

Evaluating the Fairness of Time-of-Use Pricing for Residential Electricity in Southern California

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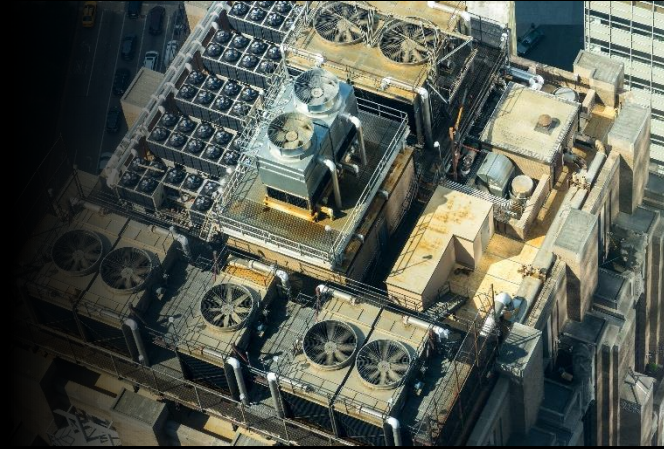
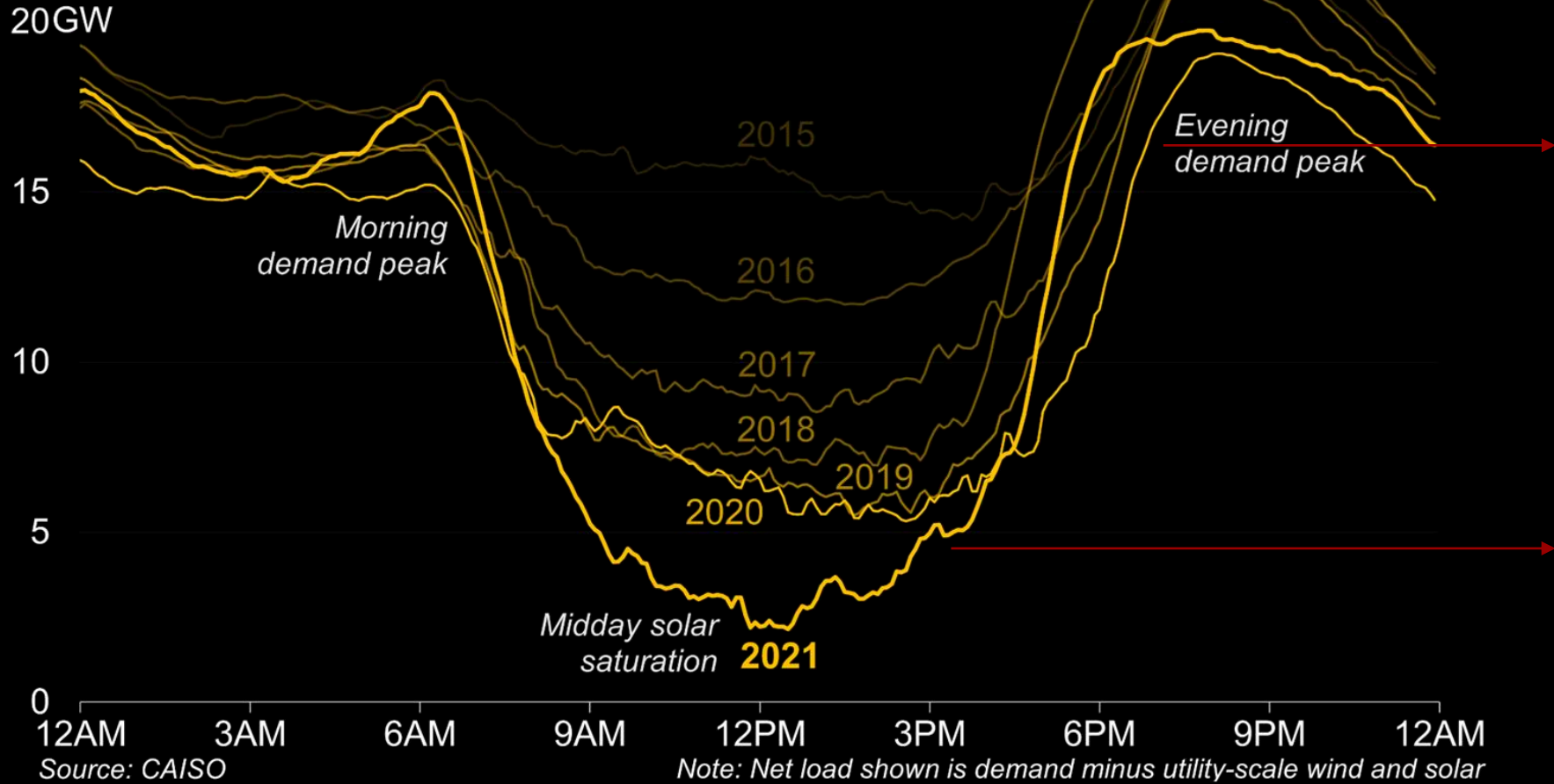
USC Viterbi

