Residential Rate Design and Electric Vehicles

Presentation for US EPA

The Regulatory Assistance Project (RAP)®

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www.raponline.org
1 Introduction
What does this rate design say?

$1.50  $2.25  $2.75
Price Can Influence When EVs Are Charged

Dallas/Ft Worth
(standard rates)

San Diego
(time-of-use rates)

Copied from: M.J. Bradley, 2017
Outline

• Beneficial Electrification and Electric Vehicles
• Smart Rate Design – General Principles & Terms
• Residential Rate Design Examples, Electric Vehicle Considerations
• Multi-family Residential Charging and Non-Residential Issues Identification
• Fast Charging and Medium, Heavy-duty Vehicle Issues
• Discussion
What makes electrification beneficial?

Three Criteria: Achieve at Least One Without Adversely Impacting the Others

1. Saves Customers Money Long-Term; New Services
2. Reduces Environmental Impacts
3. Enables Better Grid Management
Understand the Emissions Effects of Changes in Load
The Grid Is Getting Cleaner

Marginal Units by Fuel

PJM System Data
MISO marginal fuels - winter

Source: MISO 2017-2018 Winter Assessment Report, April 2018
Recognize the Value of Flexible Load for Grid Operations
Value of Flexibility for Integrating Renewable Energy

Avoid Home Charging during these hours

Source: California ISO

Workplace Charging

Regulatory Assistance Project (RAP)®
Design Rates to Encourage Beneficial Electrification
What’s special about EVs?
“Fueling” EVs

100,000 EVs =

116 MW of wind
(37% capacity factor)

52 MW of natural gas
(80% capacity factor)

154 MW of solar
(27% capacity factor)
Electric Vehicles Are A Lot Like Water Heaters
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 supplies a full day’s supply
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

Not Residential
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. Put a smart charging station there.
3 Rate Design Principles
Key Terms for Rate Design:

- **Time of Use (TOU):** Time-varying price for energy.
- **Non-Coincident Peak (NCP) Demand:** A customer’s highest usage during the month.
- **Coincident Peak (CP) Demand:** A customer’s usage during the period of system maximum usage.
Key Terms for Residential Rate Design:

• **Customer Charge**: Fixed monthly fee to access utility service

• **Energy Charge**: Price per kilowatt-hour of consumption

• **Demand charge**: Monthly fee based on the highest instantaneous usage rate (usually highest hour) during the month or year. (CP or NCP)
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 in proportion to how much they use the grid, and when they use the grid.
Principle #2

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

Customers delivering power to the grid should receive full and fair value—no more and no less.
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.
4 Rate Design Examples
Types of Residential Rates

- Flat Rate
- Seasonal Rate
- Inclining Block Rate
- Time-of-Use Rate
- Combined Inclining Block / TOU Rate
- Critical Peak Pricing / Peak-Time Time Rebates
## Flat Rate

<table>
<thead>
<tr>
<th>Indiana–Michigan Power (Indiana)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Customer Charge</strong></td>
<td>$7.30/month</td>
</tr>
<tr>
<td><strong>Energy Charge</strong></td>
<td>$0.08634/kWh</td>
</tr>
</tbody>
</table>
Unbundled Flat Rate (Typical in Restructured Regions)

<table>
<thead>
<tr>
<th>Northwestern Utilities (Montana)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Charge</td>
<td>$5.25/month</td>
</tr>
<tr>
<td>Delivery Charge</td>
<td>$0.0285/kWh</td>
</tr>
<tr>
<td>Power Charge</td>
<td>$0.0645/kWh</td>
</tr>
</tbody>
</table>
# Flat Rate/Seasonal

## Xcel Energy (Minnesota)

<table>
<thead>
<tr>
<th></th>
<th>Summer Energy</th>
<th>Winter Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Charge</td>
<td>$8.00/month</td>
<td>$0.0739/kWh</td>
</tr>
<tr>
<td>Summer Energy</td>
<td>$0.0867/kWh</td>
<td></td>
</tr>
<tr>
<td>Winter Energy</td>
<td></td>
<td>$0.0739/kWh</td>
</tr>
</tbody>
</table>

