BERKELEY LAB

Load Management, Demand Response, and Effective Incentives

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NASUCA Annual Meetings 2022

DOE/LBNL Technical Training

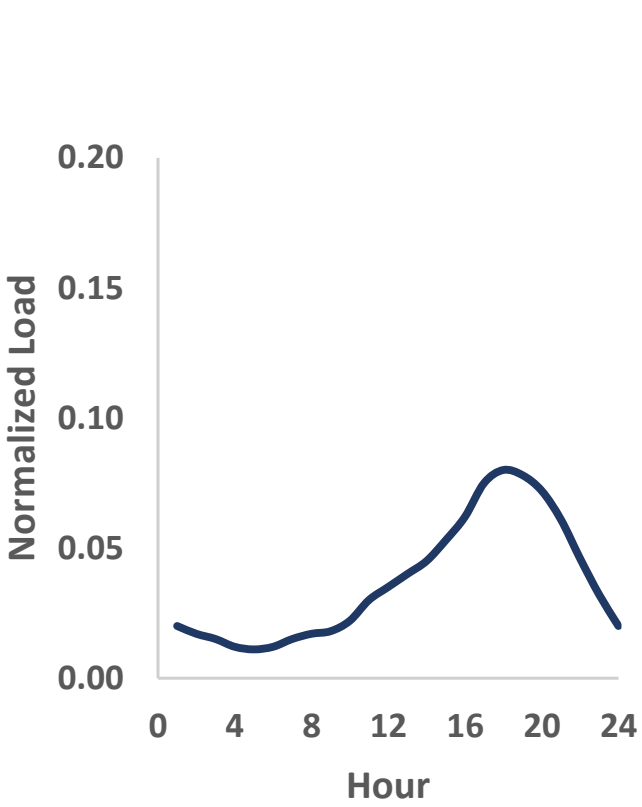
November 15, 2022

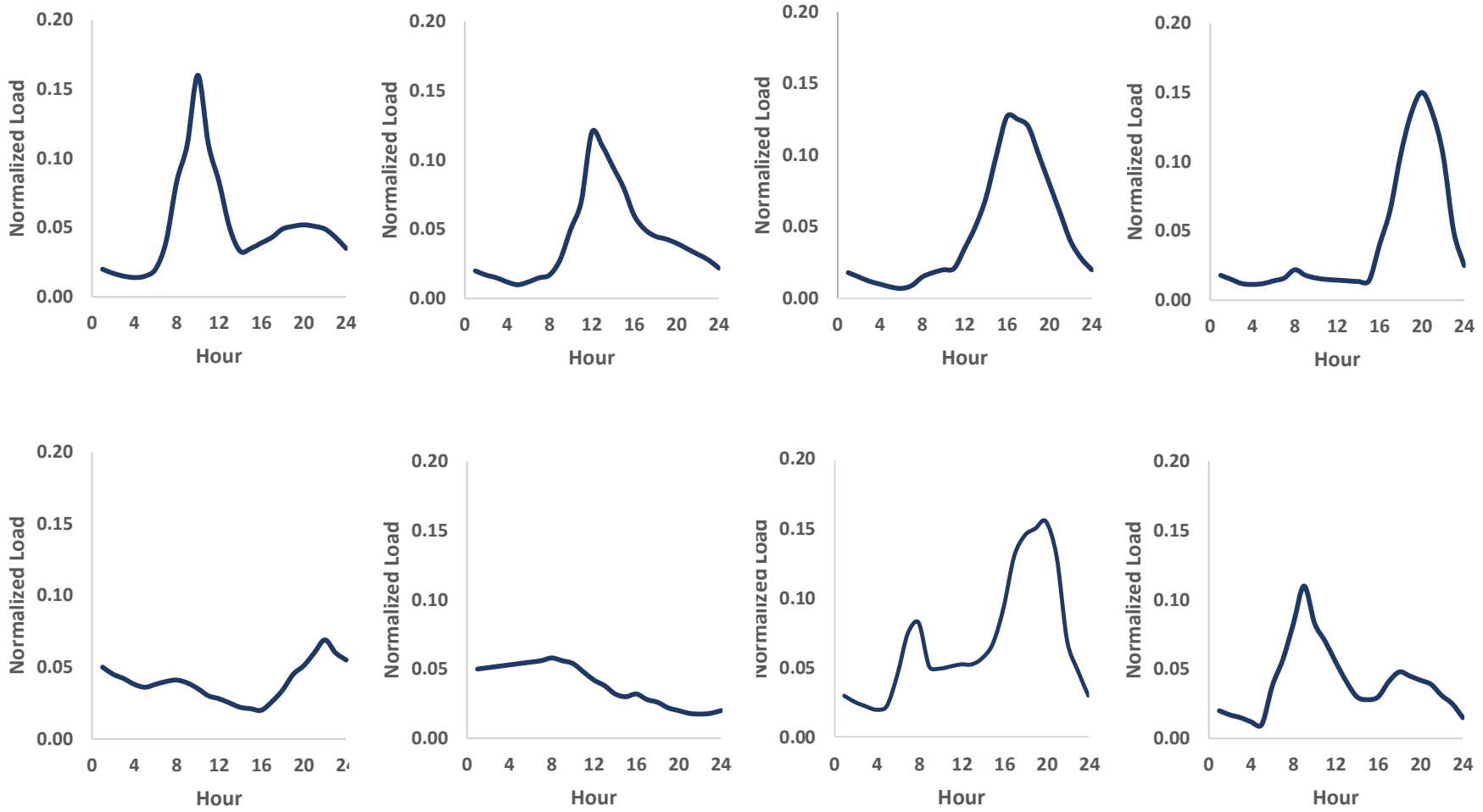
This work was funded by the U.S. Department of Energy's Office of Electricity, under Contract No. DE-AC02-05CH11231.

Data explosion in energy sector

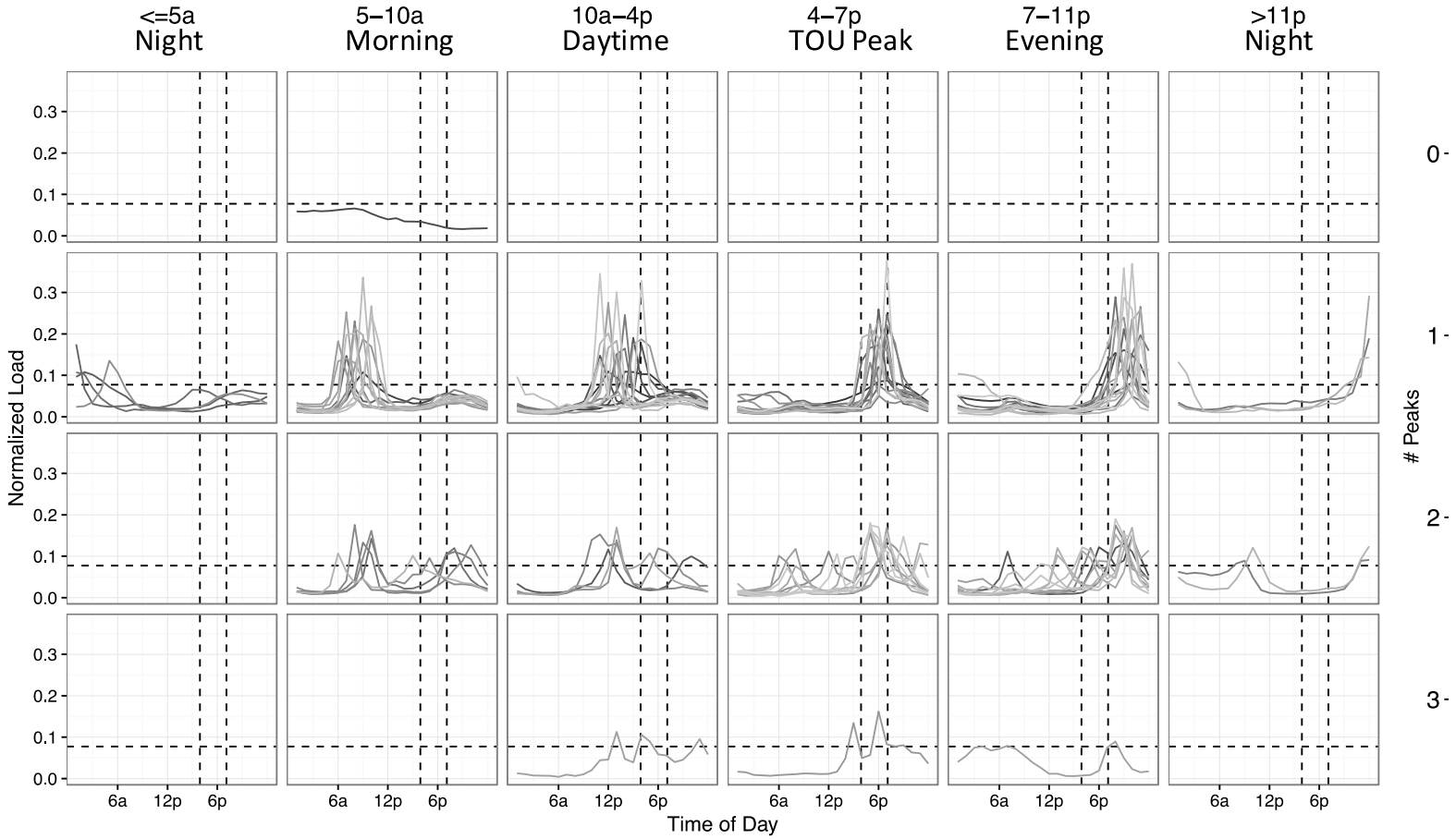
- Advanced Metering Infrastructure, smart thermostats, smart appliances, electric vehicles
- Linked to other time and location-specific information (temperature, census, satellite)
- Provide vast, constantly growing streams of rich data

Are all residential customers the same?





Group Load Shapes Based on When and How Many Customer Load Peaks Occur



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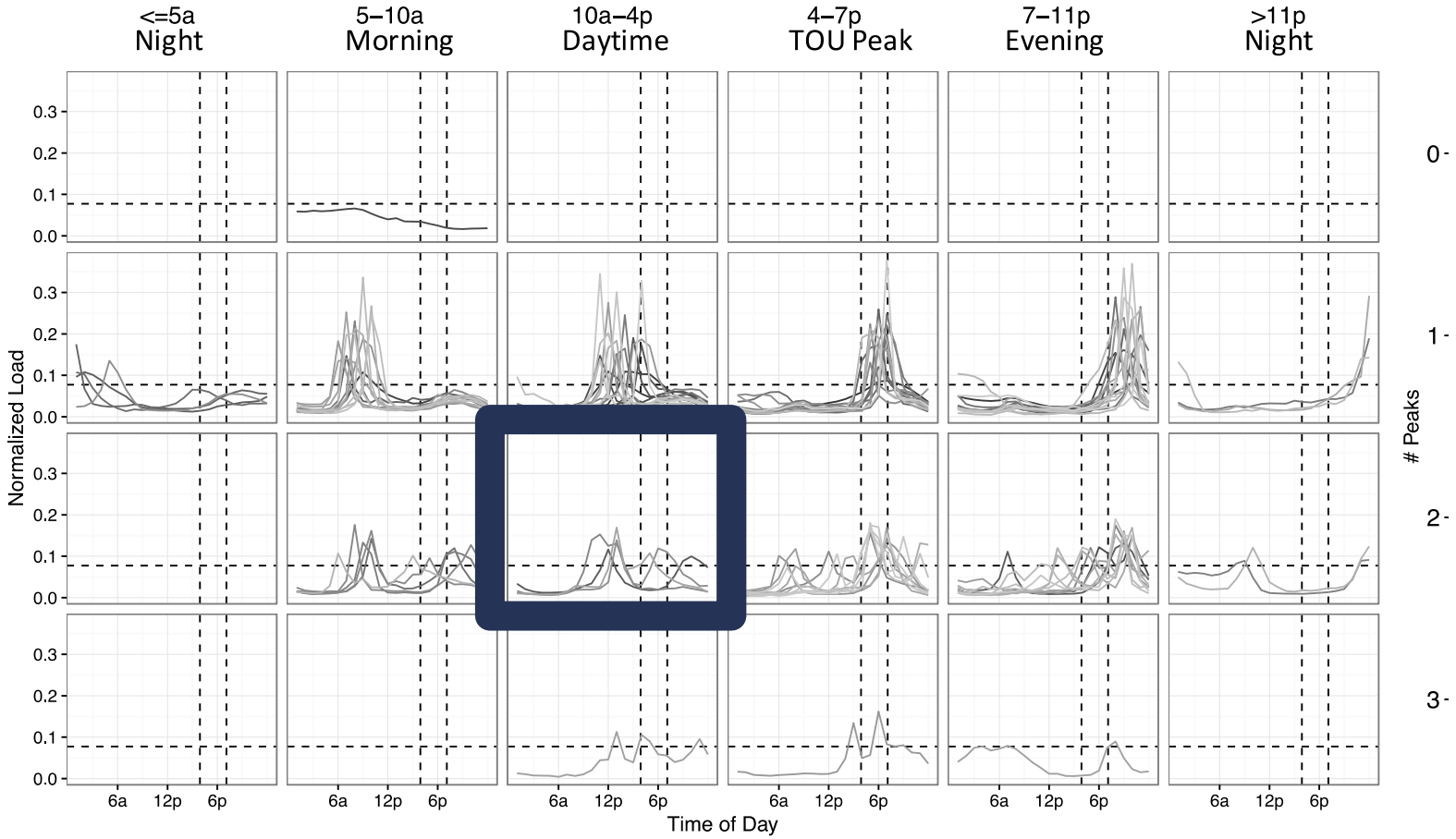

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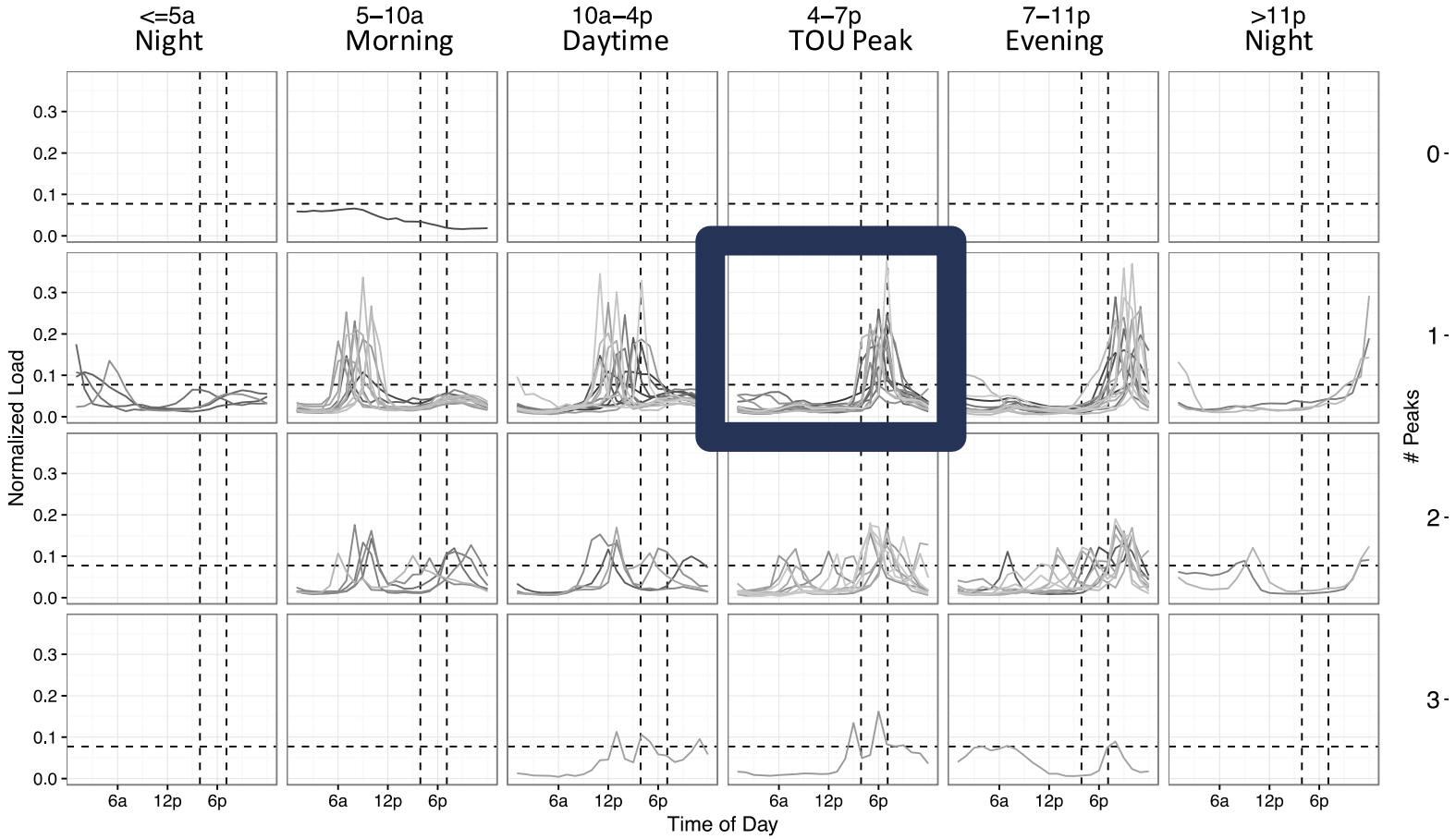

