Demand Response

An Overview

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February 6, 2006
**Demand Response & Advanced Metering Coalition (DRAM)**

Outreach and education on DR Technologies

- eMeter
- DCSI/TWACS
- Echelon
- Elster Electricity
- MeterSmart/EMON
- Comverge
- Invensys
- GoodWatts
- Landis + Gyr
- SmartSynch
- EnerNOC
- Silver Spring Networks
- Hunt Technologies
- Electric City Corp
United States Demand Response Coordinating Committee (DRCC)

Sponsorship of research, education, and forums on DR & Official U.S. vehicle for participation in IEA DR Program

- AEP
- National Grid
- TVA
- Southern Company
- PIER Demand Response Research Center (DRRC)
- NYSERDA
- MidAmerican
- Ameren
- ISO-NE
- Salt River Project
- PJM
- SCE
- SDG&E
- PG&E
- MISO
Demand Response

DRCC Definition

- Providing wholesale and retail electricity customers with the ability to choose to respond to time-based prices and other types of incentives by reducing and/or shifting usage, particularly during peak demand periods, such that modifications in customer demand become a viable option for addressing pricing, system operations and reliability, infrastructure planning, operation and deferral, and other issues.
Demand – An Evolutionary Perspective

- Conservation
  - Running out of oil
- Load Management
  - Curtailment and Control
- Efficiency – Phase 1
  - Get the same benefit with less energy
- Demand Side Management
  - Utility-oriented; IRP
- Efficiency – Phase 2
  - Beyond the end use
- Demand Response
  - Dynamic, communication and price-based
- Optimization (Smart Age)
  - Systems approach: Smart Grid, Smart Homes, Smart appliances
Demand Response Terminology

- Demand Response vs. Energy Efficiency
- Demand Response = Load Management (also load shifting/reduction)
- Wholesale vs Retail
- (Direct) Load Control vs. Pricing
- Load Responsive vs. Price Responsive
- Emergency/Reliability vs. Price Responsive
Demand Response Terminology

- Dynamic pricing vs. time-based vs. time-of-use vs. time-differentiated
- AMR vs. AMI = Advanced Metering = Smart Metering
- Real-Time vs. Day Ahead
- Distributed Generation (DG) vs. Distributed Resources vs. Clean Energy
Demand Response – Then and Now

- Emergency-driven
- Blackout-avoidance
- Reliability-focused
- Old Technology
- Blunt Instrument
- One size fits all
- Opt-in

- Customer choice
- Optimize Efficiency
- Mass Mkt Capability
- New Tech; Internet
- Tie to Mkt Dynamics
- Risk/Reliability tool
- Smart Bldgs & Appl.
- Opt-out
Types of Demand Response

- Curtailment Programs
- Interruptible Rates
- Distributed Generation
- Load Responsive Programs
- Price Responsive Programs
- Demand Bidding
- Negawatt Block
- Time-based Rates and Dynamic Pricing
  - Time-of-Use (TOU)
  - Real-Time (RTP)
  - Critical Peak Pricing (CPP)
Puget Sound Energy

Summer Pricing

RESIDENTIAL TIME-OF-DAY RATES

Variable rates available only to Personal Energy Management customers. Other customers pay fixed rate.

Price per Kilowatt Hour (kWh)*

6.25¢
5.36¢
4.70¢

Morning 17% of today's average usage
Midday 22% of today's average usage
Evening 17% of today's average usage
Economy 44% of today's average usage

Mon-Sat, Mon-Sat, Non-Sat, Mon-Sat, all day Sun & Holidays

Summer Fixed Rate: 5.36¢

*All "effective" rates based on average April-September usage at 864 kWh per month.
Effective rates reflect PSE and conservation credits that reduce the official rates listed on customers' bills.
**Critical Peak Pricing Structure**

- **Price per kWh**
  - Off-Peak
  - Peak (2-7 pm)
  - Critical Peak (2-7 pm)

- **Notification to Customer** (by 5 p.m.)

