Rate Design and Electric Vehicles

Presentation for Massachusetts DEP

Regulatory Assistance Project (RAP)®

Nancy L. Seidman
www.raponline.org
Outline

• Rate Design Principles
• What’s Special about EV Charging?
• Rate Design Examples
• Summary and Resources
Rate Design Principles
Principles of Smart Rate Design

1. Customers should be able to connect to grid for no more than the cost of connecting to grid.

2. Customers should pay for grid services and power supply in proportion to how much they use these services and how much power they consume.

3. Customers who supply power to grid should be fairly compensated for full value of power they supply.
Key Terms for Rate Design

- **Customer Charge**: Fixed monthly fee to access utility service
- **Energy Charge**: Price per kilowatt-hour of consumption
- **Demand charge**: A rate charged on a customer’s highest 15- or 30-minute individual peak usage
  - Typically defined as highest non-coincident individual peak over the whole month, but sometimes during “peak window”
Key Terms for Rate Design

- **Time of Use (TOU) rate**: Time-varying kWh prices with preset times and price schedules
- **Critical peak pricing (CPP)**: Higher rate for highest 50-100 hours in year
- **Peak time rebate (PTR)**: Bill discount for reductions below baseline at peak times
- **Vehicle-to-grid**: Range of advanced programs to provide grid services from EV batteries
What’s Special about EVs?
EV Charging Opportunity

- 1,000 miles/month @ 25 mph average = 40 hours
- Driven: 40 hours/month
- Charging: 40 hours/month
- Parked: 680 hours/month

**Challenge:** Find 40 low-cost, low emission hours out of 680 hours that vehicle is parked each month.
Value of Flexibility for Integrating Renewable Energy

Avoid Home Charging during these hours

Source: California ISO
Understand the Emissions Effects of Changes in Load
Three “Levels” of EV Charging

**Level 1:** Standard household current (120 Volts)  
1.5 kW  Adds about 4 miles range per hour

**Level 2:** High capacity residential circuit (240 Volts)  
6.6 kW  Adds about 20 miles range per hour

**Level 3:** Fast commercial chargers in public areas with very large electricity connection:  
Up to 350 kW  Adds up to 200 miles in 15 minutes
Level 2 EV Charging is a Lot Like… An Electric Water Heater!
Really!

**Electric Vehicle**
- 3.3 – 6.6 kW
- 2,000 – 4,000 kWh/year
- Can avoid morning and early evening peak charging
- Batteries likely equal a full day’s supply

**Water Heater**
- 4.4 – 5.5 kW
- 2,000 – 4,000 kWh/year
- Can avoid morning and early evening peak charging
- Tank usually covers a full day’s supply
Public DC Fast Charging

- May be needed to enable the EV transformation
- Very High Capacity: 40 kW to 350 kW
Medium- and Heavy-Duty Vehicles

- Require power levels similar to fast charging
  - Similar location and rate issues
- Fleet operators have the additional issues as well
  - Route timing, battery capacity, and charging time
3 Rate Design Examples
# Residential TOU Rate

## United Illuminating (CT)

<table>
<thead>
<tr>
<th></th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Customer Charge</strong></td>
<td>$0.183</td>
<td>$0.183</td>
</tr>
<tr>
<td><strong>Off-Peak</strong></td>
<td>$0.396</td>
<td>$0.360</td>
</tr>
<tr>
<td><strong>On-Peak</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Customer Charge**: $12.84
Visual of Demand charges

- Demand = 7 kW
- Demand charge = $5/kW
- Demand charge for month = $35
### Demand Charges and Fast Charging

<table>
<thead>
<tr>
<th>Description</th>
<th>Rate</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-coincident peak demand charge</strong></td>
<td>$10/kW</td>
<td>100 kW</td>
<td>$1000</td>
</tr>
<tr>
<td><strong>Energy charge (not time-differentiated)</strong></td>
<td>$0.10/kWh</td>
<td>1000 kWh</td>
<td>$100.00</td>
</tr>
<tr>
<td><strong>Total bill</strong></td>
<td></td>
<td></td>
<td>$1100.00</td>
</tr>
<tr>
<td><strong>Average $/kWh</strong></td>
<td></td>
<td></td>
<td>$1.10</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Rate</th>
<th>Quantity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Non-coincident peak demand charge</strong></td>
<td>$2/kW</td>
<td>100 kW</td>
<td>$200.00</td>
</tr>
<tr>
<td><strong>Energy charge</strong></td>
<td>$0.12</td>
<td>1000 kWh</td>
<td>$120.00</td>
</tr>
<tr>
<td><strong>Total bill</strong></td>
<td></td>
<td></td>
<td>$320.00</td>
</tr>
<tr>
<td><strong>Average $/kWh</strong></td>
<td></td>
<td></td>
<td>$0.32</td>
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## Illustrative Smart Rate Design

