Basics of Cost of Service Regulation

Peter Cappers

EV Grid Assist – Rates & Incentives
October 25, 2022

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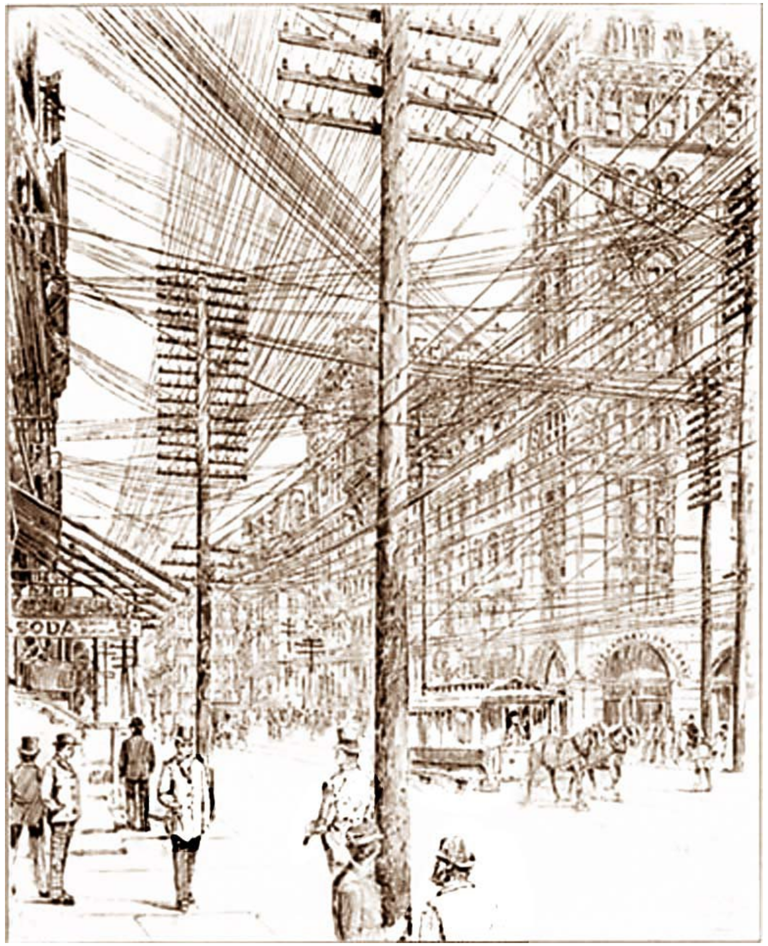
Allowing more than one company in a network industry to compete results in redundancy and higher costs



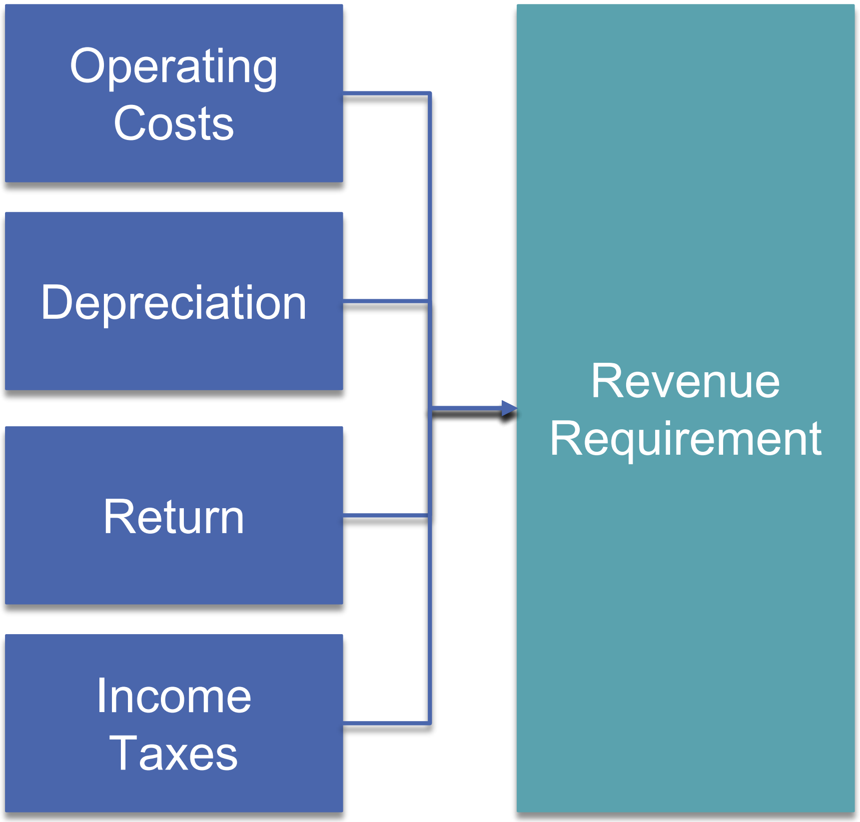
Source: https://commons.wikimedia.org/wiki/File:New_York_utility_lines_in_1890.jpg

Overview of Cost of Service (COS) Regulation

- Electric utilities are generally monopolists
- Absent a competitive market, regulators must play role of enforcing economic efficiency
- Regulators strive to approve rates that are reflective of the costs of the services rendered by utilities
  - Costs must be deemed to be prudently incurred for inclusion in rates
  - Assets paid for in rates should be used and useful
  - Rates must be deemed fair and reasonable
  - Rates must allow a utility **the opportunity** to both sufficiently recover its incurred costs and to earn returns comparable to what a similarly situated utility would achieve

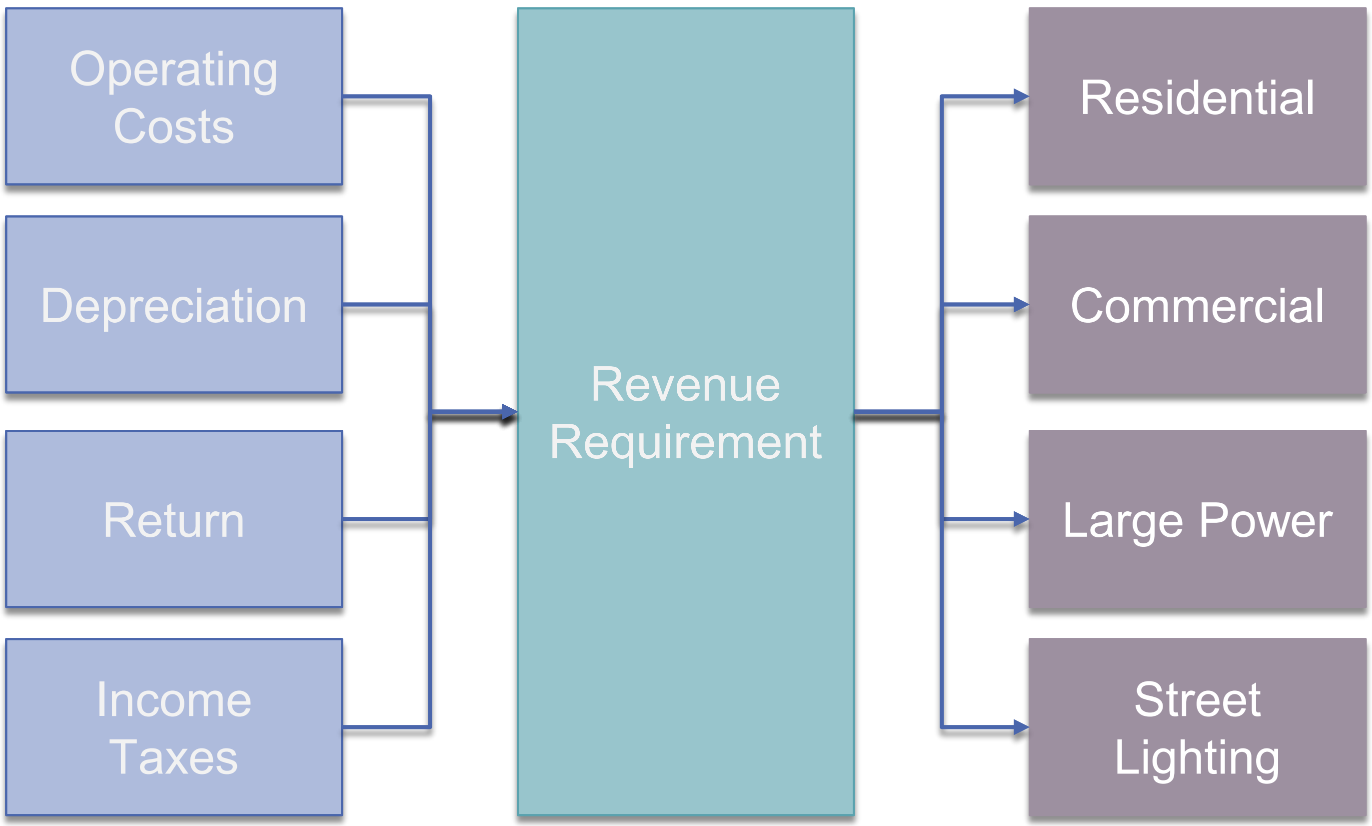
Elements of a Cost of Service (COS) Study

1. Determine the annual cost of serving all of the utility's customers



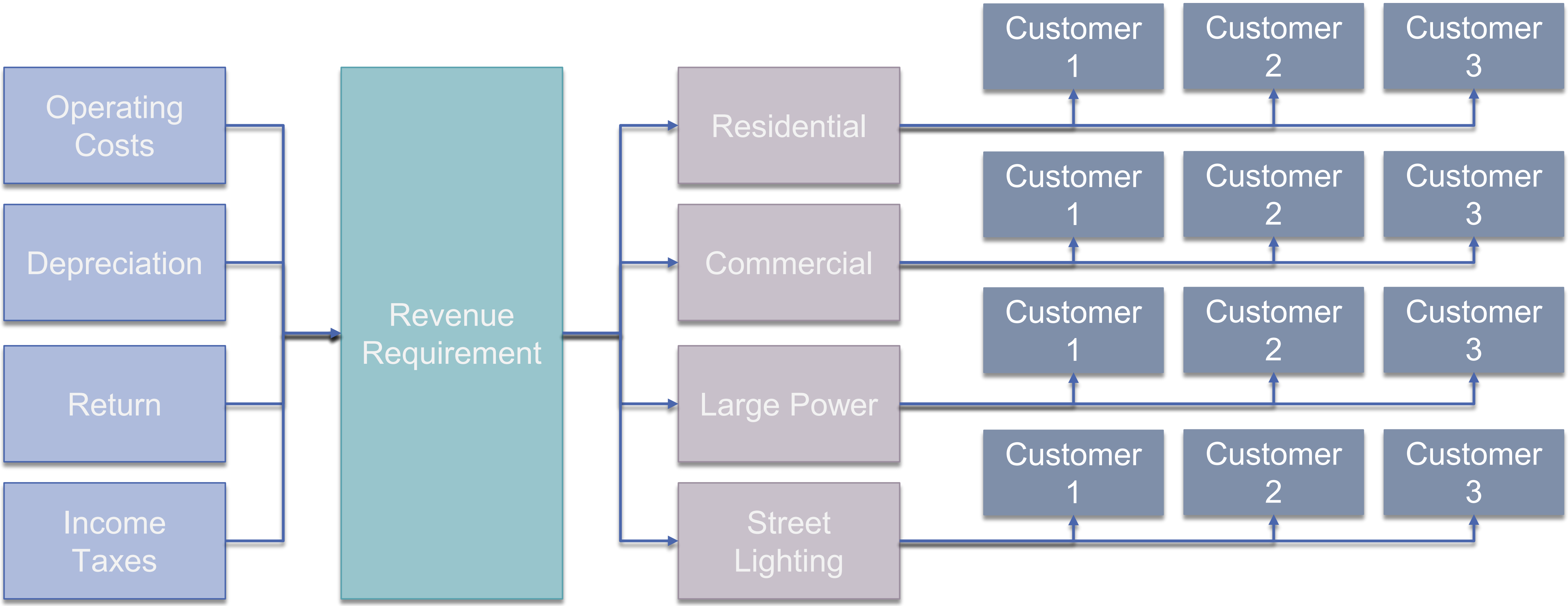
Elements of a Cost of Service (COS) Study

