Electricity Pricing: Drivers, Practices and Pitfalls

Financial Research Institute Advanced Seminar

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Three Reasons Rate Design Will Evolve
I. Data Can Be (Needs to Be) Better

- FERC Uniform System of Accounts
  - Important industry standard but not specific enough for some purposes
- Overall system load and generation data
- Location-specific T&D data have become more sophisticated
- Customer-specific data
  - Load sampling is no longer necessary with AMI
Simplified rate-making process

1. **Determine revenue requirement**
   - Net rate base: (Plant in service – depreciation reserve)
   - Rate of return
   - Depreciation expense: (Plant in service x depreciation rate)
   - Operating expense: (Fuel + purchased power + labor + labor overheads + supplies + services + income taxes)
   - Other taxes

   = $ millions

2. **Allocate costs among customer classes**
   - Residential
   - Commercial
   - Industrial
   - Street lighting

3. **Design retail rates**
   - Dollars per month
   - Cents per kWh peak
   - Cents per kWh off-peak
   - Dollars per month
   - Cents per kWh peak
   - Cents per kWh off-peak
   - Dollars per month
   - Cents per kWh peak
   - Cents per kWh off-peak
   - Dollars per kW monthly
   - Dollars per light per month
Traditional Embedded Cost of Service Study (ECOSS) Process
The Demand Classification is Splintering

1950

2020
Modern Embedded Cost of Service Study Process
II. Flexible DERs Will Grow Fast

- Flexible load will grow
- Electrification will amplify flexible load
- Distribution sited resources will become smart
## Example of Flexible Load Profiles

<table>
<thead>
<tr>
<th>Sector</th>
<th>End Use</th>
<th>Enabling Technology Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>Battery-electric and plug-in hybrid vehicles</td>
<td>Level 1 and Level 2 charging interruption</td>
</tr>
<tr>
<td></td>
<td>Behind-the-meter batteries</td>
<td>Automated DR (Auto-DR)</td>
</tr>
<tr>
<td>Residential</td>
<td>Air conditioning</td>
<td>Direct load control (DLC) and Smart communicating thermostats (Smart T-Stats)</td>
</tr>
<tr>
<td></td>
<td>Pool pumps</td>
<td>DLC</td>
</tr>
<tr>
<td>Commercial</td>
<td>HVAC</td>
<td>Depending on site size, energy management system Auto-DR, DLC, and/or Smart T-Stats</td>
</tr>
<tr>
<td></td>
<td>Lighting</td>
<td>A range of luminaire-level, zonal and standard control options</td>
</tr>
<tr>
<td></td>
<td>Refrigerated warehouses</td>
<td>Auto-DR</td>
</tr>
<tr>
<td>Industrial</td>
<td>Processes and large facilities</td>
<td>Automated and manual load shedding and process interruption</td>
</tr>
<tr>
<td></td>
<td>Agricultural pumping</td>
<td>Manual, DLC, and Auto-DR</td>
</tr>
<tr>
<td></td>
<td>Data centers</td>
<td>Manual DR</td>
</tr>
<tr>
<td></td>
<td>Wastewater treatment and pumping</td>
<td>Automated and manual DR</td>
</tr>
</tbody>
</table>

NREL Flexible Load Futures

Figure 16. Total flexible load (left) and flexible load share of total load (right)

Only moderate end-use technology advancement cases are shown.

Source: “NREL Electrifications Futures Study” (2020)
Brattle National Potential 2030

The national potential for load flexibility

A portfolio of load flexibility programs could triple existing DR capability, approaching 200 GW (20% of system peak) by 2030

U.S. Cost-Effective Load Flexibility Potential

Distribution Sited Resources Will Become Smarter & Interactive with Flexible Load

- And there is more, we haven’t even talked about:
  - Grid Integrated Efficient Buildings
  - Smart, interactive solar
  - Smart, interactive batteries
  - Resilience hubs and microgrids
III. Utilities will Evolve as Open Access and Outcome-Based Regulation Emerge

- Outcome-based regulation will align utility compensation with facilitating the fleet of Flexible Load, Storage, DG, GEBs, and Microgrids
- Utilities will finally become non-discriminatory open access providers and facilitators on electric distribution systems driven by energy optimization
The Basics: Smart Rate Design
Rate design should make the choices the customer makes to optimize their own bill consistent with the choices they would make to minimize system costs.
Algorithm for Socially Efficient Price Signals

1. Start with short-run marginal costs where you can
2. Layer in long-run marginal costs
3. Add any unpriced externalities
4. End by allocating and pricing “residual” costs that must be recovered through rates
RAP has described how technological change and the emergence of DERs affect residential rate design.

And RAP’s Lead Article In Ahmad’s EJ Special Issue On Rate Design in October 2018 provides Non-Residential Rate Design guidance.
Principle #1

A customer should be allowed to connect to the grid for no more than the cost of connecting to the grid.
Principle #2

Customers should pay for the grid and the power supply in proportion to how much they use and when they use it.
Principle #2

Customers should pay for the grid and the power supply in proportion to how much they use and when they use it.
Principle #3

Customers delivering services to the grid should receive the full and fair value – no more and no less.
## Advanced Residential Rate Design

