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Rate Design to Maximize Grid Benefits: Smart EV Rate Design is Smart Rate Design

CPUC ZEV Rate Design Forum

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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 and resource planning
  - Former PUC Commissioner and Energy Advisor to Governor Guinn, NV
  - Serving on EIM Governing Body
  - PhD Economics (Carolina), BA Math (UC Davis)

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.

1 What’s Special About EVs?

EV Charging Basics

- Level 2 charger draws 6.6 kW
- 1,000 miles/month @ 4 miles/kWh = 250 kWh
- This equals 38 hours of charging out of 720 hours/year
- Or, in electric terms, a **5% load factor**
- Any form of demand charge that takes the 6.6 kW into account will be a significant part of the bill
- 1 gallon (40 miles) = ~10 kWh (40 miles)

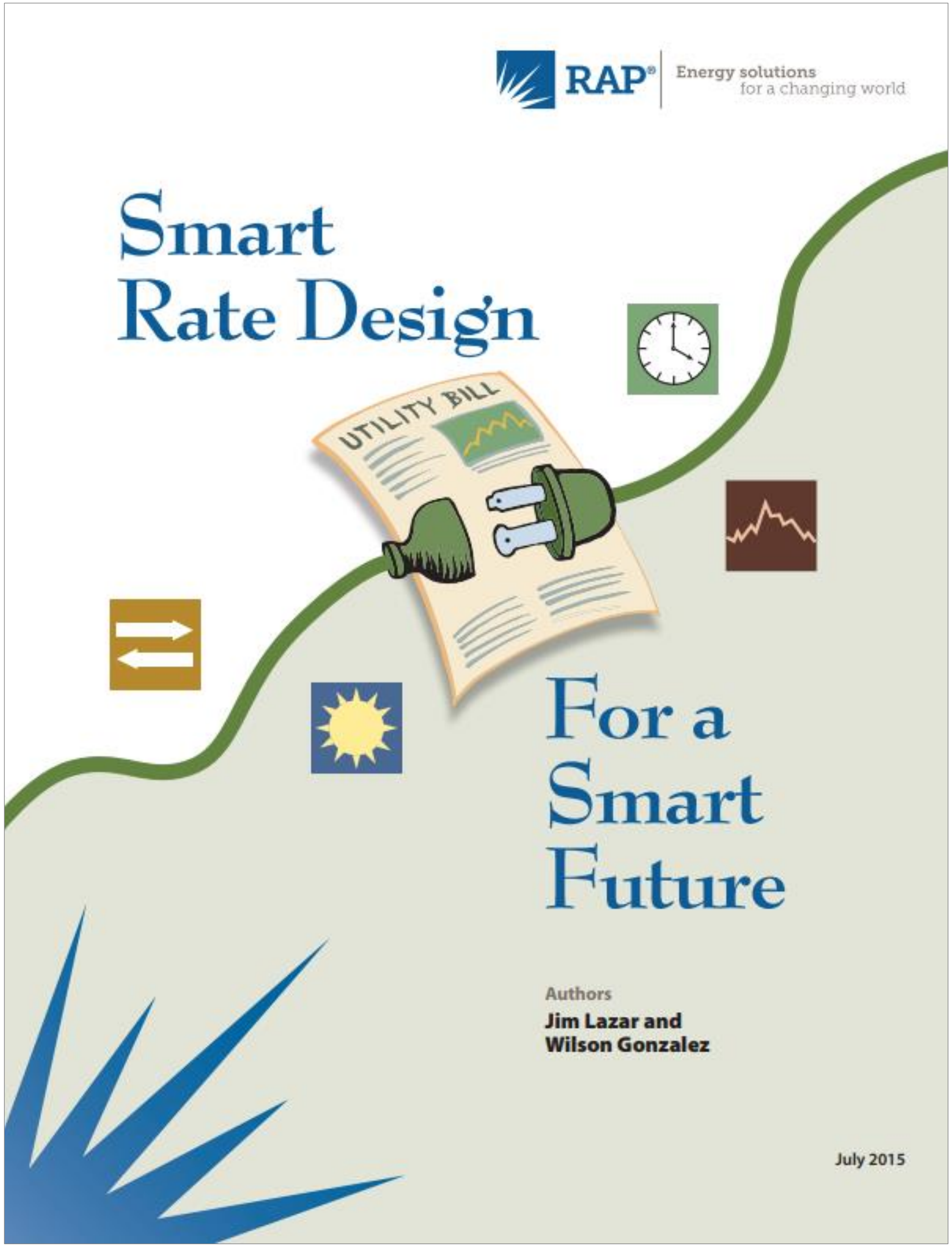
EV Charging Opportunity

- 1,000 miles/month @ 25 mph average = 40 hours
- Driven: 40 hours/month
- Parked: 680 hours/month
- Charging: 38 hours/month

We should be able to find 38 low-cost hours out of the 680 hours that vehicle is parked each month!