School of Engineering
*Sonny Astani Department of Civil
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New challenges to the electricity grid are emerging due to the rapid adoption of variable renewable energy sources

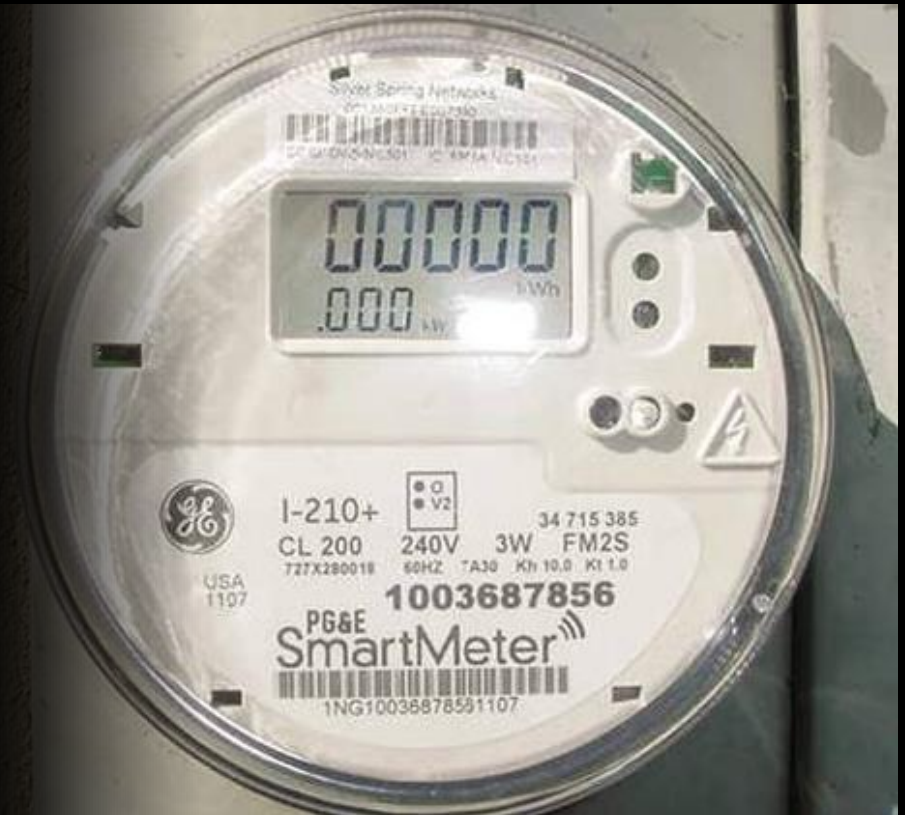
California's duck curve is dipping deeper than ever

Lowest net load day each year in CAISO, 2015-2021



Utilities can now leverage automated metering infrastructure to get intraday insights into the residential sector

- Automated metering infrastructure can provide readings at hourly or sub-hourly levels for residential customers economically and at scale
- Academic research lags behind in developing ways to characterize residential electricity sector as a whole