<table>
<thead>
<tr>
<th>Cost Recovery Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Charge ($/mo.)</td>
</tr>
<tr>
<td>$10</td>
</tr>
<tr>
<td>Site Infrastructure ($/individual NCP kW)</td>
</tr>
<tr>
<td>$1</td>
</tr>
<tr>
<td>Bidirectional Distribution Network Charge (Cents/kWh on imports and exports)</td>
</tr>
<tr>
<td>5 cents</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symmetric Charges and Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-peak (cents/kWh)</td>
</tr>
<tr>
<td>5 cents</td>
</tr>
<tr>
<td>Mid-peak (cents/kWh)</td>
</tr>
<tr>
<td>12 cents</td>
</tr>
<tr>
<td>On-peak (cents/kWh)</td>
</tr>
<tr>
<td>28 cents</td>
</tr>
<tr>
<td>Critical peak (cents/kWh)</td>
</tr>
<tr>
<td>75 cents</td>
</tr>
</tbody>
</table>
Pitfall: Most Commercial Rate Design Does Not Align Pricing with System Costs
Non-Res Problems & Solutions

**Problem #1:** Most non-residential rates do not align customer rates with system costs

**Solution #1:** Non-Coincident Peak (NCP) Demand Charges should be lower

**Problem #2:** Technological change and the emergence of DERs (including ZEVs) make improvement necessary

**Solution #2:** Time-of-Use Rate Design reflects system costs better than non-coincident (NCP) and coincident peak (CP) demand charges
A Typical Rate for Large NR Customers (Generic)

Customer Charge: $100/month

Demand Charge: $10/kW

Energy Charge: $0.12/kWh
What’s the problem?

Customer Charge: $100/month

Demand Charge: $10/kW
Not Linked to System Conditions

Energy Charge: $0.12/kWh
Not Time-Differentiated
Pitfall: Dynamic Pricing Will Reach It’s Potential But Not The Optimal Default Tariff Yet
Dynamic Pricing Can Be Effective If:

- LMP and CRR exist down to the feeder
- Free entry and exit on the distribution system
- Utility has the opportunity to be revenue adequate
- Political tolerance for scarcity pricing exists
Dynamic Pricing Is Not Yet Optimal Because:

- Distribution system over-built (analog tech)
- Structural change massive (digital tech)
- Barriers to entry on the distribution system
- Embedded cost recovery
- Political tolerance for scarcity pricing low in many places
Pitfall: Beware - Subscription Pricing Can Be Done Poorly
Some Questions to Ask about Subscription Tariffs

• Does the subscription tariff hide price signals that will discourage conservation and discourage efficient customer choice and use of DERs?
• Is the tariff from a competitive provider or subject to competitive pressure from competitive offerings?
• Does the tariff promote or deter competitive innovation?
Policy Example Pitfall: Poor Rate Design Can Deter EV Adoption And Electrification
Residential: TOU rates with a CPP

Encourage Beneficial Charging

• Sends price signals for all hours, with a strong signal deterring use in highest stress hours (may be peak, may be ramping)

• Encourages electric vehicle charging during off-peak and shoulder hours

• Flat rates and high non-coincident demand charges make EV charging artificially expensive and do not align individual choice with system benefits
What about today’s typical non-residential rate design?

- 6.6 kW @ $12/kW $66
- 250 kWh @ $.010/kWh $30

- Total Cost: $96
- Cost/kWh: $96/250 = $.38/kWh
- FLUNKS “cheaper than gasoline” test
- Demand Charge is 68% of total bill
Typical System Load Profile (without solar)

Source: LBNL
Workplace and Home Charging and the Duck Curve

Trends in resource development are leading toward a growing need for flexible generating capacity starting in 2015.

- Home Charging w/o TOU
- Workplace Charging

Net load - March 31
- 2012 (actual)
- ramp need ~13,000 MW in three hours
- over generation risk
- 2018 2019
- 2020
Comparison of Three Rates: Consequences for NR EV Adoption

<table>
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<th>Antiquated Rate</th>
<th>Coincident Peak Demand Charge</th>
<th>Smart Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand Charge</td>
<td>$10/kW</td>
<td>$10/kW</td>
<td>$2/kW</td>
</tr>
<tr>
<td>Demand Measurement</td>
<td>NCP</td>
<td>4 PM - 8 PM</td>
<td>Site Infrastructure</td>
</tr>
<tr>
<td>Energy</td>
<td>$0.12/kWh</td>
<td>$0.12/kWh</td>
<td>$.05 - $.75/kWh</td>
</tr>
<tr>
<td>Energy Measurement</td>
<td>No TOU</td>
<td>No TOU</td>
<td>TOU</td>
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# Smart Rate => Workplace EV Charging

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## Electric Vehicle Charging Cost Per Month

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<tr>
<th></th>
<th>6.6 kW</th>
<th>250 kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCP Demand</td>
<td>$ 66.00</td>
<td>$ 13.20</td>
</tr>
<tr>
<td>CP Demand</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>Energy</td>
<td>$ 30.00</td>
<td>$ 30.00</td>
</tr>
<tr>
<td>Total</td>
<td>$ 96.00</td>
<td>$ 30.00</td>
</tr>
<tr>
<td>Average $/kWh</td>
<td>$ 0.384</td>
<td>$ 0.120</td>
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Rate Design Takeaway
Rate design should make the choices the customer makes to optimize their own bill consistent with the choices they would make to minimize system costs.
About RAP & Carl

• The Regulatory Assistance Project (RAP) is an independent, non-partisan NGO dedicated to accelerating the transition to a clean, reliable efficient energy future.

• Carl is a Principal with RAP & lives in Davis, CA
  • Focused on market design, pricing and resource planning
  • Former PUC Commissioner and Energy/Economic Advisor to Governor Guinn (NV)
  • Served on EIM Governing Body
  • PhD Economics (Carolina), BA Math (UC Davis)
About RAP

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Learn more about our work at raponline.org

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