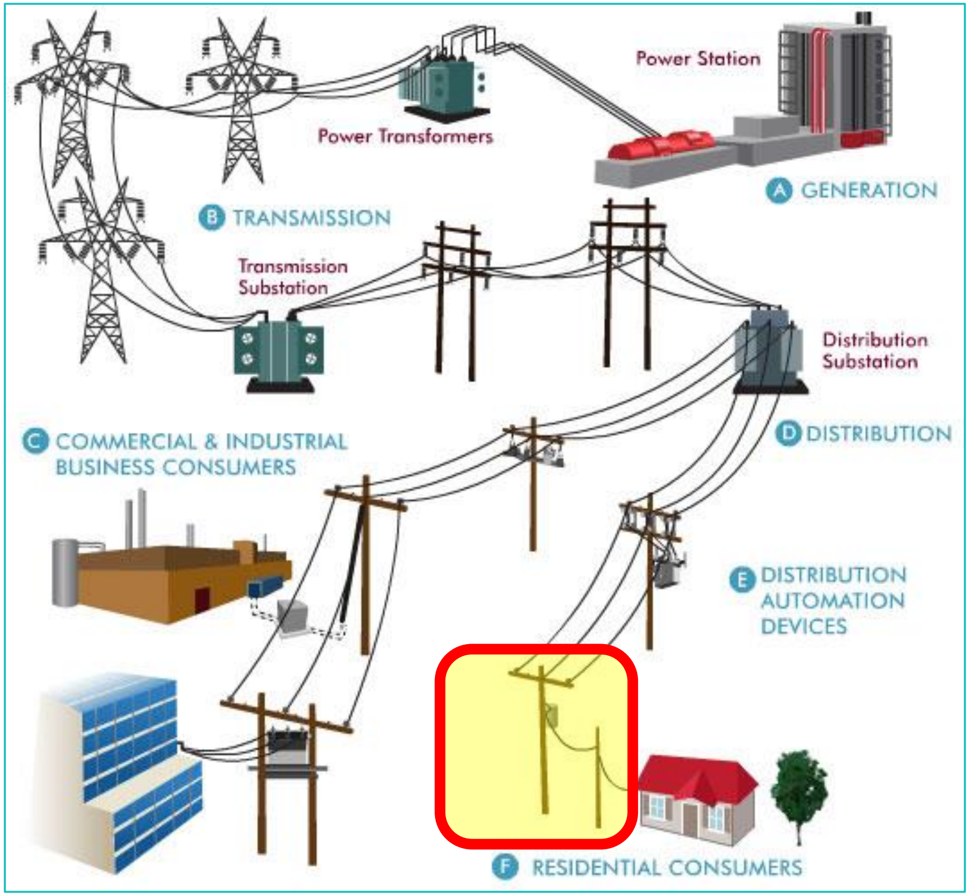
2 Smart Rate Design?

RAP has described how technological change and the emergence of DERs affect residential rate design.



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.

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Principle #3

Customers delivering services to the grid should receive the full and fair value – no more and no less.

Bottom Line: Smart Rates (Generic)

Customer-Specific Charges		
Customer Charge	$/Month	$ 3.00
Transformer:	$/kVA/Mo	$ 1.00

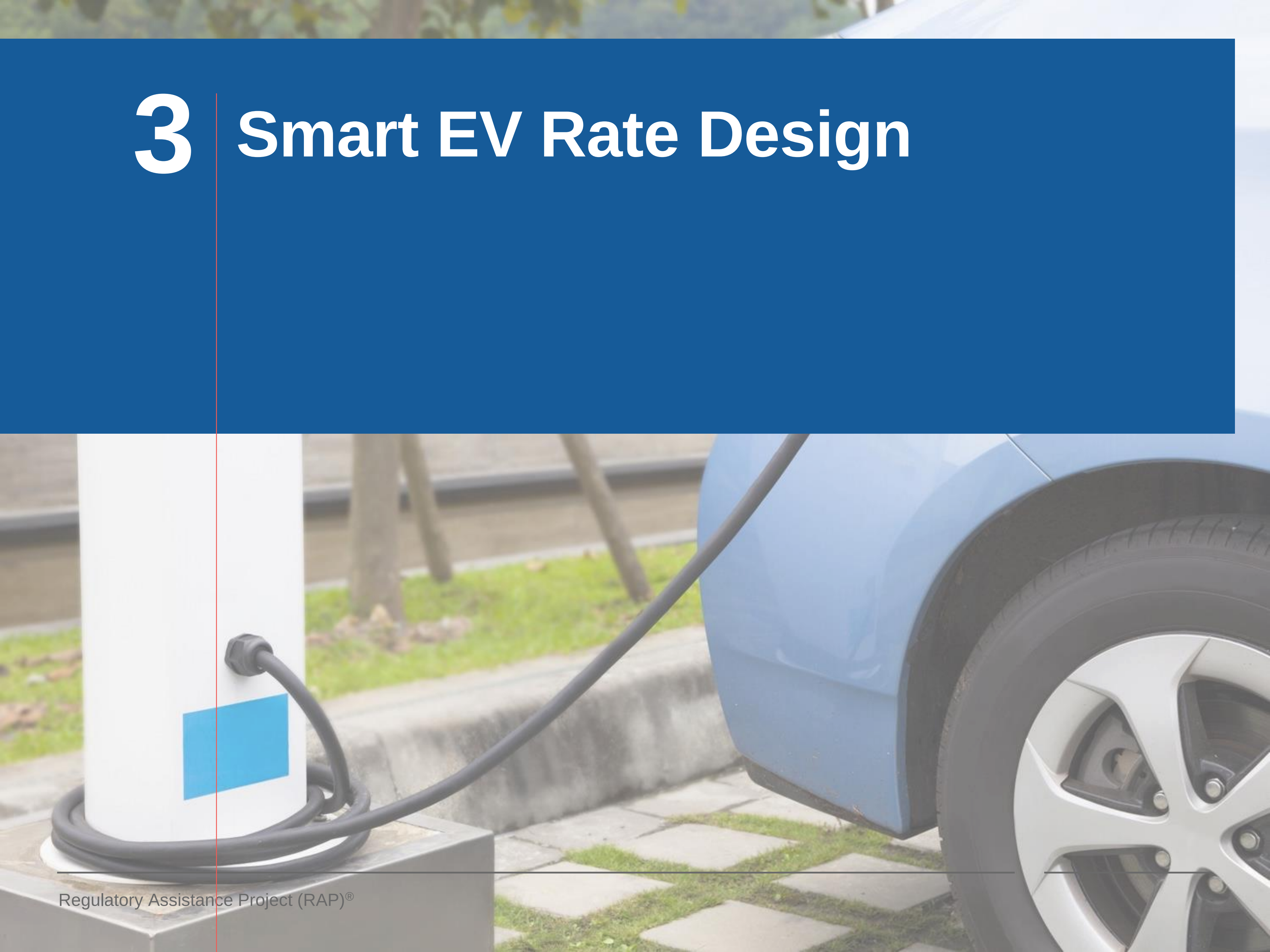
Energy Charges

Off-Peak	$/kWh	$ 0.08
Mid-Peak	$/kWh	$ 0.12
On-Peak	$/kWh	$ 0.18

Smart Rate Flourishes for CA (and elsewhere)

