintain delivery system reliability and stability, and

3. Utilize the most environmentally gentle **renewable**, **storage**, and **generation alternatives**.
Defining Demand Response

“Demand Response: Changes in electric use by demand-side resources from their normal consumption patterns in response to changes in the price of electricity, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized.”

Issue:
The historic focus of DR on reducing usage during periods of high wholesale market prices or maintaining system reliability does not fully address potential new applications of DR in areas of distribution congestion management, renewable integration, balancing, and volt/VAR applications.
## Demand Response Options

<table>
<thead>
<tr>
<th>2010 FERC Survey Program Classifications¹</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1</strong> Direct Load Control</td>
<td>Sponsor remotely shuts down or cycles equipment</td>
</tr>
<tr>
<td><strong>2</strong> Interruptible Load</td>
<td>Load subject to curtailment under tariff or contract</td>
</tr>
<tr>
<td><strong>3</strong> Emergency Demand Response</td>
<td>Load reductions during an emergency event Combines direct load control with specified high price</td>
</tr>
<tr>
<td><strong>4</strong> Load as Capacity Resource</td>
<td>Pre-specified load reductions during system contingency</td>
</tr>
<tr>
<td><strong>5</strong> Spinning Reserves</td>
<td>Load reductions synchronized and responsive within the first few minutes of an emergency event</td>
</tr>
<tr>
<td><strong>6</strong> Critical Peak Pricing w/Control</td>
<td>Combines direct load control with specified high price</td>
</tr>
<tr>
<td><strong>7</strong> Non-Spinning Reserves</td>
<td>Demand side resources available within 10 minutes</td>
</tr>
<tr>
<td><strong>8</strong> Regulation Service</td>
<td>Increase or decrease load in response to real-time signal</td>
</tr>
<tr>
<td><strong>9</strong> Demand Bidding and Buyback</td>
<td>Customer offers load reductions at a price</td>
</tr>
<tr>
<td><strong>10</strong> Time-of-Use Pricing</td>
<td>Average unit prices that vary by time period.</td>
</tr>
<tr>
<td><strong>11</strong> Critical Peak Pricing</td>
<td>Rate/price to encourage reduced usage during high wholesale prices or system contingencies</td>
</tr>
<tr>
<td><strong>12</strong> Real-Time Pricing</td>
<td>Retail price fluctuates hourly or more often to reflect changes in wholesale prices on day or hour ahead</td>
</tr>
<tr>
<td><strong>13</strong> Peak Time Rebate</td>
<td>Rebates paid on critical peak hours for reductions against a baseline</td>
</tr>
<tr>
<td><strong>14</strong> System Peak Response Transmission Tariff</td>
<td>Rates / prices to reduce peaks and transmission charges</td>
</tr>
</tbody>
</table>

¹ Source: Lawrence Berkeley National Laboratory - Smart Grid Technical Advisory Project 5/6/2011
Transitioning DR to Smart Grid

Demand Response
- Bundled structure emulates a “pilot”
- separate incentives
- targeted end-uses
- participation restrictions
- utility control
- high equipment costs
- restricted operations

Customer Participation
- Targeted end-uses
- Single load shape objective
- Participation Incentives
- Participation Restrictions

Incentives
- Opt-In Opt-Out
- DR-EE Integrated
- Performance Based Incentives
- Baselines

System Operations
- High Equipment Cost
- Utility Centric Control
- Restricted Operations
- Lack of System Integration
- Limited Inter-operability
- Lack of Automation

Customer Acceptance
- Customer Control
- Automation

Equity
- Limited Inter-operability
- Lack of Automation

Adaptability
- Baselines
- Participation Restrictions
- Performance Based Incentives
- Opt-In Opt-Out
- DR-EE Integrated
- Participation Incentives

Load Shape Potential
- Single load shape objective
- Targeted end-uses
- Participation Incentives
- Participation Restrictions

System Operations
- High Equipment Cost
- Utility Centric Control
- Restricted Operations
- Lack of System Integration
- Limited Inter-operability
- Lack of Automation
Transitioning DR to Smart Grid

Conventional DR

- Utility Options
  - Incentives
  - Technology
  - Utility Control

- Bundled Programs

Approach to Smart Grid DR

- Price, Reliability, and Event Signals
- Price, Reliability and Event Data Model
- Customer Owned Technologies and Control Strategies
- Customer Infrastructure

Automation
Why Should Regulators be Concerned?