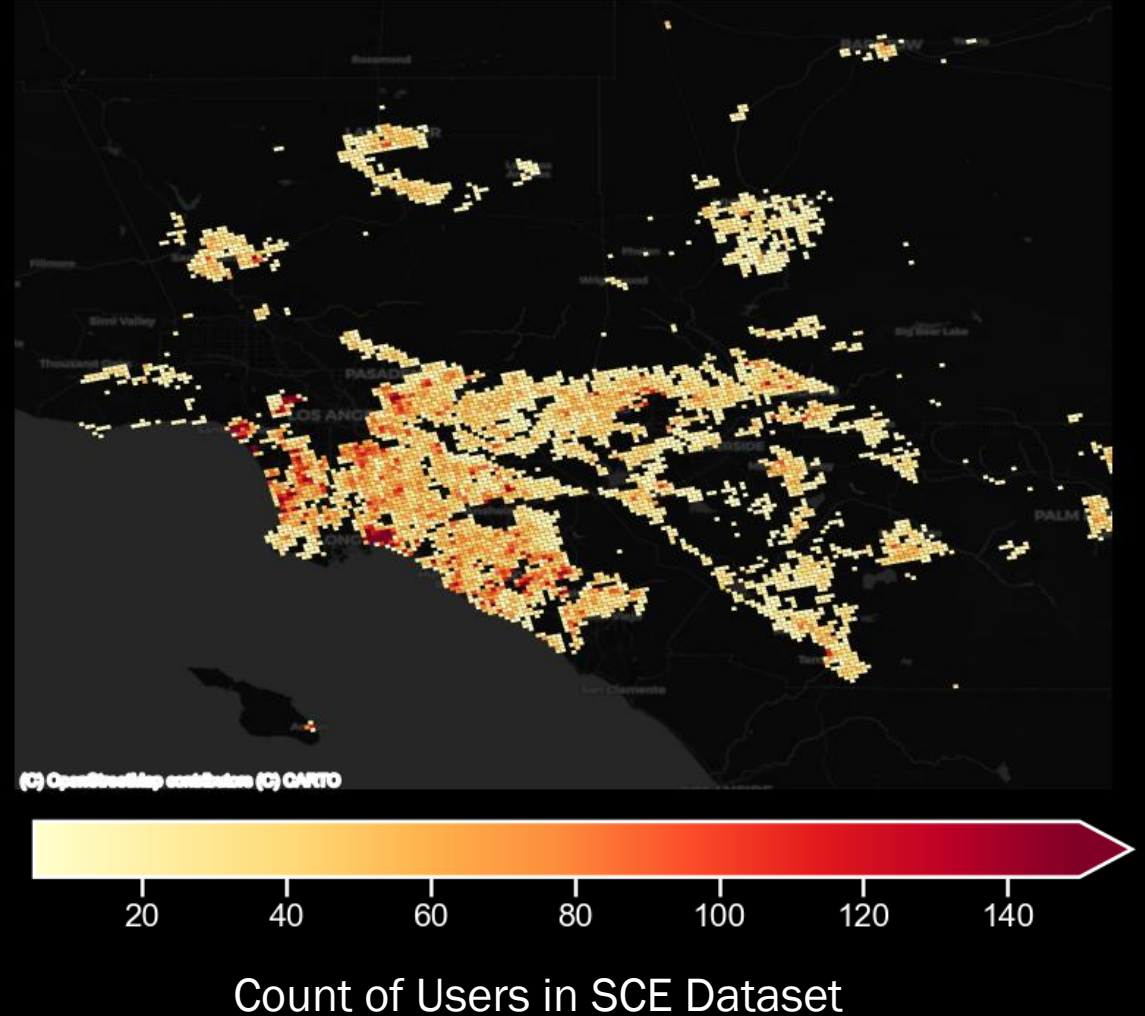


What is the shape of residential load profiles in Southern California?