- TOU Smart Rate Flourishes:
  - Add time periods, consider CPP & feather TOU periods
  - Unbundle distribution rates (TOU)
    - Transaction & consumption volumes
    - Location specific impacts can be handled through bill credits
- Granular (location and time) dynamic rates will emerge but TOU rates needed for 5+ years

3 Smart EV Rate Design



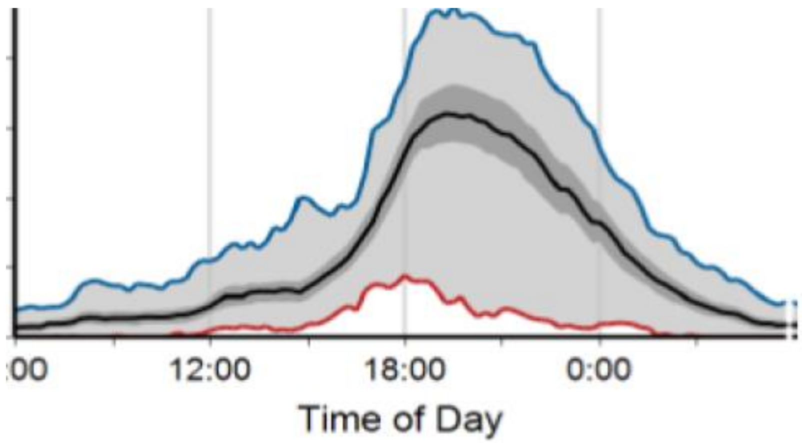
Rate design should make the choices the customer makes to minimize their own bill consistent with the choices they would make to minimize system costs.

TOU rates with a CPP encourage beneficial charging behavior

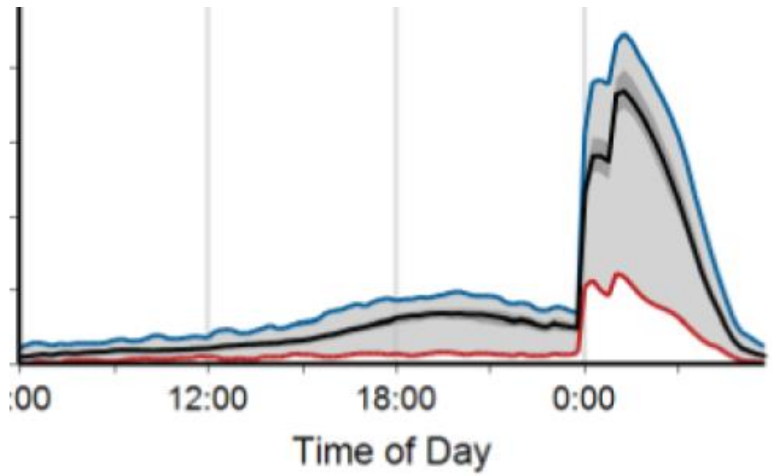
- Recognizes the system benefit of sharing infrastructure capacity
- Sends price signals for all hours, with a strong signal deterring use in highest stress hours (may be peak, may be ramping)
- Encourages electric vehicle charging during off-peak and shoulder hours
- Also: encourages use of air conditioning controls, ice storage and batteries to flex use away from stress periods toward surplus periods

3a Residential Charging

Price Can Influence When EVs Are Charged



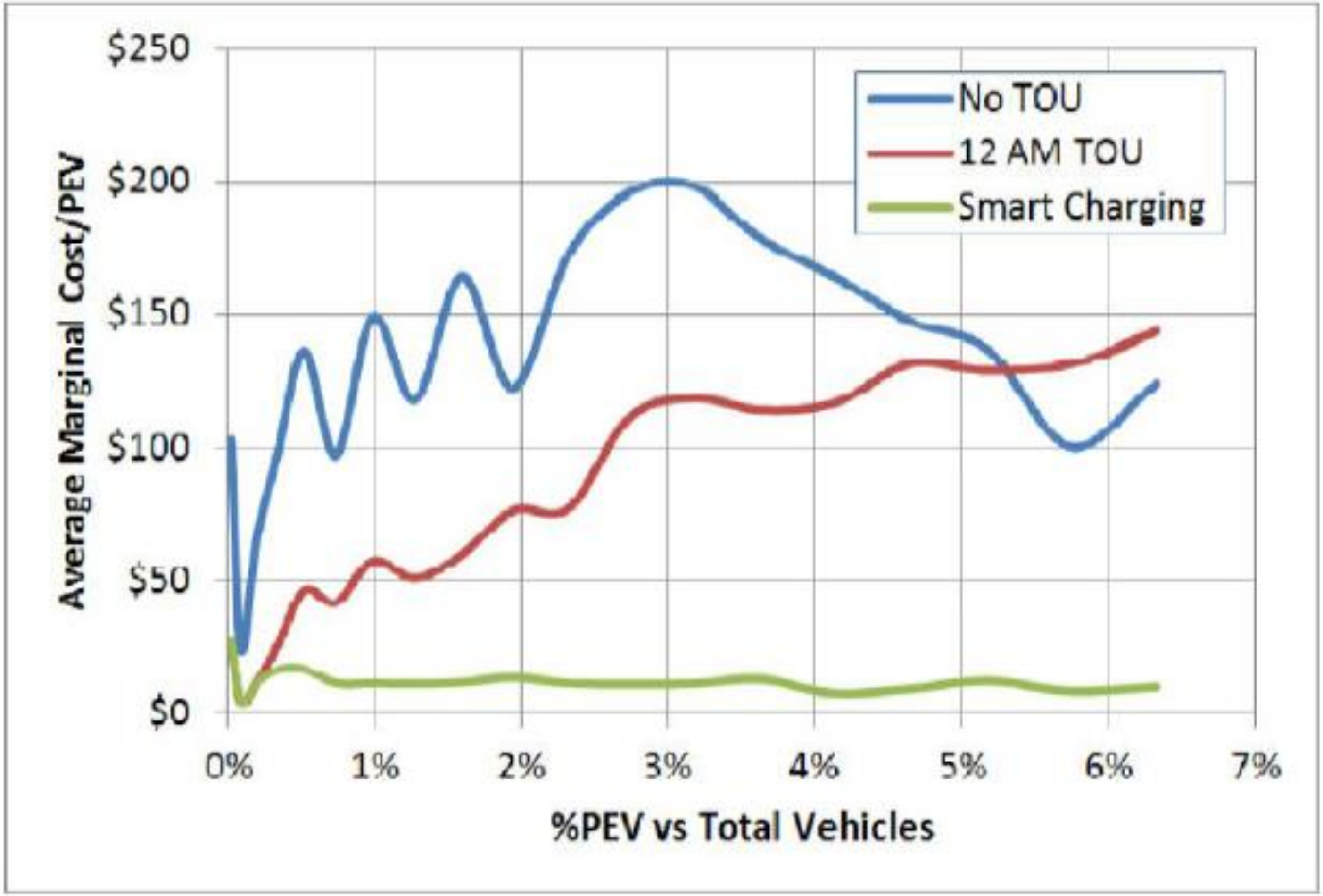
Dallas/Ft Worth
(standard rates)