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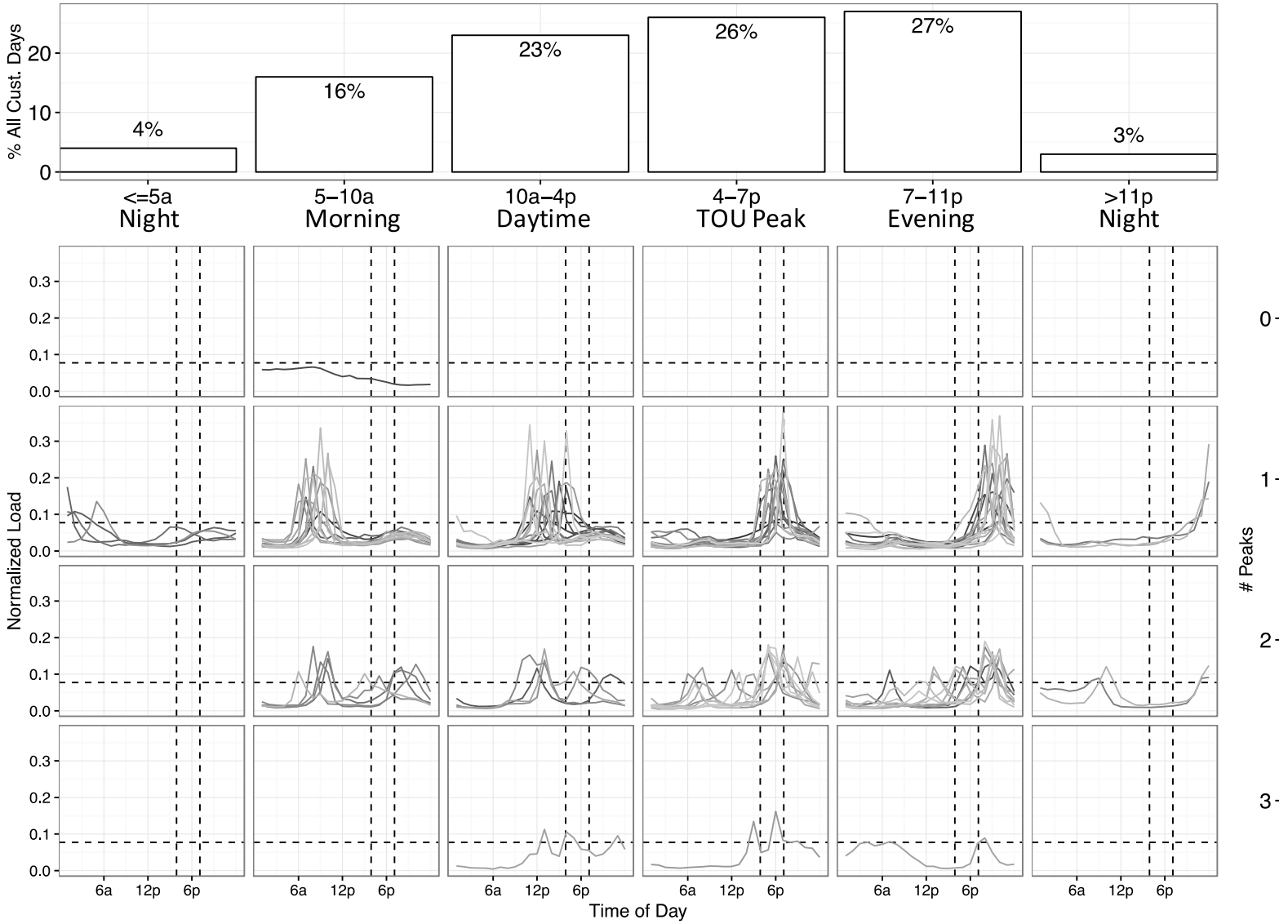

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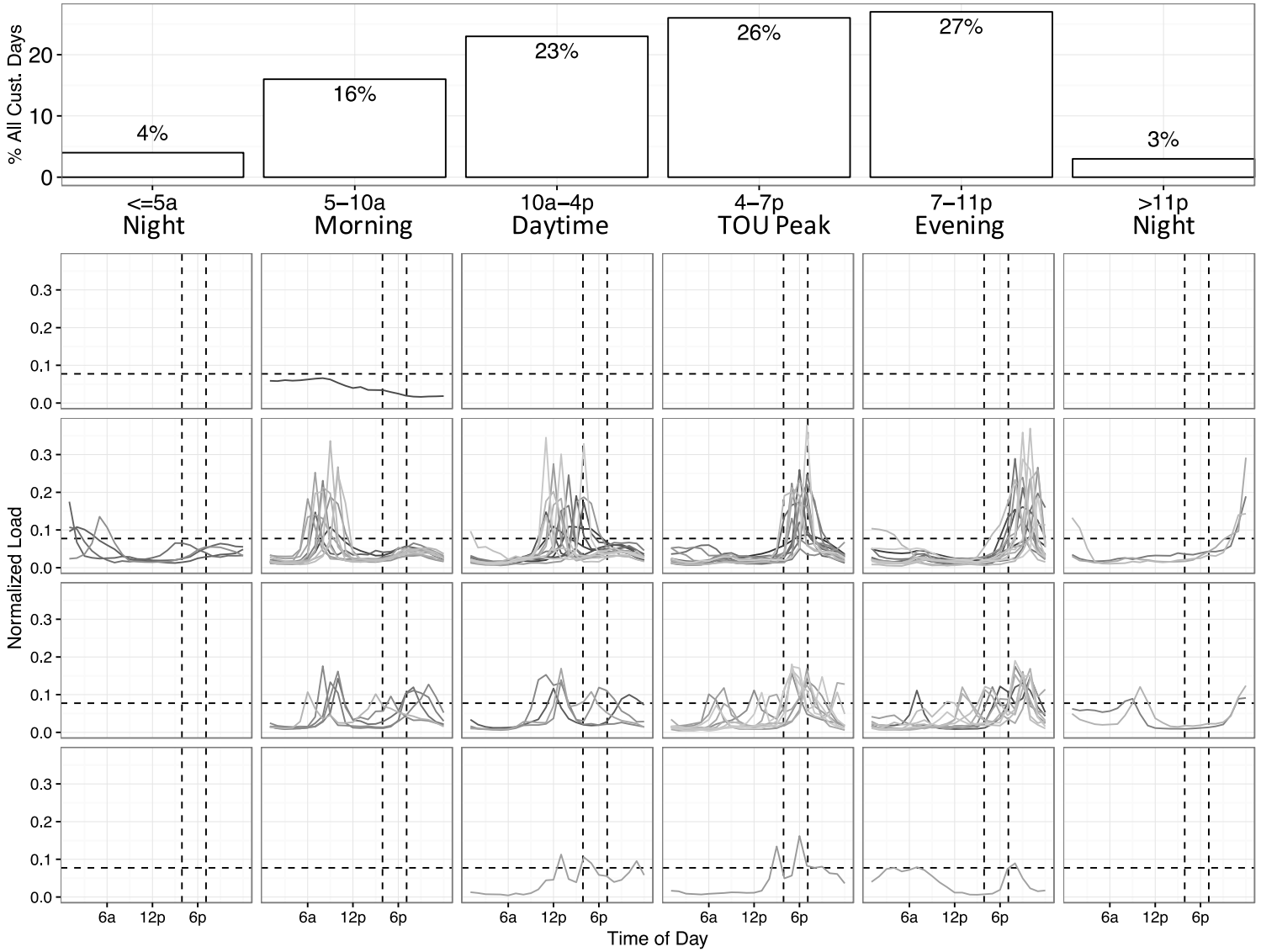

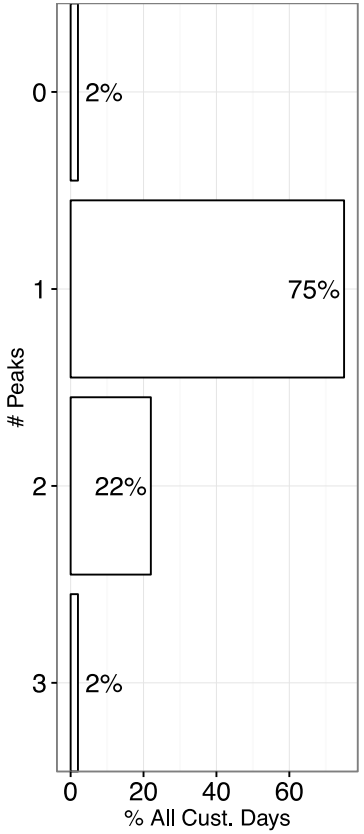

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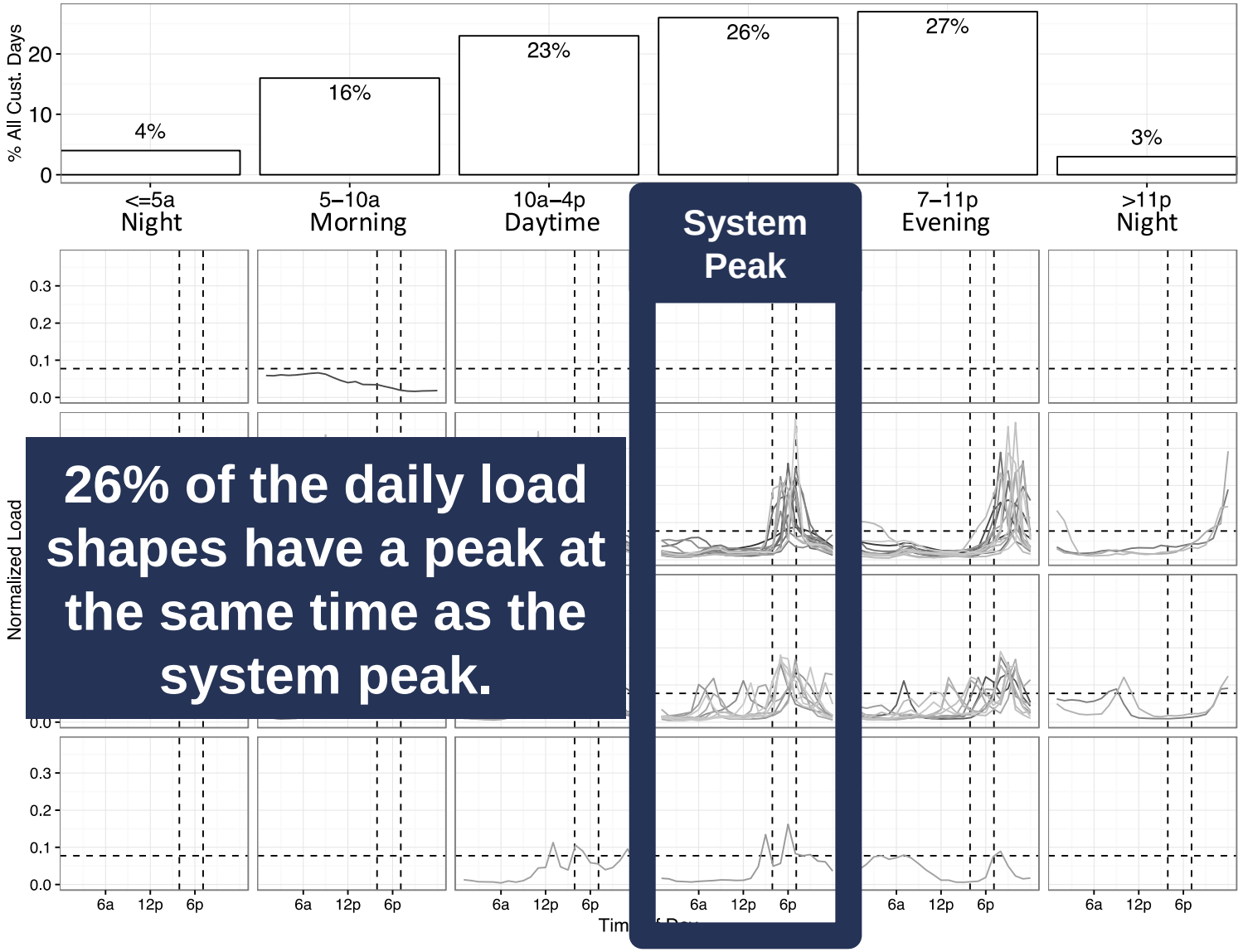
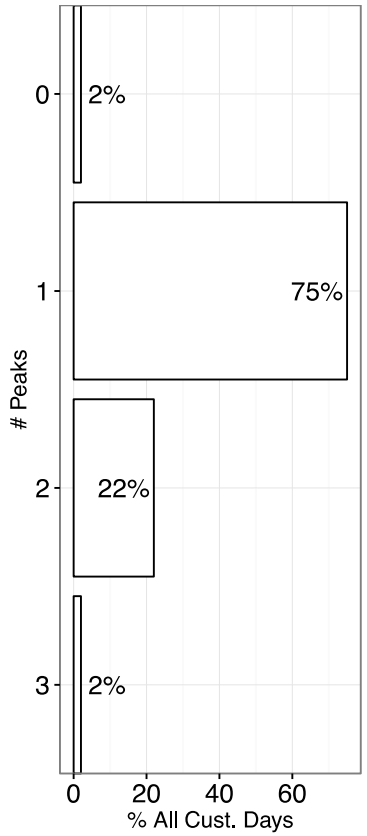


26% of the daily load shapes have a peak at the same time as the system peak.



