Demand Response in Restructured Wholesale Electricity Markets

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Agenda

• Historical background

• Alternative approaches

• Economic evaluation

• Conclusion
The difficulty lies, not so much in developing new ideas, as in escaping from old ones, which ramify, for those brought up as most of us have been, into every corner of our minds.

John Maynard Keynes
Historical Background

• PURPA (1978) introduced competition into electricity generation that led to restructuring of the electric industry
• The electricity restructuring started on April 20, 1994, when the California Public Utility Commission (CPUC) issued its Blue Book – the California electricity crisis in 2000-2001
• The Energy Policy Act of 2005 provides a Congressional mandate for demand response in organized wholesale electricity markets – It directs FERC to “work with States, stakeholders and experts to identify and address barriers to the adoption of demand-response programs” and “encourage States to coordinate, on a regional basis, State energy policies to provide reliable and affordable demand-response services to the public.”
• On March 18, 2010, FERC issued the proposed rule on demand-response compensation in organized wholesale electricity markets (NOPR)
Product Definition of Demand Response

• According to FERC’s definition
  – Demand response means a reduction in the consumption of electric energy by a customer in response to an increase in the price of electricity or other market incentives
  – Demand response resource represents a customer’s capability of providing demand response

• Demand response resource can be thought of as a composite option, or a derivative product, with four relevant components
  – Baseline or a quantity threshold (CBL), which is established only when the unlimited quantity option in the basic electric service is exercised
  – Price threshold in the wholesale energy market (X)
  – Offer price in the wholesale energy market (Offer)
  – Compensation rule for the demand reduction, which is the difference between the actual consumption (Q) and the baseline, when certain conditions are satisfied (e.g. Q<CBL, LMP>X, LMP>Offer)

• Demand response resource is akin to a capacity product (ex ante), but once exercised, demand reduction is an energy product (ex post)
# Alternative Demand Response Compensation Approaches

<table>
<thead>
<tr>
<th></th>
<th>Traditional Approach</th>
<th>Second-Best Pricing Approach</th>
<th>First-Best Contract-Based Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contract for baseline</strong></td>
<td>No contract</td>
<td>Implicit contract</td>
<td>Implicit or explicit contract</td>
</tr>
<tr>
<td><strong>Who sets customer’s baseline</strong></td>
<td>Market operator</td>
<td>Market operator</td>
<td>Load-serving entity or demand-response provider</td>
</tr>
<tr>
<td><strong>How much to pay for demand reduction</strong></td>
<td>Wholesale market price</td>
<td>Wholesale market price less retail rate</td>
<td>Wholesale market price</td>
</tr>
<tr>
<td><strong>Who pays for the cost of demand reduction</strong></td>
<td>Load-serving entity and local distribution company</td>
<td>Load-serving entity</td>
<td>No cost allocation is required</td>
</tr>
</tbody>
</table>

- **Contract for baseline**: No contract, Implicit contract, Implicit or explicit contract, Explicit contract
- **Who sets customer’s baseline**: Market operator, Market operator, Load-serving entity or demand-response provider, Retail customer’s choice
- **How much to pay for demand reduction**: Wholesale market price, Wholesale market price less retail rate, Wholesale market price
- **Who pays for the cost of demand reduction**: Load-serving entity and local distribution company, Load-serving entity, No cost allocation is required
The Traditional Approach

The market operator recovers the demand-response payments by allocating these costs to the market participants using administrative mechanisms.

ISO/RTO: Market operator
GEN: Generator
LSE: Load serving entity
DRP: Demand resource provider
LMP: wholesale market price
Load: Customer load
RR: Retail rate
DR: demand reduction

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Unintended Effects with Missing Property Rights

• The traditional approach is inherited from a vertically integrated utility
  – pays a customer for demand reduction at the full wholesale market price
  – uses an administratively determined customer baseline
  – The ownership or entitlement for the energy from demand reduction is unspecified

• Unintended effects
  – Inefficient price formation
  – Load shifting behind the meters
  – Moral hazard and adverse selection
Double Payment Incentive Causes Inefficient Market Outcome

• Double payment refers to the double benefits that customers receive from both bill savings (RR) and demand reduction payments (LMP) for the same demand reduction

• Risk free profit can be made by putting generators behind the meter while receiving payments for demand reduction

• An example
  – A consumer is willing to pay $250/MWh for energy (or this could be the cost to run a backup generator behind the meter)
  – the retail rate is $100/MWh
  – The consumer offers the opportunity cost of $150/MWh (= $250 - $100) for load reduction
  – The real-time LMP of $160/MWh, and the load reduction offer is cleared
  – This entails a social cost of $90/MWh (= $250 - $160)
Double payment incentive causes inefficient price formation

- Consumer’s opportunity cost = Demand reduction payment

- Deadweight losses

- Demand reduction

- Q

- P

- RTP+RR

- RTP

- RR

- D

- C

- Q_1

- Q_0

- Q_{Peak}

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Load Shifting Behind the Meters

- A manufacturing company owns two identical facilities
- Both facilities consume identical amounts of electricity at 80 MW/hour, when they run at the usual 80% of capacity