- Conventional DR signaling is not necessarily compatible with system operating or customer needs, automation, or smart appliances.
- DR control strategies may not be compatible with smart appliances, evolving customer automation technologies, or carbon mitigation.
- DR rate and incentive options do not provide capability to support integration of intermittent resources or electric vehicles.
- Conventional retail DR cost effectiveness will be influenced over time due to appliance and building efficiency gains and renewable penetration.
A Demand Response Perspective

Dynamic Pricing

Static Pricing

Rate Design

1. System and Customer Capability to Respond

2. Service Levels Optimized

3. Increasing Levels of Granularity of Controls

Increasing Speed of Telemetry

Spinning Reserve (fast) DR

DR 1.0

DR 2.0

Requires Automation

Applications over a Time Continuum

Metering and Communication Needs

5/6/2011

Lawrence Berkeley National Laboratory - Smart Grid Technical Advisory Project
1. **Energy Efficiency** programs reduce overall electricity consumption, generally also at times of peak demand.

2. **Price Response** programs move consumption from times of high prices to times of lower prices (real time pricing or time of use) – expanded to address transmission distribution congestion management.

3. **Peak Shaving** programs require more response during peak hours and focus on reducing peaks on high-system load days – expanded to address transmission distribution congestion management.

4. **Reliability Response** (contingency response) requires the fastest, shortest duration response. Response is only required during power system “events.” – This is new and slowly developing.

5. **Regulation Response** continuously follows minute-to-minute commands from the grid in order to balance the aggregate system load and generation – This is also very new and appears to be very promising for certain loads.

From Load Shedding to Load Shaping

Load Shedding (DR 1.0)
- Text, email or phone call to building manager
- Manual control of building load
- “Best guess” at results
- Can’t calculate comfort impacts

Load Shifting (DR 1.5)
- Electronic signal to BMS or EMS
- Pre-programmed static control strategies to shift building load
- Results determined by pre-calculated setting in BMS
- Limited provision for tenant comfort
- Validate results after the event (or billing cycle)

Load Shaping (DR 2.0)
- Electronic signal to building IQ DR event incorporated into optimization parameters
- Predictive energy optimization plans response tailored to building, weather and specific DR structure
- System adapts in real-time to changes in conditions
- Results are managed to precise DR program
- Tenant comfort parameters incorporated into building response
- Real-time tracking of impact and results.

## DR Smart Grid Requirements

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Description</th>
</tr>
</thead>
</table>
| **1. Performance-Based Incentives** | • Customers rewarded based on their actual performance.  
• Customers not paid only to participate. |
| **3. Dispatchability** | DR automated and dispatchable. |
| **4. Ubiquitous Availability – Participation Implications** | • DR available on all circuits throughout the utility system.  
• Capacity and energy are inseparable from a customer perspective  
• EE a condition of service for all customers, why not DR? |
| **5. Control Strategies – Customer Choice** | The customer determines what, when, and how to control their loads. |
| **6. Simultaneous Economic and Reliability Options** | Customers allowed to simultaneously participate in day-ahead economic and real-time reliability options. |
| **7. Market-based Technology** | Customers acquire automated systems and DR equipment and services through open market providers. |
| **8. Integrated Demand Response and Efficiency** | Incentives and operations integrate DR and EE. |
Demand Response Simplified

Objectives
- Reliability
- Economics
- Congestion
- Intermittent Resources

Data Model
- Schedule
- Price
- Signaling

Automation
- Manual
- Automated

Control Strategies
- Centralized
- Gateway
- Embedded

Standards
- ZigBee™
- openADR

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Demand Response Issues

- Market Model: Utility versus Customer Centric?
- Participation: Opt-in versus Opt-out
- Rates and Incentives – is dynamic pricing necessary?
- Control Strategies: utility vs. customer control?
- Automation – necessary or not?
- Standards – ZigBee SEP and OpenADR
### Market Model: Bundled versus Open?