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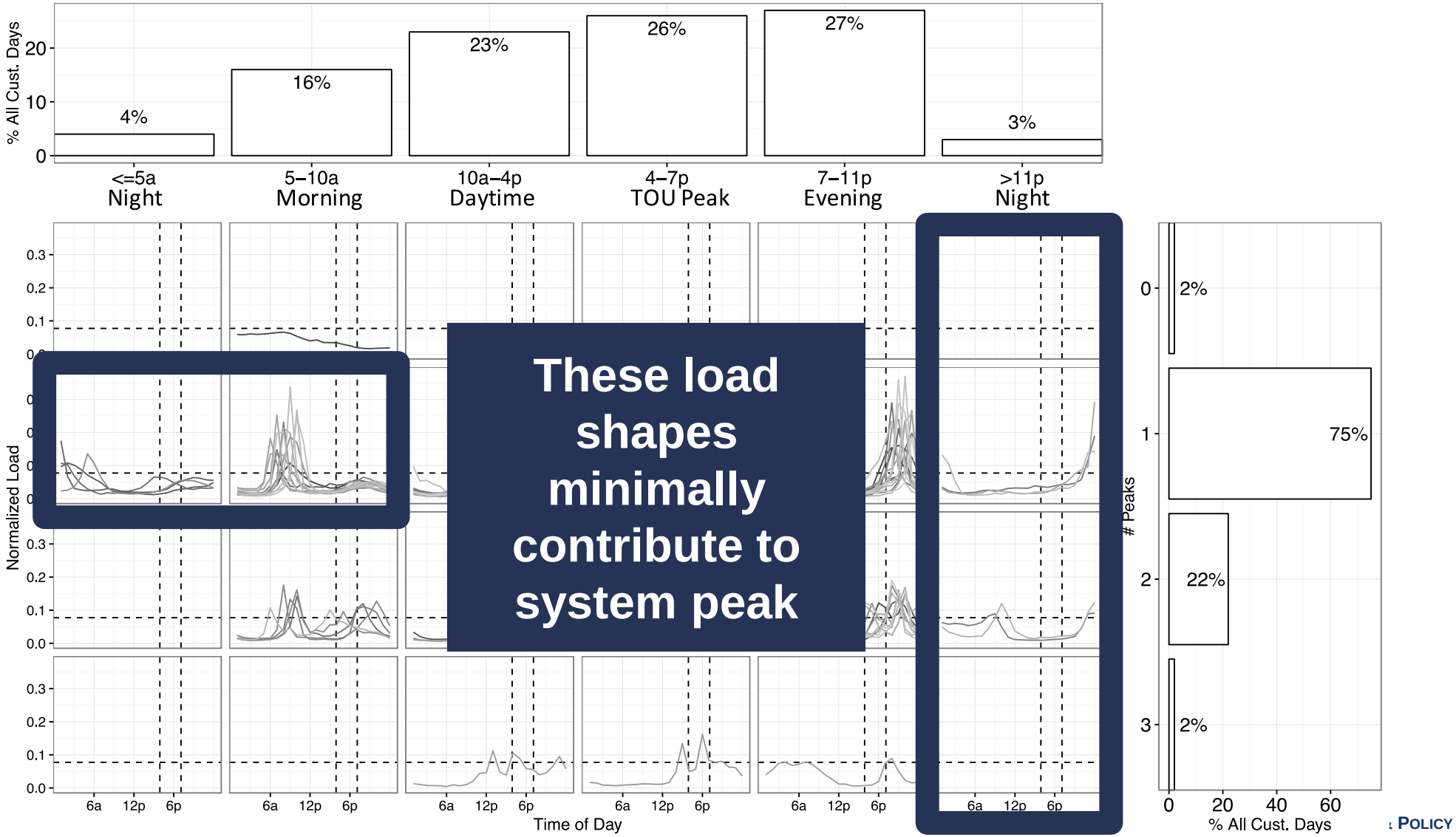

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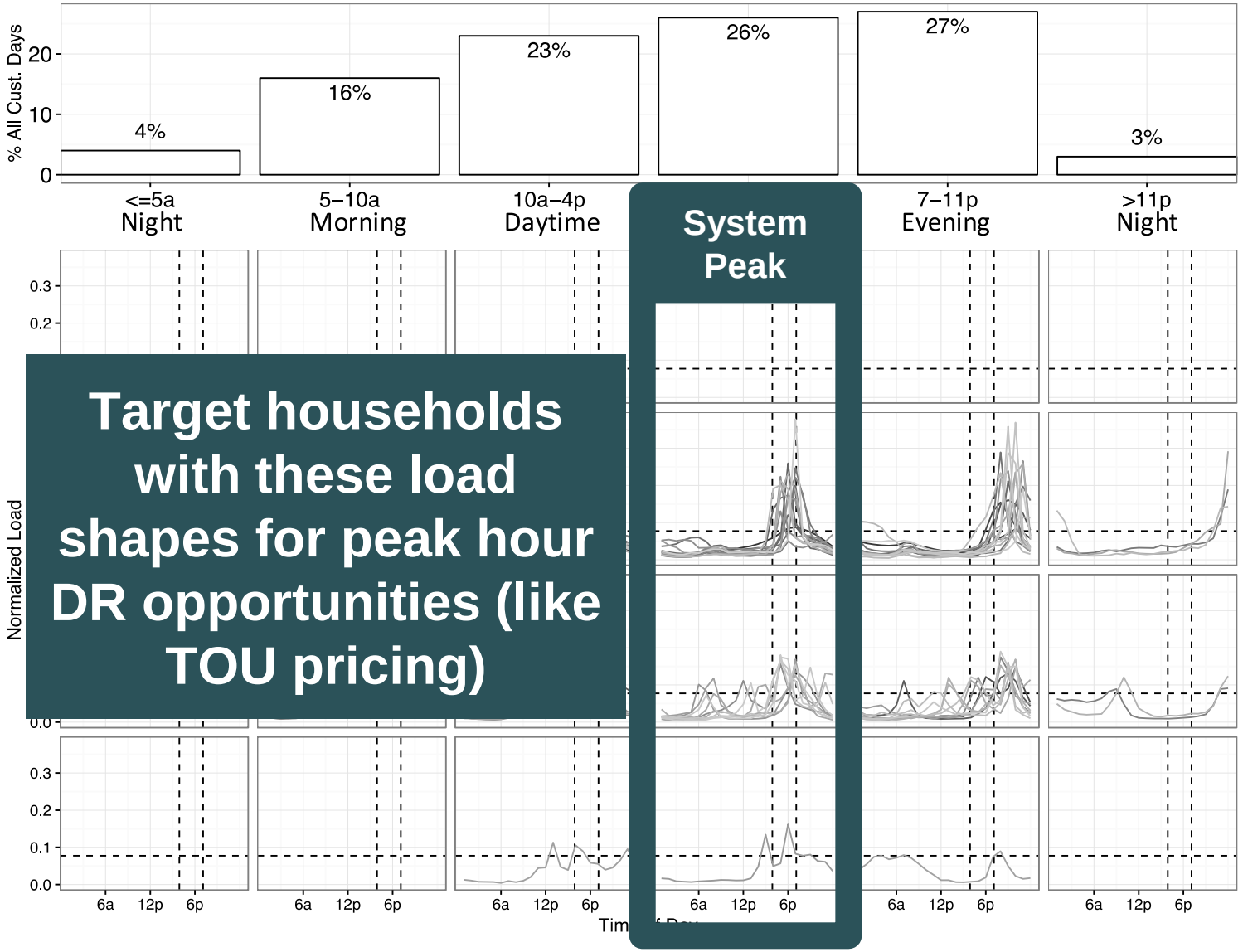
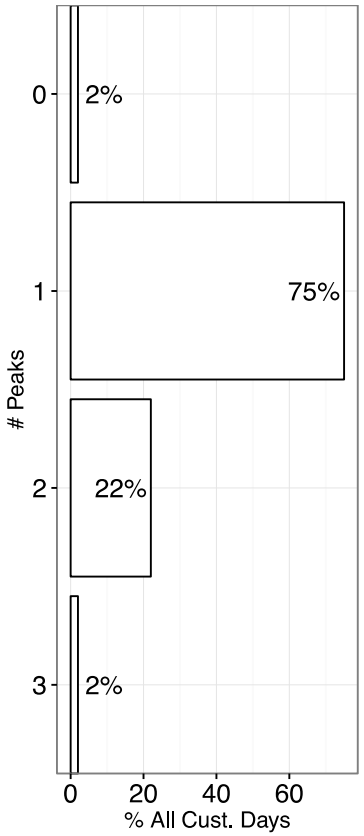


Target households with these load shapes for peak hour DR opportunities (like TOU pricing)



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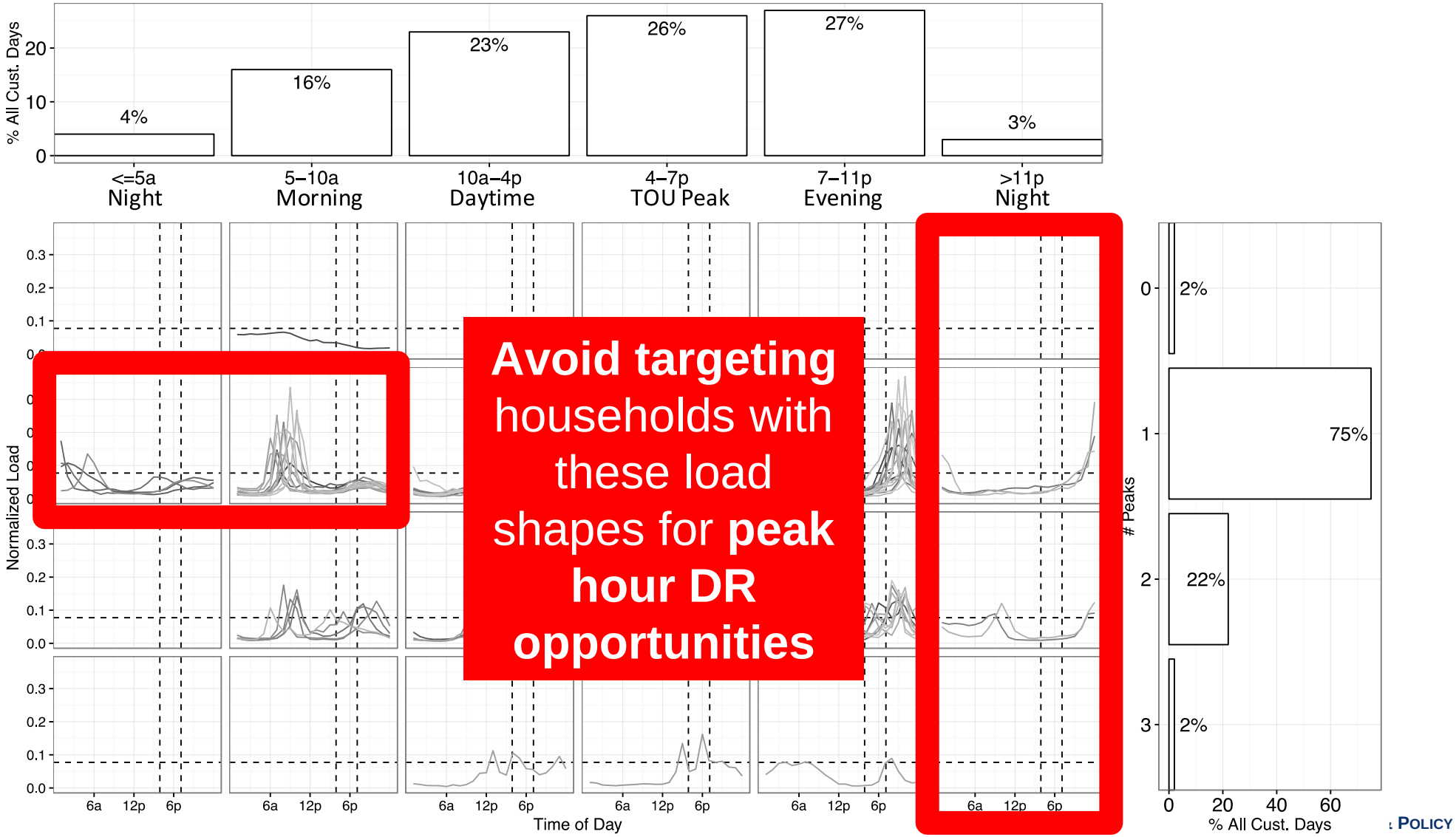

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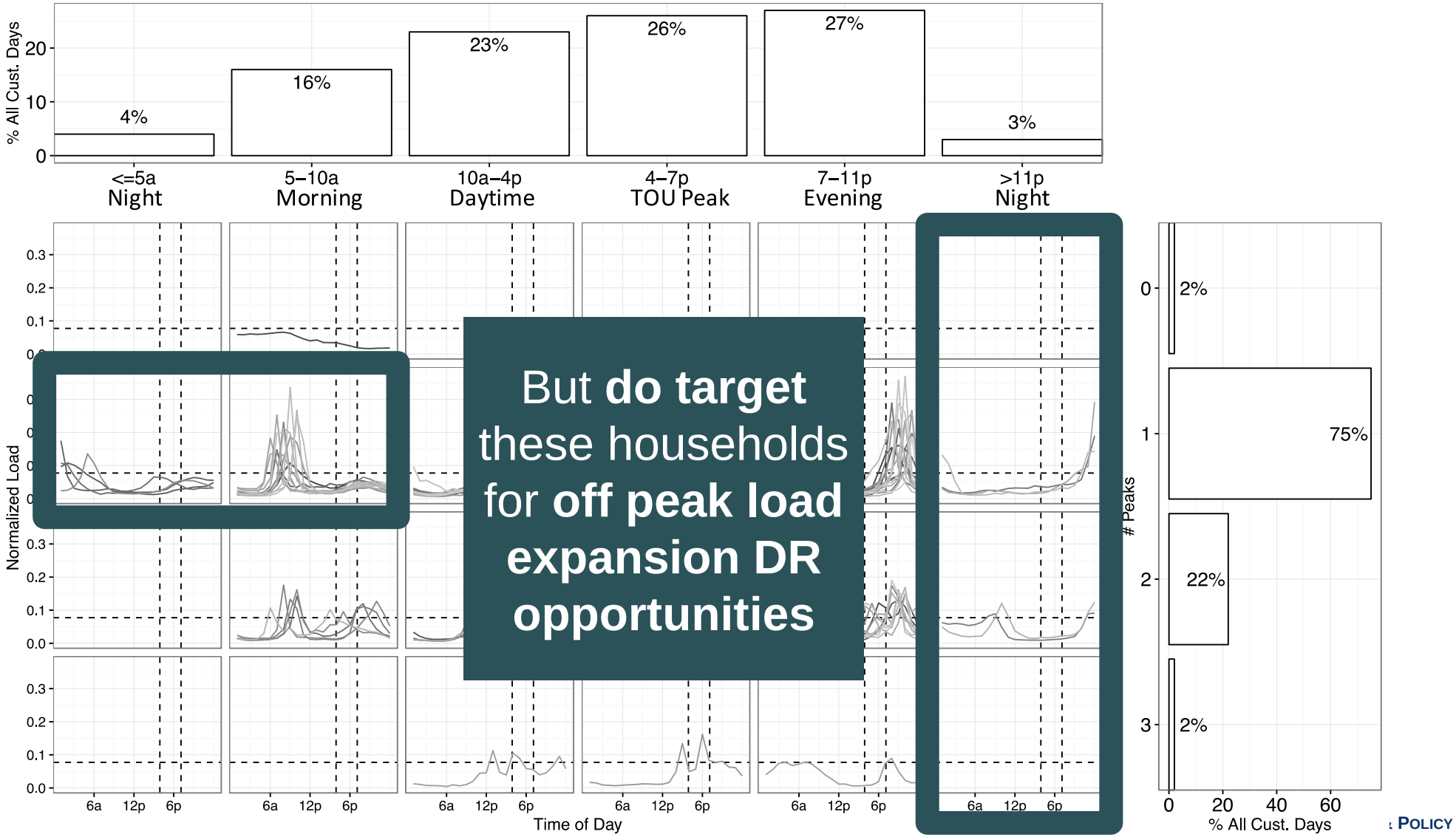
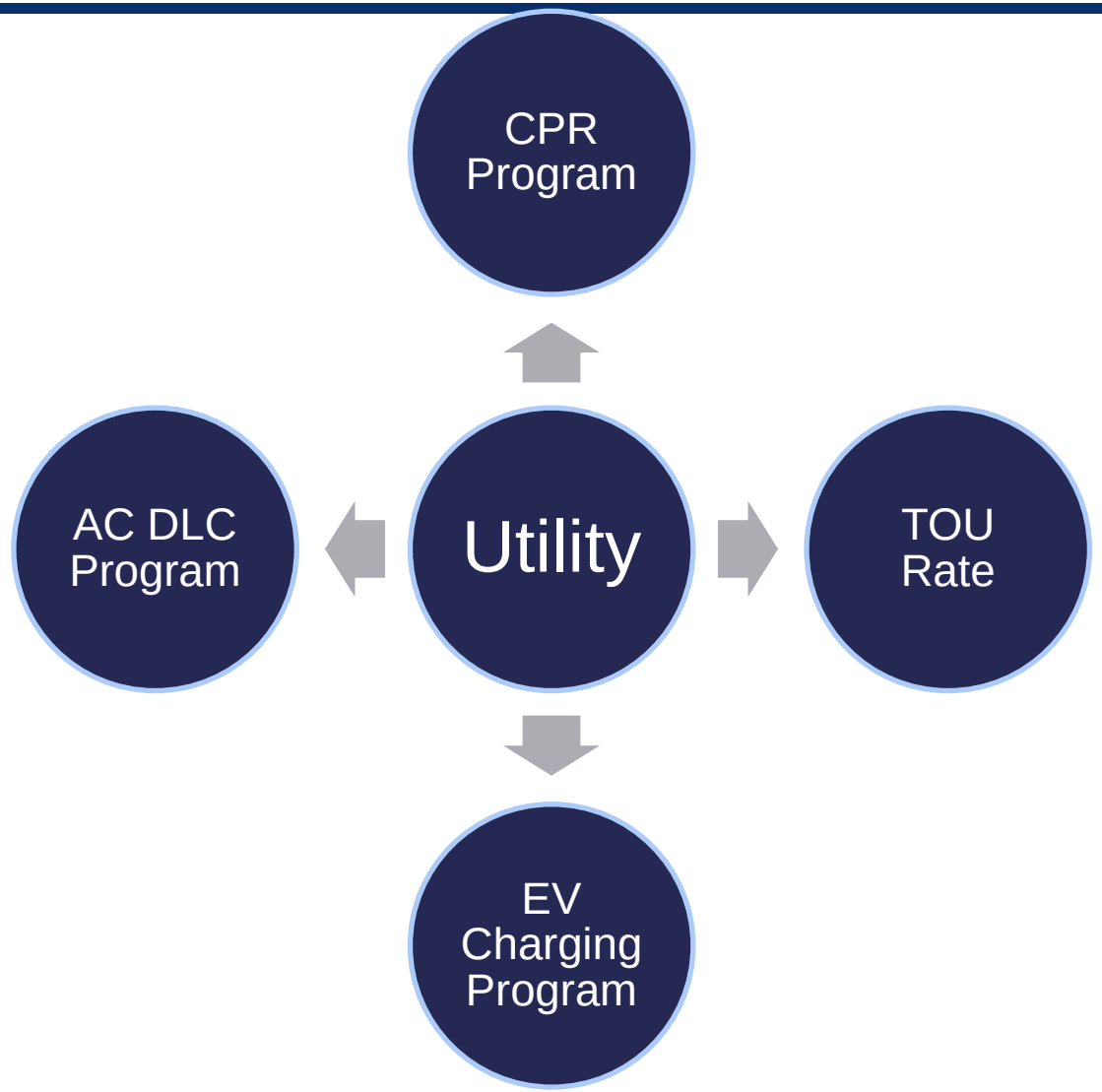


