Demand Charges and Cost Causation

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What are demand charges?

• Demand charges are any pricing element based on an individual customer’s max kW measurement
  – Often 15-, 30-, or 60-minute intervals
• Two varieties under specific consideration
  – Traditional - based on customer’s non-coincident peak (NCP) anytime during a billing period
  – “Peak window” – based on customer NCP during predefined hours, similar to on-peak period for TOU rate
Economists on demand charges

- W. Arthur Lewis (1941):
  - “The maximum rate at which the individual consumer takes is irrelevant; what matters is how much he is taking at the time of the station's peak.”

- Alfred Kahn (1970):
  - Demand charges are “basically illogical.”

- Severin Borenstein (2016):
  - “[I]t is unclear why demand charges still exist.”
Key issues

• Historic justifications for demand charges are fading away
• Demand charges are an inefficient way to price shared system capacity generally
  – Overcharge customers with load diversity and undercharge customers that hog capacity
• Narrower applications for demand charges may be appropriate
  – Likely a proxy for a more sophisticated system of time- and location-varying rates
RATE DESIGN PRINCIPLES
Why do we regulate utilities?

• Efficient competition and control of monopoly pricing
• Reliable provision of service
• Societal equity (e.g., universal access and affordability)
• Environmental and public health requirements
Goals of rate-making

- Effective recovery of revenue requirement
- Customer understanding, acceptance, and bill stability
- Equitable allocation of costs
- Efficient forward-looking price signals
Rate design should make the choices the customer makes to minimize their own bill.

Consistent with the choices they would make to minimize system costs.
BRIEF TOUR THROUGH HISTORY
Let there be light!

- Electric utility debate in the 1890s
  - British engineer Hopkinson described concept of demand charges
  - Demand meter invented by Arthur Wright
  - TOU meter invented by Gisbert Kapp
- Basic pattern established in early 20th century
  - Demand charges for industrial customers
  - Flat volumetric kWh charges for small customers
The nature of capacity costs have changed

- **1950s**
  - Many utility systems were dominated by thermal steam generation

- **1960s**
  - Modern combustion turbine invented
  - Nuclear power emerges

- **1970s**
  - Oil crises -> fuel shortages and price differentiation
  - Beginning of modern environmental regulation

- **1980s and 1990s**
  - PURPA implementation and then restructuring in many areas
  - Introduction of energy efficiency programs and demand-side resources
  - Emergence of combined cycle generation

- **2000s**
  - Major increase in natural gas extraction from hydraulic fracturing
  - Emergence of wind, solar, advanced meters and smart grid
To infinity and beyond…

- Massive increases in computing power and data storage capabilities
- High penetrations of variable renewable resources change operation and economics of electric system
- Energy management technology becomes cheap and widespread
- Electrification of transportation and heating may increase load
- Continued cost declines for clean distributed generation and energy storage
THE INEFFICIENCIES OF DEMAND CHARGES
Traditional case for demand charges

- Customer NCP demand could be a proxy for contribution to peak
- Prerequisites include:
  - High correlation between customer NCP and system peak
  - High cost of time-differentiated metering
  - Little or no economically shiftable load
Lower load-factor customers can share capacity

• Morning loads
• Evening loads
• 24/7 loads
System peak and NCP demand charges

None of the customers peak at the time of the system peak.
Gross peak or net peak?
Falling cost of metering and shifting load

- Advanced metering means that time-based rates are just as easy as demand charges
- Energy management technology and low-cost storage make it easier for customers to shift load
“Demand-related” costs

- Not all capacity costs are “demand-related”
- Many capacity investments are undertaken for energy-related benefits
  - Generation capacity costs that are not targeted at peaks or reliability issues
  - Transmission lines for remote generation and year-round energy exchanges
  - Any T&D costs designed to lower line losses
- Not all demand-related costs are driven by system peak
  - Reliability risk from system peak is spread over many hours with similar loads
  - Shoulder and off-peak seasons still have risks
Does the “peak window” demand charge solve the problem?