San Diego
(time-of-use rates)

Copied from: M.J. Bradley, 2017

Potential Grid Savings Are Huge



Source: Berkheimer et al, SAE Paper, 2014

Current PG&E Residential Rate

Standard E-1 Tariff:
$2.80/gallon equivalent

Baseline Usage	$	0.212
100% - 400% of Baseline	$	0.280

PG&E Optional EV Tariff:
$1.30/gallon equivalent

	On-Peak	Part-Peak	Off-Peak
Summer	$0.473	$0.260	$0.128
Winter	$0.330	$0.204	$0.130

Burbank Water and Power EV Rate (Optional)

Fixed Charge		
Multi-Family		$ 10.23
Single-Family		$ 11.63
400 Amp and Larger		$ 17.23
Nights and Weekends		**$ 0.083**
Mid-Peak		$ 0.167
Summer 4 - 7 PM		$ 0.250

Smart Charging Flourishes

- Feather TOU periods
- Utility or Aggregator Control
- Beyond TOU: Dynamic Pricing

The Home Charging Challenge

One-Third of Californians Live In Multi-Unit Rental Apartments

Subject	California					
	Occupied housing units		Owner-occupied housing units		Renter-occupied housing units	
	Estimate	Margin of Error	Estimate	Margin of Error	Estimate	Margin of Error
Occupied housing units	12,807,387	+/-18,852	6,929,007	+/-37,726	5,878,380	+/-22,644
UNITS IN STRUCTURE						
1, detached	58.5%	+/-0.1	82.6%	+/-0.1	30.0%	+/-0.2
1, attached	7.0%	+/-0.1	7.0%	+/-0.1	7.0%	+/-0.1
2 apartments	2.4%	+/-0.1	0.7%	+/-0.1	4.5%	+/-0.1
3 or 4 apartments	5.6%	+/-0.1	1.1%	+/-0.1	10.8%	+/-0.1
5 to 9 apartments	6.1%	+/-0.1	1.1%	+/-0.1	12.0%	+/-0.1
10 or more apartments	16.9%	+/-0.1	2.8%	+/-0.1	33.4%	+/-0.2
Mobile home or other type of housing	3.6%	+/-0.1	4.7%	+/-0.1	2.2%	+/-0.1

