Demand Response:
Time-differentiating technologies, rates, programs, metrics and customer behavior

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When do we use electricity?

*California ISO system load, typical summer day*
Why we need time-differentiating technologies, rates, programs, metrics and customer behavior:

EE focuses on saving kWh, DR on saving kW, and both result in fewer power plants, fuel consumption, and emissions (including GHG).

Both reduction in energy consumption (energy efficiency) and reduction in energy demand (demand response) are required to make the grid more economically efficient and reduce its environmental impact.

Understanding customer behavior is necessary to:

• Improve demand response efforts and save more energy
• Measure and understand demand response program effectiveness
• Develop and distribute effective demand reduction technologies
Technologies
- Smart Meters
- Interval Meters
- Home Area Networks
- Auto DR
- PCTs

Rates
- Dynamic Rates
- Time of Use Rates
- Real Time Pricing
- Critical Peak Pricing
- Direct Load Control
- Critical Peak Pricing

Programs
- Traditional Interruptibles
- Aggregator Contracts

Metrics
- Program Evaluation
- Load Impact Protocols
- Cost-effectiveness protocols
The *Standard Practice Manual* (SPM)

- Developed to measure the cost-effectiveness of *Energy Efficiency* programs
- Use four tests to measure cost-effectiveness from four perspectives:
  - *Society*: The Total Resource Cost (TRC) test
  - *Program Administrator*: The Program Administrator (PAC) test
  - *Ratepayers*: The Ratepayer Impact Measure (RIM) test
  - *Participant*: The Participant Test
Cost-effectiveness tests for Demand Response (based on the SPM)

<table>
<thead>
<tr>
<th>INPUT:</th>
<th>TEST:</th>
<th>TRC (Society)</th>
<th>PAC (Utility)</th>
<th>RIM (Ratepayers)</th>
<th>Participant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administrative costs</td>
<td>COST</td>
<td>COST</td>
<td>COST</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoided costs of supplying electricity</td>
<td>BENEFIT</td>
<td>BENEFIT</td>
<td>BENEFIT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bill increases</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>COST</td>
</tr>
<tr>
<td>Bill reductions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BENEFIT</td>
</tr>
<tr>
<td>Capital costs to participant</td>
<td>COST</td>
<td></td>
<td></td>
<td></td>
<td>COST</td>
</tr>
<tr>
<td>Environmental Benefits</td>
<td>BENEFIT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incentives paid</td>
<td></td>
<td>COST</td>
<td>COST</td>
<td></td>
<td>BENEFIT</td>
</tr>
<tr>
<td>Increased supply costs</td>
<td>COST</td>
<td>COST</td>
<td>COST</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market benefits</td>
<td>BENEFIT</td>
<td>BENEFIT</td>
<td>BENEFIT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Participant non-monetary benefits</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BENEFIT</td>
</tr>
<tr>
<td>Revenue gain from increased sales</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>BENEFIT</td>
</tr>
<tr>
<td>Revenue loss from decreased sales</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>COST</td>
</tr>
<tr>
<td>Transaction costs to participant</td>
<td>COST</td>
<td></td>
<td></td>
<td></td>
<td>COST</td>
</tr>
<tr>
<td>Value of service lost</td>
<td>COST</td>
<td></td>
<td></td>
<td></td>
<td>COST</td>
</tr>
</tbody>
</table>

Shaded rows indicate those costs and benefits which are not listed in the SPM but have been added to the Demand Response draft protocols.
SPM tests that include customer perspectives

**Participant Test**

Benefits = Bill Reductions + Incentives Paid + Non-monetary benefits

Costs = Capital costs + Transaction costs + Value of service lost

**Total Resource Cost Test**

Benefits = Avoided cost of supplying electricity + Environmental benefits + Market benefits + Non-monetary benefits

Costs = Administrative costs + Capital costs + Increased supply costs + Transaction costs + Value of service lost
The old approach

**Participant Test**
Benefits = Bill Reductions + Incentives Paid + Non-monetary benefits
Costs = Capital costs + Transaction costs + Value of service lost

**Total Resource Cost Test**
Benefits = Avoided cost of supplying electricity + Environmental benefits + Market benefits + Non-monetary benefits
Costs = Administrative costs + Capital costs + Increased supply costs + Transaction costs + Value of service lost

**Know:** Part. Test Benefits > Costs; Ignore Bill Reductions, Increased supply costs

**Assume:** Part. Benefits ≈ Costs; Non-monetary, Market benefits negligible

**Therefore:** Capital costs + Transaction costs + Value of service lost ≈ Incentives Paid

**Total Resource Cost Test**
Benefits = Avoided cost of supplying electricity + Environmental benefits
Costs = Administrative costs + Incentives Paid
How accurate is the old approach?