<table>
<thead>
<tr>
<th></th>
<th>Residential</th>
<th>Medium C&amp;I</th>
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</thead>
<tbody>
<tr>
<td>Customer Charge ($/mo.)</td>
<td>$4</td>
<td>$20</td>
</tr>
<tr>
<td>Site Infrastructure ($/kW)</td>
<td>$1</td>
<td>$2</td>
</tr>
<tr>
<td>Off-peak (cents per kWh)</td>
<td>7 cents</td>
<td>5 cents</td>
</tr>
<tr>
<td>Mid-peak (cents/kWh)</td>
<td>9 cents</td>
<td>8 cents</td>
</tr>
<tr>
<td>On-peak (cents/kWh)</td>
<td>14 cents</td>
<td>13 cents</td>
</tr>
<tr>
<td>Critical peak (cents/kWh)</td>
<td>75 cents</td>
<td>75 cents</td>
</tr>
</tbody>
</table>
New PG&E Commercial EV rate design proposal

1) Customers choose subscription level, based on charging needs

Subscription Charge

$184 / 50 kW connected charging

Customers that want to manage charging loads can opt for a lower subscription level.

2) Subscription remains consistent month-to-month

If site charging power exceeds subscription, customer pays an average for that month.

3) Energy usage is billed based on time-of-day pricing

Energy Charge

11¢ / kWh | 9¢ / kWh | 30¢ / kWh

Charging is cheapest mid-day, when PG&E has higher levels of renewable energy generation.

Customers should avoid charging during peak hours from 4-10 p.m., when possible.
“Fueling” EVs

100,000 EVs =

116 MW of wind
(37% capacity factor)

154 MW of solar
(27% capacity factor)

52 MW of natural gas
(80% capacity factor)
What’s 100 MW worth in health benefits?

Annualized capital cost
$20.2 million
(37% capacity factor)

Annualized capital cost
$12.2 million (27% capacity factor)

<table>
<thead>
<tr>
<th>Health Benefits</th>
<th>Low values, 3% discount ($ millions)</th>
<th>High value, 3% discount ($ millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northeast (Wind)</td>
<td>5.0</td>
<td>11.2</td>
</tr>
<tr>
<td>Northeast (Solar)</td>
<td>4.6</td>
<td>10.4</td>
</tr>
</tbody>
</table>
2018 marginal emissions in New England

PJM NOx emissions 2014-2018

Other Rate Design Considerations

- Flat rates are typically cheaper than gasoline
- Customers will shift to lower-cost hours
- Demand charges cause significant issues for low utilization fast chargers
- Low-emission hours and low-cost hours may be different periods
- Smart charging may be an alternative to smart rate design
Conclusions

• Rate design affects air quality
• DEP can explain why – Collaboration is key
• Knowing grid marginal emissions helps design rates and improve charging options
• Utilize flexible demand to meet air quality goals
Resources from RAP

- Smart Rate Design for a Smart Future
- Taking First Steps: Insights for States Preparing for Electric Transportation
- Beneficial Electrification: 4 part series
- Principles of Modern Rate Design
- Smart Non-Residential Rate Design
- Getting from here to there – Regulatory Considerations for Transportation Electrification
- EV grid blog post – Calming Chicken Little
- Value Added: Measuring the Health Benefits of Energy Efficiency and Renewables
About RAP

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

Learn more about our work at raponline.org

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EPA’s health benefits per kilowatt-hour (BPK) values

Use to quickly estimate the monetary value of health benefits from reductions in fine particulate matter (PM$_{2.5}$) due to energy efficiency (EE) and renewable energy (RE)

- Free
- Easy to use
- Peer-reviewed

BPK values (¢/kWh) are available for:

- 10 regions of the United States
- Solar, wind, uniform and peak EE

Technical report provides details on methodology and appropriate uses
EPA used existing tools and expert input to develop the BPK values

**Scenarios**

- **Wind** 100 MW
- **Solar** 100 MW
- **Uniform EE** 500 GWh
- **Peak EE** 200 GWh (12-6 pm weekdays)

**AVERT**

- Estimate changes in electricity generation
- Estimate changes in emissions of NOx, SO2, and primary PM2.5

**COBRA**

- Estimate air quality changes (primary and secondary PM2.5)
- Estimate dollar value of public health benefits

**Health Benefits**

- Regional factors (¢/kWh) for estimating the monetized health benefits of kWh saved through EE or generated through RE
2016 marginal emissions in New England