But **do target** these households for **off peak load expansion DR opportunities**

Analyze Load Shapes to Better Understand Customer Experience with Existing Rate or Program Offerings



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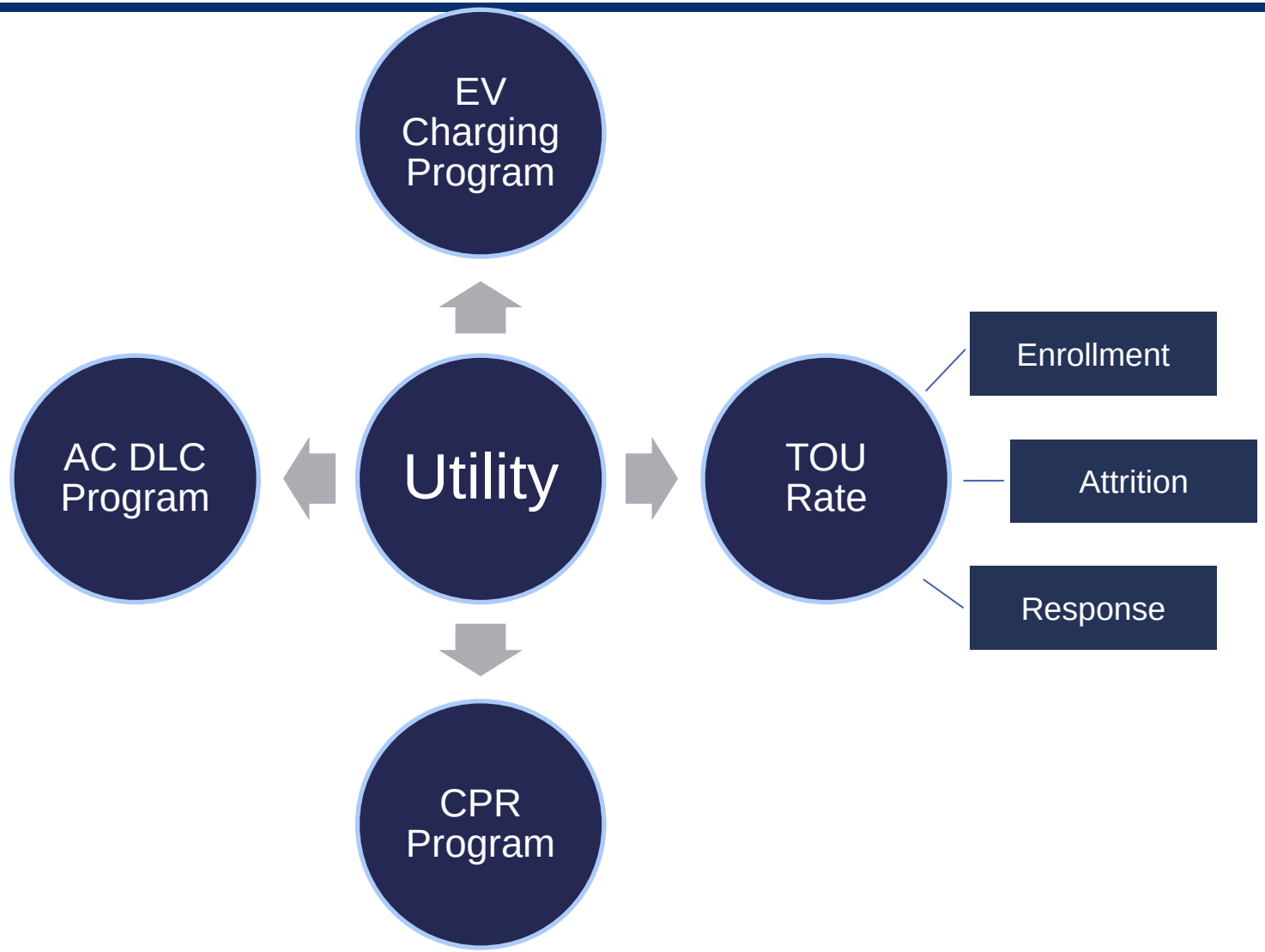
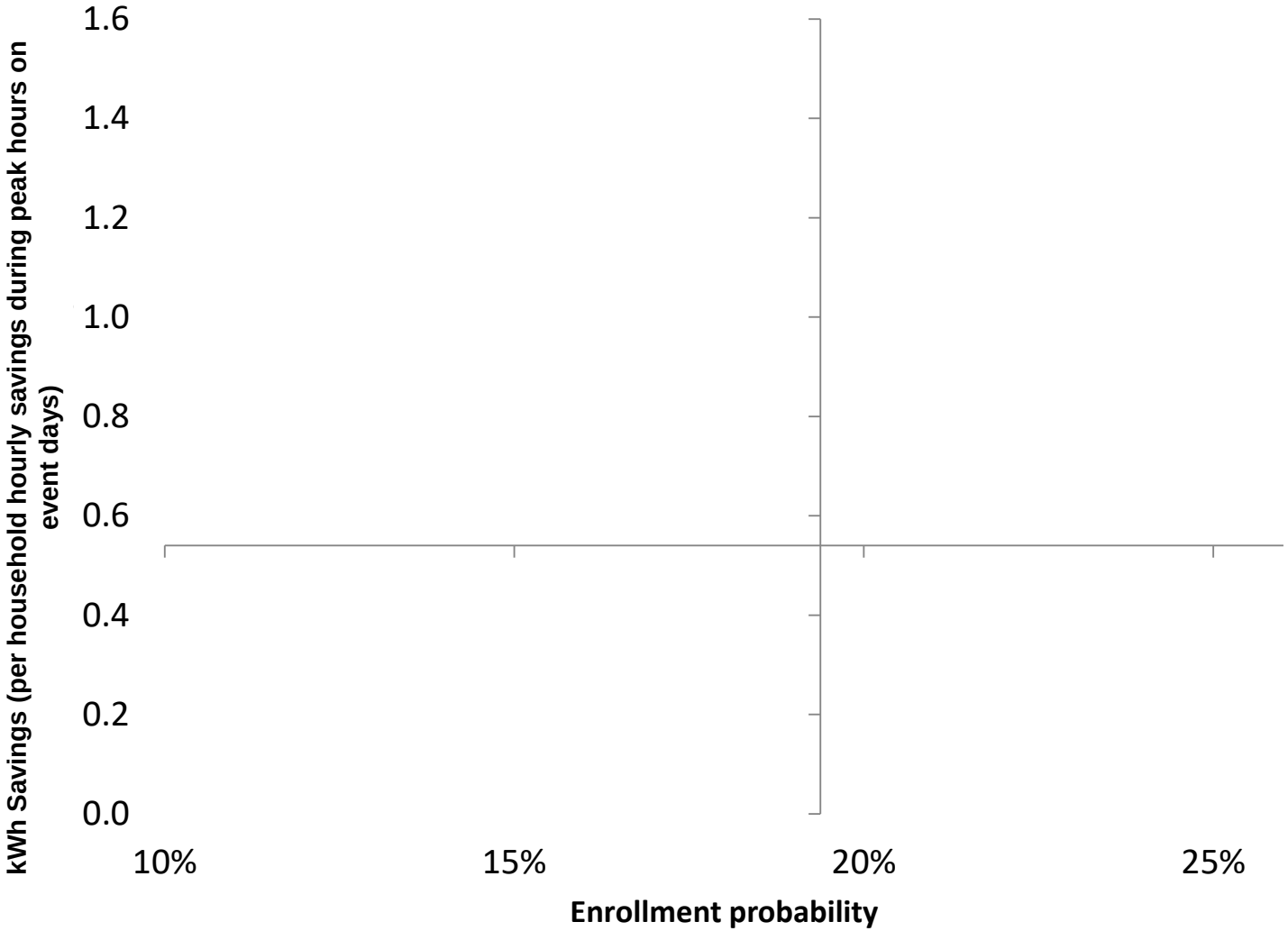
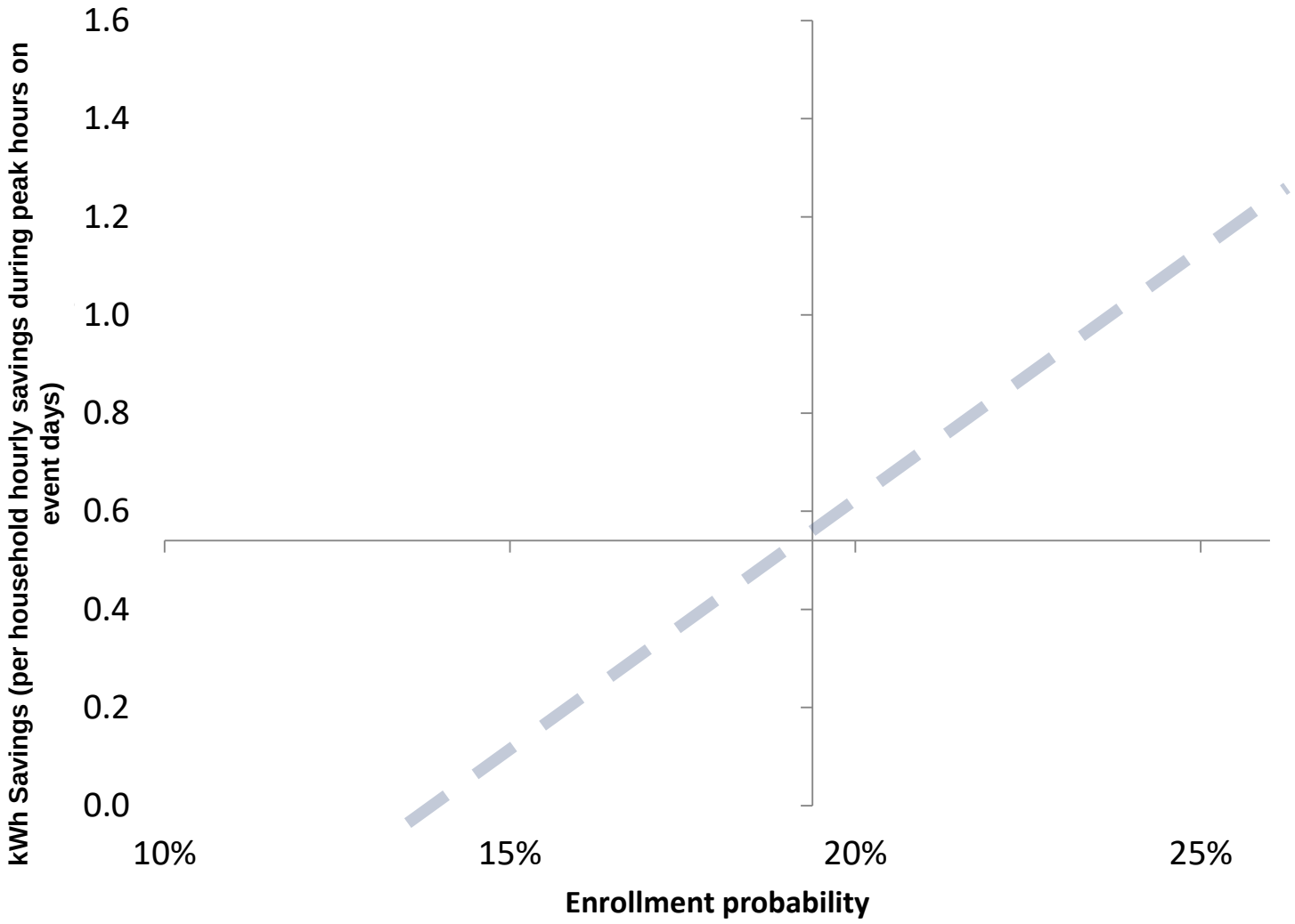


Load Shape Analysis
TOU Enrollment vs. Response



Do Customers Who are More Likely to Enroll Also Provide Greater Load Response?



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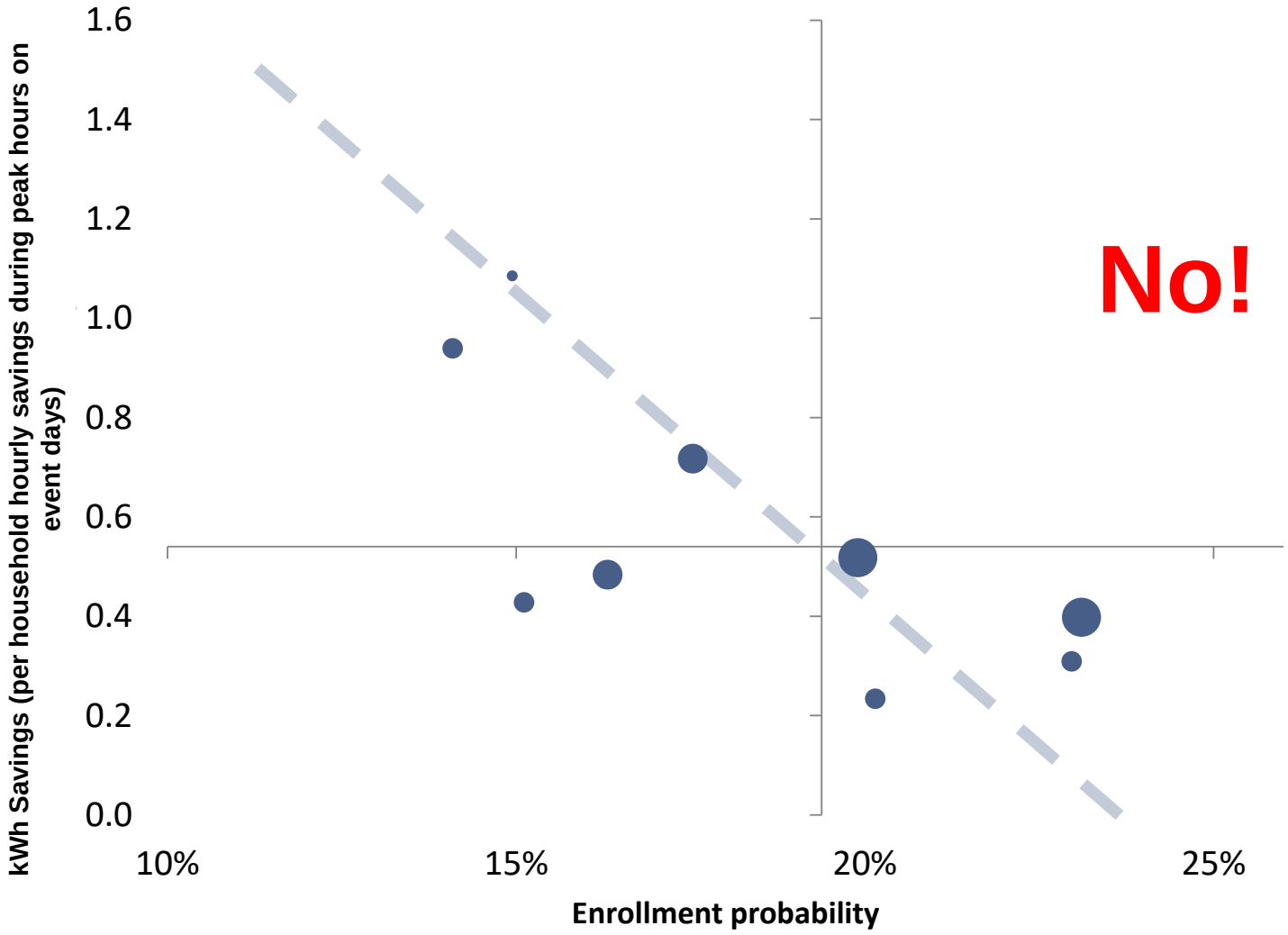
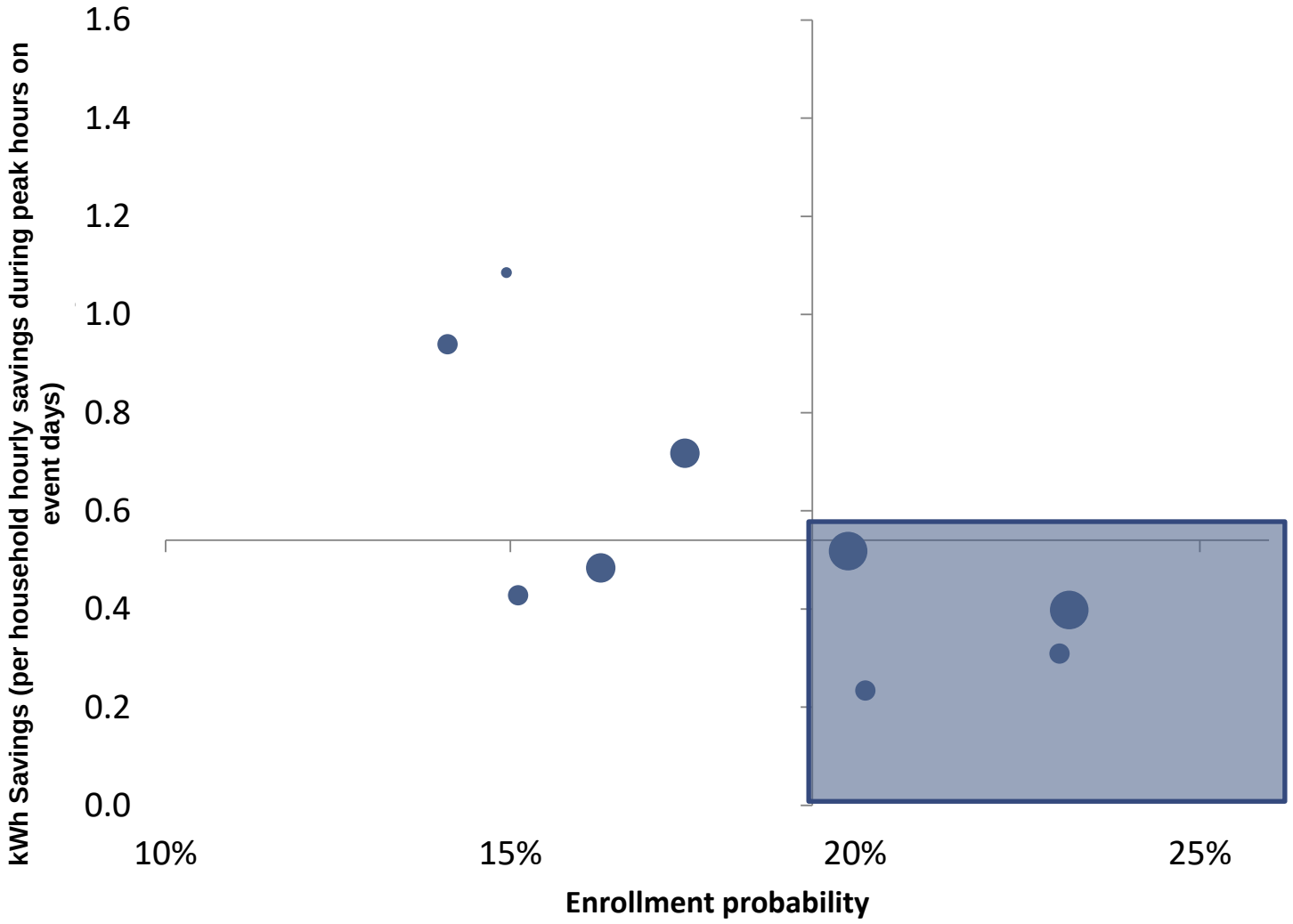