<table>
<thead>
<tr>
<th>Participation</th>
<th>Utility Centric DR</th>
<th>Customer Centric DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Who Controls</td>
<td>Targeted loads</td>
<td>All Customers</td>
</tr>
<tr>
<td></td>
<td>Limited to Large C/I &amp; Residential</td>
<td></td>
</tr>
<tr>
<td>What is Controlled</td>
<td>Interruptible Rates</td>
<td>Customer</td>
</tr>
<tr>
<td></td>
<td>Res. HVAC, Water Heating</td>
<td>All Loads Available</td>
</tr>
<tr>
<td>Control Equipment</td>
<td>Utility Provided</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Few Suppliers</td>
<td></td>
</tr>
<tr>
<td>Incentives</td>
<td>Fixed / Participation Payments</td>
<td>Customer Provided</td>
</tr>
<tr>
<td></td>
<td>Baseline metrics</td>
<td>Many Market Suppliers</td>
</tr>
<tr>
<td>DR Products</td>
<td>Generally limited to Reliability and Economics</td>
<td>Capacity, Energy, Ancillary Services Markets; Congestion Management</td>
</tr>
<tr>
<td>DR, EE, Renewable Integration</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Participation: Opt-in versus Opt-out

“...how a choice is presented can affect the actions of decision makers, who have a tendency to stick with the default option.” *

- **Opt-In**
  - Customer decides
  - Customer controls
  - Requires education
  - Subject to inertia
  - Perception?

- **Opt-Out**
  - Customer decides
  - Customer controls
  - Requires education
  - Overcomes inertia
  - Perception?

Yes, especially to achieve consumer benefits:

- Rate structures provide price signals that link the utility system and the customer.
- Price establishes the customer value function.
- Price enables benefits of smart grid to be achieved.
Is dynamic pricing necessary?

<table>
<thead>
<tr>
<th>Smart Grid Goal</th>
<th>Non-Dynamic Rates</th>
<th>Dynamic Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tiered*</td>
<td>Time of Use (TOU)</td>
</tr>
<tr>
<td>Energy Efficiency</td>
<td>Need longer-term studies and coordination with demand response and distributed resource programs.</td>
<td></td>
</tr>
<tr>
<td>Demand Response – Reliability (Day-ahead)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>DR – Congestion Mgt, Ancillary Services (Day-of)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Solar Photovoltaic's</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Energy Storage</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Electric Vehicles</td>
<td>No</td>
<td>Partial</td>
</tr>
</tbody>
</table>

*Flat rates contribute nothing toward these goals. Tiered (inclining block) rates theoretically incent conservation. Peak time rebates and dynamic pricing require advanced metering systems.
Control Strategies:

Utility vs. Customer Control

1. Utility or Service Provider
   - DR Logic
   - Control Signal
   - Gateway or EMS
   - Appliance or Load

2. Utility or Service Provider
   - Price, Reliability, or Event Signal
   - Gateway or EMS
   - DR Logic
   - Appliance or Load

3. Utility or Service Provider
   - Price, Reliability, or Event Signal
   - Gateway or EMS
   - DR Logic
   - Smart Appliance

Source: “Direct versus Facility Centric Load Control for Automated Demand Response, Grid Interop 2008, Koch, E., Piette, M”
Automation: Necessary or Not?