4 Smart Non-Residential Rate Design

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

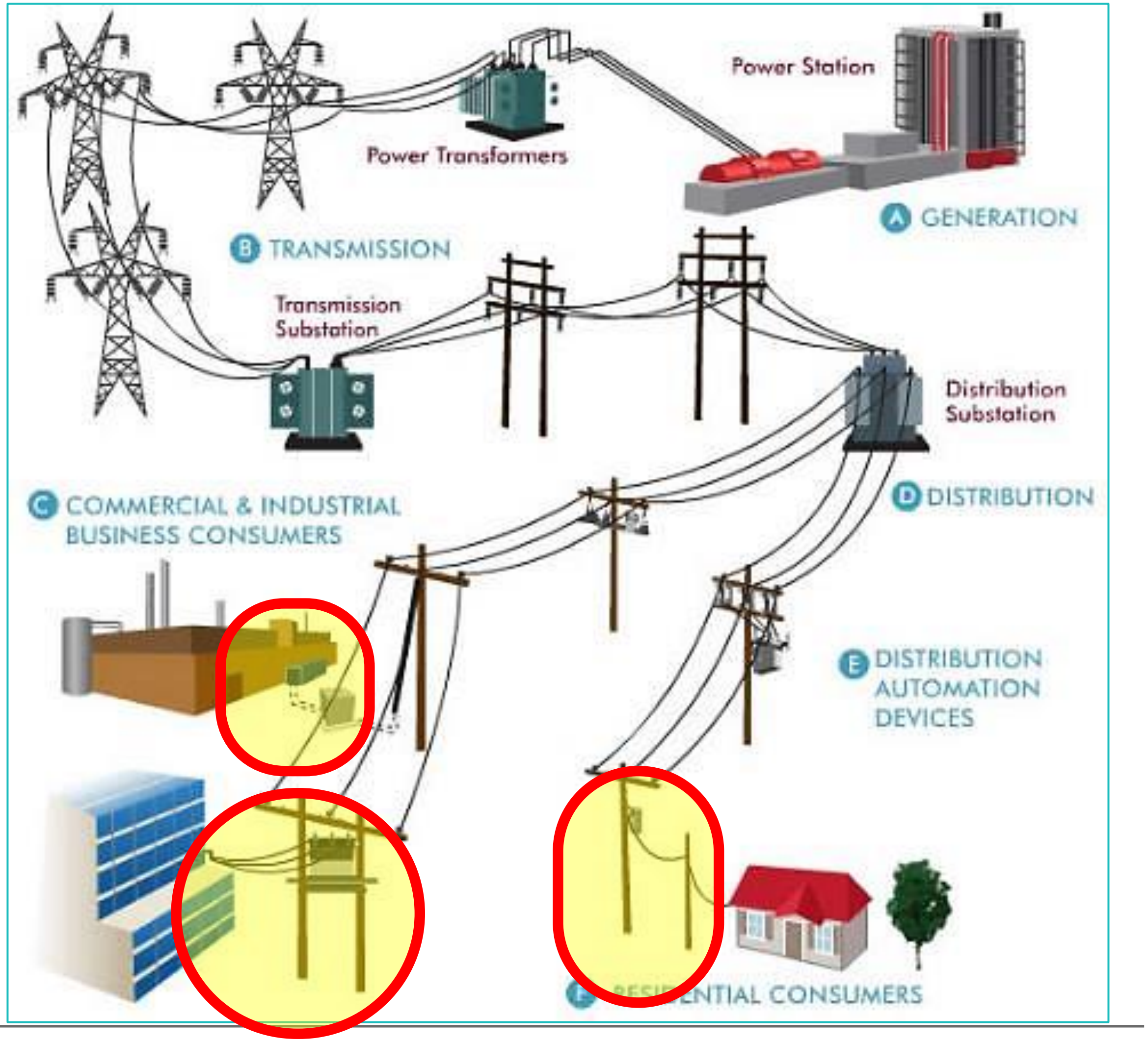
Not Linked To System Peak

Energy Charge: $0.12/kWh

Not Time-Differentiated

4a Solution #1: NCP Demand Charges Should be Lower

Costs that Vary with Customer NCP: Final Line Transformer and Service Drop



Site Infrastructure Charge

Customer Type	NCP Demand	$/kW	Site Infrastructure Charge
Small Retail or Office	20 kW	$2	$40/month
Supermarket	300 kW	$2	$600/month
Office Tower	600 kW	$2	$1,200/month
Suburban Shopping Mall	2,000 kW	$2	$4,000/month

Load Diversity Between School and Church

Weekday 4-8 PM	On-Peak	5	15	20
Weekday 9-4	Mid-Peak	5	45	50
Nights	Off-Peak	5	5	10
Weekend Day	Off-Peak	45	5	50

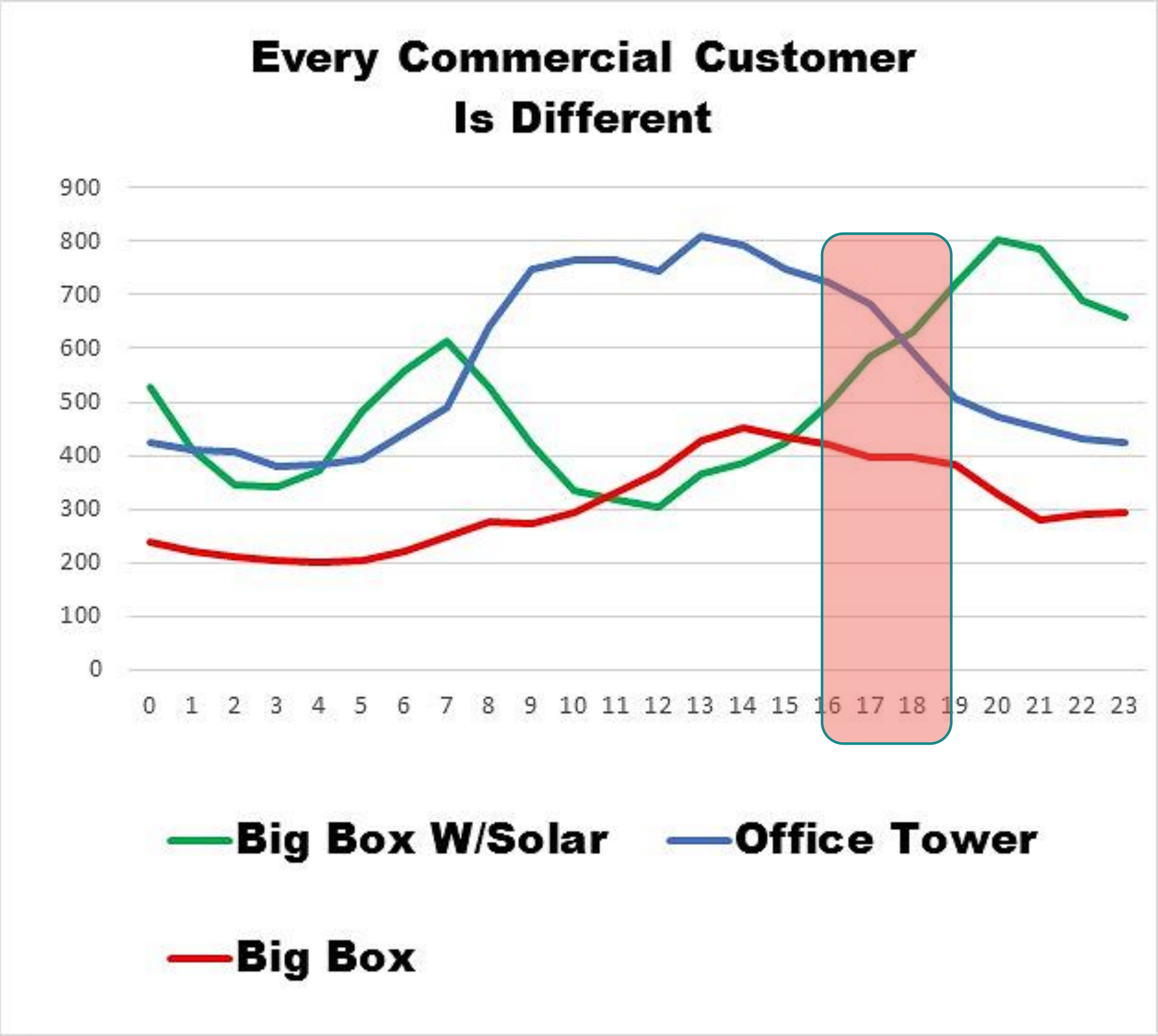
Church and School Demands Are Low During System Peak

NCP Demand Charges Fail to Reward Load Diversity

- Limit NCP Peak demand charges to site infrastructure.
- All shared generation and transmission capacity costs should be reflected in system-wide time-varying rates so that diversity benefits are equitably rewarded.