## Newfoundland Power

<table>
<thead>
<tr>
<th></th>
<th>Summer</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per kWh</td>
<td>$0.0965/kWh</td>
<td>$0.1190/kWh</td>
</tr>
</tbody>
</table>
Most Common Residential Rate Design: Inclining Block

Goals include:

- Allocate low-cost resources
- Encourage conservation
- Provide essential needs at affordable cost
- Recognizes lower cost of apartment service
# Residential Inclining Block Rate

**City of Palo Alto (California)**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>Customer Charge</strong></td>
<td>None</td>
</tr>
<tr>
<td><strong>First 300 kWh</strong></td>
<td>$0.096/kWh</td>
</tr>
<tr>
<td><strong>Next 300 kWh</strong></td>
<td>$0.130/kWh</td>
</tr>
<tr>
<td><strong>Over 600 kWh</strong></td>
<td>$0.174/kWh</td>
</tr>
</tbody>
</table>
Rate Designs That Encourage Off-Peak Charging of EVs

• Well-designed Time of Use Prices (TOU)
• Critical Peak Price (CPP)
• Peak Time Rebates
• Transparent Real Time Prices (RTP)
### Example TOU Rate:

<table>
<thead>
<tr>
<th>City of Tallahassee, Florida</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Charge</td>
</tr>
<tr>
<td>Off-Peak</td>
</tr>
<tr>
<td>On-Peak</td>
</tr>
</tbody>
</table>
TOU and Inclining Block Rates Have Very Different Impacts on EVs

<table>
<thead>
<tr>
<th>Inclining Block Rate</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Charge</td>
<td>$5.00</td>
</tr>
<tr>
<td>First 500 kWh</td>
<td>$0.08</td>
</tr>
<tr>
<td>Additional kWh</td>
<td>$0.15</td>
</tr>
</tbody>
</table>
TOU and Inclining Block Rates Have Very Different Impacts on EVs

<table>
<thead>
<tr>
<th>TOU Rate</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Customer Charge</td>
<td><strong>$5.00</strong></td>
</tr>
<tr>
<td>Off-Peak</td>
<td><strong>$0.08</strong></td>
</tr>
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<td><strong>$0.15</strong></td>
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TOU and Inclining Block Rates Have Very Different Impacts on EVs

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<tr>
<th></th>
<th>TOU Rate</th>
<th>Inclining Block Rate</th>
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</thead>
<tbody>
<tr>
<td>Customer Charge</td>
<td>$5.00</td>
<td>Customer Charge</td>
</tr>
<tr>
<td>Off-Peak</td>
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<td>First 500 kWh</td>
</tr>
<tr>
<td>On-Peak</td>
<td>$0.15</td>
<td>Additional kWh</td>
</tr>
</tbody>
</table>

- TOU rate provides an incentive to charge off-peak
- EV users are likely to be larger-than-average users
- Inclining block rate will mean charging at the higher block rate(s)
## Fixed-Period TOU Rates With Inclining Block Design

### Ft. Collins, Colorado

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Charge</td>
<td>$6.16/month</td>
</tr>
<tr>
<td>Off-Peak</td>
<td>$0.066/kWh</td>
</tr>
<tr>
<td>On-Peak</td>
<td>$0.235/kWh</td>
</tr>
<tr>
<td>Tier Charge (surcharge on all usage over 700 kWh)</td>
<td>+$0.018/kWh</td>
</tr>
</tbody>
</table>
### Critical Peak Residential Rate Design

#### Cost to Connect to the Grid

<table>
<thead>
<tr>
<th>Service</th>
<th>Unit</th>
<th>Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billing</td>
<td>$/mo</td>
<td>$4.00</td>
</tr>
<tr>
<td>Line Transformer</td>
<td>$/kVA/Mo</td>
<td>$1.00</td>
</tr>
</tbody>
</table>