- **Days of the Week**
  - Sunday
  - Monday
  - Tuesday
  - Wednesday
  - Thursday
  - Friday
  - Saturday
**Gulf Power GoodCents Select**

### GoodCents SELECT
- **Participation Charge**: $4.95/Month
- **Standard Residential Rate**: 6.3 cents/kWh

**Price Per kWh**
- **LOW**: 4.2 cents
- **MEDIUM**: 5.4 cents
- **HIGH**: 10.0 cents
- **CRITICAL**: 30.9 cents

*All prices are as of 06/07/02, excluding customer and/or participation charges and any applicable taxes. These prices are subject to change.*

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**Residential Service Variable Pricing (RSVP) Rate**

- **Percent of Annual Hours In Effect**
  - **Low Price**: 28%
  - **Medium Price**: 59%
  - **Critical Price**: 12%
  - **High Price**: 1% (Maximum)

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**Price per kWh**

- **Standard Residential Rate**: 6.3 cents
- **Critical Rate**: 30.9 cents (Limited To 87 Hrs/Yr)
- **High Rate**: 5.4 cents
- **Low Rate**: 4.2 cents
- **All rates are subject to change.**
Demand Response Sponsors

- Traditional Utilities
  - IOUs
  - Munis
  - Coops
- Restructured Utilities
- ISOs
- State entities
- Competitive Retail Marketers
Demand Response Players

- Advanced Metering
- Communications and Controls
- Meter Data Management
- Curtailment Service Providers (CSPs)
- Demand Response Providers
- Distributed Generation
- Building Optimization/EMS
- Smart End Use (smart thermostat)
- Customer Communication
- Thermal Storage
- Smart Grid
Types of Demand Response – Price-based vs. Reliability

- Emergency/reliability
  - Goal is “load acting as a resource”
  - Demand reductions occur via dispatch by system operators
  - Reductions are included in resource/supply portfolio
    - Same as a power plant (with limitations)
  - Response levels more variable
    - Minimal foreknowledge by end-use customers
    - Dispatch reasons varied
    - Less diversity in loads involved
Types of Demand Response – Price-based vs. Reliability

- **Price-based**
  - Goal is to provide price signal
  - Demand reductions occur via voluntary end-use customer response
  - Reductions are included in load forecasts
    - Same as other tariffs and energy efficiency
  - Response levels become more predictable as a function of:
    - Transparency/foreknowledge of prices
    - Weather
    - Experience
    - Diversity (number and types of customers)
Demand Response - Retail

- State Jurisdictional
- Load Serving Entity (LSE) Driven
- Load Control
- Smart Technology (Thermostat)
- Advanced Meter
- Dynamic Pricing
- Opt in vs Opt out
- Longer lead time but more institutional?
- Larger Resource Overall?
Demand Response - Wholesale

- Emergency and Economic Varieties
- Day Ahead Pricing
- Real-Time Pricing
- Independent System Operator (ISO) Driven
- FERC Focus
- Demand Response Providers and Facilitators
- Demand Bidding and Exchanges
- Aggregation for small customers
- Quick Ramp Up
DR – Why Policy Makers Like It

- Optimize the system between supply and demand
- Moderate price spikes during peak period
- Mitigate market power of suppliers
- Avoid unnecessary supply/T&D investment
- Improve reliability of grid
- Solve specific geographic congestion
- Create a smart grid
- Outage management and restoration
- Providing customers with new options
Demand Response – Issues for Policy Makers

- State vs Federal Jurisdiction
- Tie to Deregulation
- Competitive Metering and other services
- Who pays for the Technology
- Need for Pilots
- Cost Recovery and Stranded Costs
- Use of System Benefit (wires) Charges
- Chicken and Egg
- Opportunity Costs
- Lost revenues
“It is the policy of the United States that time-based pricing and other forms of demand response, whereby electricity customers are provided with electricity price signals and the ability to benefit by responding to them, shall be encouraged, the deployment of such technology and devices that enable electricity customers to participate in such pricing and demand response systems shall be facilitated, and unnecessary barriers to demand response participation in energy, capacity and ancillary service markets shall be eliminated. It is further the policy of the United States that the benefits of such demand response that accrue to those not deploying such technology and devices, but who are part of the same regional electricity entity, shall be recognized”

- Several major drivers for advanced metering and demand response:
  - Requirement that all federal building have advanced metering by 2012 (Section 103)
  - Requirement that states consider a new standard which would require time-based pricing and advanced meters to be offered by utilities or otherwise provided (Section 1252)
  - Requirement that DOE Report to Congress on DR and make recommendations to Congress (Section 1252)
  - Requirement that FERC conduct annual DR assessments (Section 1252)
EPACT - Federal Metering

- Included in changes to Federal Energy Management Program (FEMP)
- By 10/1/12, all federal buildings required to have advanced meters
- By 02/08/06, DOE must establish guidelines for agencies to carry out the requirement
- By 08/08/06, Federal Agencies must submit an implementation plan
EPACT – Smart Meters and DR