2. Determine the cost responsibility for each customer class



Elements of a Cost of Service (COS) Study

3. Design rates that collect class-level revenue requirement for all customers in the class



Components of Revenue Requirement (RR)

Operating Costs + **Depreciation** + **Return** + **Income Tax**

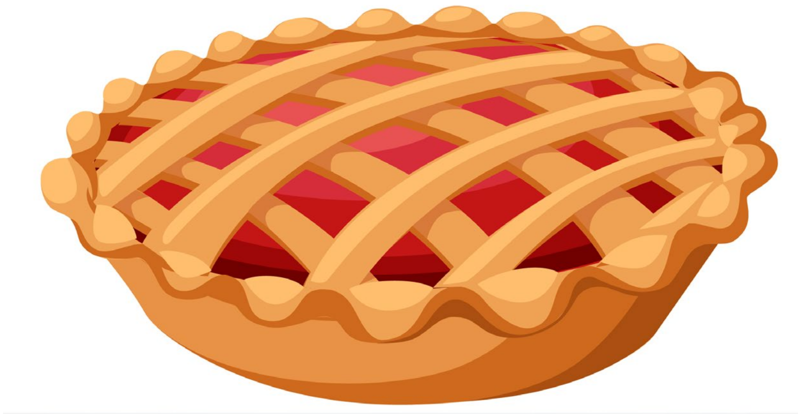
- **Example:**
  - Fuel & Purchased Power
  - Fixed O&M
  - Insurance
  - Taxes (excluding income tax)
  - Salaries

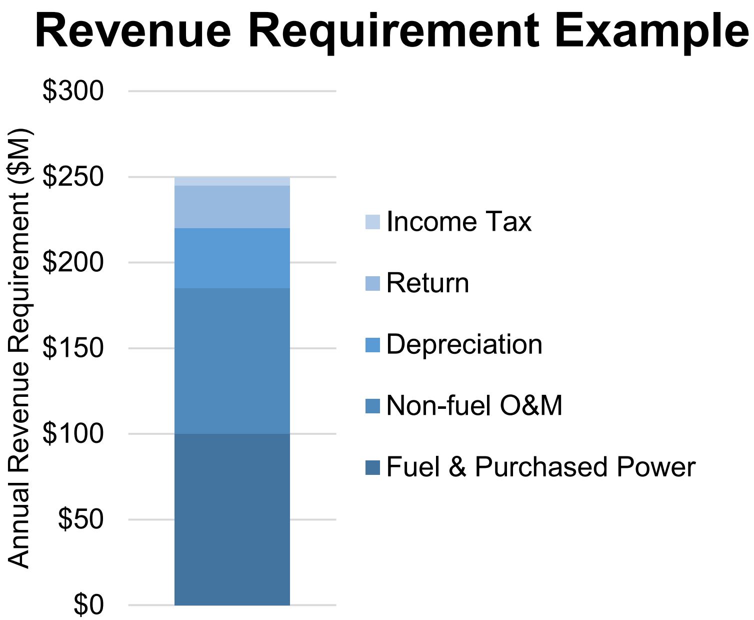
- **Example:**
  - Depreciation is return **of** utility capital invested in assets
  - Depreciation equals gross investment in assets ÷ useful life of assets
  - Collection of the depreciation amount ensures that the cost of each asset is collected equally over its useful life

- **Example:**
  - Return **on** capital invested in rate base assets
  - Debt interest
  - Equity return (ROE)

- **Example:**
  - State income tax
  - Federal income tax
  - Note income tax is not applicable to all utilities

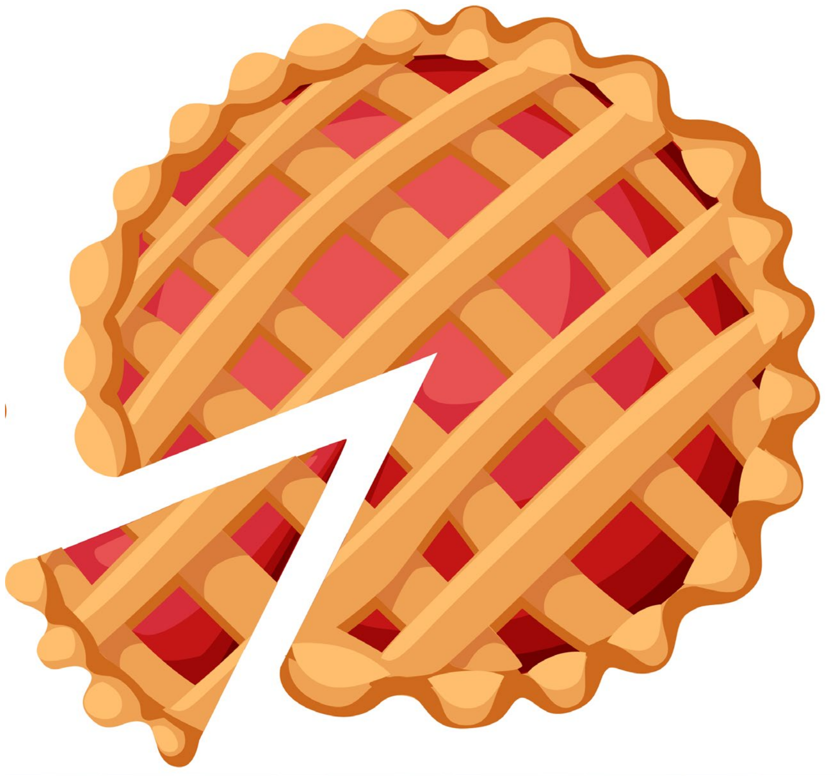
Test Year Revenue Requirement (RR)





- The annual revenue requirement amount can be compared to the size of a pie that is needed to serve all of the utility's retail customers over a year
- The "Test Year" RR is the amount used to design rates in the general rate case. This may be a recent historical value or a future projected value.

Allocation of RR to Customer Classes



- The revenue requirement allocation determines revenue requirement amount that each customer class is responsible for
- This is analogous to dividing the pie into slices that correspond to the revenue responsibility for <u>each customer class</u>

Allocation Factors Allocate RR to Customer Classes

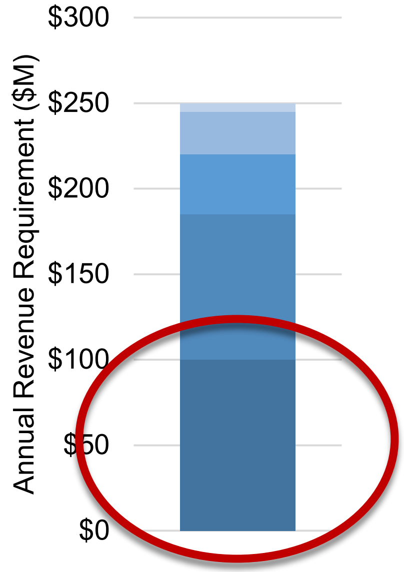
- In the cost of service study, "allocation factors" are used to allocate each cost in the revenue requirement to individual customer classes
- Allocation factors should match how costs are incurred (cost drivers)

Embedded Cost Category	Example Allocation Factors
Fuel, Variable O&M	**Energy usage** in each class (i.e., annual kWh consumption, by class)
Fixed O&M **Depreciation** **Return** **Income Tax** Cost categories: Distribution, Transmission, Generation, Customer	**Coincident Peak Demand** in each class (i.e., 1 CP, 2 CP, 4 CP, 12 CP) **Number of Customers** in each class (i.e., meters, accounts)

Cost Allocation Example:
Fuel & Purchased Power Costs

Allocation Component	Total	Residential	Commercial
Fuel & Purchased Power ($M)	**$100**		
Allocator: Energy Usage (MWh)	600,000	230,000	370,000
Allocation Factor (%)	100%	38%	62%
Allocated RR ($MM)	$100	$38	$62

Revenue Requirement Example



- This example shows the allocation of fuel & purchased power costs among residential and commercial customer classes using an energy usage (MWh) allocator

Rate Design

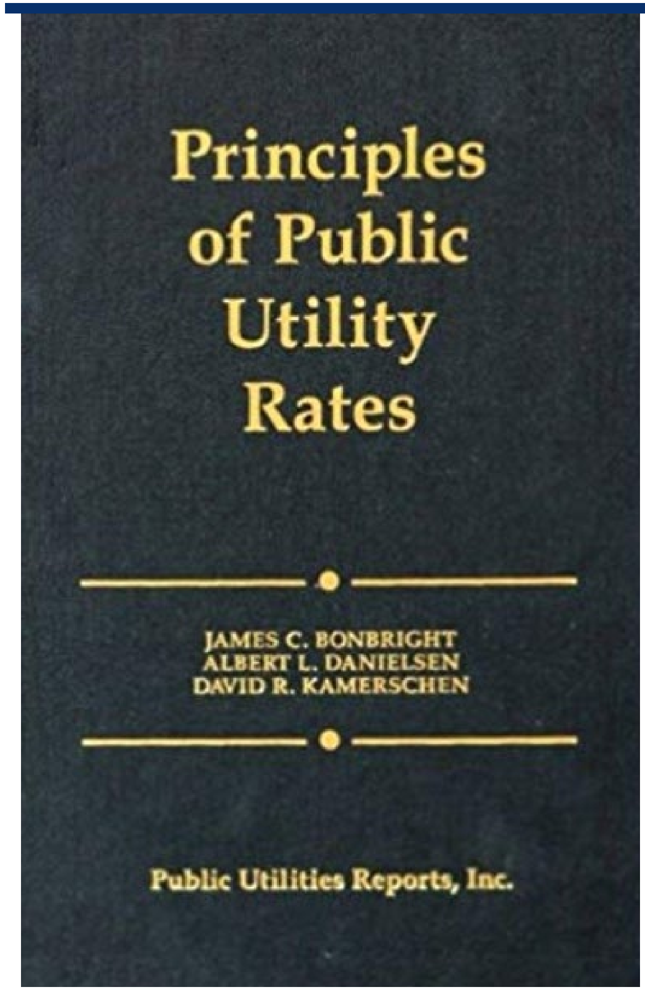
- Rate design determines how each slice of the revenue requirement pie is collected
- The rate design step allocates revenue responsibility to <u>each customer in each class.</u>
- Ideally, the entire slice of pie is collected from customers annually.