Are Structural Winners the Most Likely to Enroll but the Least Likely to Provide a Sizable Load Response?



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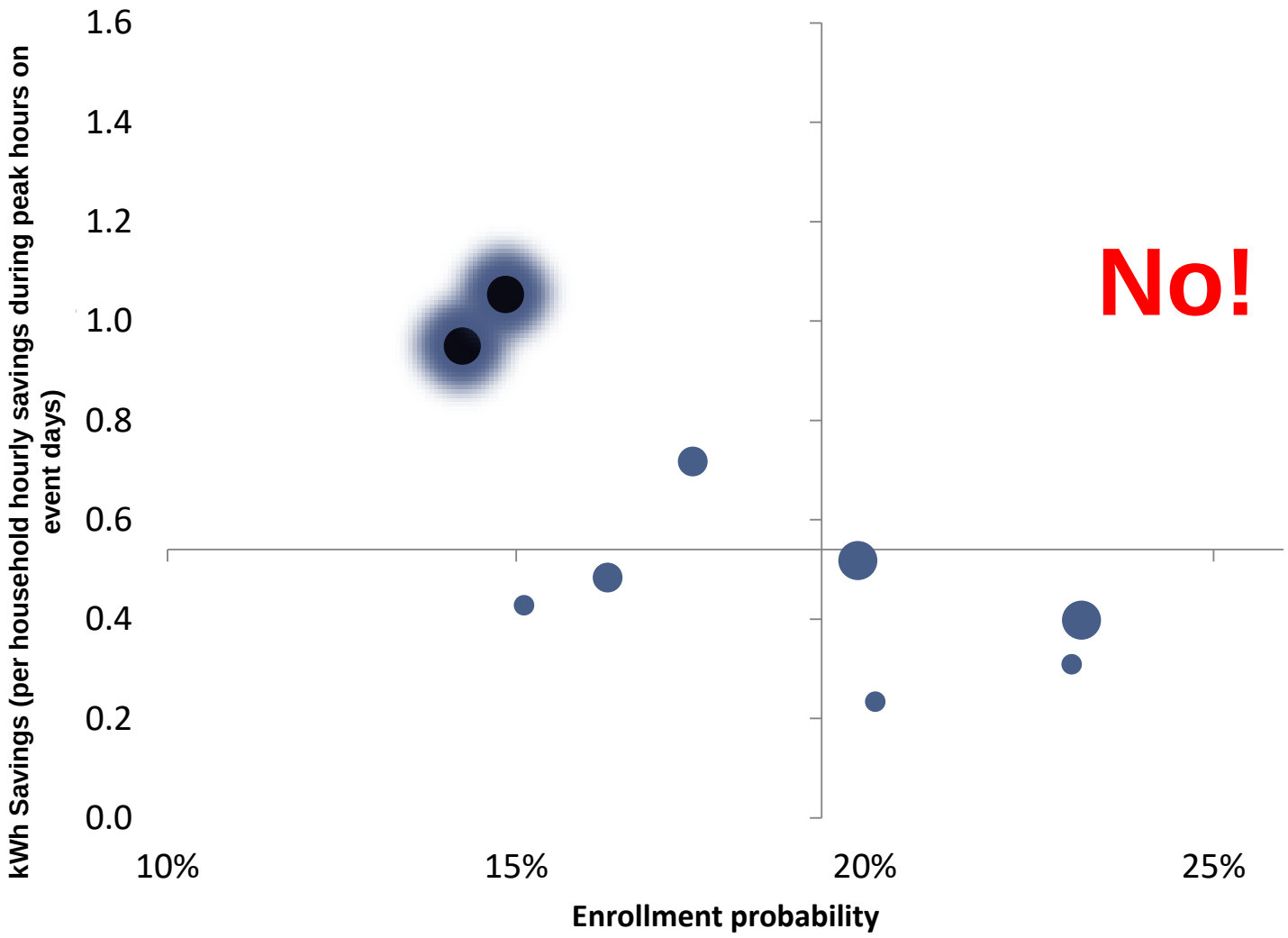
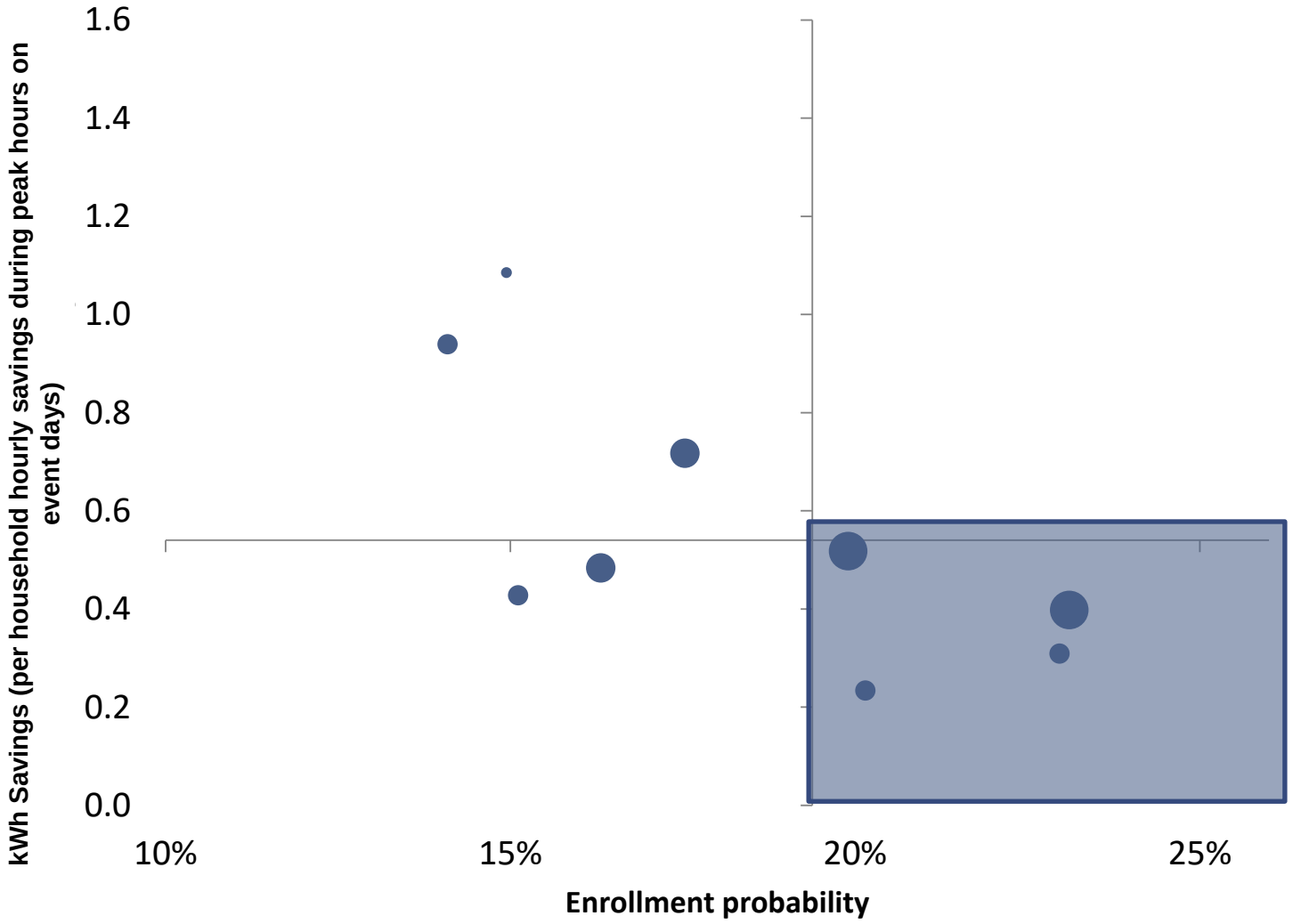


Who are the Customers Most Likely to Enroll but the Least Likely to Provide a Sizable Load Response?



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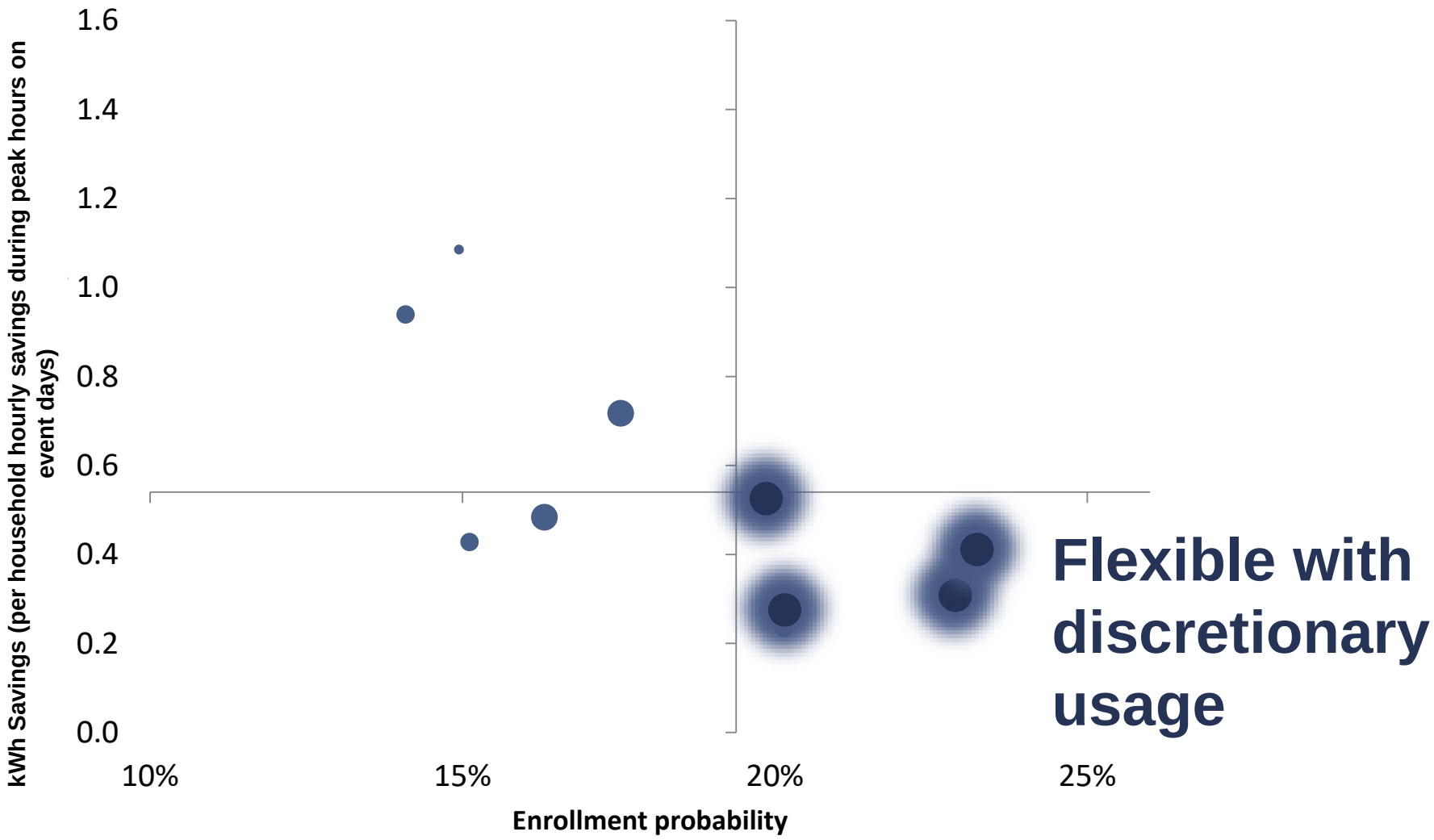

Develop Customer Supply Curves for Marketing New or Existing Rate Offerings

Which Customers are *Most* Cost Effective to Pursue?