- **Time-based Metering and Communications Requirement:**
  - Utility Requirement: By 02/08/07, Utilities must offer time based rate schedule and provide metering to customers requesting such.
  - State Regulatory Requirement: By 02/08/07, States must conduct an investigation whether it is appropriate to implement the new requirement.
EPACT – Smart Meters and DR

Utility Requirement

- Rates must vary according to wholesale costs
- Rates shall enable consumer to manage use and costs through advanced metering and communications technology
- Types to be offered include: TOU, CPP & RTP and credits for large customers in peak reduction agreements
- Must provide customers requesting the rate with a time-based meter that will enable the rate
EPACT – Smart Meters and DR

- **State Regulatory Requirement**
  - State must consider cost effectiveness of metering deployment
  - State must determine responsibilities of marketers vs utilities in competitive states
  - Conflicting dates for commencement of hearings and conclusion of consideration of standard
  - Grandfathering allowed
EPACT – FERC & DOE

- **DOE**
  - Technical Assistance to States
  - Regionality Encouraged
  - Report to Congress

- **FERC**
  - Annual Regional Assessment
    - Saturation/penetration of technologies
    - Potential Assessment
    - Planning Assessment
State Policy Developments

- EPACT Proceedings (OH, LA, MT)
- Pre-EPACT Activity (Mid-Atlantic/MADRI, TX, CA, OR, ID)
- State-wide DR (CA)
- Repeal of Competitive Metering (VA, TX, NY)
- Incentives for Utilities (MADRI, CT)
- Renewal of DSM Policy (AZ, AR)
- Individual Utility Proceedings (IL)
- Portfolio Standards (PA, NV)
- Use of SB funds for DR (NY)
- Grid-targeted DR (PacNW, MA)
Gulf Power

- CPP rate plus TOU – 5X differential
- 6000 customers paying $14.95/month
- Peak Reduction
  - Summer 40%
  - Winter 50%
- Overall usage reduction
  - 40% during peak periods
  - 20% and 5% for high and medium TOU
- High customer satisfaction; less than 2% churn rate
Gulf Power – Research Results

I pay more attention to my electricity consumption now that I am on the GoodCents Select Program.

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Strongly Disagree</td>
<td>15</td>
<td>4%</td>
</tr>
<tr>
<td>2 Disagree</td>
<td>37</td>
<td>11%</td>
</tr>
<tr>
<td>3 Agree</td>
<td>102</td>
<td>29%</td>
</tr>
<tr>
<td>4 Strongly Agree</td>
<td>193</td>
<td>56%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>347</td>
<td>100%</td>
</tr>
</tbody>
</table>

I have NOT had to significantly adjust my lifestyle with the GoodCents Select Program.

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
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<td>16</td>
<td>5%</td>
</tr>
<tr>
<td>2 Disagree</td>
<td>47</td>
<td>14%</td>
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<tr>
<td>3 Agree</td>
<td>140</td>
<td>40%</td>
</tr>
<tr>
<td>4 Strongly Agree</td>
<td>144</td>
<td>41%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>347</td>
<td>100%</td>
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</table>
## Gulf Power - Research Results

### Would you recommend GoodCents Select to others?

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Yes</strong></td>
<td>311</td>
<td>89%</td>
</tr>
<tr>
<td><strong>No/uncertain</strong></td>
<td>37</td>
<td>11%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>348</td>
<td>100%</td>
</tr>
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</table>

### Have you recommended GoodCents Select to anyone?

<p>| | | |</p>
<table>
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<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td><strong>Yes</strong></td>
<td>255</td>
<td>82%</td>
</tr>
<tr>
<td><strong>No/uncertain</strong></td>
<td>56</td>
<td>18%</td>
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<td><strong>Total</strong></td>
<td>311</td>
<td>100%</td>
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</table>
Top Ten Criticisms of DR - Myths, Misconceptions, or Urban Legends

- Advanced Metering Systems are too expensive
- Advanced Metering needs more development and new national standards
- Large Industrial customers are best; residential customers won’t respond
- No conservation effect; bad for the environment
- DR is only for restructured markets
- Utilities get all the benefits; they should pay all the costs
- DR is bad for low-income customers
- Customers in different parts of the country react differently
- DR will not respond quickly enough and cannot be relied upon
- There is enough DR infrastructure and capacity already out there
No. 1

Advanced Metering Systems are too expensive
Advanced Metering Costs Are Reasonable

- Summary of data collected in several eastern U.S. utility procurements
- Independent consultant compared total capital cost and operating benefits of automating meters via AMI vs. AMR