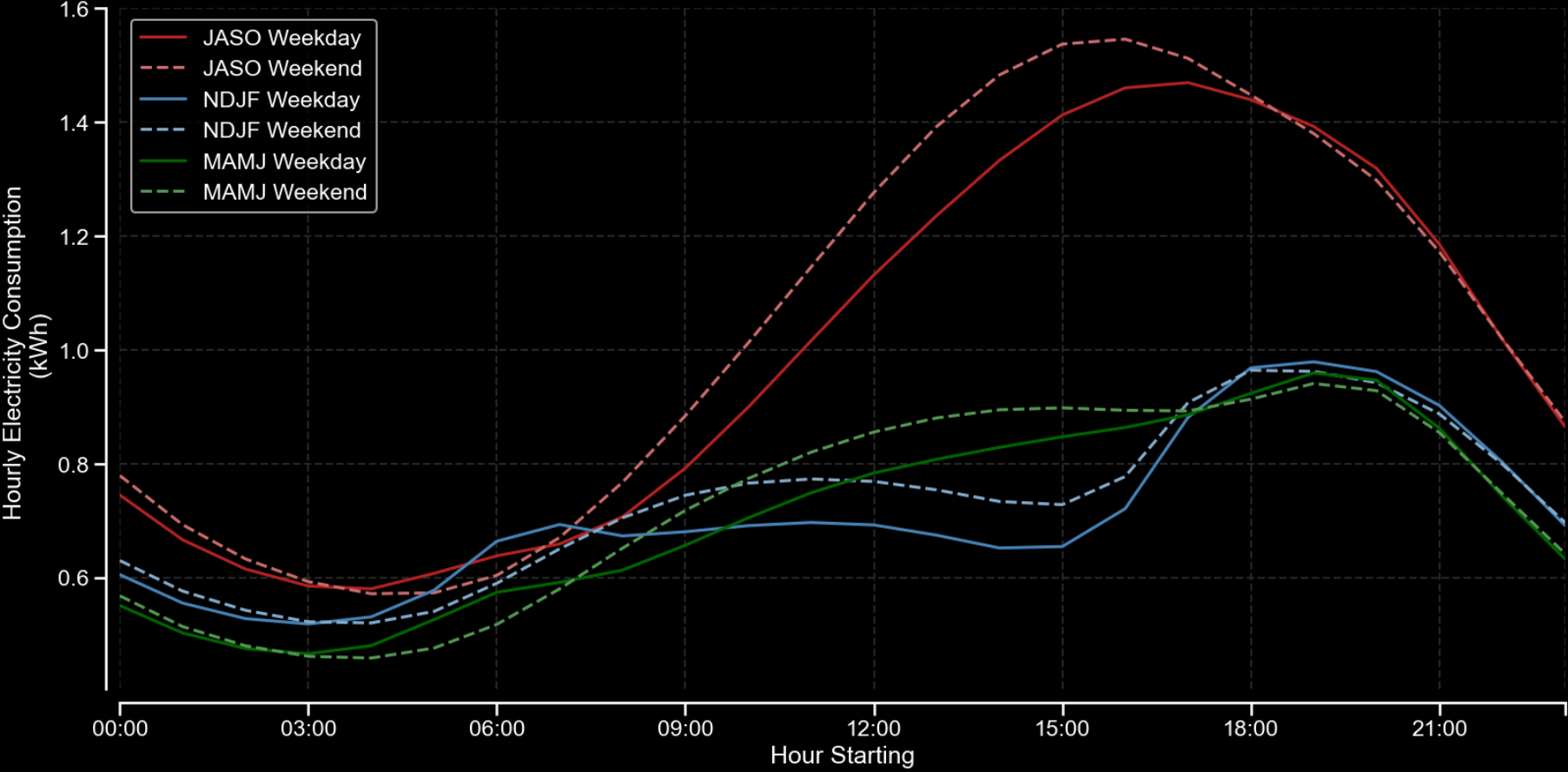
We use data from smart meters across Southern California Edison's (SCE) service area

- We looked at 200,000 homes from SCE's service area
- Data from 5% of SCE's residential customers, representative of SCE territory
- After filtering, we have ~160,000 users
- SCE consists of diverse populations and climates



Residential sector loads have strong seasonal and diurnal patterns

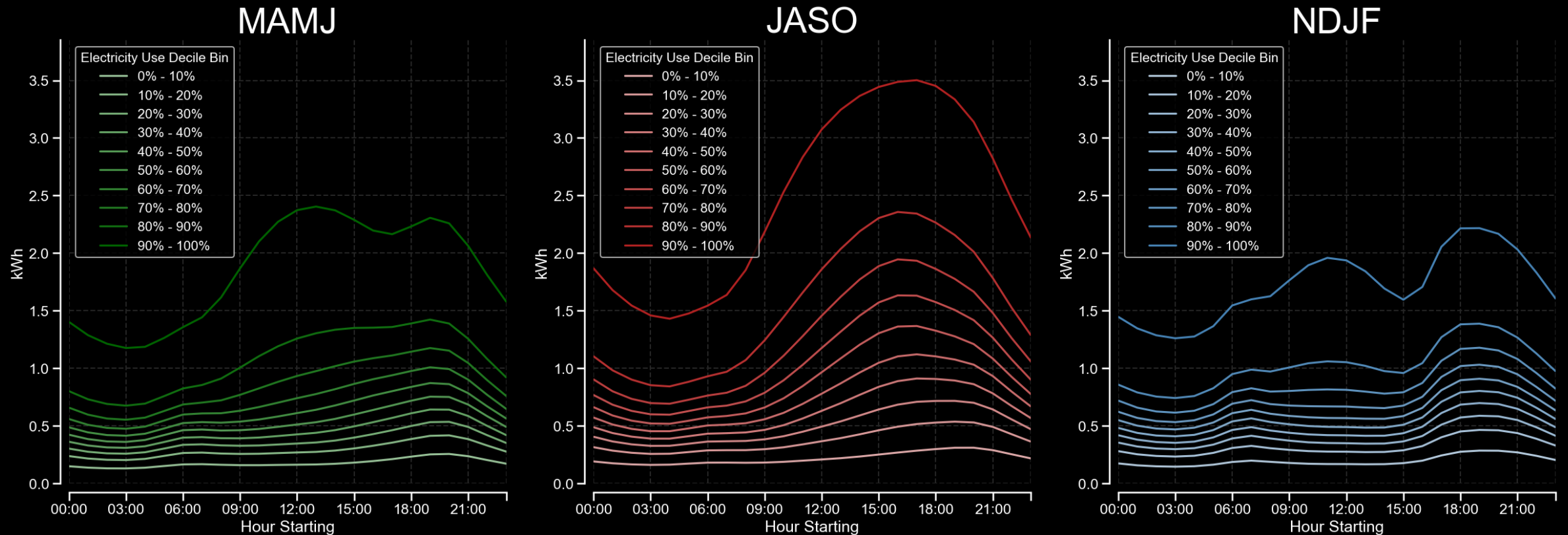
Average Load Profile in Southern California
By Season and Day Type