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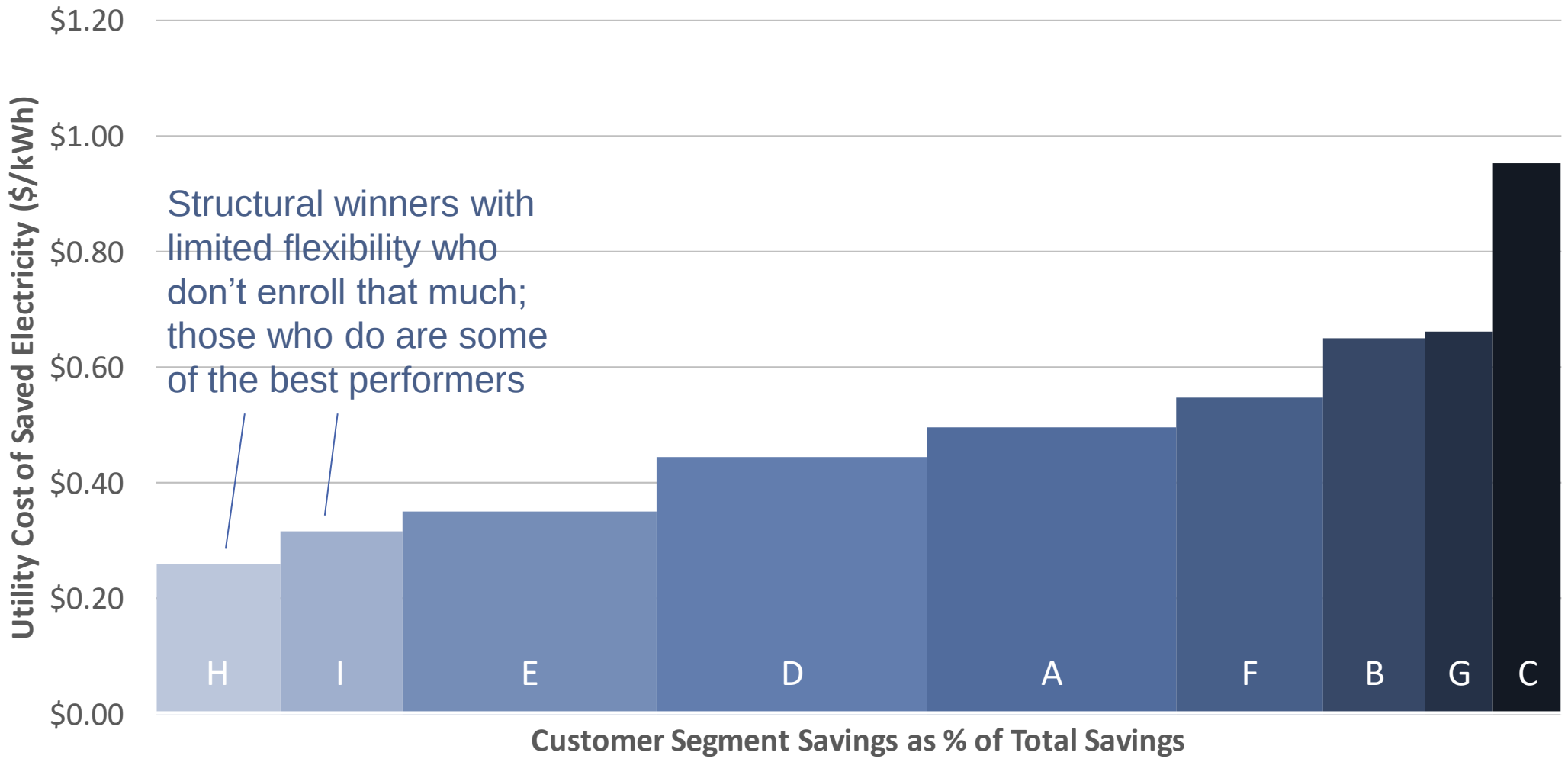

Which Customers are *Least* Cost Effective to Pursue?

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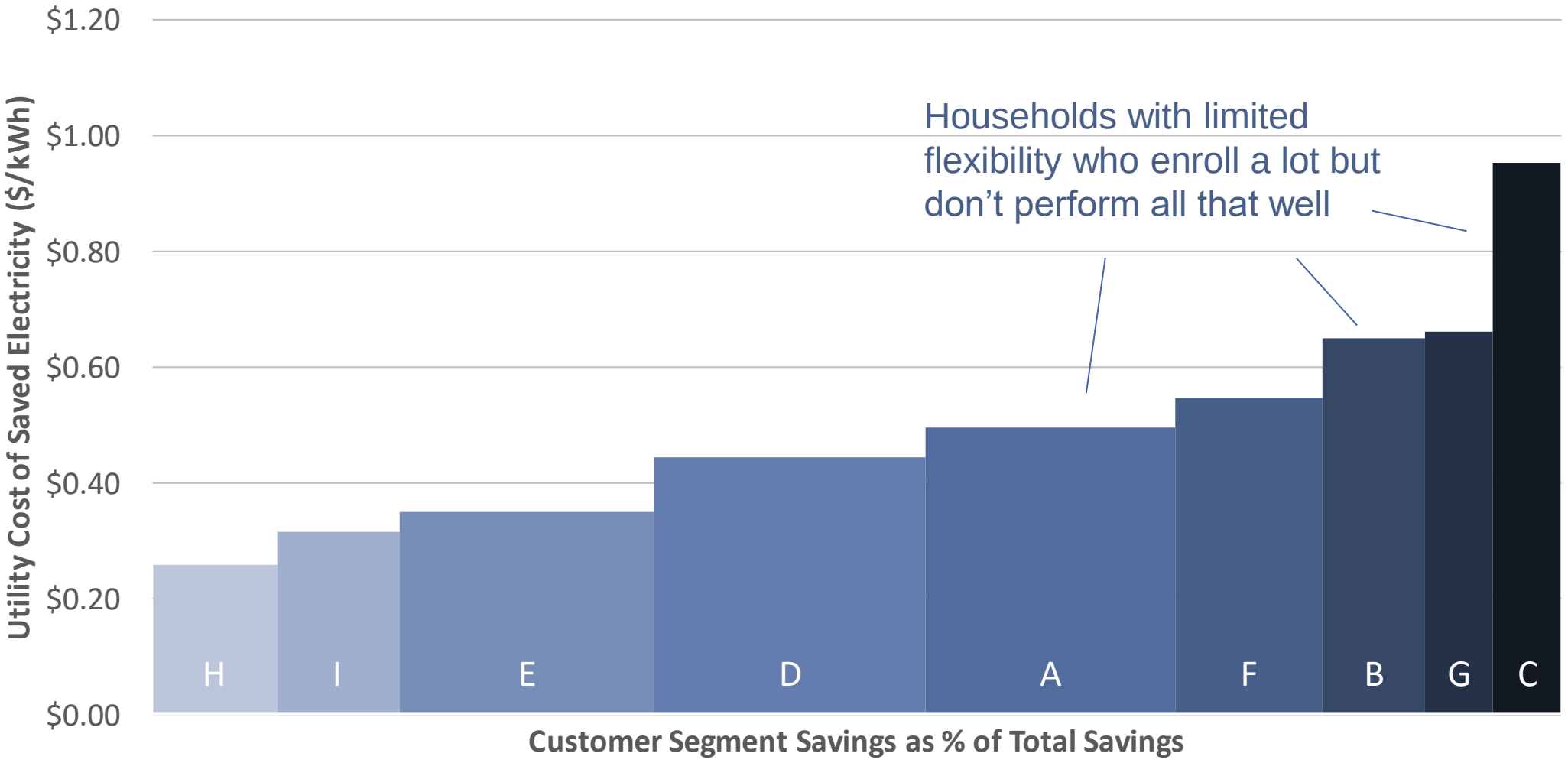
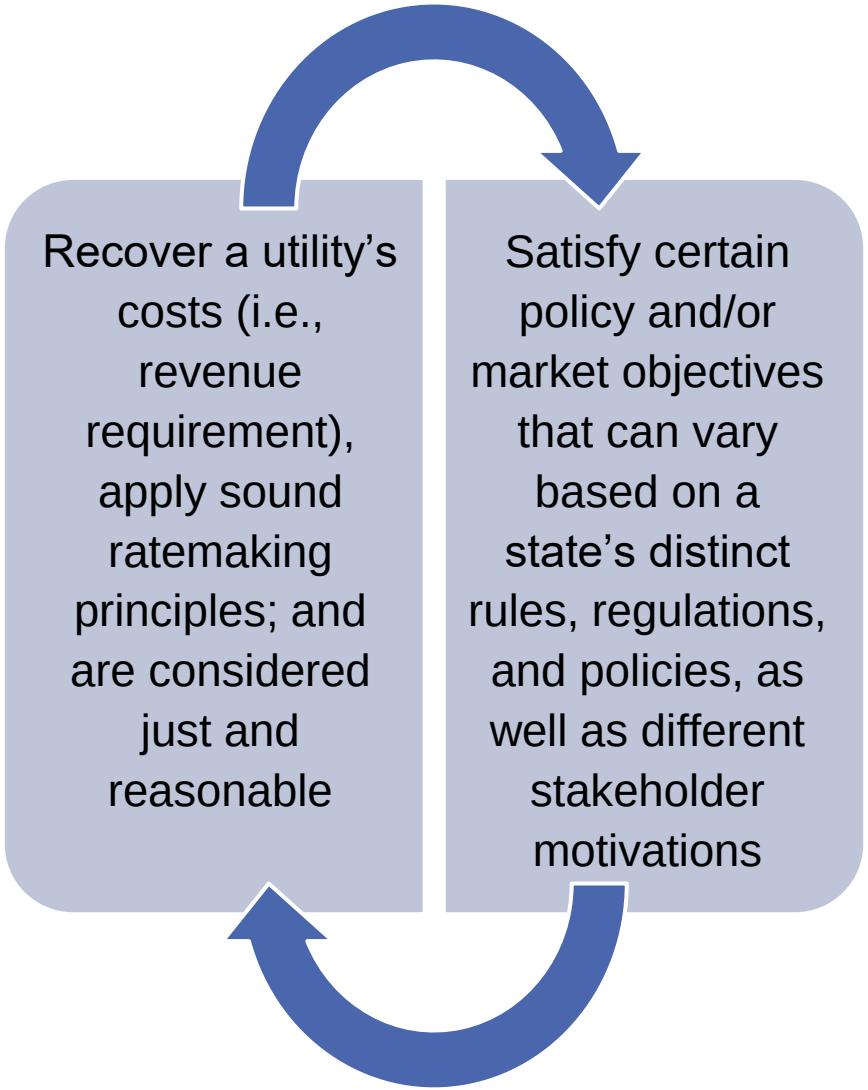


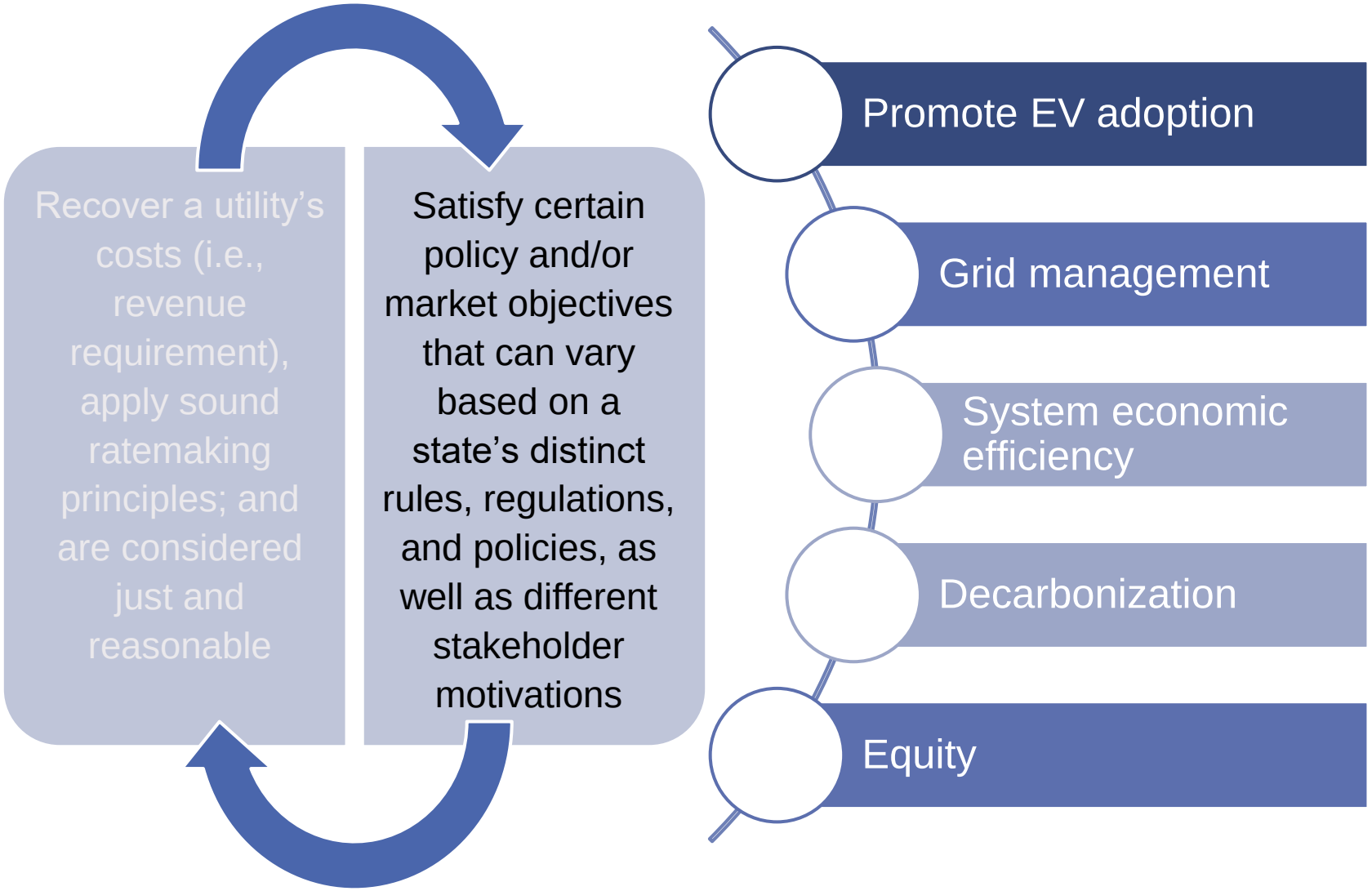
A number of factors and trends are motivating new or modified rate designs

- Utilities are deploying advanced metering infrastructure (AMI)
- Distributed energy resource (DER) cost declines and technological innovations
- Adverse affects from net energy metering (NEM)
- Concerns about utility fixed cost recovery and revenue sufficiency
- Desire for fair and equitable access and impacts of different rate designs and offerings
- Variable renewable energy (VRE) integration issues (e.g., over-generation and net load shape impacts)

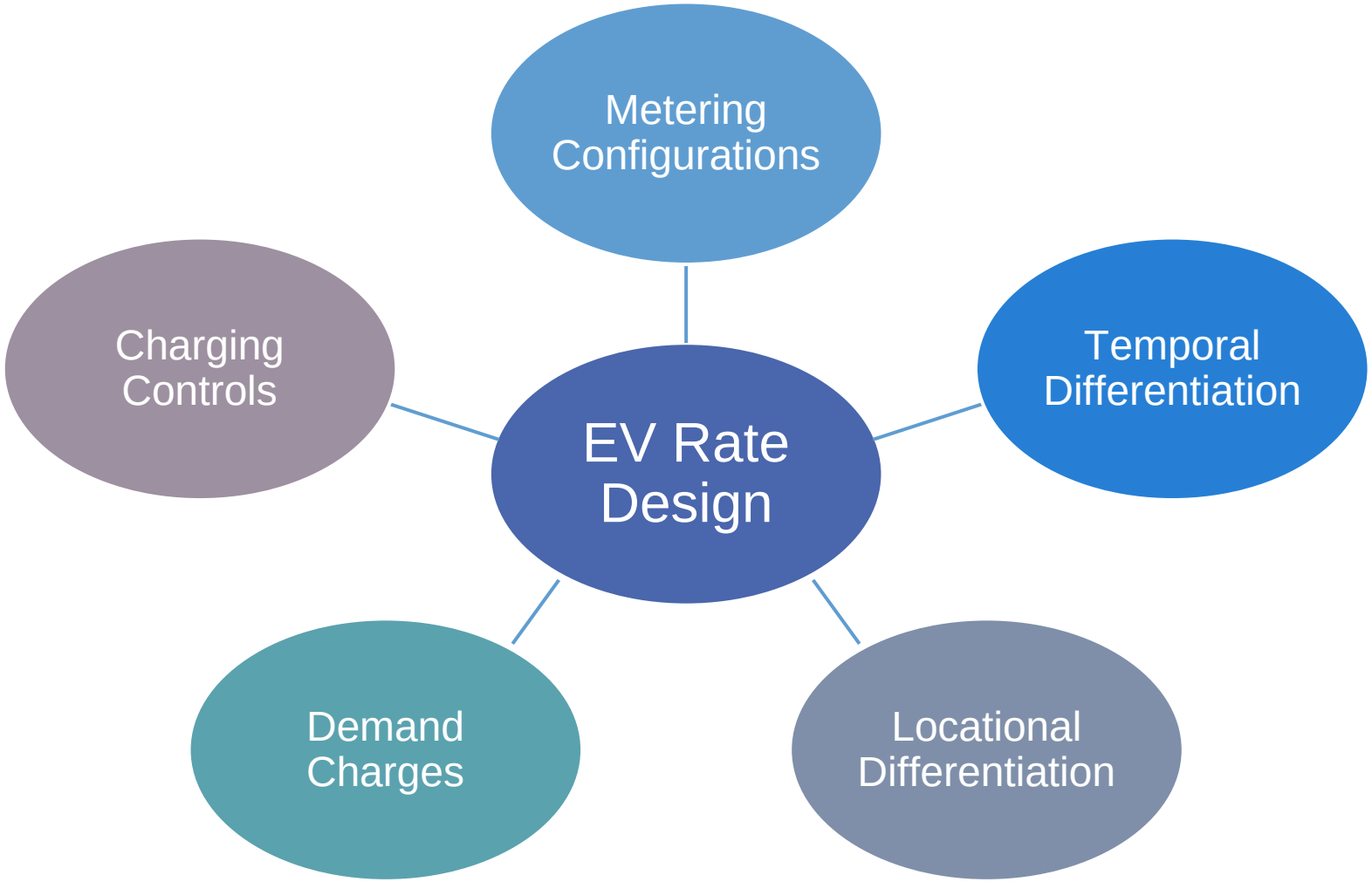
Retail rates are designed based on two broad concepts