Business case
- Benefits limited to documented utility operating savings
- No demand response, rate, customer, or system opportunity benefits considered

Includes meters, communications, training, IT support, and installation

### Technologies

<table>
<thead>
<tr>
<th>Automated Meter Reading (AMR)</th>
<th>Functional Capability</th>
<th>Advanced Metering Infrastructure (AMI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Expected Payback (years)</td>
<td>kWh Usage</td>
<td>Dispatchable Rates</td>
</tr>
<tr>
<td>Drive-by Systems</td>
<td>kW Interval Data</td>
<td>Outage Monitoring</td>
</tr>
<tr>
<td>10</td>
<td>Dispatchable Rates</td>
<td>Read on Demand</td>
</tr>
<tr>
<td>8</td>
<td>Tamper Detection</td>
<td>Selectable Billing Dates</td>
</tr>
<tr>
<td>6.5</td>
<td>Outage Monitoring</td>
<td>Customer Usage Profiles</td>
</tr>
<tr>
<td>$92</td>
<td>Read on Demand</td>
<td>Dynamic Load Research</td>
</tr>
<tr>
<td>$25</td>
<td>Selectable Billing Dates</td>
<td></td>
</tr>
</tbody>
</table>

### Average Dollar Cost per Meter Installed
- Automated Meter Reading (AMR)
- Advanced Metering Infrastructure (AMI)
Advanced metering technology needs to develop further and nationwide standards are needed before it can be developed on a wide scale.
AMR/AMI Market Growing Unhindered

Market penetration
- 250 million U.S. electric, gas & water meters
- About 1/3 are automated
  - About 2/3 via drive-by communications
  - Remainder via fixed networks

Standards
- Primary need is access to data by customers
  - Easily done at system level
    - like other industries
    - Web
    - IVR
- Field deployments are no obstacle to system-level open architecture

U.S. AMR Market Shipments

Open Interface

Wide Area Network

Data Center

Utility User

Consumer

Distribution lines

Wireless gateway

Distribution Substation

2005, 35 million
No. 3

Large industrial customers are the best candidates for demand response, particularly since residential customers will not accept dynamic pricing.
- **Large Industrial Customers bring on large loads quickly but...**
  - Usually require longer notification
  - Have higher churn rate

- **Residential Customers**
  - Diversity provides reliability
  - Can provide significant long term load
Programs Greater than 100 MW

- **Southeastern Region**
  - FPL; FPC; Oglethorpe; Duke; Gulf Power

- **Northeastern Region**
  - PEPCO; BGE; PSEG; JCPL

- **Midwestern Region**
  - ComEd; Buckeye; NSP; DTE

- **Western Region**
  - SCE; SMUD

*Comverge is the supplier to over 90% of these Programs*

- **5 Gigawatts**

**Major Turnkey/Virtual Peaking Capacity (VPC) Programs**

- Utah Power, SDG&E, HL&P, ISO-NE I, ISO-NE II, Gulf Power

*Comverge is the owner/operator of 100% of these Programs*

- **400 Megawatts**
## Penetration Rates for Major DLC Programs

### Selected Residential DLC Programs

<table>
<thead>
<tr>
<th>Utility</th>
<th>DLC Program Participants</th>
<th>Total Residential Customers</th>
<th>Implied Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progress - Florida Power</td>
<td>800,000</td>
<td>1,301,374</td>
<td>61%</td>
</tr>
<tr>
<td>Buckeye Power</td>
<td>150,000</td>
<td>325,621</td>
<td>46%</td>
</tr>
<tr>
<td>Cobb EMC, Georgia</td>
<td>55,000</td>
<td>124,710</td>
<td>44%</td>
</tr>
<tr>
<td>Vectren</td>
<td>40,000</td>
<td>116,979</td>
<td>34%</td>
</tr>
<tr>
<td>Pepco</td>
<td>150,000</td>
<td>628,600</td>
<td>24%</td>
</tr>
<tr>
<td>Xcel Energy (NSP area only)</td>
<td>265,000</td>
<td>1,167,634</td>
<td>23%</td>
</tr>
<tr>
<td>Baltimore Gas &amp; Electric</td>
<td>225,000</td>
<td>1,001,000</td>
<td>22%</td>
</tr>
<tr>
<td>SMUD</td>
<td>100,000</td>
<td>474,413</td>
<td>21%</td>
</tr>
</tbody>
</table>

Data Compiled using the following sources:

Most customers said they would prefer to continue on the new rate after the pilot, and roughly 65% are still on a time-varying rate after one year even though the participation incentive was discontinued and they are now paying a monthly meter charge of $3 to $5.