- Automation increases load response.
- Provides customers with “set and forget” capability.
- Improves persistence of response over time.
- Provides fast response necessary for real-time response.

Rate Group | No Smart Thermostat | With Smart Thermostat
--- | --- | ---
Residential-CPP | 29% | 49%
Residential-Peak Time Rebate | 11% | 17%
All Electric-CPP | 22% | 51%
All Electric-Peak Time Rebate | 6% | 24%

Average Critical Peak Day – Year 1

<table>
<thead>
<tr>
<th>Peak Load Reduction</th>
<th>Critical Peak Fixed</th>
<th>Critical Peak Variable With Automated Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>12.5%</td>
<td>34.5%</td>
</tr>
</tbody>
</table>

California SPP 2003

PowerCents DC 2010
NERC and WECC rules for contingency reserve response (both spinning and non-spinning) require full response in 10 minutes. The SCE load management dispatch system consistently demonstrated full response from all four distribution feeder groups in less than 80 seconds.

DEFINITION:

- ZigBee is the brand name for a low-power wireless radio communication standard built on the IEEE 802.15.4 standard.
- HomePlug is the brand name for a power line communication standard built on IEEE P1901.
- ZigBee (wireless) and HomePlug (power line) require hardware and software components certified by each groups alliance-designated testing facilities.

PURPOSE:

- ZigBee-HomePlug Smart Energy Profile (SEP 2.0) is expected to provide software applications and code to support pricing, demand response, and related energy applications.
- Expected to operate within the customer premise, supporting device registration, device monitoring, and utility control.

STATUS AND POTENTIAL ISSUES:

(a) lack of backward compatibility between SEP 1.0 and SEP 2.0
(b) SEP 1.0 built into existing meters, not activated due to security concerns
(c) SEP 2.0 still in development, originally due out May 2010.
(d) March 2011, SGIP forms 90-day emergency PAP 18 to resolve SEP 1.0-2.0 compatibility issues.
**DEFINITION:** OpenADR is an open standards-based communications data model designed to promote common information exchange for demand response price and reliability signals between the utility, aggregator, or Independent System Operator and electric customers.

**PURPOSE:**

- Provides Internet-based interoperable price, reliability, or event signals to customer programmed automated facility energy management or control systems.
- Customer systems listen for OpenADR signals, which preserves the customer firewall and internal system security.
- Applications support all customer types and DR options allowing demand response to be a dispatched, fully automated event, with no manual intervention.

**STATUS AND POTENTIAL ISSUES:**

(a) Developed and commercialized by the Demand Response Research Center
(b) Pilots began in 2003, commercialized in 2006
(c) Broad implementation support by over 60 control vendors, with implementations planned and in process in multiple states and countries.
(d) National standard work due for completion 2011.

Many Methods for Integrating Pricing, Communications and Control to Automate Demand Response

- **Open ADR**
  - **Data Models**
    - **OpenADR**
    - Smart Energy Profile 1.0
    - Smart Energy Profile 2.0
    - CIM
    - 61850
  - **Physical Communications**
    - WiFi 802.11x
    - Ethernet 802.3
    - ZigBee / Zwave 802.15.4
    - Home Plug Powerline

- **Customer Systems / Controls Listen for Signal**

- **Customer**
  - **Control Strategies**
    - Air Conditioner Control
    - Lighting – dimming
    - Refrigerator – delay defrost
    - Building Controls
    - Storage

**ZigBee SEP: Addresses Customer Systems / Controls**

OpenADR and ZigBee included among the original NIST 16 Smart Grid Standards.
Standards: OpenADR

What is the Demand Response Research Center?

- **Established:** in 2004 at the Lawrence Berkeley National Laboratory by the California Public Interest Energy Research Program (PIER) as an initiative of the California Energy Commission.

- **Objective:** to develop, prioritize, conduct and disseminate multi-institutional research to facilitate demand response.