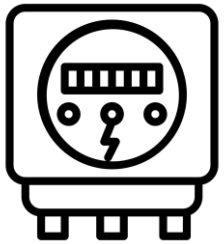
Five policy-driven objectives used as the basis for EV retail rate design



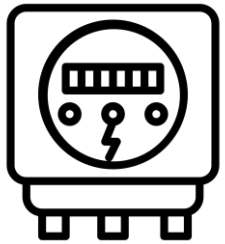
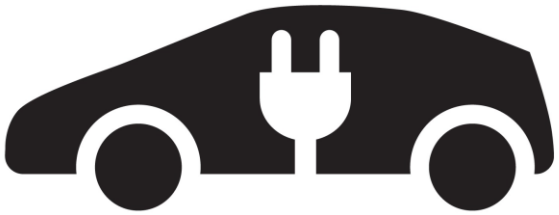
EV rate design typically comprised of five (5) different components



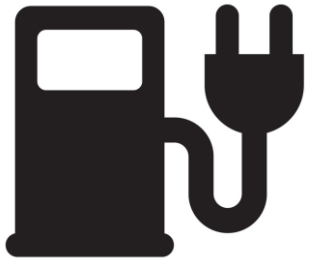
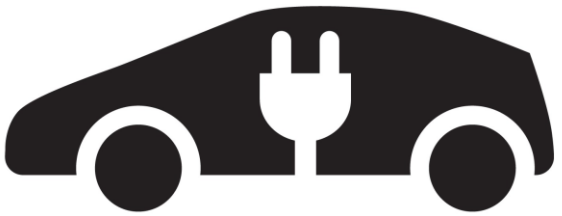
Metering Configurations




Whole home/facility consumption
via account meter

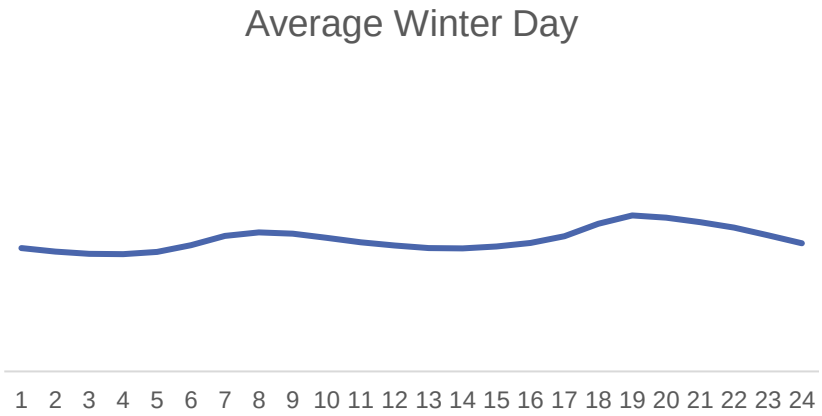



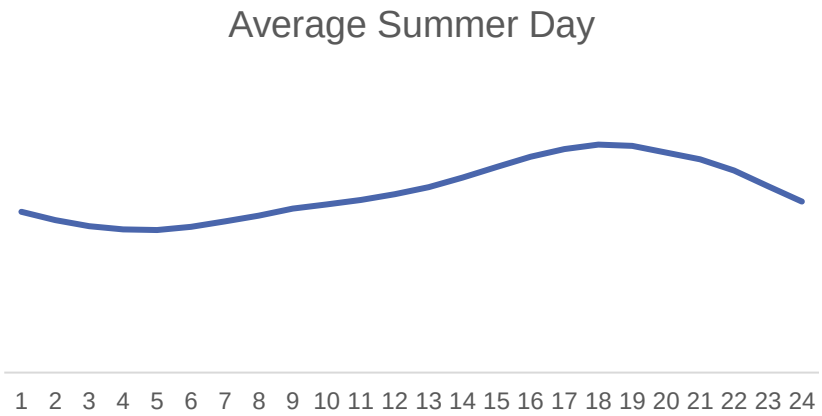
EV charging consumption
via account meter

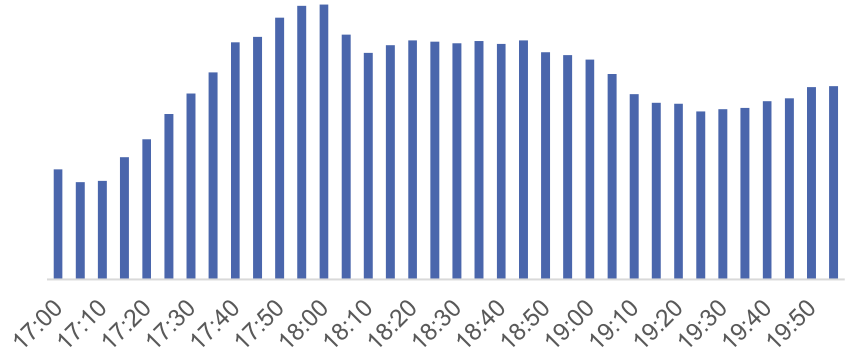
Submetering via EVSE or vehicle

Temporal Differentiation

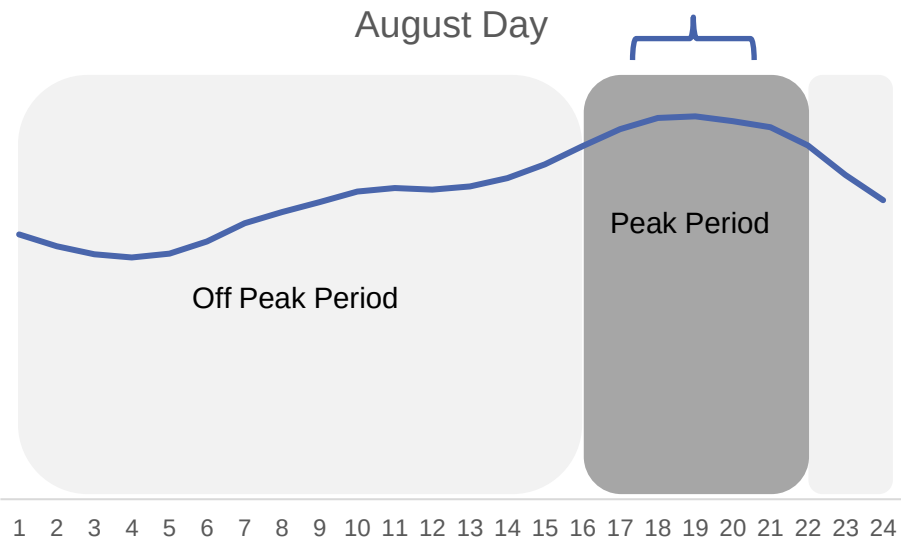




Seasonal Differentiation



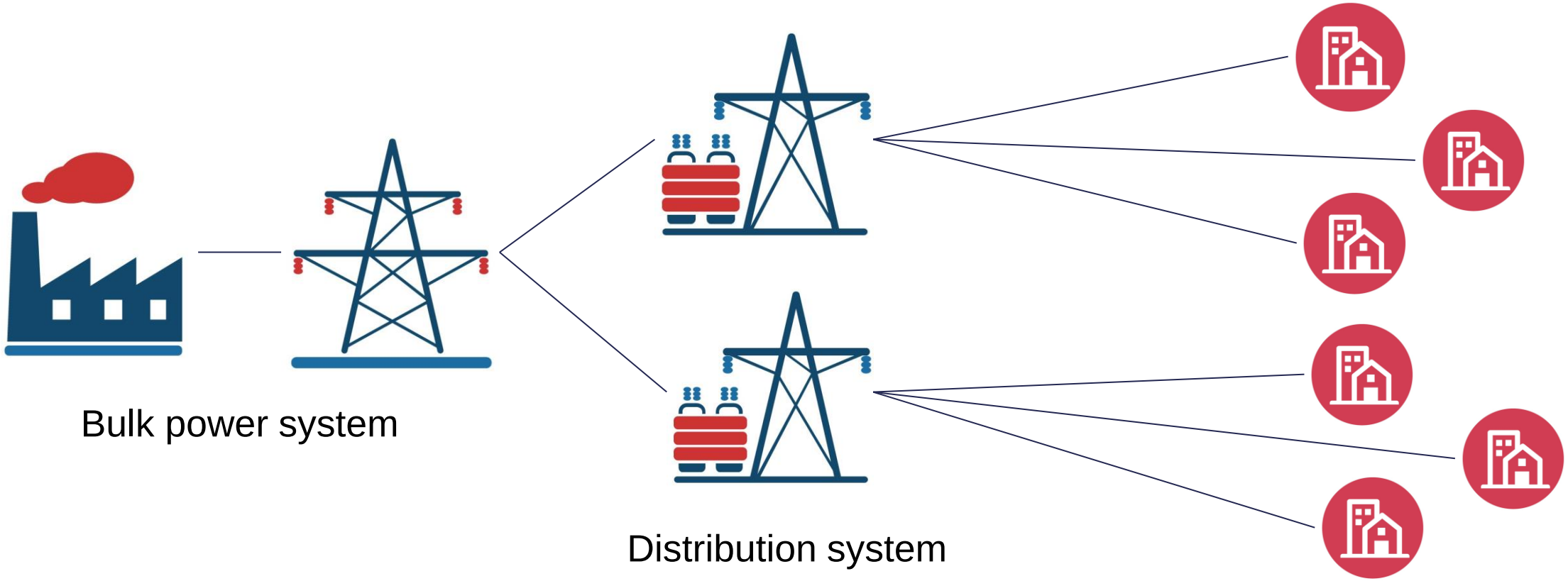
Sub-hourly Differentiation



Hourly and Period Differentiation

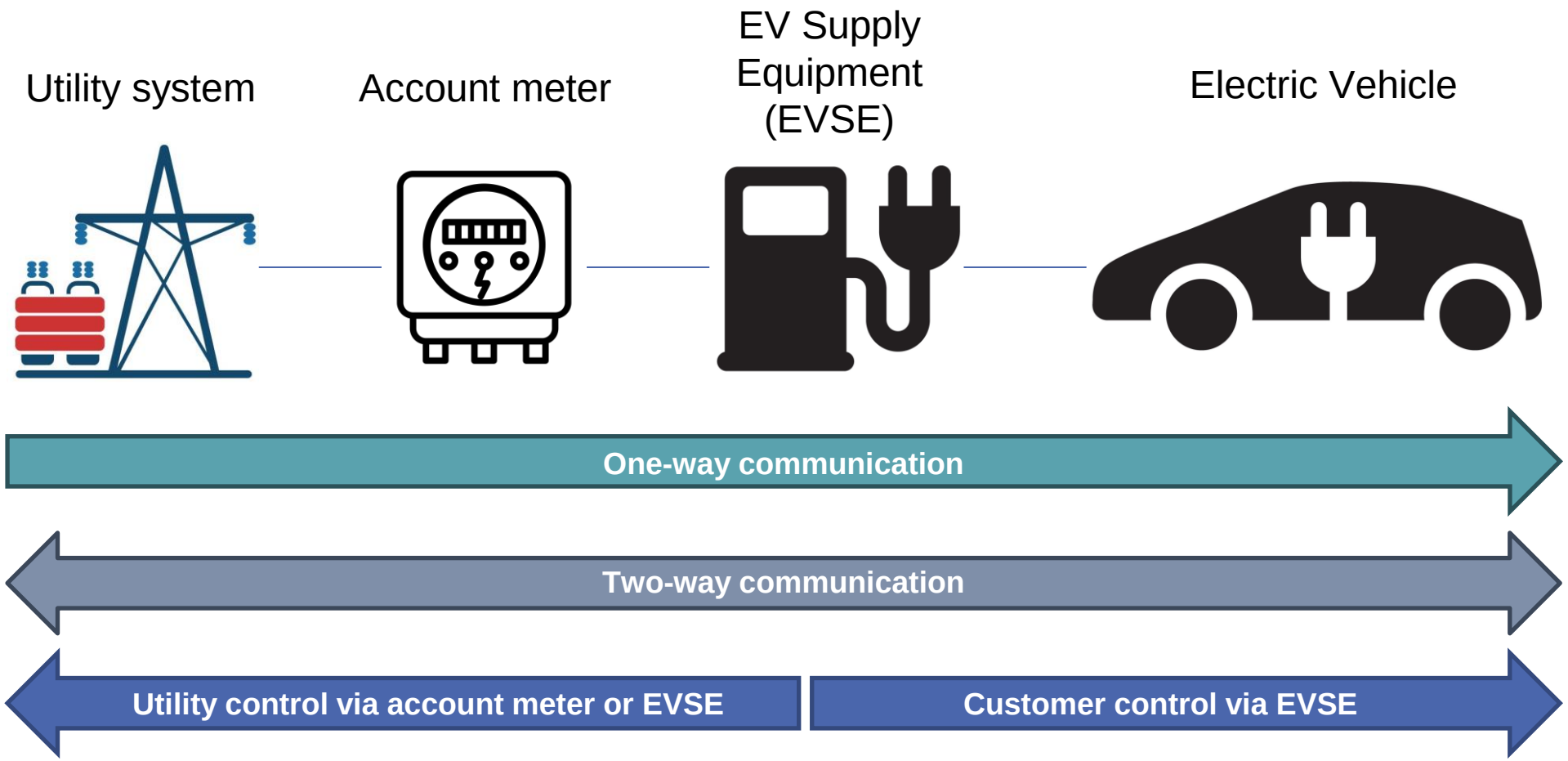
Note that figures show temporal differentiation in *load* but there is also temporal differentiation in system *costs* and *emissions* that could be used as the design basis

Locational Differentiation



Demand Charges

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

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Decarbonization rates communicate marginal emissions rates with differentiation consistent with them

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

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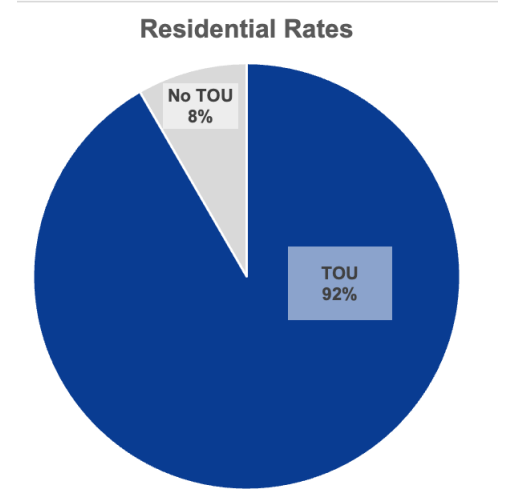
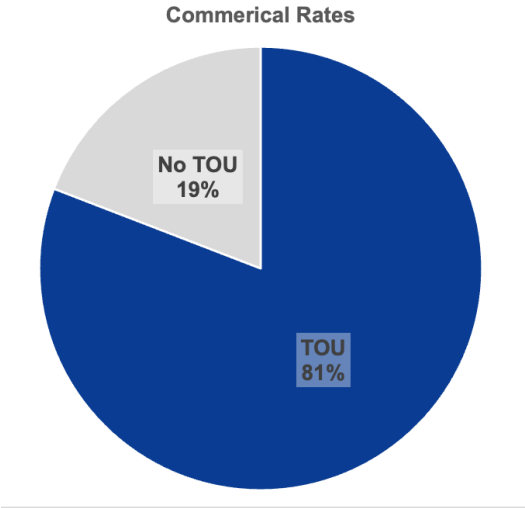
Observations: Regulatory and Rate Activity