Percent of Customers Who Would Prefer to Continue on Pricing Plan

<table>
<thead>
<tr>
<th>Pricing Plan</th>
<th>Percent of Customers Who Would Prefer to Continue</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPP-F</td>
<td>82.0</td>
</tr>
<tr>
<td>TOU</td>
<td>76.0</td>
</tr>
<tr>
<td>CPP-V</td>
<td>72.0</td>
</tr>
<tr>
<td>Total</td>
<td>80.0</td>
</tr>
</tbody>
</table>
No. 4

Demand Response shifts usage but does not decrease it overall
Demand Response Can Reduce Consumption

- Results of literature survey
  - Time-based pricing programs result in average total consumption reduction of 4 percent
    - Approximately 25 pilot programs
  - Information feedback programs average conservation of 11 percent
    - 38 pilot programs

<table>
<thead>
<tr>
<th>Table 2: Conservation Effects Shown in Feedback Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>--------------------------</td>
</tr>
<tr>
<td>Savings</td>
</tr>
<tr>
<td>20%</td>
</tr>
<tr>
<td>20% of peak weekdays only</td>
</tr>
<tr>
<td>15-19% Mondays through Saturdays</td>
</tr>
<tr>
<td>10-14%</td>
</tr>
<tr>
<td>5-9%</td>
</tr>
<tr>
<td>0-4%</td>
</tr>
<tr>
<td>Unknown</td>
</tr>
</tbody>
</table>
Results at Gulf Power and replicated in California and other pilots show an overall 3.8% conservation effect.
Gulf Power Implements Critical Peak Pricing...

**GoodCents SELECT**
- Participation Charge $4.95/Month
- Standard Residential Rate 6.3 cents/kWh

<table>
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<tr>
<td>CRITICAL</td>
<td>30.9 cents</td>
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</table>

*All prices are as of 06/07/02, excluding customer and/or participation charges and any applicable taxes. These prices are subject to change.

**Residential Service Variable Pricing (RSVP) Rate**
- | Percent of Annual Hours In Effect |
- | Low Price                       |
- | Medium Price                    |
- | Critical Price                  |
- | High Price                      |

- Low Price: 28%
- Medium Price: 59%
- Critical Price: 12%
- High Price: 1%

**Price per kWh**
- Standard Residential Rate 6.3 cents
- Critical: 30.9 cents (Limited To 87 Hrs/Yr)
- High: 10.0 cents
- Medium: 5.4 cents
- Low: 4.2 cents
... And Gets Results

Over 2kW Average Reduction
Results cont’d…

AVG HOURLY DEMAND ON JAN 24 AT HOUR 7 AND 8, 2003

4 kW Shift During Critical Winter Peak
No. 5

Demand Response only makes sense in a restructured market
Demand Response in Regulated Markets

- Significant cost savings and reliability improvements by reducing demand 100 hours per year
- Other consumer benefits
  - Energy information and awareness
  - Conservation
  - Ability to manage bills
- California pilots
  - Critical peak pricing
    - Average of about 13% peak demand reduction
    - Nearly 90% of participants said the program should be offered to other customers
  - Critical peak rebates
    - “Carrot” approach
    - Average reduction of 10%
    - Over 60% volunteer rate
No. 6

Utilities receive all of the benefits of DR and thus should incur all of the costs.
No. 7

Demand Response is bad for low income customers
Low-Use, Low-Income Customers Benefit As Well

- Use less on-peak to start with
- More price elastic than high-income users

Percentage of Summer On-Peak Use by Monthly Usage Level

SCE Customers

Source: TURN Testimony in SCE General Rate Case, August 2003

Bills on Non-Time-Based Rates vs. on Dynamic Rates

High-users pay $1.17/mo more with no shifting
Low-users save $1.66/mo with no shifting

Sources: TURN Comments, 02-12-30 and PG&E CPP rates, Tariff 3A
No. 8

Customers in different parts of the country have been shown to react differently to demand response pricing and programs.
Population, central air conditioning (CAC) saturations, and weather vary significantly across California’s diverse climate zones. The SPP sample was segmented across four climate zones.