- **Scope:** technologies, policies, programs, strategies, and practices, emphasizing market connections and implementation.

- **OpenADR:** initially established as a research project in 2003 to automate and expand demand response in large commercial and industrial facilities.
Standards: OpenADR Design

OpenADR Data Models for Price and Reliability

- Allows DR to be a dispatchable resource
- Improves DR reliability, predictability, and value
- Increases customer participation and reduces response cost

Open Data Models
- Simplify and reduce cost of DR
- Creates interoperability among customer systems
- Creates interoperability between wholesale and retail systems

Automation

Price and Reliability Signals
- Allows customers to choose level of response and how to enable DR strategies
- Provides ability to embed automation in customer control systems.
# Standards: DRRC OpenADR Research

## Automated Demand Response
- **Initial Research** 2002
- **Expanded Research** 2003-2006
- **Commercialization** 2006-2009
  - Open Source DR Automation Server 2009
  - AutoDR Dynamic Pricing 2009

## Technical Strategies
- Pre-Cooling 2003-2009
- DR Quick Assessment Tool 2006-2009
- Dimmable Lighting 2006-2009
- Small C/I AutoDR SCE 2009
- PCT Radio Coverage 2008
- AutoDR Price Mapping Demo 2009
- Open Source DR Automation 2009
- Wireless Protocol OpenADR 2009

## Case Studies
- Case Studies Industrial, Ag, Water
- DR at UC Campus 2008-2009
- Refrigerated Warehouses, Wastewater
- Industrial Controls
- Bell Carter Green Energy Mgmt. 2008-2010

## Related Pricing and Behavior
- DR Pricing / Rates Scoping 2006
- DR Rates 2008
- Behavior
  - TOU 2007
  - CPP Small C/I
- DR Decision, Information, Control 2008-2010

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CAISO
- Demo Lab
- Participating Load Pilots

Seattle City Light
- 2008-2009

ZigBee Harmonization
- 2009

Initiate Standards
- Donate to OASIS, UCAIug 2007

NiST 2009

OpenADR Alliance

DR and Ancillary Services
- Regulation Pilot

Renewables and DR

Wireless Protocol
- OpenADR 2009
Standards: OpenADR System Architecture

Commercial and Industrial Customers

Residential – Small Commercial Customers
OpenADR - only existing open data model to bridge communications between utility and control systems in commercial, industrial and residential facilities.

“Price Mapping Demonstration Project” extended OpenADR capability into small commercial and residential.
### Example of Price Data Models

**Hourly Prices Mapped to Tiers**

<table>
<thead>
<tr>
<th>Time</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00</td>
<td>$0.06</td>
</tr>
<tr>
<td>1:00</td>
<td>$0.06</td>
</tr>
<tr>
<td>2:00</td>
<td>$0.06</td>
</tr>
<tr>
<td>3:00</td>
<td>$0.06</td>
</tr>
<tr>
<td>4:00</td>
<td>$0.06</td>
</tr>
<tr>
<td>5:00</td>
<td>$0.06</td>
</tr>
<tr>
<td>6:00</td>
<td>$0.06</td>
</tr>
<tr>
<td>7:00</td>
<td>$0.08</td>
</tr>
<tr>
<td>8:00</td>
<td>$0.08</td>
</tr>
<tr>
<td>9:00</td>
<td>$0.08</td>
</tr>
<tr>
<td>10:00</td>
<td>$0.10</td>
</tr>
<tr>
<td>11:00</td>
<td>$0.10</td>
</tr>
<tr>
<td>12:00</td>
<td>$0.10</td>
</tr>
<tr>
<td>13:00</td>
<td>$0.12</td>
</tr>
<tr>
<td>14:00</td>
<td>$0.12</td>
</tr>
<tr>
<td>15:00</td>
<td>$0.12</td>
</tr>
<tr>
<td>16:00</td>
<td>$0.12</td>
</tr>
<tr>
<td>17:00</td>
<td>$0.22</td>
</tr>
<tr>
<td>18:00</td>
<td>$0.22</td>
</tr>
<tr>
<td>19:00</td>
<td>$0.14</td>
</tr>
<tr>
<td>20:00</td>
<td>$0.14</td>
</tr>
<tr>
<td>21:00</td>
<td>$0.12</td>
</tr>
<tr>
<td>22:00</td>
<td>$0.10</td>
</tr>
<tr>
<td>23:00</td>
<td>$0.10</td>
</tr>
</tbody>
</table>