4b Solution #2: Time Of Use Rate Design Reflects System Costs Better Than Coincident Peak Demand Charges

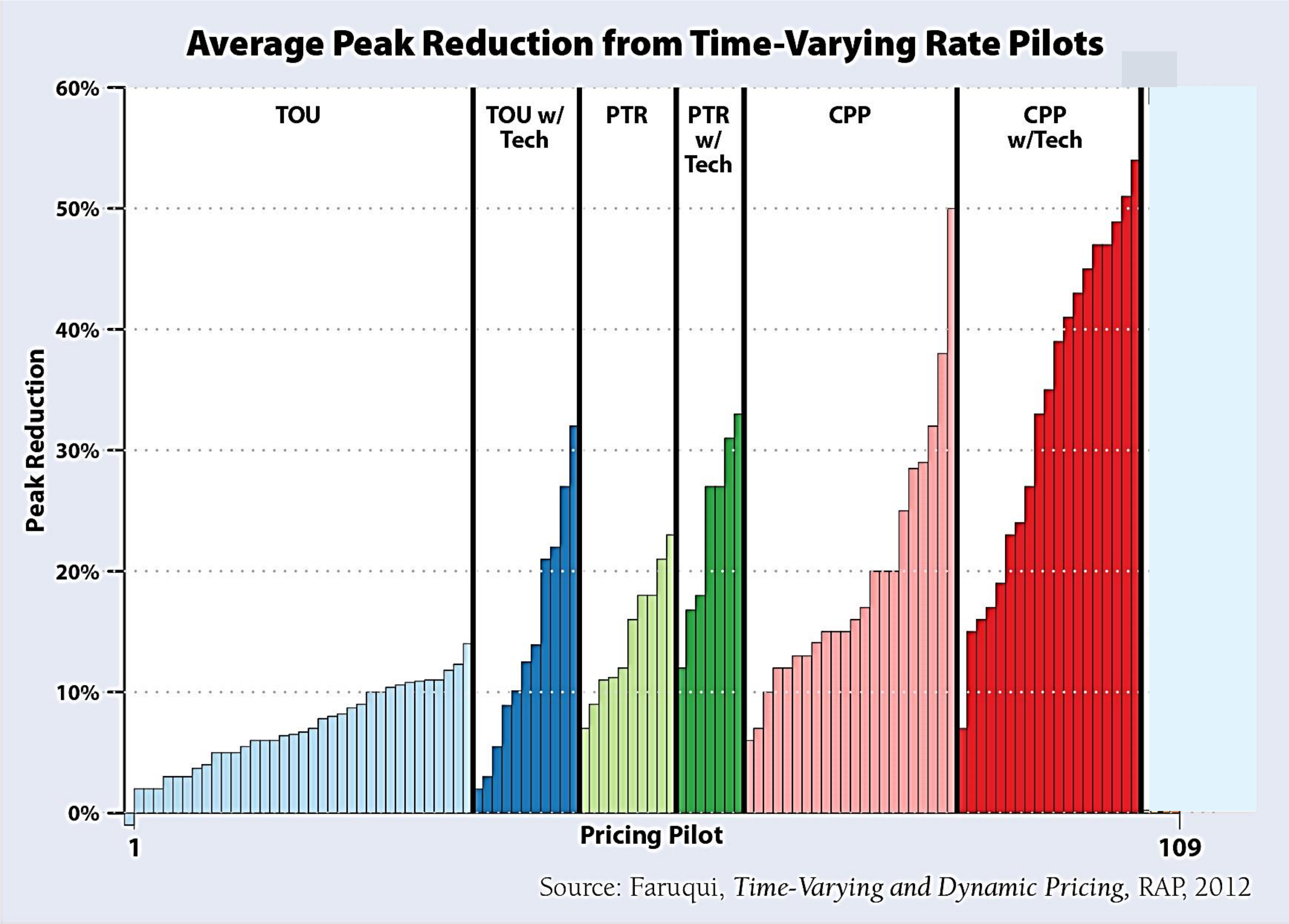
Three Actual Large Commercial Customers



None of the customers peak at the time of the system peak

Rate Designs That Address Peak Demand

- Well-designed Time of Use Prices (TOU)
- Critical Peak Price (CPP)
- Peak Time Rebates
- Transparent Real Time Prices (RTP)
- Weak: Coincident Peak Demand Charges


Average Peak Reduction from Time-Varying Rate Pilots
60%
50%
40%
30%
20%
10%
0%
Peak Reduction
TOU
TOU w/ Tech
PTR
PTR w/ Tech
CPP
CPP w/Tech
1
Pricing Pilot
109
Source: Faruqui, *Time-Varying and Dynamic Pricing*, RAP, 2012

Illustrative Future
Non-Residential Rate Design

	Production	Transmission	Distribution	Total	Unit
Metering, Billing			$100.00	$100.00	Month
Site Infrastructure Charge			$2/kW	$2/kW	kW
Summer On-Peak	$0.140	$0.020	$0.040	$0.20	kWh
Summer/Winter Mid-Peak	$0.100	$0.015	$0.035	$0.15	kWh
Summer/Winter Off-Peak	$0.070	$0.010	$0.020	$0.10	kWh
Super Off-Peak	$0.030	$0.010	$0.010	$0.05	kWh
Critical Peak	Maximum 50 hours per year			$0.75	kWh

Optional Dynamic/Real-Time Pricing

- An energy cost component, charged on a per kWh basis, that fluctuates hourly
- Tied to granular locational marginal prices
- Transmission, distribution, and residual generation costs would be collected in TOU rates