#### Energy Consumption

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Unit</th>
<th>Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-Peak</td>
<td>$/kWh</td>
<td>$0.07</td>
</tr>
<tr>
<td>Mid-Peak</td>
<td>$/kWh</td>
<td>$0.09</td>
</tr>
<tr>
<td>On-Peak</td>
<td>$/kWh</td>
<td>$0.14</td>
</tr>
<tr>
<td>Critical Peak</td>
<td>$/kWh</td>
<td>$0.74</td>
</tr>
</tbody>
</table>
Peak-Time Rebates: The Maryland Solution

Customer Charge: $7.90/month
Distribution Charge: $.0315/kWh
Default Energy: $.0766/kwh
Critical Peak Rewards: -$1.25/kWh

1 PM to 7 PM on “Energy Savings Days”

https://youtu.be/cVCq7SIJnlQ
Residential Rate Design Summary

- Flat rates are typically cheaper than gasoline
- Customers will shift to lower-cost hours
- Low-emission hours and low-cost hours may be different periods
- Smart charging may be an alternative to smart rate design
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
Load Diversity: An Important Concept in Rate Design
Individual Load Shapes Vary

Customer 1: 36% Load Factor

Customer 2: 44% Load Factor

Customer 3: 38% Load Factor

Individual Load Shapes
Diversity Between Classes
6 EV Considerations
Technology Can Help
Technology Can Help
Smart Charging: BMW-style

**FIGURE 6** BMW i ChargeForward Smart Phone App

Interface of the BMW i ChargeForward smartphone app
Keep It Simple For Consumers

Smart Charge Controller

Economy Charge
- Full by 7 AM
- $1.50

Urgent Charge
- Current Rate: $6.00

Custom Charge
- Time Needed
Green Power Subscription

Smart Charge Controller

**GREEN Power Only**
- 80% charged by 7 AM:
- $2.00

**Urgent Charge**
- Current Rate:
- $6.00

**Custom Charge**
- Time Needed
Multi-Family and Workplace Charging Issues
EVs are a Realistic Car for Urban Families Today

2013 Nissan Leaf S

$8,991 25,604 mi.

Exterior Color: Silver • Interior Color: Gray • Transmission: Single-Speed Fixed Gear • Drivetrain: FWD
But Where to Charge?
New Multifamily

- Code changes to require EV charging in assigned or shared parking spaces
- Role for Vendors
Existing Multifamily

- Much more challenging installation cost
- Requires shared spaces and chargers
- Role for Vendors
Curbside Charging

- Works well in lower-density applications
- Utility-provided or Vendor-provided
Workplace Charging

- Applicable to subset of customers
- Requires installation
- Commercial rate design issues
- Free, or vendor-provided options
8 Fast Charging
Fast Charging

- May be needed to enable the EV transformation
- Very High Capacity: **40 kW up to 350 kW**
Fast Charging Costs and Pricing

• Commercial rate “demand charges” can make this prohibitive.
• Because they are used infrequently, the demand charge can drive the cost up to $1.50/kWh, or $15/gallon equivalent.
• Commercial rate design reform needed.
• Embed capacity costs in TOU energy prices, not demand charges.
9 Medium and Heavy Duty Vehicles
Medium and Heavy Duty Vehicles

- Require power levels similar to fast charging
- Therefore, similar location, timing issues and solutions
- Transit operator considerations – routes, demand charges
- Commitment of public transit fleets to conversions depends on a favorable rate design
Recommendations/Next Steps

- Rate Design is a powerful tool
- Find low cost periods to stimulate EVs
- Ensure low cost is also low emissions
- Encourage cross agency collaboration
- Evaluate and refine your programs
Resources from RAP

- Smart Rate Design for a Smart Future
- Beneficial Electrification: Ensuring Electrification in the Public Interest
- EV grid blog post – Calming Chicken Little
- Getting from here to there – Regulatory Considerations for Transportation Electrification
- Principles of Modern Rate Design
- Smart Non-Residential Rate Design

And forthcoming, Beneficial Electrification: Considerations for Transportation
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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