**Prices Mapped to Price Tiers**

<table>
<thead>
<tr>
<th>Start</th>
<th>End</th>
<th>Price Tier</th>
</tr>
</thead>
<tbody>
<tr>
<td>0:00</td>
<td>6:59</td>
<td>Low</td>
</tr>
<tr>
<td>7:00</td>
<td>12:59</td>
<td>Medium</td>
</tr>
<tr>
<td>13:00</td>
<td>16:59</td>
<td>High</td>
</tr>
<tr>
<td>17:00</td>
<td>18:59</td>
<td>Critical</td>
</tr>
<tr>
<td>19:00</td>
<td>21:59</td>
<td>High</td>
</tr>
<tr>
<td>22:00</td>
<td>23:59</td>
<td>Medium</td>
</tr>
</tbody>
</table>

**Prices Mapped to Relative Tiers**

<table>
<thead>
<tr>
<th>Price Tier</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>$0.00 - $0.06</td>
</tr>
<tr>
<td>Medium</td>
<td>$0.06 - $0.11</td>
</tr>
<tr>
<td>High</td>
<td>$0.11 - $0.18</td>
</tr>
<tr>
<td>Critical</td>
<td>&gt; $0.18</td>
</tr>
</tbody>
</table>

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5/6/2011

Lawrence Berkeley National Laboratory - Smart Grid Technical Advisory Project
Standards: OpenADR Price Response
Standards: OpenADR Price Response

### Pacific Gas & Electric Company 2007

<table>
<thead>
<tr>
<th></th>
<th>Avg. Reduction</th>
<th>Avg. Cost/kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&gt;200kW)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commercial (79)</td>
<td>13%</td>
<td>$85</td>
</tr>
<tr>
<td>Industrial (3)</td>
<td>52%</td>
<td>$37</td>
</tr>
</tbody>
</table>

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![Graph showing average peak load reduction (MW)](chart.png)

- **2007**: 114 C&I Sites, 16.3 MW
- **2008**: 196 C&I Sites, 31.3 MW
- **2009**: 303 C&I Sites, 55.4 MW
- **2010**: Project based on IOU filings and DOE Smart Grid Investment Grants
- **2011**: 160 MW

5/6/2011

Lawrence Berkeley National Laboratory - Smart Grid Technical Advisory Project
## SMUD Small Commercial EE-DR Integration

<table>
<thead>
<tr>
<th>Business Type</th>
<th>Program Option</th>
<th>Energy Efficiency</th>
<th>Demand Response</th>
<th>Monthly Bill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>Direct Control (11)</td>
<td>-27%</td>
<td>-38%</td>
<td>-27%</td>
</tr>
<tr>
<td></td>
<td>CPP (23)</td>
<td>-32%</td>
<td>-24%</td>
<td>-32%</td>
</tr>
<tr>
<td>Retail</td>
<td>Direct Control (8)</td>
<td>-15%</td>
<td>-22%</td>
<td>-26%</td>
</tr>
<tr>
<td></td>
<td>CPP (20)</td>
<td>-19%</td>
<td>-14%</td>
<td>-31%</td>
</tr>
<tr>
<td>Restaurant</td>
<td>Direct Control (1)</td>
<td>-8%</td>
<td>-1%</td>
<td>-7%</td>
</tr>
<tr>
<td></td>
<td>CPP (8)</td>
<td>-10%</td>
<td>-3%</td>
<td>-12%</td>
</tr>
<tr>
<td>All Customers (71)</td>
<td></td>
<td><strong>-20%</strong></td>
<td><strong>-14%</strong></td>
<td><strong>-23%</strong></td>
</tr>
</tbody>
</table>
Standards: OpenADR Winter/Summer Impacts

- Same buildings in summer and winter DR events.
- Same infrastructure used to respond to signals during summer/winter events.