Retail rates are designed based on two broad concepts

Recover a utility's costs (i.e., revenue requirement), apply sound ratemaking principles; and are considered just and reasonable

Satisfy certain policy and/or market objectives that can vary based on a state's distinct rules, regulations, and policies, as well as different stakeholder motivations

Rate Design Criteria (Bonbright Principles)



- **Commonly employed rate design principles include the following:**
  - Customer understanding
  - Ease of implementation
  - Collects utility's cost of service
  - Fairly apportions costs among customers
  - Avoids undue discrimination
- **Balancing these principles can be more of an art rather than a science**
  - Typically involves prioritizing policy goals such as sending economically efficient price signals, achieving GHG targets, enabling or promoting technology adoption of distributed resources

Rate Design: Common Rate Components

$/kWh Volumetric Energy Charge

- **Options**: Flat, differs by quantity (inclining/declining blocks) and/or time-of-use (peak vs. off-peak period).
- **Science**: Ideally based on energy costs driven by electricity usage. Can include generation capacity costs.
- **Art**: In actuality, balances policy goals and ability of customers to understand and respond to price signals.

Rate Design: Common Rate Components

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$/kW-mo Volumetric Demand Charge

- **Options**: Differs by customer peak demand measurement period (i.e., coincident or non-coincident). May also vary by time of use.
- **Science**: Ideally based on fixed costs driven by distribution and/or generation capacity infrastructure.
- **Art**: In actuality, balances metering ability and customer understanding of demand-based price signals.

Rate Design: Common Rate Components

$/kWh — Volumetric Energy Charge

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$/kW-mo — Volumetric Demand Charge

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- **Art**: In actuality, balances metering ability and customer understanding of demand-based price signals.

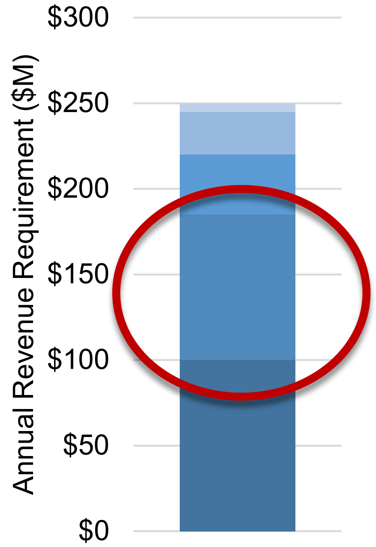
$/Month — Customer Charge

- **Options**: Differs by customer class, size of customer (kWh, kW).
- **Science**: Ideally based on customer-related fixed costs (metering, billing, accounts).
- **Art**: In actuality, balances energy price signal and low-usage customer impacts.

Rate Design Example

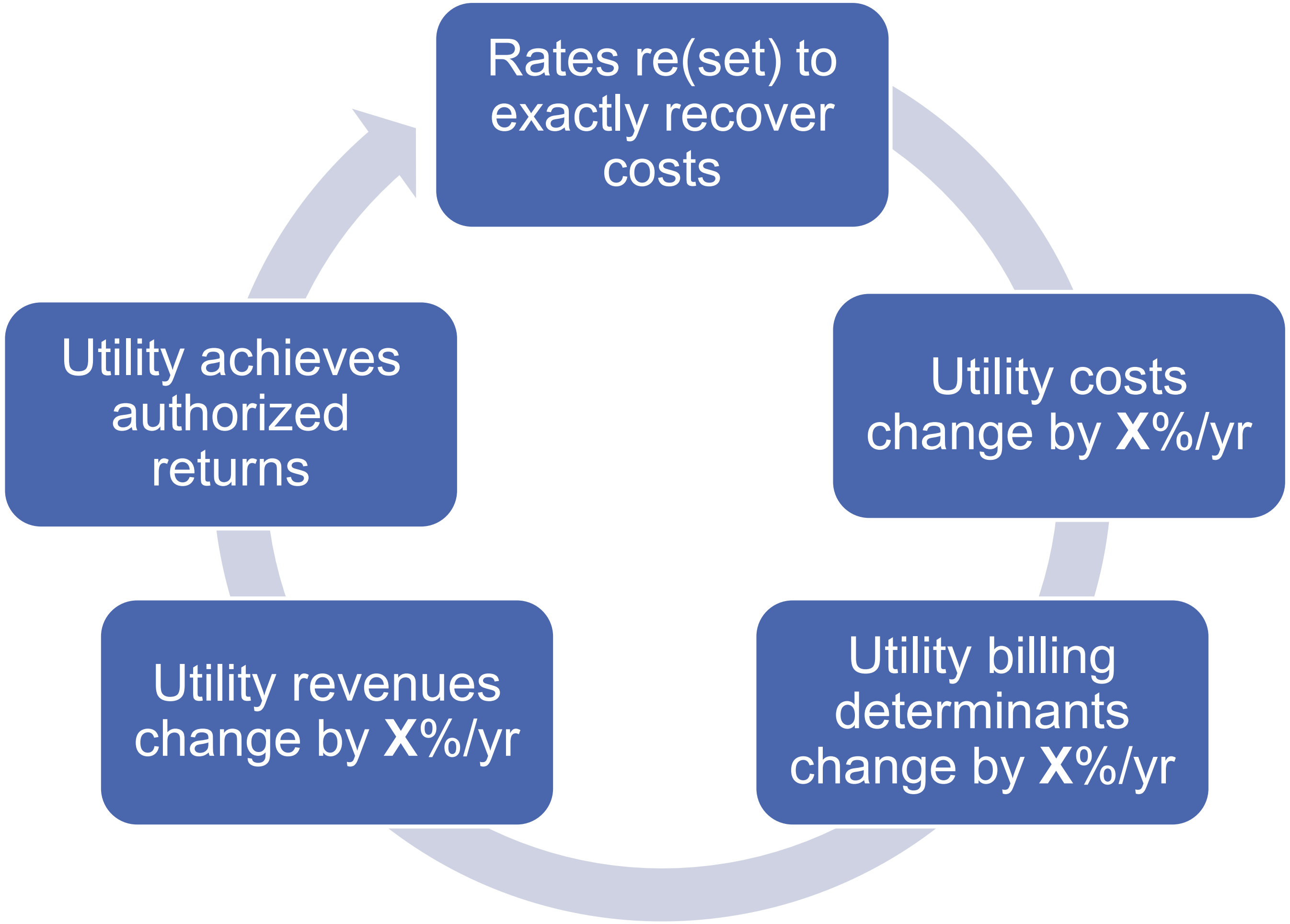
RR Component	Total	Residential	Commercial
Non-fuel O&M			
(A) Allocated RR ($MM)	$85	$41	$44
(B) Billing Determinants (MWh)	600,000	230,000	370,000
Rate = A / B (¢/kWh)	**$14.2**	**$17.8**	**$11.9**

Revenue Requirement Example

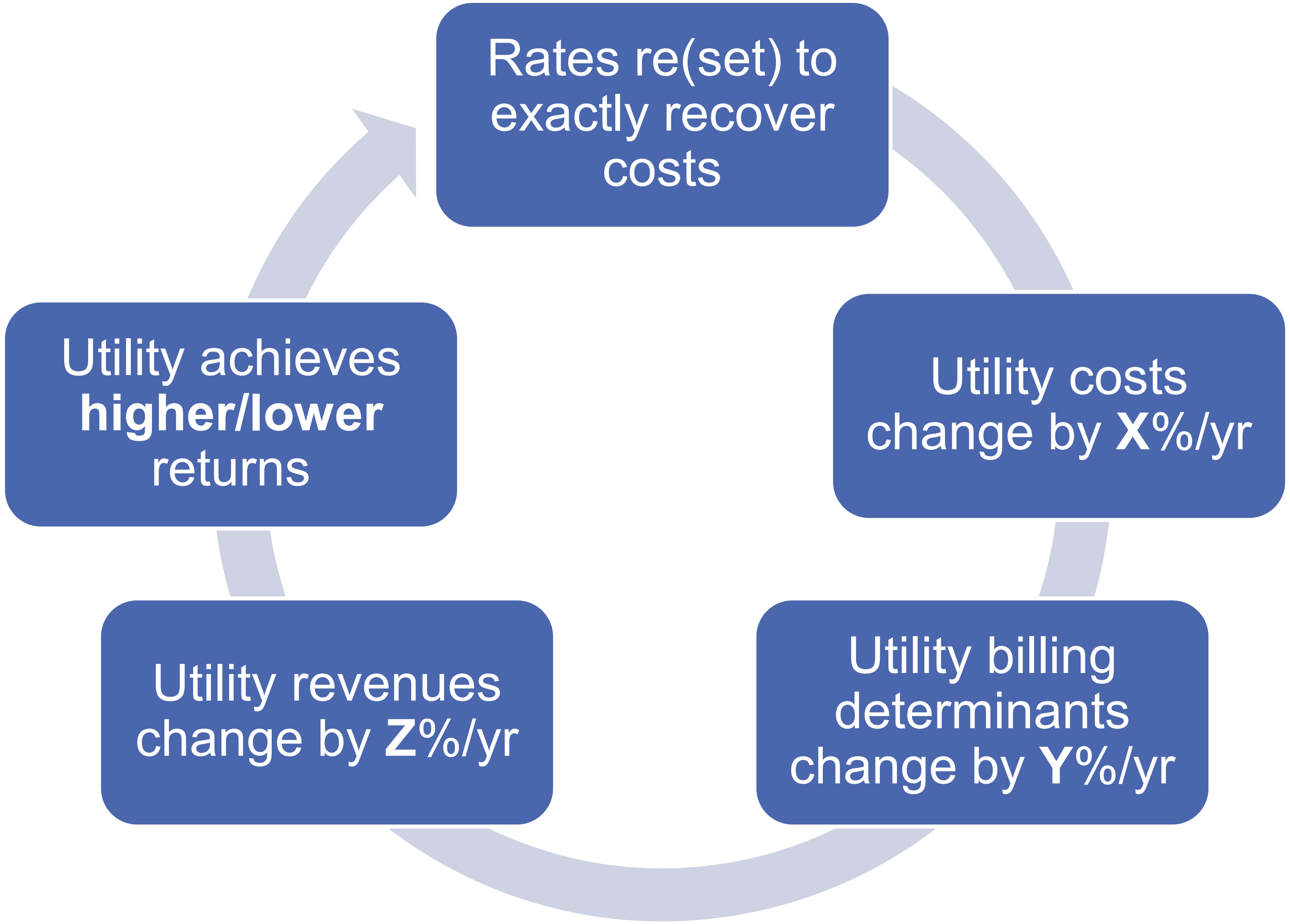


- In summary:
  - Rates are designed to collect the revenue requirement that is allocated to each customer class
  - For each class and rate component, rates equal the allocated RR ÷ billing determinants