**Total Resource Cost Test (new)**
Benefits = Avoided cost of supplying electricity + Environmental benefits + Market benefits + Non-monetary benefits
Costs = Administrative costs + Capital costs + Transaction costs + Value of service lost

**Total Resource Cost Test (old)**
Benefits = Avoided cost of supplying electricity + Environmental benefits
Costs = Administrative costs + Incentives Paid

However:
Participant Benefits > Participant Costs, so Incentives Paid are not a good proxy for customer costs
Non-monetary benefits ≠ 0
Market benefits ≠ 0
Environmental benefits include only a small GHG adder

*The current approach overestimates the costs and underestimates the benefits, hence severely underestimating benefit/cost ratios.*
Hard-to-quantify cost and benefits

Environmental Benefits
- Help the environment
- Reduce carbon footprint
- Better public image
- Better energy management
- Prevent blackouts

In other words, the benefits of changing customer behavior.

Market Benefits

Non-monetary benefits

Transaction costs

Opportunity costs associated with education, equipment installation, program applications, energy audits, etc. In other words, the costs of changing customer behavior.

Value of service lost

Productivity losses and comfort costs.
<table>
<thead>
<tr>
<th>Influence</th>
<th>Example</th>
<th>How can it be influenced?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual value of service lost</td>
<td>decreased production</td>
<td>Subsidies, high prices, bill protection, better technology</td>
</tr>
<tr>
<td>Perceived value of service lost</td>
<td>decreased comfort</td>
<td></td>
</tr>
<tr>
<td>Ownership/control</td>
<td>homeowner/renter; company large enough to employ system manager</td>
<td>Legislation/regulation</td>
</tr>
<tr>
<td>Decision-making authority/flexibility</td>
<td>customers differ in their decision-making procedures.</td>
<td>Marketing, incentives/rebates</td>
</tr>
<tr>
<td>Ability to respond</td>
<td>type of industry or processes; medical conditions</td>
<td>Incentives/rebates</td>
</tr>
<tr>
<td>Resistance to change</td>
<td>finds changing behavior expensive or difficult</td>
<td>Extremely high prices might have an impact.</td>
</tr>
<tr>
<td>Risk sensitivity</td>
<td>enrolling in program may result in higher bills; investing in new equipment may not</td>
<td>Incentives/rebates, bill protection</td>
</tr>
<tr>
<td>Awareness of program</td>
<td>customer does not know about or understand program</td>
<td>Marketing</td>
</tr>
<tr>
<td>Awareness of rate structure</td>
<td>customer understanding of bill</td>
<td>Marketing; changes in rate structure</td>
</tr>
<tr>
<td>Relative discount rate</td>
<td>poorer people have higher discount rates</td>
<td>Incentives/rebates, low income programs</td>
</tr>
<tr>
<td>Availability of capital</td>
<td>poorer people have low availability of capital; middle income people and small businesses may be reluctant to make large investments for long term payoffs.</td>
<td>Incentives/rebates, low income programs</td>
</tr>
<tr>
<td>(lack of ) Price sensitivity</td>
<td>some people don’t care about the price of energy</td>
<td>Use of OPT-OUT rather than OPT-IN</td>
</tr>
<tr>
<td>Trust</td>
<td>some people do not trust utilities and/or government agencies</td>
<td>Marketing</td>
</tr>
<tr>
<td>Environmental values</td>
<td>customers who respond to environmental incentives rather than, or in addition to, price incentives</td>
<td>Marketing</td>
</tr>
<tr>
<td>Awareness of environmental issues</td>
<td>customers who might respond to environmental incentives</td>
<td>Marketing; other educational materials/efforts</td>
</tr>
<tr>
<td>Civic/corporate responsibility</td>
<td>some people feel it is their responsibility to reduce peak demand, especially during emergencies</td>
<td>Marketing</td>
</tr>
</tbody>
</table>

**Value of service lost**  **Transaction Costs**  **Non-monetary benefits**
Time-differentiating technologies, rates, programs, metrics and customer behavior save energy and money, decrease GHG and other emissions, and make the grid more efficient.

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