Average Peak-Period Temperature
July Through September 2003/2004

<table>
<thead>
<tr>
<th>Zone</th>
<th>Critical Days</th>
<th>Normal Weekdays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zone 1</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>Zone 2</td>
<td>26</td>
<td>24</td>
</tr>
<tr>
<td>Zone 3</td>
<td>31</td>
<td>29</td>
</tr>
<tr>
<td>Zone 4</td>
<td>37</td>
<td>34</td>
</tr>
</tbody>
</table>

- 12% of Pop CAC Sat = 7%
- 48% of Pop CAC Sat = 29%
- 30% of Pop CAC Sat = 69%
- 10% of Pop CAC Sat = 73%
The SPP showed that the primary reason why price responsiveness varied across regions was because of differences in air conditioning saturations.

Percent Change In Residential Peak-Period Energy Use
(Avg CPP-F Prices/Avg 2003/2004 Weather)
The variation across climate zone and air conditioning ownership is even greater when measured in absolute rather than percentage terms, as price responsiveness and the magnitude of load are both larger in hotter zones.
Demand Response resources cannot respond fast enough and are not reliable enough to be counted upon for reliability purposes
• Typical response times of under one minute.
• Tests conducted this past summer show that direct load control can qualify as a non-spinning reserve product.
  • Multiple tests showed an average of under 5 minutes under emergency conditions
  • E-mail down, server down, verbal notification...
100% cycling test

- Control Strategy was 100% shed held for ½ hour.
- ADI Strategy gives graceful return to normal operations
- Note payback period at end of event
- Event is 14:30 to 15:00
  - Results based on Wasatch front in Salt Lake system load 3,645 to 3,599 at 97 degrees
  - Load represents drop of 1-2% of entire total load
No. 10

There is plenty of demand response infrastructure out there already that is available if we need it.
“Ideal” 5-10 % of total peak load not being satisfied throughout country

Historically “demand response rich” regions seeing little new demand response investment

- Dis-aggregation has broken up value chain
- Legacy programs mothballed, dwindling or maintaining at best
Issue: Demand Response and Energy Efficiency

- Fraternal twins in the same DSM family
- Complementary vs. Competitive
  - Conservation effect of demand response
  - Information effect of demand response technologies
  - Neither one can fully do what the other one does best
- Need to work together
- Demand response is not trying to steal the other twin’s allowance
Issue: Demand Response and the Environment

- Net Reductions
- Fuel Mix On-Peak vs Off-Peak
- Distributed Generation (DG)
  - Clean vs Dirty DG
  - EPA Study as part of NEDRI
  - EPA-State Clean Energy Partnerships
- Alternative Portfolio Standards
  - Pennsylvania
  - Illinois
  - Nevada
- Dynamic Emissions Management
Issue: Demand Response and Distributed Generation

- Demand Side vs Supply Side
- Clean vs Dirty
- Size and Interconnection
- Customer Requirements vs Generation Sales
Issue: Competitive vs Regulated

- Much of U.S. is not restructured
- Competitive commodity market did not deliver demand response
- Technology costs high on a disaggregated basis
- Marketers struggling with basic product
- Competitive providers limited to ISO programs & direct to C/I Customers
Issue: Customer Acceptance

- Demand Response is based on principle that customers are price elastic for all products, even electricity.
- With most demand response being made available to customers via programs, program design, marketing and delivery is also important.
- There is a lot of data available on customer acceptance, but yet many pilots are still designed to test for it.
Issue – Customer Acceptance

What we know about Customers

- They are price elastic
- They like information about their electricity purchases
- They like having technology
- They want understandable programs
- They want help in participating
- Civic duty works – but for how long
Puget Sound Market Research Results

• Attitudes toward time-differentiated pricing
  – 67% - TOU is a good idea
  – 66% - reduces need for power plants
  – 64% - TOU pricing is fair
  – 72% - concept is easy to understand
  – 37% - should pay the same price no matter what time of day they use power

• Customer reaction to information
Puget: Types of Actions Taken by Customers

- Shift use: 43% Information Only, 89% TOU Pricing
- Reduce use: 41% Information Only, 49% TOU Pricing
- Buy efficient equipment: 4% Information Only, 8% TOU Pricing
- Install more insulation: 1% Information Only, 1% TOU Pricing
- Use backup heat more: 1% Information Only, 2% TOU Pricing

The chart shows the percentage of customers taking various actions, with the yellow bars representing Information Only and the orange bars representing TOU Pricing.
Issue: Technology

- DR without Technology
- Direct Load Control
- Informational Display
- Advanced Metering and Communications
- Automated Communications and Controls
- Smart Thermostats
- Energy Management Systems
- Building Optimization
- Bidding and Dispatch Systems and Platforms
- Virtual Negawatt Systems
- Distributed Generation
# Metering Technologies