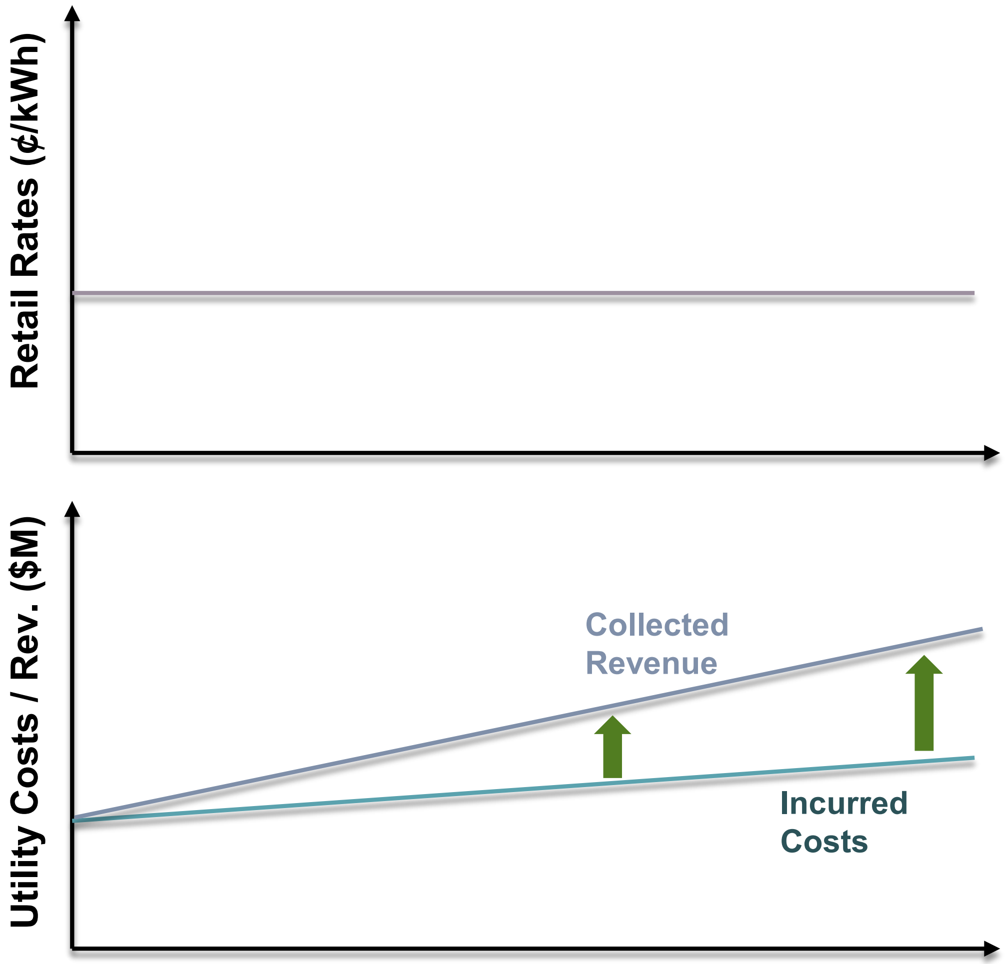
Ideal Outcome of CoS Ratemaking



Most Likely Outcome of CoS Ratemaking

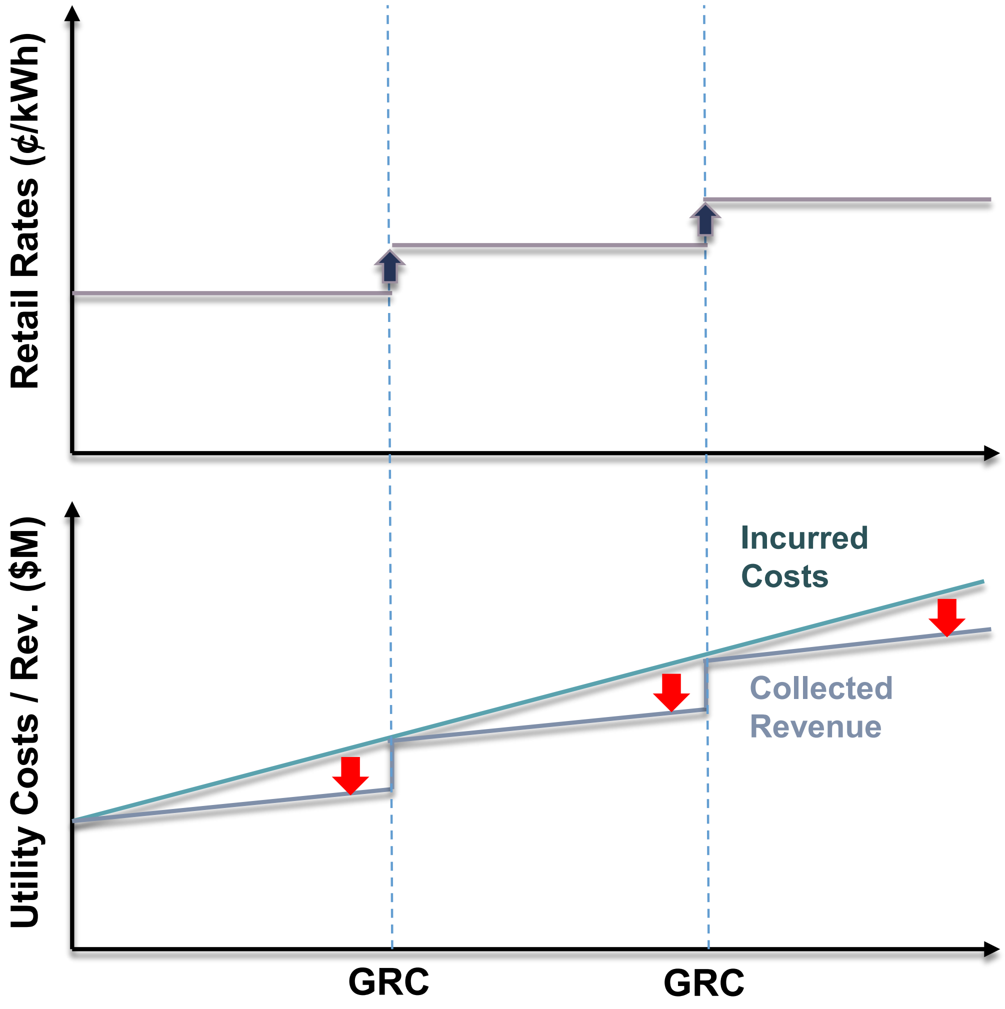


Revenue Growth > Cost Growth



- When **revenue growth exceeds cost growth** between general rate cases (GRC), *ceteris paribus*, utility **financial** picture **improves**
- Utility increases its annual profits by not carrying out a GRC, leaving rates as is
- Regulators would need to compel utility to file a GRC, which in this scenario would reduce rates, but this only solves the problem temporarily
  - Even if the utility files periodic GRCs, this issue persists between rate cases

Cost Growth > Revenue Growth

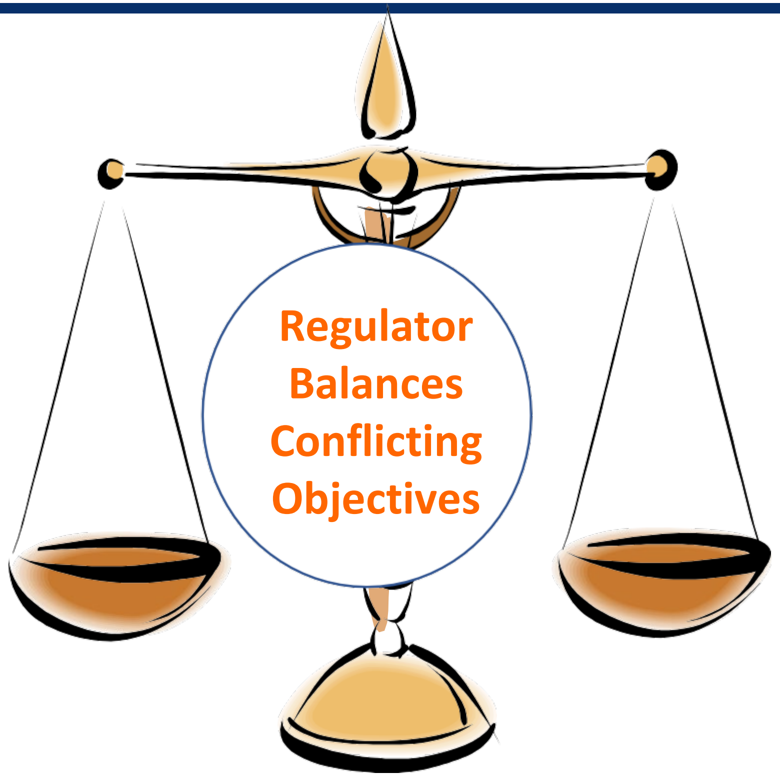


- When **cost growth exceeds revenue growth** between GRCs, *ceteris paribus*, the utility **financial** picture gets **worse**
- The utility can have more frequent GRCs, but that only solves the problem temporarily
  - If the utility does not file a GRC, the problem just keeps getting worse
- More systemic issues may need to be addressed

The Regulatory Balancing Act: Balancing Utility, Policy and Ratepayer Objectives

Utility Financial Health

- Allowed revenue requirement & allowed rate of return
- Allowed rate levels
- Approval of capital expenditures
- Interval between general rate cases
- Surcharges, decoupling



Impacts on Ratepayers

- Retail rate levels
- Bill impacts
- Complexity of rate structures
- Distributed resource programs, including program incentives
- Cost Shifts from DER programs

Common Policy Issues:

- GRC frequency, rate designs, Low-income customer protections
- Distributed resource program size, incentives
- Utility vs third-party ownership of generation
- Utility shareholder incentives
- Providing predictable regulation to support beneficial utility financial health outcomes

Questions/Comments

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Electric Vehicle Rate Design Overview

Andy Satchwell

EV Grid Assist – Rates & Incentives

October 25, 2022

This work was funded by the U.S. Department of Energy's Office of Electricity, under Contract No. DE-AC02-05CH11231.