<table>
<thead>
<tr>
<th>BPA Seattle City Light</th>
<th>Avg. Reduction</th>
<th>Avg. Cost/kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter (4)</td>
<td>14%</td>
<td>$76</td>
</tr>
<tr>
<td>Summer (5)</td>
<td>16%</td>
<td>$108</td>
</tr>
</tbody>
</table>

Seattle City Light

Seattle City Light
Summer Test (8/11/2009) Outside Temp: 88°F
Standards: OpenADR Ancillary Service

Load as Pseudo Generation

CAISO Participating Load Response

<table>
<thead>
<tr>
<th>Forecasted vs Actual Ramp Time (MW/ min)</th>
<th>Forecasted vs. Actual Average Hourly Shed (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HE 15:00</td>
</tr>
<tr>
<td>0.002 / 0.006</td>
<td>20 / 72</td>
</tr>
</tbody>
</table>
Standards: OpenADR Industry Support

Utilities, Aggregators, and ISOs
- Pacific Gas & Electric (PG&E)
- Southern California Edison
- California ISO
- Consumers Energy
- Direct Energy
- Duke Energy
- SMUD
- NV Energy
- Enernoc
- Global Energy Partners
- NYSERDA
- Commonwealth Utility Companies
- BPA

Research Organizations
- CITRIS
- EPRI
- Electric Power Research Institute
- EPRI Marconi Research
- EHR
- CLTC

Testing, Certification, & Alliances
- Intertek
- Quality Logic
- TUV
- openADR

Technology Integrators
- Echelon
- Honeywell
- Akuacom
- LMK
- RTP Controls
- emax
- Bentley
- Pulse Energy
- SAP
- Advanced Telemetry
- Grid Manager
- Stonewater Controls Systems
- ADVANTECH
- e-Radio
- ALSTOM
- UI Solar
- CII

Control and Technology

Industrial
- Power Solutions
- GE
- Ingersoll Rand
- Iris
- Yokogawa
- IC Systems
- EDS

Commercial & Industrial
- Siemens
- Balfour Beatty
- Mitsubishi
- Lenze
- FPE Power Technologies
- Johnson Controls
- Novar

Commercial
- Cisco
- Lutron
- ADR Systems
- Stelios
- Altron
- Automated Logic
- EATON
- Beckhoff

Small Commercial and Residential
- Lineage Power
- JetLUN
- EZ Integration, Inc.
- Ubikwirete
- Universal Devices
- Universal Lighting Technologies
- Grid Data
- BEO
- TENDRIL
Standards: OpenADR Lessons Learned

**Automation**
- Allows DR to be a dispatchable resource *(wholesale and retail DR).*
- Improves DR reliability, predictability, and value *(summer / winter).*
- Increases customer participation and reduces response cost *(transparent retail to wholesale DR conversion).*

**Open Data Models**
- Simplify and reduce cost of DR *(embedded clients).*
- Creates interoperability among customer systems.
- Creates interoperability between wholesale and retail systems.

**Price and Reliability Signals**
- Allows customers to choose level of response and how to enable DR strategies *(increases DR response).*
- Provides ability to embed automation in customer control systems *(increases DR reliability, customer participation).*

**Cost**
- Expanding support for OpenADR and use of embedded software clients reduces implementation costs.
## 6.30 Demand Response

### References

<table>
<thead>
<tr>
<th>Title</th>
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<tr>
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<tr>
<td>5</td>
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</table>
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