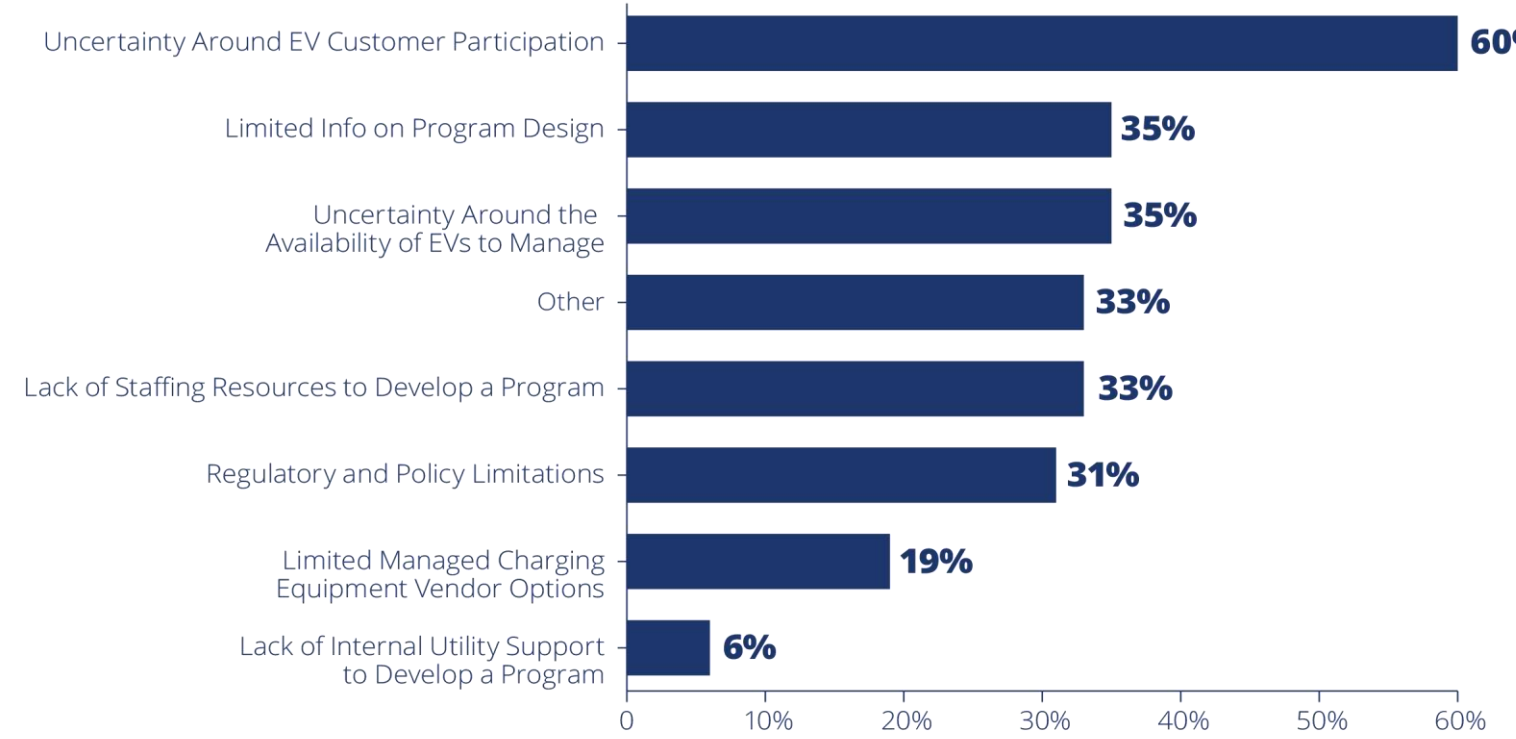
- **Motivation:** The overwhelming majority of rate activity (>85%) is focused on Grid Management
- **Temporal-Differentiation:** “Vanilla” TOU rates are the dominant rate structure (>90% residential; >80% commercial)
- **Demand Charges:** Over 20 states are examining demand charge alternatives for public and DCFC, particularly at lower load factors
- **Metering Configurations:** There is an increasing attention given to telematics, submetering and requiring separate meters





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/

How can utilities be more effective?

Use data analytics to more cost-effectively target market, educate, and inform customers of opportunities

Use data analytics to more effectively de-risk opportunities to ensure more equitable access to the benefits they could provide

Use data analytics via pilots to more effectively test out viability of new rate designs and more concretely assess ways to overcome barriers

Questions/Comments

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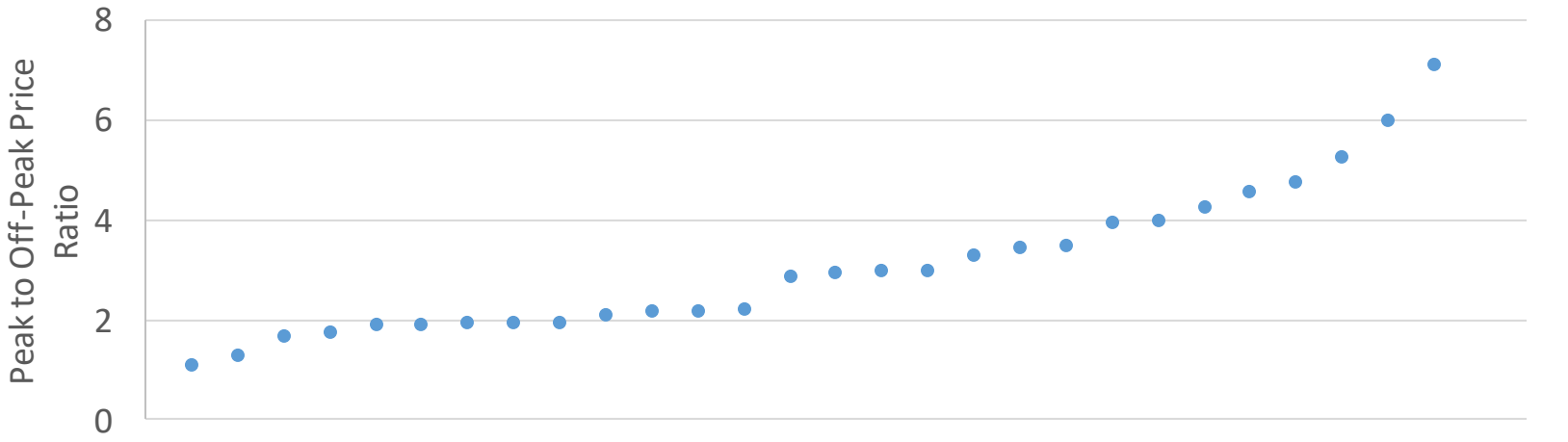
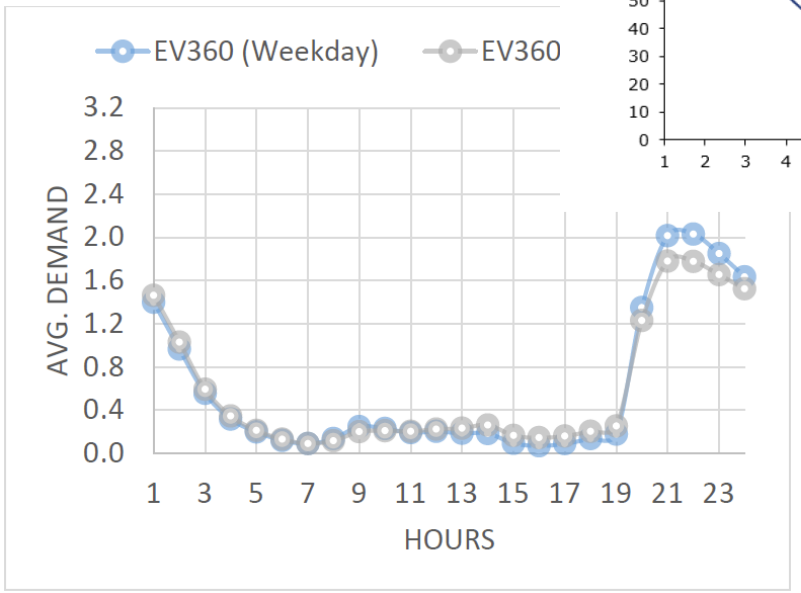
Appended slides on customer response to EV retail rates

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

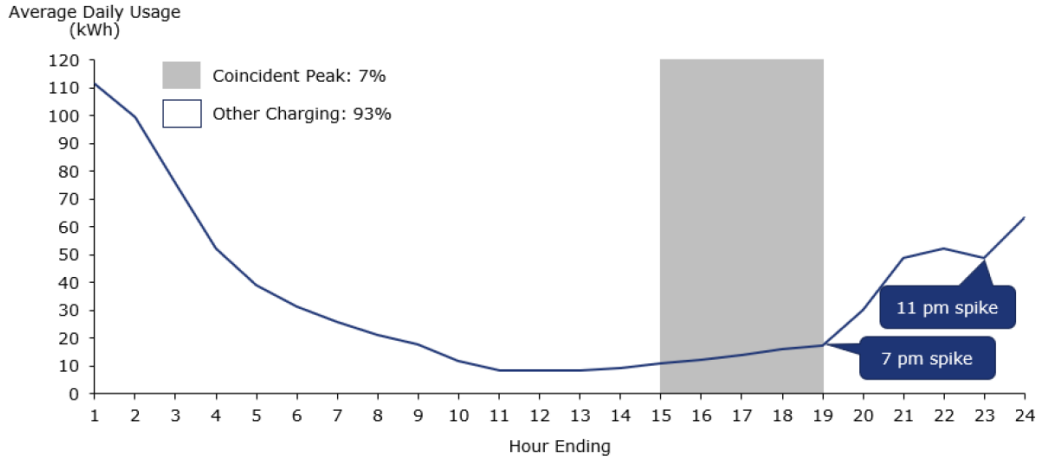


Properly designed rates can be an effective tool for managing EV charging behavior

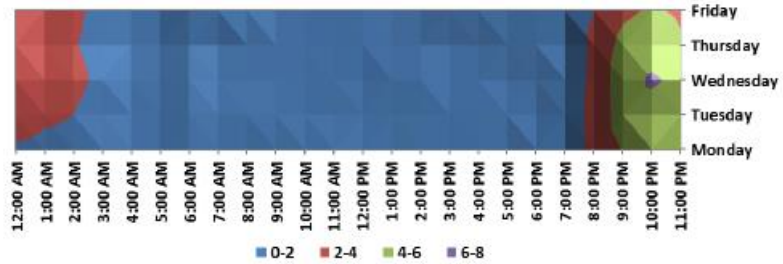


Source: McDougall, L., Donnelly, A. and Chandra, K. (2019) Austin Energy's Residential "Off Peak" Electric Vehicle Charging Subscription Pilot: Approach, Findings, and Utility Toolkit. EV360 Whitepaper. Austin Energy, Austin, TX.

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



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



ure 4-1
erage weekly load shape (kW) for PIV customers

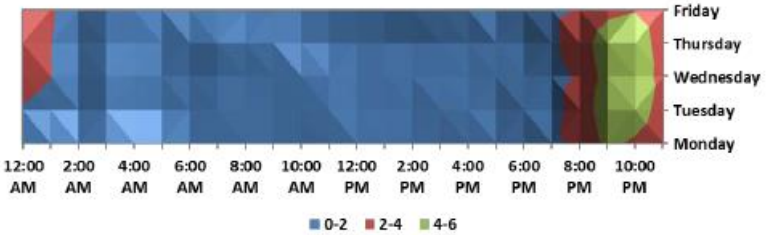


Figure 4-2
Average weekly load shape (kW) for PIV-Green Customers

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

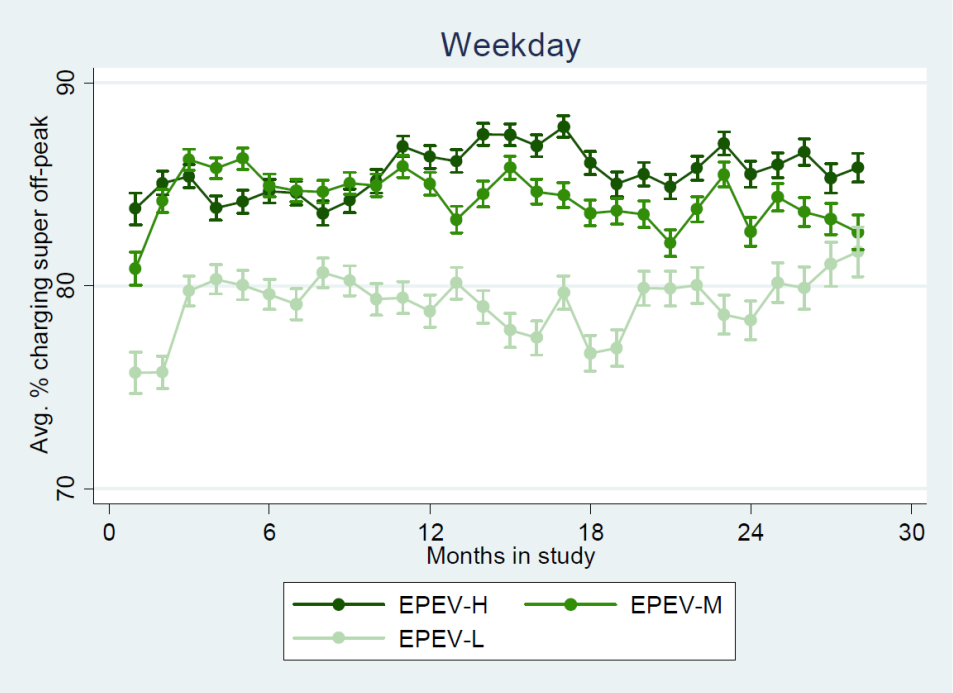
Tests of Pairwise Differences in Percentage Charging Shares Between Rates				
Day Type	**Charging Share**	**EPEVL – EPEVM**	**EPEVL – EPEVH**	**EPEVM – EPEVH**
Weekday	% Peak	1.8	3.08	1.29
	% Super Off-Peak	-4.16	-6.04	-1.87
Weekend	% Peak	2.33	3.25	0.92
	% Super Off-Peak	-4.06	-6.62	-2.55
	Significant @ 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

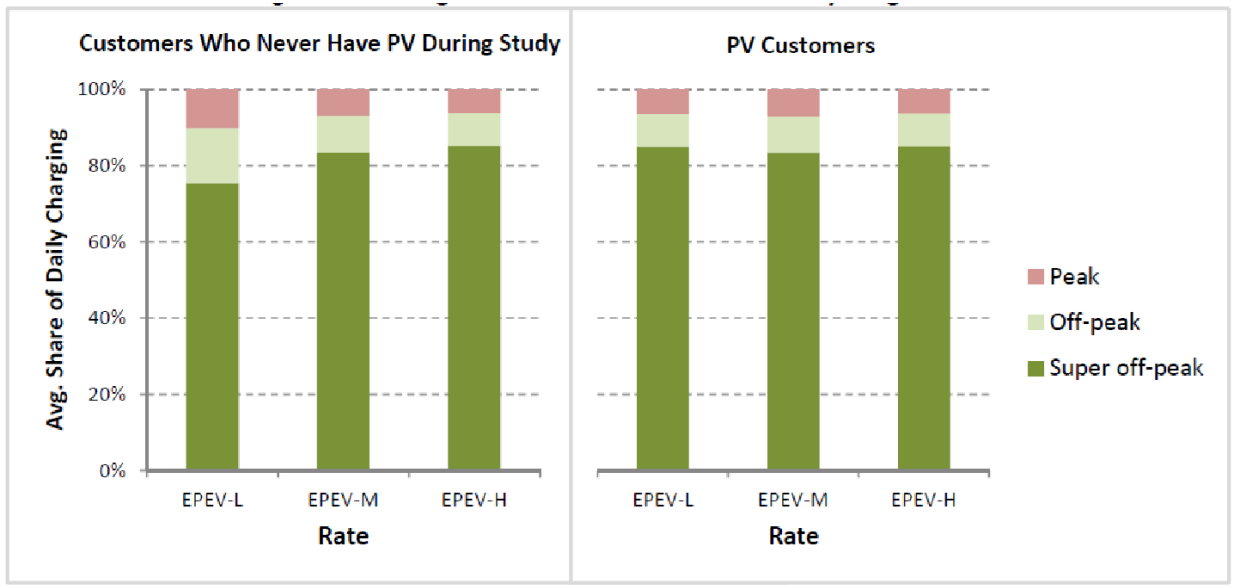
Customers are more responsive to changes in the peak or off-peak prices, but less so super off-peak

- 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