A number of factors and trends are motivating retail rate reforms

- Utilities are deploying advanced metering infrastructure (AMI)
- Distributed energy resource (DER) cost declines and technological innovations
- Utilities are reaching net energy metering (NEM) caps
- Concerns about utility fixed cost recovery and revenue sufficiency
- Desire for fair and equitable compensation for net electricity export
- Variable renewable energy (VRE) integration issues (e.g., over-generation and net load shape impacts)

There are several studies and actions that precede changes to rate design

Studies

- ❑ Resource valuation analysis (*quantifies benefits and/or costs of additional resource*)
- ❑ Cost-benefit analysis (*quantifies ratio of costs to benefits depending on perspective*)
- ❑ Rate and bill impacts analysis (*quantifies change in average and/or participating customer's rate or bill*)

Actions

- ❑ General rate case
- ❑ Commission investigation
- ❑ Legislative directive or order
- ❑ Stakeholder collaborative

Retail rates are designed based on two broad concepts

Recover a utility's costs (i.e., revenue requirement), apply sound ratemaking principles; and are considered just and reasonable

Satisfy certain policy and/or market objectives that can vary based on a state's distinct rules, regulations, and policies, as well as different stakeholder motivations

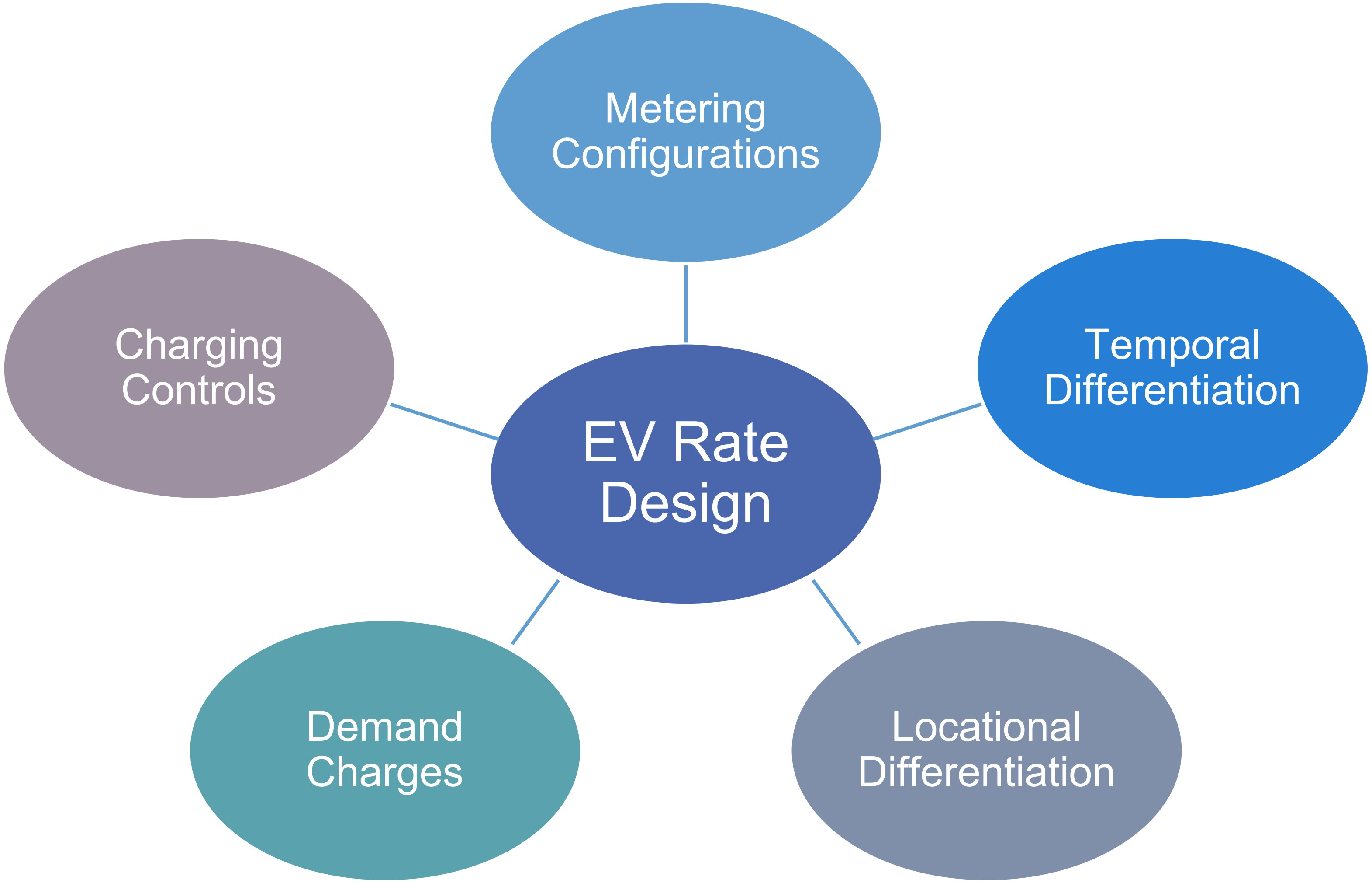
Five policy-driven objectives used as the basis for EV retail rate design

Recover a utility's costs (i.e., revenue requirement), apply sound ratemaking principles; and considered just and reasonable

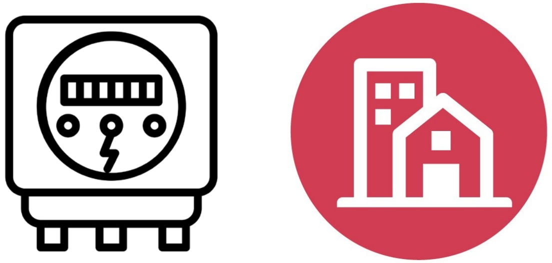
Satisfy certain policy and/or market objectives that can vary based on a state's distinct rules, regulations, and policies, as well as different stakeholder motivations

- Promote EV adoption
- Grid management
- System economic efficiency
- Decarbonization
- Equity

EV rate design typically comprised of five (5) different components



Metering Configurations

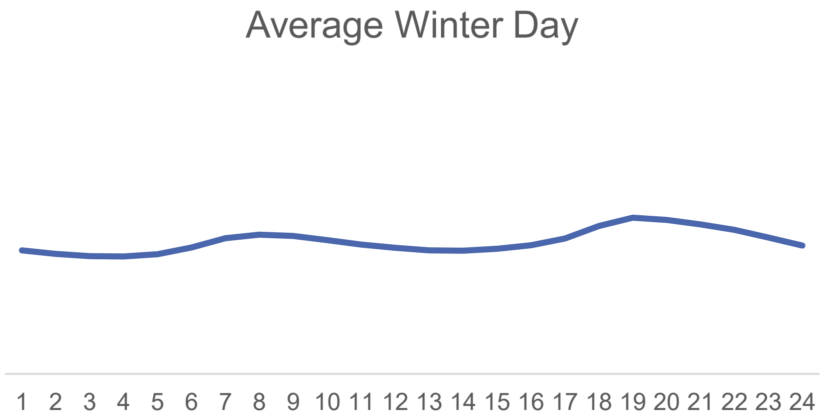


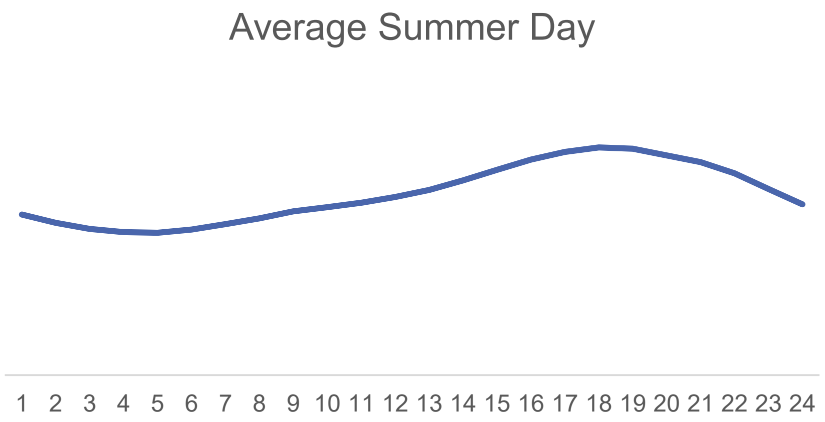
Whole home/facility consumption
via account meter