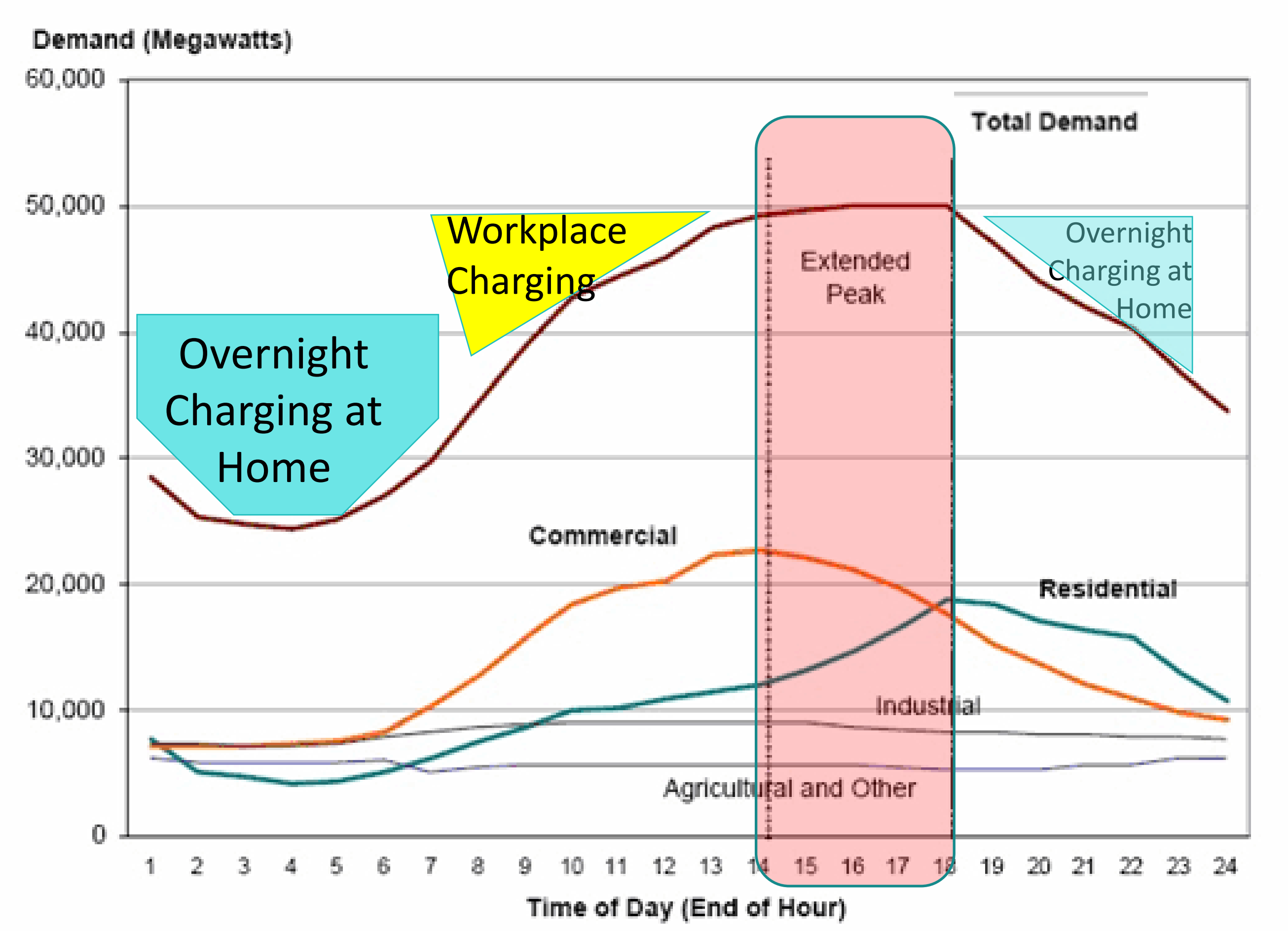
5 Workplace Charging

EV Charging On Today's Typical Non-Residential Rate

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

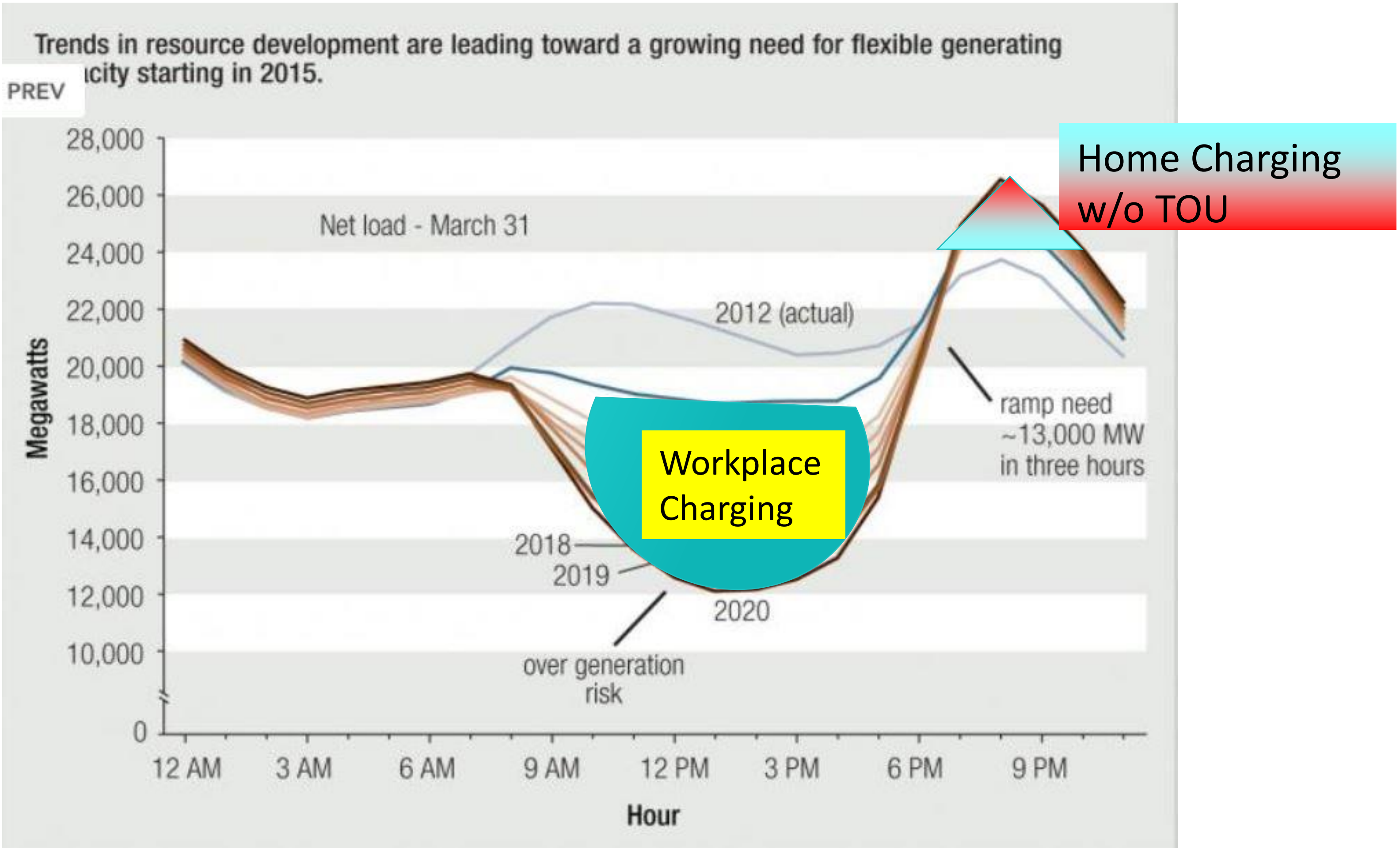
- Total Cost: $96
- Cost/kWh: $96/250 = $.38/kWh
- FLUNKS "cheaper than gasoline" test
- Demand Charge is 68% of total bill