<table>
<thead>
<tr>
<th></th>
<th>Day One</th>
<th>Day Two</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Customer Baseline (MW)</td>
<td>Electricity Consumption (MW)</td>
</tr>
<tr>
<td>Facility 1</td>
<td>80</td>
<td>100</td>
</tr>
<tr>
<td>Facility 2</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>160</td>
<td>20</td>
</tr>
</tbody>
</table>
Demand Subscription Provides the Missing Link

Wholesale Market
- Energy service
- Ancillary services
- Capacity requirement

Retail Market
- Energy service
- Full delivery services
- Price risk hedge

Demand Subscription

Demand Response

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Demand Subscription Service for Customers

- Demand subscription service involves a two-settlement system in retail services
  - A customer subscribes (ex ante) specific levels of energy services under prescribed conditions and terms for the standard service
  - The customer receives refund (ex post) for any unused amount of energy at the default rate (e.g. wholesale real-time price)

- A demand response program allows the consumer
  - To sell any unused amount at the greater of the default rate or the wholesale real-time price, if they differ
  - To buy any amount above the subscribed amount at the wholesale market price

- Demand subscription naturally defines a contract-based “two-sided” customer baseline
  - Establishes energy entitlement and ownership so that demand reductions can be offered into the wholesale market
Demand Subscription Service Promotes Consumer Choices

- Demand subscription service lowers the barriers to dynamic pricing and price-responsive demand for win-win results

- It enables customers to benefit from investment in advanced metering infrastructure and demand management technologies

- It establishes a platform for retail service providers to compete in innovative service offerings customized to customer’s different needs beyond the basic service plans
A Numerical Example

• Demand Curves
  – Peak hour: Demand (in MW) = 22,000 – 20 x Price (in MWh)
  – Off-peak hour: Demand (in MW) = 11,000 – 10 x Price

• Supply Curve for all hours
  – Supply (in MW) = 4000 + 100 x Price

• Other Assumptions
  – The wholesale price equals the marginal cost of supply
  – The profit margin for retail service provider equals zero due to free entry
  – The fixed-price retail rate equals the consumption-weighted average of wholesale prices
### Comparing Alternative Approaches

<table>
<thead>
<tr>
<th>Case description</th>
<th>Case 1 Price-Insensitive Demand</th>
<th>Case 2 Price-Responsive Demand</th>
<th>Case 5 Demand Subscription</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Peak hour (6 hours)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demand (MW)</td>
<td>20,000</td>
<td>19,000</td>
<td>19,000</td>
</tr>
<tr>
<td>Wholesale price ($/MWh)</td>
<td>$160.00</td>
<td>$150.00</td>
<td>$150.00</td>
</tr>
<tr>
<td>Retail price ($/MWh)</td>
<td>$100.00</td>
<td>$150.00</td>
<td>$98.18</td>
</tr>
<tr>
<td>∆ CS from Case 1 ($million/year)</td>
<td>-</td>
<td>($2,135)</td>
<td>$134</td>
</tr>
<tr>
<td>∆ PS from Case 1 ($million/year)</td>
<td>-</td>
<td>($427)</td>
<td>($427)</td>
</tr>
<tr>
<td><strong>Off-Peak hour (18 hours)</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Demand (MW)</td>
<td>10,000</td>
<td>10,364</td>
<td>10,364</td>
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<tr>
<td>Wholesale price ($/MWh)</td>
<td>$60.00</td>
<td>$63.64</td>
<td>$63.64</td>
</tr>
<tr>
<td>Retail price ($/MWh)</td>
<td>$100.00</td>
<td>$63.64</td>
<td>$98.18</td>
</tr>
<tr>
<td>∆ CS from Case 1 ($million/year)</td>
<td>-</td>
<td>$2,433</td>
<td>$163</td>
</tr>
<tr>
<td>∆ PS from Case 1 ($million/year)</td>
<td>-</td>
<td>$243</td>
<td>$243</td>
</tr>
<tr>
<td><strong>All Hours</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy consumption (GWh/Year)</td>
<td>109,500</td>
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<td>109,699</td>
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<tr>
<td>∆ CS from Case 1 ($million/year)</td>
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<td>$297</td>
</tr>
<tr>
<td>∆ PS from Case 1 ($million/year)</td>
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<td>($184)</td>
<td>($184)</td>
</tr>
<tr>
<td>∆ SS from Case 1 ($million/year)</td>
<td>-</td>
<td>$113</td>
<td>$113</td>
</tr>
</tbody>
</table>

∆ CS: Change in consumer surplus (CS) which is the amount that consumers benefit by buying electricity at a price that is less than they would be willing to pay.

∆ PS: Change in producer surplus (PS) which is the amount that producers benefit by selling at a market price that is higher than they would be willing to sell.

∆ SS: Change in social surplus (SS) which is the sum of consumers’ surplus and producers’ surplus.
Conclusion

😊 If energy entitlement or ownership can be established, paying the competitive wholesale energy price for demand reduction could achieve efficient outcome

🚫 Absent energy entitlement or ownership, paying the full competitive energy price for demand reduction is likely to compromise electricity market efficiency, possibly making the cure worse than the disease

😊 Demand subscription service offers a win-win solution to encourage demand response leading to dynamic retail pricing and price-responsive demand management for a smart grid world
Thank You

😊 😊 😊