EV charging consumption
via account meter

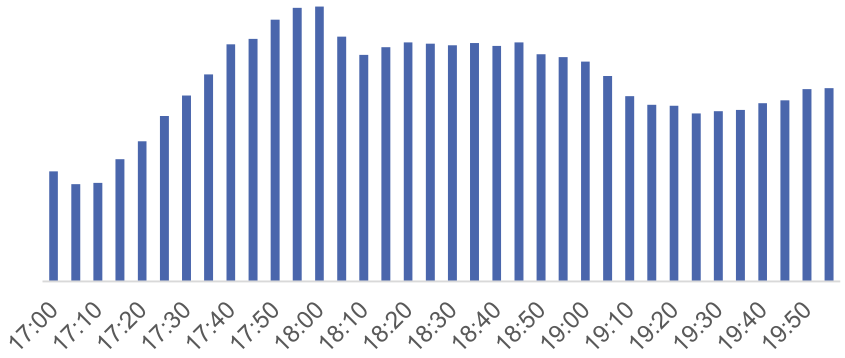
Submetering via EVSE or vehicle

Temporal Differentiation

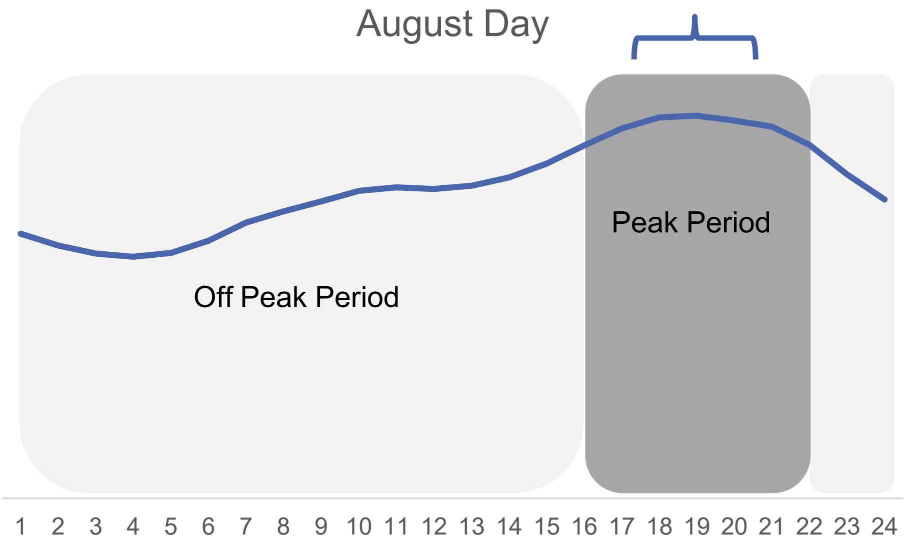




Seasonal Differentiation



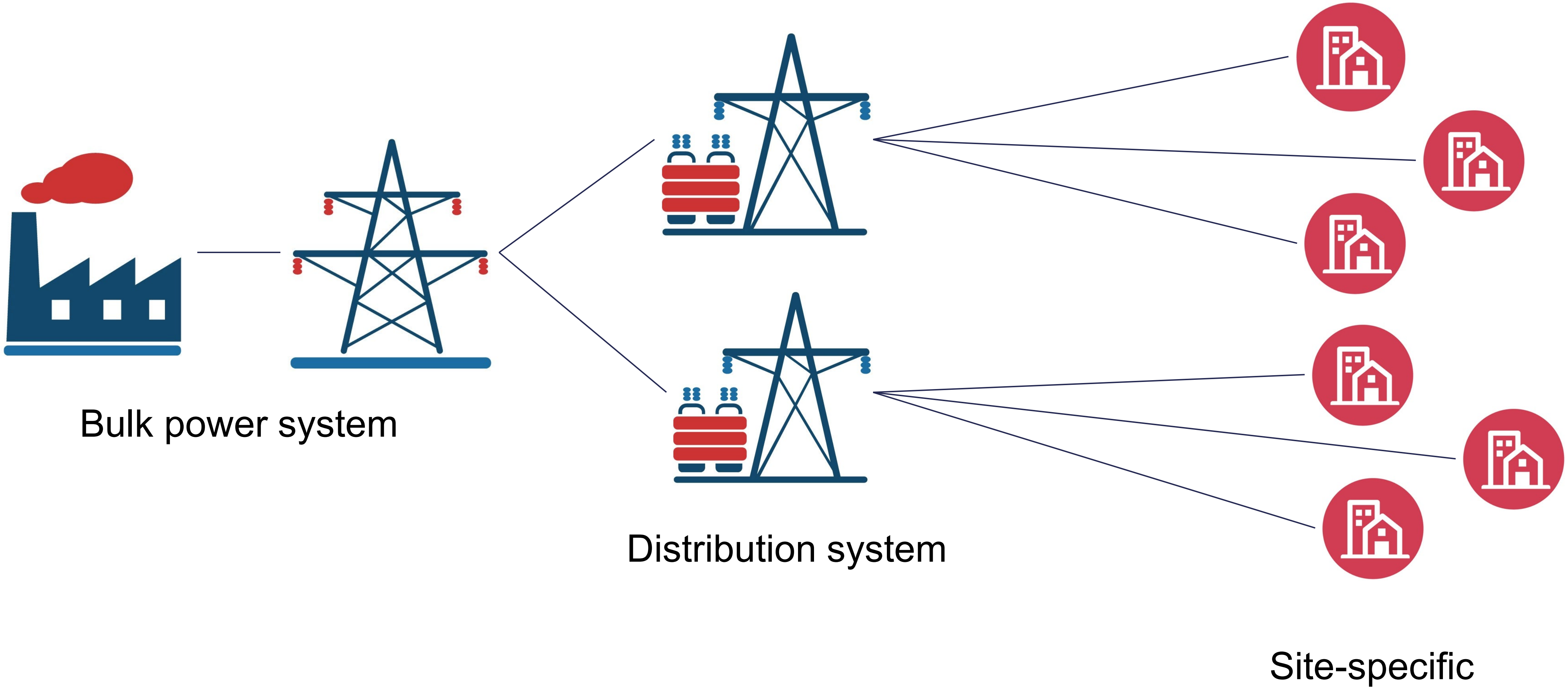
Sub-hourly Differentiation



Hourly and Period Differentiation

Note that figures show temporal differentiation in *load* but there is also temporal differentiation in system *costs* and *emissions* that could be used as the design basis

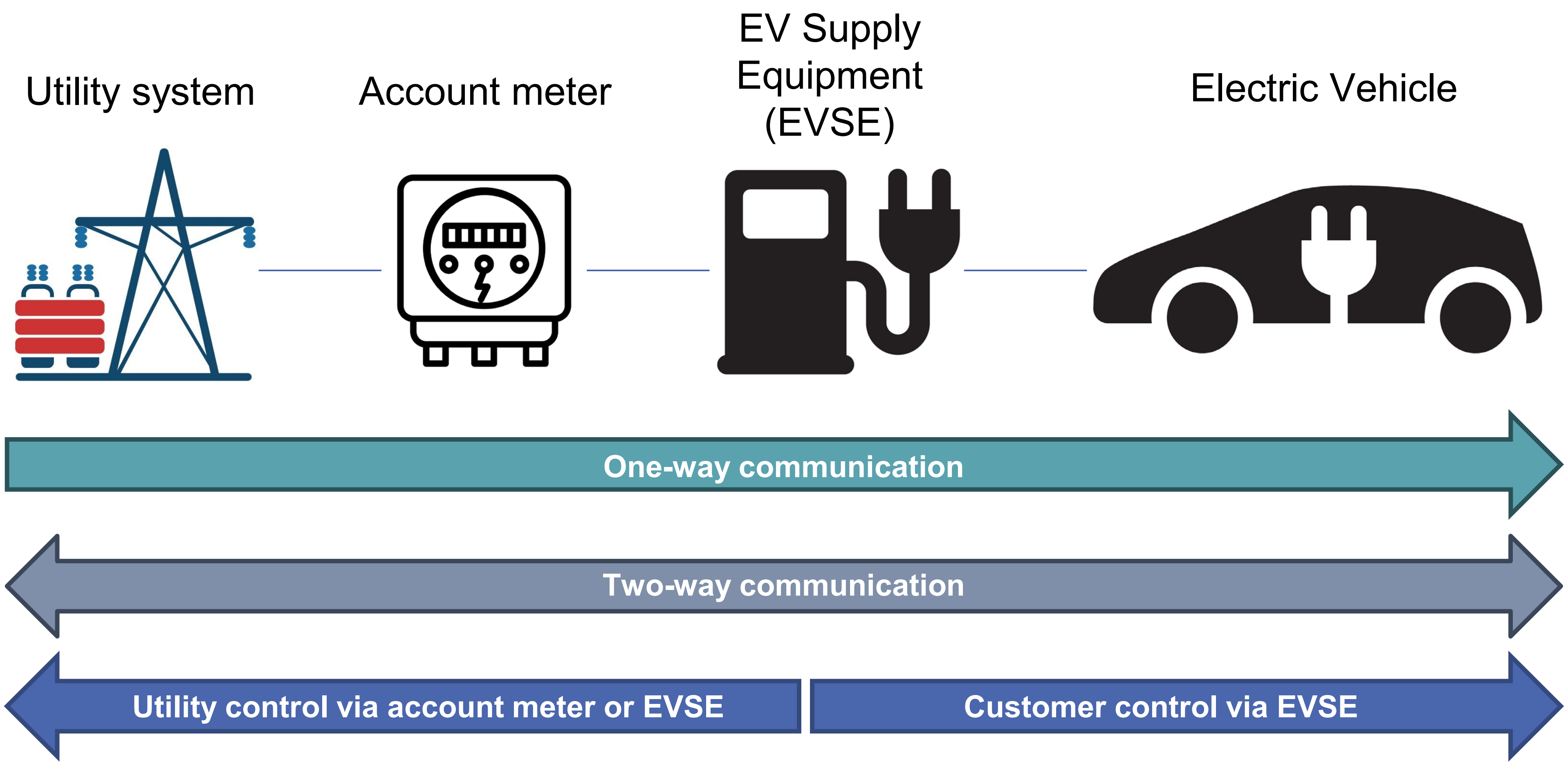
Locational Differentiation



Demand Charges

- ✓Max demand period
- ✓Demand ratchet
- ✓Seasonal
- ✓Coincident peak
- ✓Non-coincident peak

Charging Controls



Promoting EV adoption will limit rate design choices in terms of cost and simplicity

Rate Objectives	Metering Configurations	Temporal Differentiation	Locational Differentiation	Demand Charges	Charging Controls
Promote EV adoption	Whole home/facility consumption	Seasonal	Bulk power system	Max demand period	Two-way communication
Grid management	EV charging consumption	Period	Distribution system	Demand ratchet	One-way communication
System economic efficiency	Account meter	Hourly	Site-specific	Seasonal	Utility direct control via EVSE
Decarbonization	Submetering via EVSE or vehicle	Sub-hourly		Coincident peak	Customer control via EVSE
Equity				Non-coincident peak	

EV grid management rates communicate power system conditions either via price or load signals

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Equity				Non-coincident peak	

Economic efficiency communicate marginal system costs to encourage charging that minimizes costs

Rate Objectives	Metering Configurations	Temporal Differentiation	Locational Differentiation	Demand Charges	Charging Controls
Promote EV adoption	Whole home/facility consumption	Seasonal	Bulk power system	Max demand period	Two-way communication
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Equity				Non-coincident peak	

Decarbonization rates communicate marginal emissions rates with differentiation consistent with them

Rate Objectives
- Promote EV adoption
- Grid management
- System economic efficiency
- Decarbonization
- Equity

Metering Configurations
- Whole home/facility consumption
- EV charging consumption
- Account meter
- Submetering via EVSE or vehicle

Temporal Differentiation
- Seasonal
- Period
- Hourly
- Sub-hourly

Locational Differentiation
- Bulk power system
- Distribution system
- Site-specific

Demand Charges
- Max demand period
- Demand ratchet
- Seasonal
- Coincident peak
- Non-coincident peak

Charging Controls
- Two-way communication
- One-way communication
- Utility direct control via EVSE
- Customer control via EVSE

Equitable EV deployment rates are based on choices that limit incremental costs

Rate Objectives	Metering Configurations	Temporal Differentiation	Locational Differentiation	Demand Charges	Charging Controls
Promote EV adoption	**Whole home/facility consumption**	**Seasonal**	Bulk power system	Max demand period	Two-way communication
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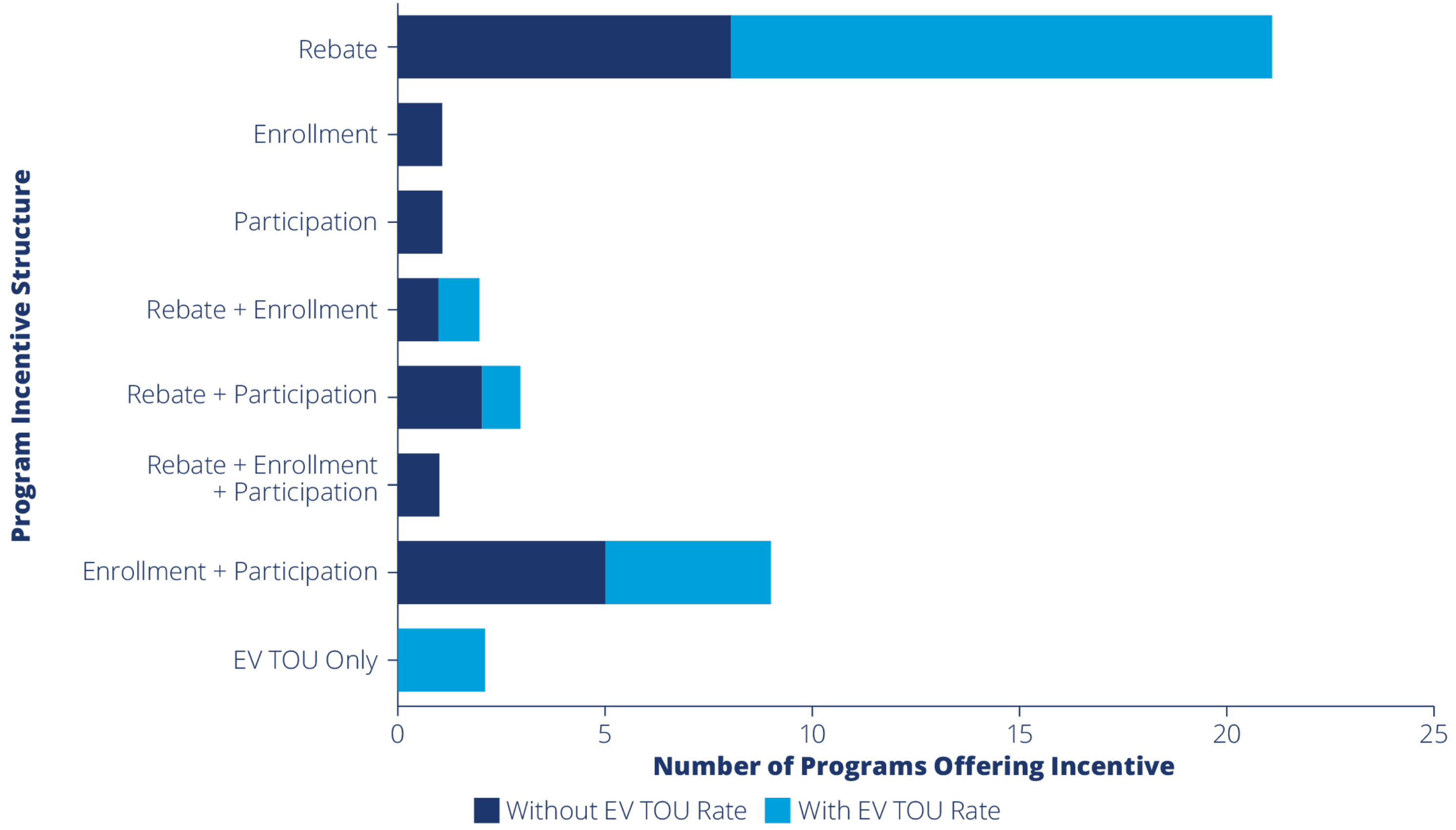
Equity				Non-coincident peak	