• Peak window demand charges provide a better incentive to reduce at peak times than traditional monthly demand charges

• Peak window demand charges share other faults of demand charges
  – Hogs versus sharers
  – Arbitrary unless there are high correlations between individual peaks and system peaks
  – Inaccurate customer response to incentives
Hogs and sharers
Diversity on line transformers

Summer peak day load from 10 residential customers on one line transformer

- Customer coincident peak
- Customer noncoincident peak

Total load shape (on different scale from remainder of figure)

Hour of day
Peak window demand charges vs. time-varying rates

• Easiest direct comparison is peak window demand charges with time-of-use rates
• Time-of-use rates can be improved by adding elements that are responsive to system conditions
  – Critical peak pricing
  – Peak-time rebates
  – Variable peak pricing
WHAT’S LEFT FOR DEMAND CHARGES?
Potential Narrower Roles for Demand Charges

- Dedicated Site Infrastructure
- Risks from Customer Variance at Peak Times
- Timer Peaks

Theme: What happens if load diversity isn’t present?
Cost Causation for Site Infrastructure

- Larger secondary customers do not share transformers
- Diversity at this part of system is lower for customers that do share transformers
- Heat build-up over time is still key issue for line transformers
- Customers in multifamily and office buildings share service drops
Typical utility estimates of diversity in residential loads

- 3,001 to 4,500 square feet
- 2,001 to 3,000 square feet
- 1,201 to 2,000 square feet
- 1,200 square feet or less
- Less than 1,000 square feet without refrigerated air

Risks at Peak Times

- Veall (1983) defines a set of conditions where a peak window demand charge is an efficient marginal cost incentive as a price on variance, which requires that either:
  - Customers are “large” relative to the system; or
  - Random load fluctuations are correlated

- Boiteux and Stasi (1952) make a risk argument for demand charges for shared distribution costs for industrial customers
Timer Peaks

Evaluation of New Roles for Demand Charges

• Dedicated site infrastructure is small portion of system costs
  – Typical demand charges do not necessarily correspond with how wear
    and tear is incurred on transformers and service drops
• Risks at peak times are real but many questions remain about details
  – Which customers?
  – What kind of correlation?
  – Is TVR still better?
• Timer peaks can be addressed through other means
  – Adjustments to time periods
  – Load management programs
KEY TAKEAWAYS
Conclusions

• In the modern electric system, a traditional monthly demand charge is no longer a good proxy for shared system costs, even for industrial customers.

• Simple time-varying rate structures are generally superior to peak window demand charges.

• Any new role for demand charges is likely narrow and serves as a proxy for a more efficient, but administratively complex, time- and location-varying rate system.
### Smart rate design for today

<table>
<thead>
<tr>
<th></th>
<th>Residential</th>
<th>Medium C&amp;I</th>
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<tbody>
<tr>
<td><strong>Customer charge ($/mo.)</strong></td>
<td>Multifamily: $7</td>
<td>$100</td>
</tr>
<tr>
<td></td>
<td>Small single-family: $10</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large single-family: $15</td>
<td></td>
</tr>
<tr>
<td><strong>Site infrastructure ($/kW)</strong></td>
<td>N/A</td>
<td>$2</td>
</tr>
<tr>
<td><strong>Off-peak (cents/kWh)</strong></td>
<td>10 cents</td>
<td>8 cents</td>
</tr>
<tr>
<td><strong>Mid-peak (cents/kWh)</strong></td>
<td>15 cents</td>
<td>12 cents</td>
</tr>
<tr>
<td><strong>On-peak (cents/kWh)</strong></td>
<td>30 cents</td>
<td>25 cents</td>
</tr>
<tr>
<td><strong>Critical peak (cents/kWh)</strong></td>
<td>75 cents (peak-time rebate)</td>
<td>75 cents</td>
</tr>
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Volumetric components reflect both import charges and export credits, which should be netted by TOU period.
Advanced residential rate design for high-DER future

<table>
<thead>
<tr>
<th>Cost Recovery Only</th>
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<tbody>
<tr>
<td>Customer charge ($/month)</td>
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<tr>
<td>Site infrastructure ($/individual NCP kW)</td>
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<tr>
<td>Bidirectional distribution flow charge</td>
</tr>
<tr>
<td>(cents/kWh on imports and exports)</td>
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<tr>
<th>Symmetric Charges and Credits</th>
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<td>Off-peak (cents/kWh)</td>
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<td>Mid-peak (cents/kWh)</td>
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THANK YOU!

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