<table>
<thead>
<tr>
<th>System Element/Feature</th>
<th>Manual</th>
<th>Automatic Meter Reading (AMR)</th>
<th>Advanced Meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meters</td>
<td>Electromechanical</td>
<td>Hybrid</td>
<td>Hybrid or solid-state</td>
</tr>
<tr>
<td>Data collection</td>
<td>Manual, monthly</td>
<td>Drive-by, monthly</td>
<td>Remote via communications network, daily or more often</td>
</tr>
<tr>
<td>Data recording</td>
<td>Total consumption</td>
<td>Total consumption or time-of-use (up to 4 monthly “buckets”)</td>
<td>Time-based (usage each hour or more often)</td>
</tr>
<tr>
<td>Primary applications</td>
<td>Total consumption billing</td>
<td>Total consumption billing</td>
<td>Pricing options</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Customer options</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Utility operations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Emergency demand response</td>
</tr>
<tr>
<td>Key software interfaces</td>
<td>Billing and customer information system</td>
<td>Billing and customer information system</td>
<td>Billing and customer information system</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Customer data display</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Outage management</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Emergency demand response</td>
</tr>
<tr>
<td>Additional devices enabled (but not included in base infrastructure)</td>
<td>None</td>
<td>None</td>
<td>Smart thermostats</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>In-home displays</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Appliance controllers</td>
</tr>
<tr>
<td>Current penetration in U.S. (residential and small commercial)</td>
<td>50%</td>
<td>35%</td>
<td>15%</td>
</tr>
</tbody>
</table>
Advanced Metering Technology

- Basic infrastructure
  - Electric meters
  - Meter communications modules
  - Communications network linking meters to utility
  - Software interfaces
    - Utility billing system
    - Customer usage display
    - Load control system
  - Advanced Metering Infrastructure (AMI) software to implement, manage, operate the system
- Additional devices enabled but not included in base
  - Smart thermostats, in-home displays, load controllers
AMI Communication Networks

Local Area Networks

- Local power lines
- Wireless

Wide Area Networks

- Telephone
- Internet
- Wireless Network

Distribution lines

Consumer

Utility User

Data Center
New Utility Capabilities Enabled by AMI

<table>
<thead>
<tr>
<th>Service</th>
<th>New Capabilities Enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Quality</td>
<td>Meter-level voltage monitoring</td>
</tr>
<tr>
<td>Distribution Automation</td>
<td>Load balancing</td>
</tr>
<tr>
<td></td>
<td>Capacitor bank switching*</td>
</tr>
<tr>
<td></td>
<td>Regulator and tap changer monitoring*</td>
</tr>
<tr>
<td></td>
<td>Transformer load management</td>
</tr>
<tr>
<td></td>
<td>Automated outage management</td>
</tr>
</tbody>
</table>

* - requires additional devices

Appearance of map with normal power status

Outage known but not yet fully mapped

Outage is now fully mapped

Monitor restoration to be sure power is fully restored
AMI Data and Software Relationships

Networks
- Wide area
- Neighborhood
- In-home

End User

Transformer

Premise

Circuit

Transformer

Network Providers

Field Technician

Data Center

AMI Operations

Outage Management System

Web Usage Display

Distribution Operations

Program Management

Billing and Customer Service

Electric Service Point

Network Module

Electric Meter

Load Controller

Smart Thermostat

In-Home Display

Contact

User Name

Account
### New Customer Options Enabled by AMI (Basic)

<table>
<thead>
<tr>
<th>Service</th>
<th>New Options Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billing</td>
<td>Choice of billing date&lt;br&gt;No estimated bills&lt;br&gt;Month-to-date bill&lt;br&gt;Projected month-end bill</td>
</tr>
<tr>
<td>Pricing</td>
<td>Flat rates&lt;br&gt;Time-of-use&lt;br&gt;Critical peak pricing&lt;br&gt;Real-time pricing</td>
</tr>
<tr>
<td>Outage Response</td>
<td>Automatic outage detection&lt;br&gt;Restoration verification</td>
</tr>
<tr>
<td>Usage Information</td>
<td>Real-time meter read&lt;br&gt;First call problem resolution&lt;br&gt;Web data access&lt;br&gt;Monthly detailed usage reports&lt;br&gt;Baseline threshold alarms&lt;br&gt;Month-to-date usage&lt;br&gt;Daily or hourly data to walk customer through usage patterns</td>
</tr>
</tbody>
</table>
## Advanced Metering Applications