Typical System Load Profile (without solar)



Source: LBNL

Workplace Charging and the Duck Curve



Comparison of Three Rates: Consequences for NR EV Adoption

	Antiquated Rate	Coincident Peak Demand Charge	Smart Rate
Demand Charge	$10/kW	$10/kW	$2/kW
Demand Measurement	NCP	4 PM - 8 PM	Site Infrastructure
Energy	$0.12/kWh	$0.12/kWh	$.05 - $.75/kWh
Energy Measurement	No TOU	No TOU	TOU

Smart Rate => Workplace EV Charging

	Antiquated Rate	Coincident Peak Demand Charge	Smart Rate
Demand Charge	$10/kW	$10/kW	$2/kW
Demand Measurement	NCP	4 PM - 8 PM	Site Infrastructure
Energy	$0.12/kWh	$0.12/kWh	$.05 - $.75/kWh
Energy Measurement	No TOU	No TOU	TOU

Electric Vehicle Charging Cost Per Month 6.6 kW 250 kWh

NCP Demand	$ 66.00		$ 13.20
CP Demand		$ -	
Energy	$ 30.00	$ 30.00	$ 12.50
Total	$ 96.00	$ 30.00	$ 25.70
Average $/kWh	$ 0.384	$ 0.120	$ 0.103

6 Fast Charging

Fast Charging

- May be needed to enable the EV transformation
- Expensive
- Seldom used
- May be used on-peak
- Very high demand: **40 kW** or more
  - At PG&E A-10 Demand Charges: ~**$550/month**, even if used only for **ONE fifteen minute interval** during the month
- Could exceed $1.50/kWh = $15/gallon equivalent

Fast Charging Costs and Pricing

- Need to overcome demand charge element of rate design
  - Locate at distribution substations or co-locate with other sporadic loads
  - Surge pricing during critical peak hours (locational on the distribution system if possible)
  - Charge G&T on a shared (network of chargers) basis, not individual locations
  - **Embed capacity costs in TOU energy prices, not demand charges, except local facilities**

Takeaways

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.

Resources from RAP

- Smart Rate Design for a Smart Future
- Designing Tariffs for Distributed Generation Customers
- Designing Distributed Generation Tariffs Well
- Rate Design Where Advanced Metering Infrastructure Has Not Been Fully Deployed
- Time-Varying and Dynamic Rate Design
- Use Great Caution in the Design of Residential Demand Charges
- Standby Rates for Combined Heat and Power Systems
- Standby Rates for Customer-Sited Resources: Issues, Considerations and the Elements of Model Tariffs

EXTRA SLIDES

Dynamic Prices can be Sufficient if:

1. LMP and CRR exist down to the feeder
2. Free entry and exit on the distribution system
3. Utility has the opportunity to be revenue adequate
4. Political tolerance for scarcity pricing exists

Barriers to Dynamic Pricing Keep It from Being Sufficient Today in Most Places

1. **Distribution system over-built (analog tech)**
2. **Structural change massive (digital tech)**
3. **Barriers to entry on the distribution system**
4. **Embedded cost recovery**
5. **Political tolerance for scarcity pricing low in many places**

What Does Utility Non-Residential Rate Design Actually Look Like?

- We examined:
  - Customer charges
  - Demand charges (Distribution and Generation)
  - Volumetric rates
  - Time of use rates
  - Seasonal rates

Antiquated Example Rate #1
(a real utility in the U.S.)

Customer Charge	$/Month	$ 209.00
Demand Charge	$/kW	$ 21.35
Energy Charge	$/kWh	$ 0.050

- Demand charge is based on NCP demand
- Energy Charge is not time-differentiated

Better: Example Rate #2
Georgia Power TOU-GS-10

Customer Charge	**$/Month**	**$ 209.00**
Demand Charge		
On-Peak	**$/kW**	**$ 15.66**
Maximum Peak	**$/kW**	**$ 5.23**
Energy Charge		
On-Peak	**$/kWh**	**$ 0.122**
Shoulder Peak	**$/kWh**	**$ 0.063**
Off-Peak	**$/kWh**	**$ 0.024**

- Higher coincident-peak demand charge
- 5 hour window
- Steep TOU energy rate

Sacramento Rate Design
NR Best of Class

Customer Charge	$108/month	
Site Infrastructure Charge	$3.80/kW/month	
Super Peak Demand Charge Summer weekdays 2-7 PM	$7.65/kW	
Energy Charge	Summer	Winter
Super Peak	$0.20	N/A
On-Peak	$0.137	$0.104
Off-Peak	$0.109	$0.083

About RAP

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