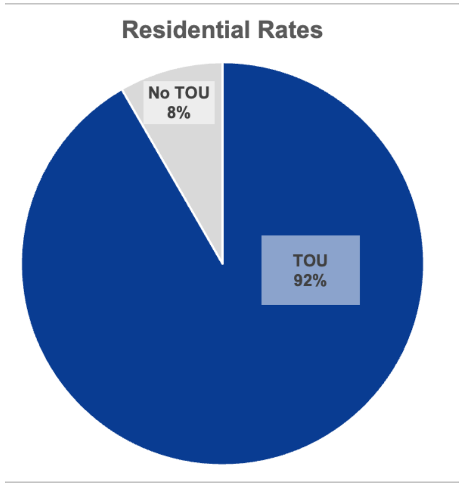
Other types of program incentives may or may not be combined with rates to achieve program objectives

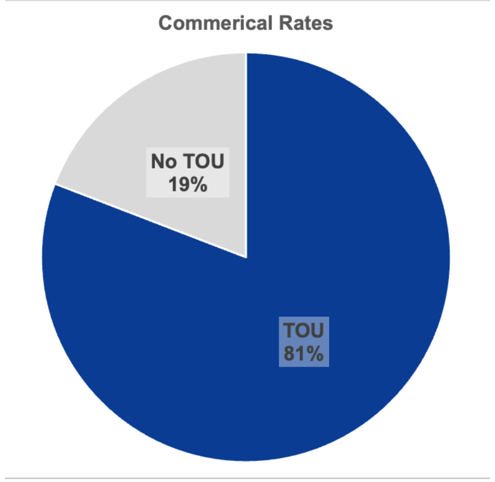


Source: Smart Electric Power Alliance, 2021.
Available at: https://sepapower.org/resource/managed-charging-incentive-design/

Observations: Regulatory and Rate Activity

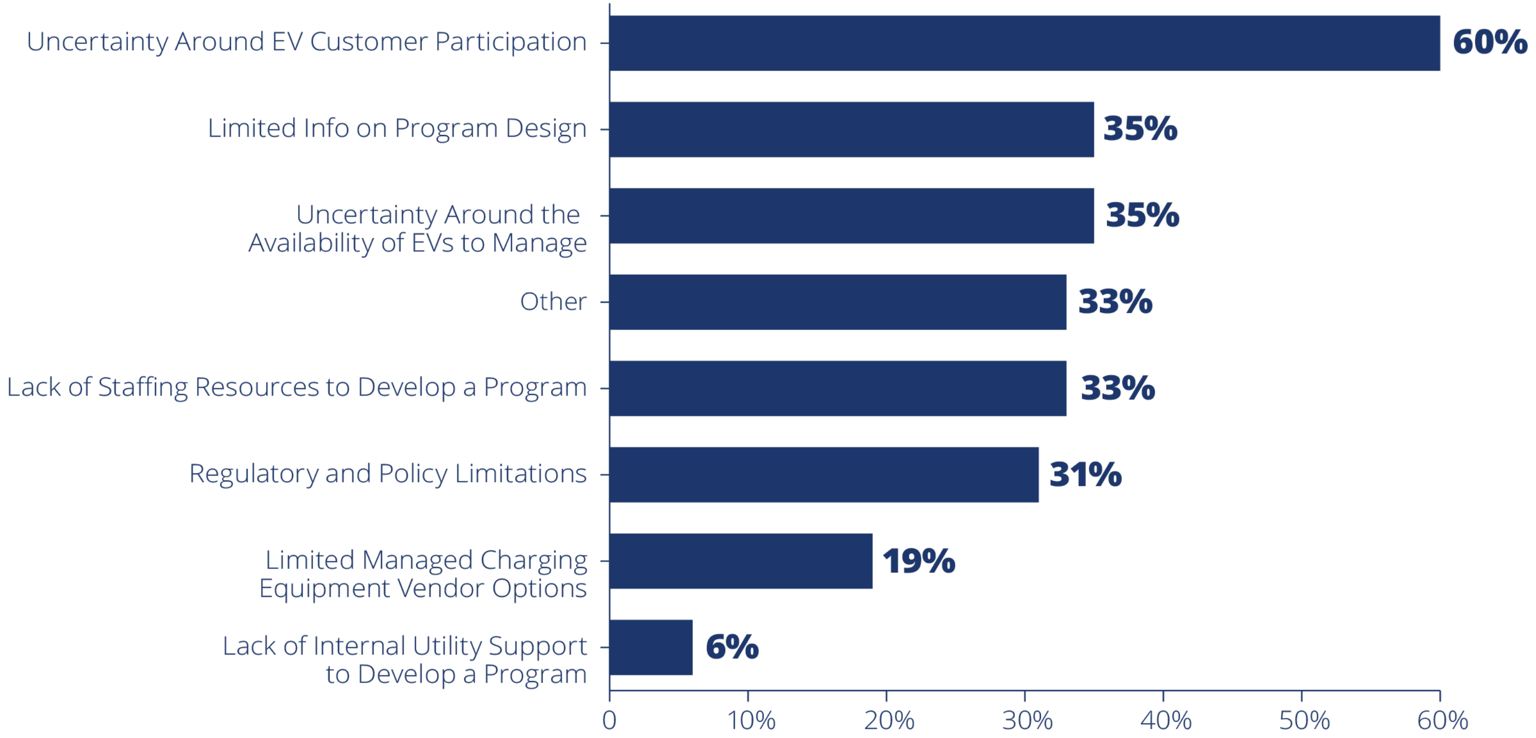
- **Motivation:** The overwhelming majority of rate activity (>85%) is focused on managing and shifting demand
- **Rate Design:** Static TOU rates are the dominant rate structure (>90% residential; >80% commercial)
- **Demand Charges:** Over 20 states are examining demand charge alternatives for public and DCFC, particularly at lower load factors





Utilities perceive uncertainty among top barriers to implementing EV managed charging programs

Figure 10. Barriers to Implementing a Managed EV Charging Program



N=48. Note: Utilities selected all that applied.

Source: SEPA, 2021

Available at: https://sepapower.org/resource/the-state-of-managed-charging-in-2021/

Forward-looking considerations for EV rate design

Implications of EV rate designs for other DER objectives and policies

Alignment of system value with EV charging

Revisiting EV rate designs as EV deployments increase and/or system conditions change

Questions/Comments

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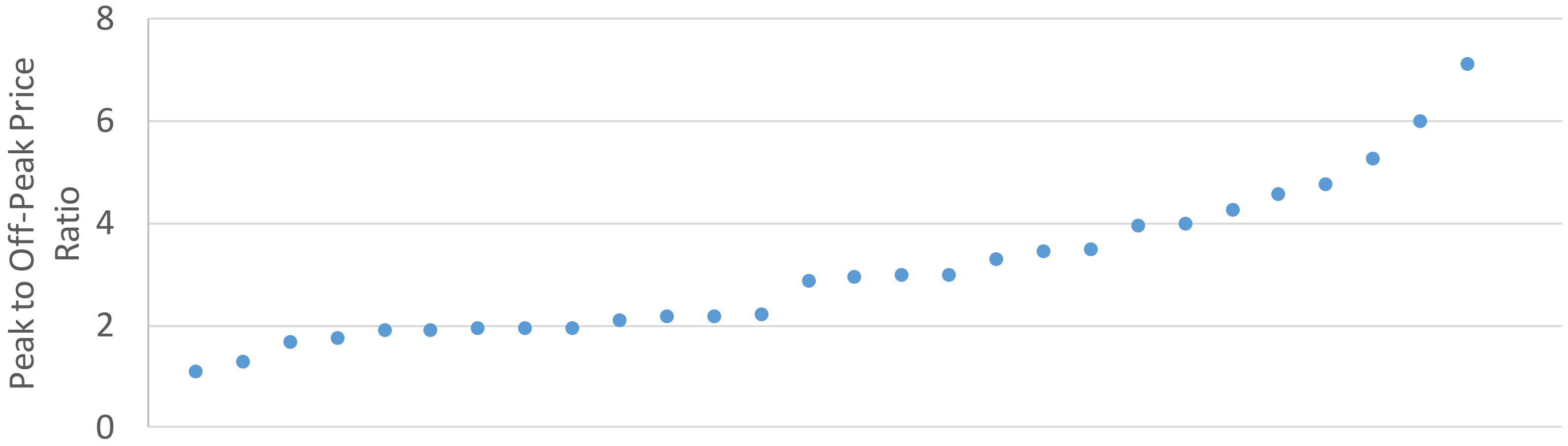
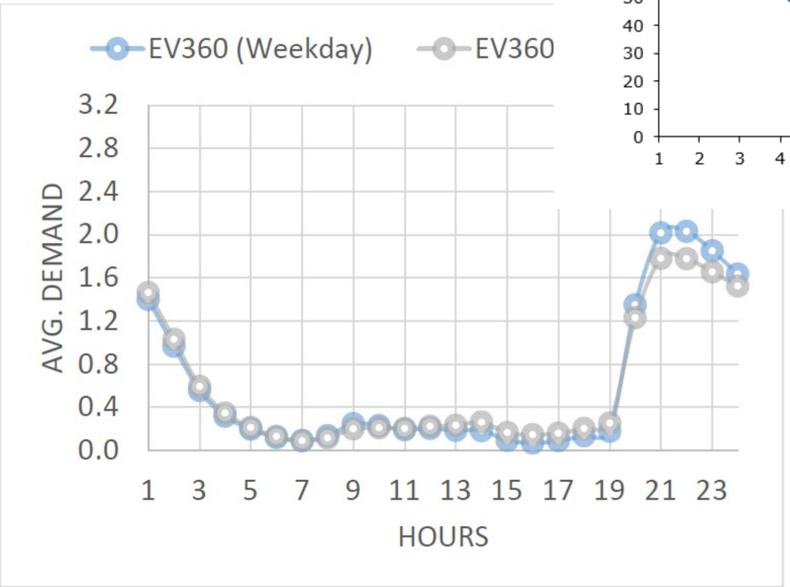
Appended slides on customer response to EV retail rates

Do customers respond to EV rates?