<table>
<thead>
<tr>
<th>Technical Capability</th>
<th>Applications Supported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hourly Data Recording</td>
<td>Dynamic pricing (real-time, critical peak, time-of-use)</td>
</tr>
<tr>
<td></td>
<td>Load research</td>
</tr>
<tr>
<td></td>
<td>Distribution system planning and asset use</td>
</tr>
<tr>
<td></td>
<td>Unaccounted for energy (energy theft, line loss, etc.)</td>
</tr>
<tr>
<td>Remote Communications</td>
<td>Remote meter reading</td>
</tr>
<tr>
<td></td>
<td>Move-in/move-out meter reading</td>
</tr>
<tr>
<td></td>
<td>Outage and restoration management</td>
</tr>
<tr>
<td>Interface to Utility Systems</td>
<td>Billing</td>
</tr>
<tr>
<td></td>
<td>Customer service</td>
</tr>
<tr>
<td></td>
<td>Distribution operations</td>
</tr>
<tr>
<td>Interface to Load Control</td>
<td>Demand reductions during emergencies</td>
</tr>
<tr>
<td></td>
<td>Automated response to dynamic pricing</td>
</tr>
<tr>
<td>Customer Data Access</td>
<td>Customer energy information and management</td>
</tr>
</tbody>
</table>
AMI Cost Elements and Options

1. **Meter with Communications Module**
   - New vs. retrofit
   - Residential/small commercial vs. large commercial

2. **Meter installation**
   - Residential/small commercial vs. large commercial
   - Primary variable is “drive time” (universal vs. scattered deployment)

3. **Local Area Network Node**
   - At premise vs. pole top vs. substation
   - Primary variables are network type and number of meters connected

4. **Wide Area Network**
   - Public vs. private network

5. **Data Center**
   - Staffing, facilities, servers, and other operations & maintenance
   - Startup and base monthly cost

6. **Field Equipment Operations & Maintenance**
   - Meters
   - Local Area Network nodes

7. **Overheads**
   - Administrative & general
   - Financing costs for capital investments

---

**Meter with Communications Module**
- +

**Meter Installation**
- +

**Local Area Network Node**
- +

**Wide Area Network Communications Services**
- +

**Data Center**
- +

**Field Equipment Operations & Maintenance**
- +

**Overheads & Administrative Costs**
- = Total Cost
Dr. DR - Who Benefits and How

- **Participants**
  - New info about their bill
  - New ability to lower their bill
  - New control over their end uses

- **Non-Participants**
  - Lower peak demand means lower peak wholesale prices, to everyone’s benefit
DR - Who Benefits and How

Utilities/LSEs

- New abilities to control load
- New information about customers
- Information to use in optimizing system operations and planning (risk management)
- New product choices for customers
DR - Who Benefits and How

Utilities/LSEs
- Automated meter reading
- Outage detection and management
- Monitoring and Verification
- Power Quality
- Automated Control
- Potential Gateway
- Reduced Operating Costs
- Customer Satisfaction
DR - Who Benefits and How

- **Regional System**
  - Optimize system operations and planning
  - Avoid unnecessary expansion
  - Address local load pockets
  - Reduce emissions in certain areas (a potential dynamic tool?)
  - Support for Renewables
DR - Who Benefits and How

- Retail Marketers and Renewables
  - Faster, more accurate settlements
  - Ability to offer new product choices as alternative to default service
  - High peak prices stimulate on-peak renewables
DR – A Chicken and Egg Situation

- DR requires enabling technology
- Enabling technology provides benefits outside of demand response
- Enabling technology provides benefits to different parties in different places
- Enabling technology is more cost-effective with DR benefits
- Multiple stakeholders and decision pockets
- Case specific, comprehensive analysis is required
DR Research Snapshots

- **ISO-NE Evaluation**

- **LBNL Niagara Mohawk RTP**

- **LBNL RTP Survey**

- **IEA Research Tasks**
  - Utility Benchmark Survey (underway)
  - Resource-Based Valuation Modelling and Analysis
  - Technology
  - Funding of DR
DR – The Challenges

- Existing infrastructure in decline
- DR funding is low
- DR needs “nourishment” in its infancy
- NGO Community not driving it like efficiency
- DR expertise and information is diverse and dispersed
- Benefits are dispersed
- Pilots need to test for right thing
- Business and policy cases are complex
- No natural flow and exchange of ideas and info
- What is known is unknown
- Much is not known
- DR not being recognized as its own discipline
- Policy makers voice support it but yet are cautious; looking for assistance and support
Thank You

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www.dramcoalition.org
www.demandresponseinfo.org