- Reviewed eleven (11) evaluation reports of EV rate offerings published between 2013-2020
- Most evaluation reports were outcomes of short-term (6 months – 2 years) pilots; very few system-wide roll outs were evaluated
- Pilots were evenly split between having whole house vs. EV-only metering
- Most pilots had at least a 2:1 peak-to-off peak price ratio and a small number had 4:1 or greater price ratio

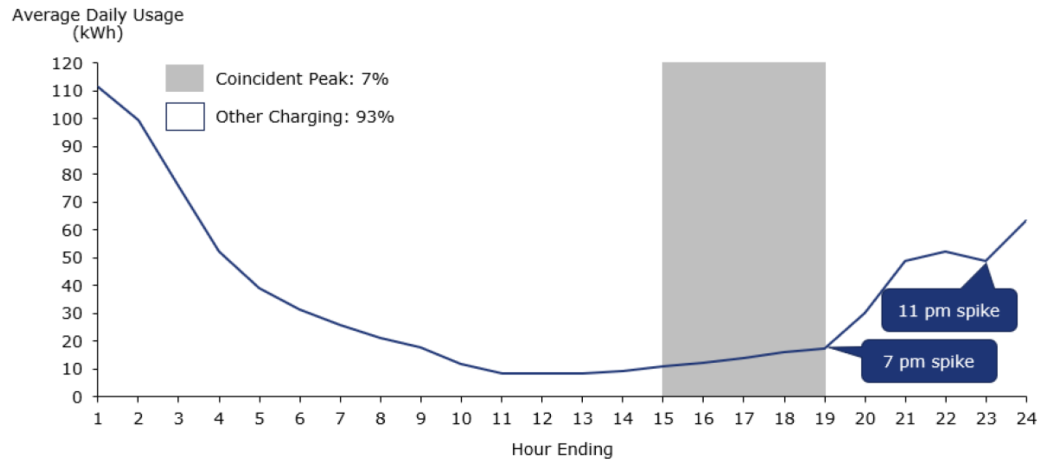


Properly designed rates can be an effective tool for managing EV charging behavior

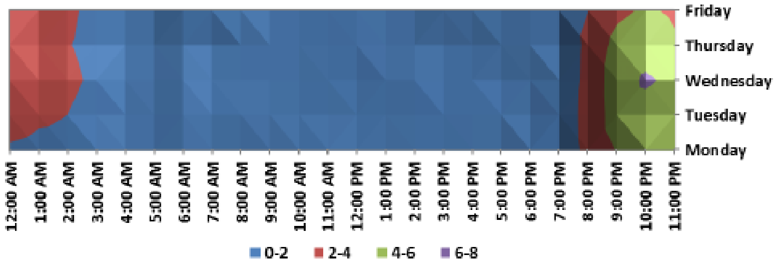


Source: McDougall, L., Donnelly, A. and Chandra, K. (2019) Austin Energy's Residential "Off Peak" Electric Vehicle Charging Subscription Pilot: Approach, Findings, and Utility Toolkit. EV360 Whitepaper. Austin Energy, Austin, TX.

Figure 11: Residential Station Usage, Oct 2019 – Apr 2020



Source: DTE Energy (2020) Charging Forward: Annual Status Report. May.



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erage weekly load shape (kW) for PIV customers

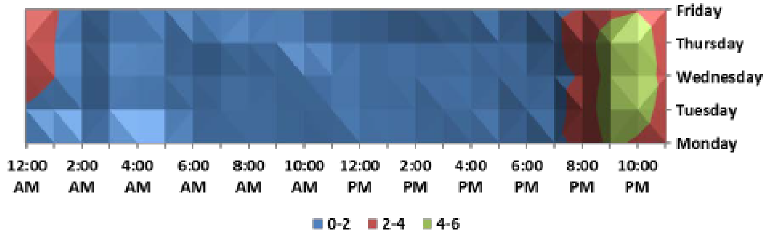


Figure 4-2
Average weekly load shape (kW) for PIV-Green Customers

Source: Dunckley, J. (2016) Pepco Demand Management Pilot for Plug-in Vehicle Charging in Maryland: Final Report - Results, Insights, and Customer Metrics. Electric Power Research Institute, Palo Alto, CA. May. 3002008798.

The higher the price ratio, the more off-peak charging is pursued

Tests of Pairwise Differences in Percentage Charging Shares Between Rates

Day Type	Charging Share	EPEVL – EPEVM	EPEVL – EPEVH	EPEVM – EPEVH
Weekday	% Peak	1.8	3.08	1.29
	% Super Off-Peak	-4.16	-6.04	-1.87
Weekend	% Peak	2.33	3.25	0.92
	% Super Off-Peak	-4.06	-6.62	-2.55

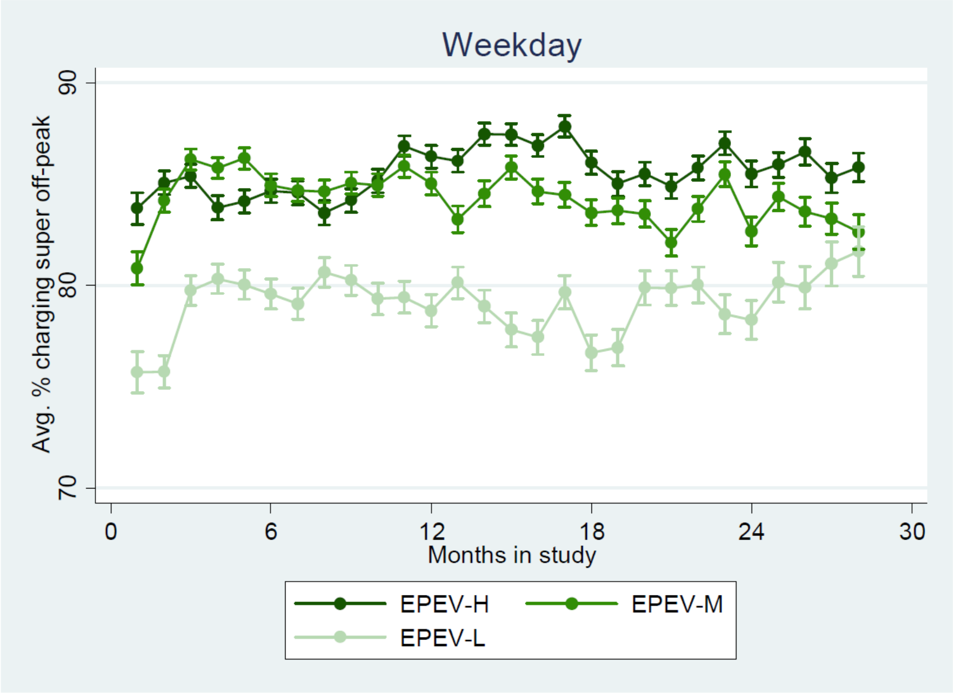
Legend
Significant @ 1%
Significant @ 5%
Not Significant @ 5%

Rate Offering	Summer Price Ratio
EPEV-H	6.0
EPEV-M	4.0
EPEV-L	1.9

Source: Cook, J., Churchill, C. and George, S. (2014) Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle Tou Pricing and Technology Study. Nexant Inc. Prepared for San Diego Gas & Electric.

- Values in the table represent differences in the share of charging load for customers on different rates
- Comparing customers on lowest price ratio (EPEV-L) and customers on highest price ratio (EPEV-H) shows lowest price ratio customers had larger share of peak period consumption but highest price ratio customers had larger share of super off-peak consumption

The higher the price ratio, the quicker customers learn to shift charging to the off-peak period



Source: Cook, J., Churchill, C. and George, S. (2014) Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle Tou Pricing and Technology Study. Nexant Inc. Prepared for San Diego Gas & Electric.

Rate Offering	Summer Price Ratio
EPEV-H	6.0
EPEV-M	4.0
EPEV-L	1.9

- Figure depicts the monthly share of charging that occurred as a function of the number of months after a customer started in the study
- Customers on EPEV-H (highest price ratio) exhibited consistent charging behavior through the entire duration of the study
- Customers on EPEV-L and EPEV-M increased charging consumption in super off-peak period by 1.8%-2.9% per month for the first four months, but remained relatively stable thereafter

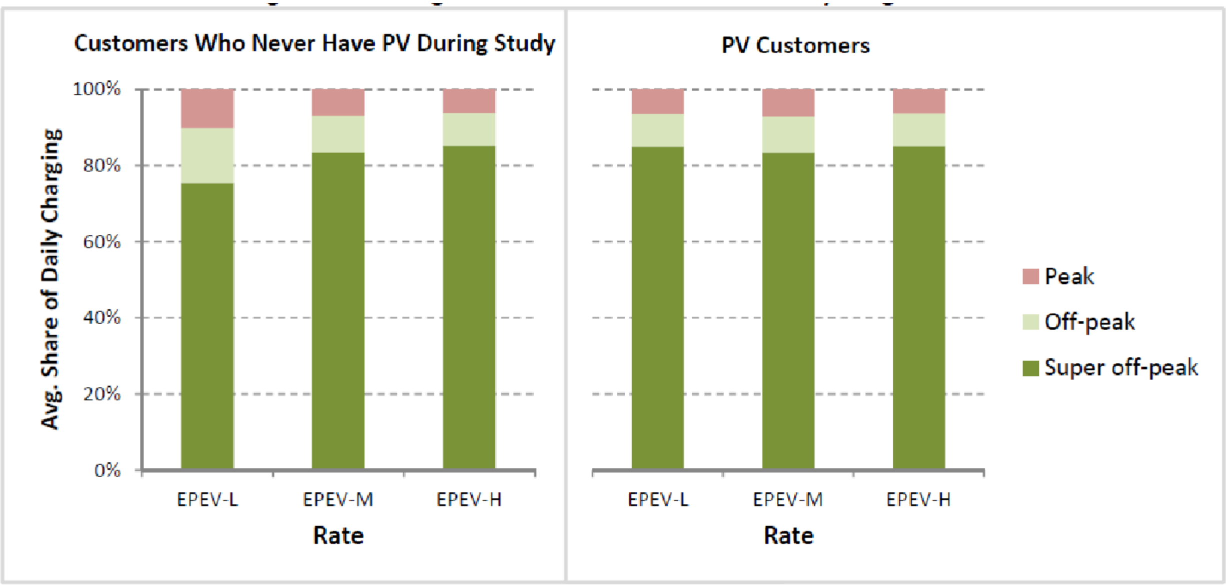
Customers are more responsive to changes in the peak or off-peak prices, but less so super off-peak

- Charging timers likely made it easier for customers to charge in the overnight super off-peak hours (12-5AM)
- Customer schedules likely limited long charging events to the off-peak (5AM-12PM and 8PM-12AM) or especially the super off-peak period
- Customers also did not seem to differentiate much between the on-peak and off-peak period in their EV charging decisions

		Peak to Super Off-Peak Ratio	Peak to Off-Peak Ratio
Summer	EPEV-L	1.9	1.6
	EPEV-M	4.0	1.6
	EPEV-H	6.0	2.6
Winter	EPEV-L	1.3	1.1
	EPEV-M	2.9	1.4
	EPEV-H	4.6	2.5

Source: Cook, J., Churchill, C. and George, S. (2014) Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle Tou Pricing and Technology Study. Nexant Inc. Prepared for San Diego Gas & Electric.

Customers who owned a PV system are significantly less responsive to prices than their non-PV counterparts



Source: Cook, J., Churchill, C. and George, S. (2014) Final Evaluation for San Diego Gas & Electric's Plug-in Electric Vehicle Tou Pricing and Technology Study. Nexant Inc. Prepared for San Diego Gas & Electric.

- PV owners exhibit more consistent shares of charging by period across the three rates relative to non-PV owners
- Selling PV electricity back to the grid may be valued more highly by customers than using it to charge their EV
- PV owners may have certain characteristics that cause them to place an even higher premium on charging overnight regardless of the prices they face