How does the proportion of residential demand vary across deciles of customers binned by annual electricity usage?

Large residential electricity users in SCE's service area consume a disproportionate amount of electricity, especially in hot months

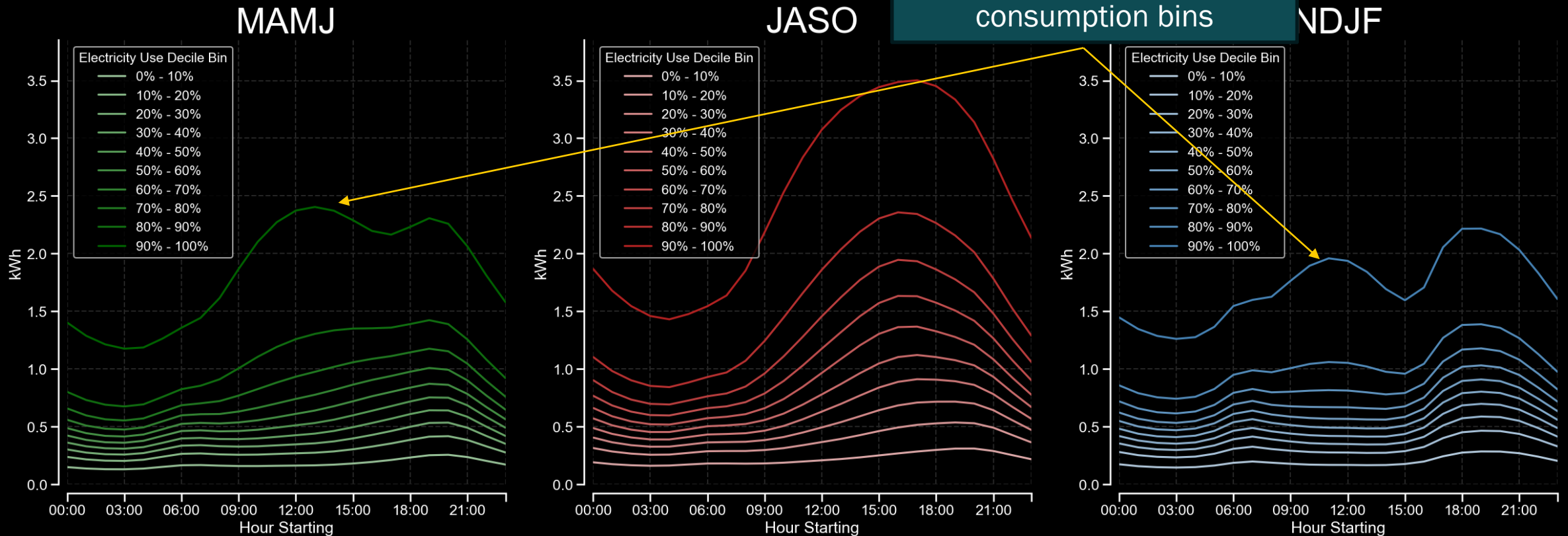
Weekday Average Residential Load Curves in Southern California
by Season and Customer Electricity Use



Large residential electricity users in SCE's service area consume a disproportionate amount of electricity, especially in hot months

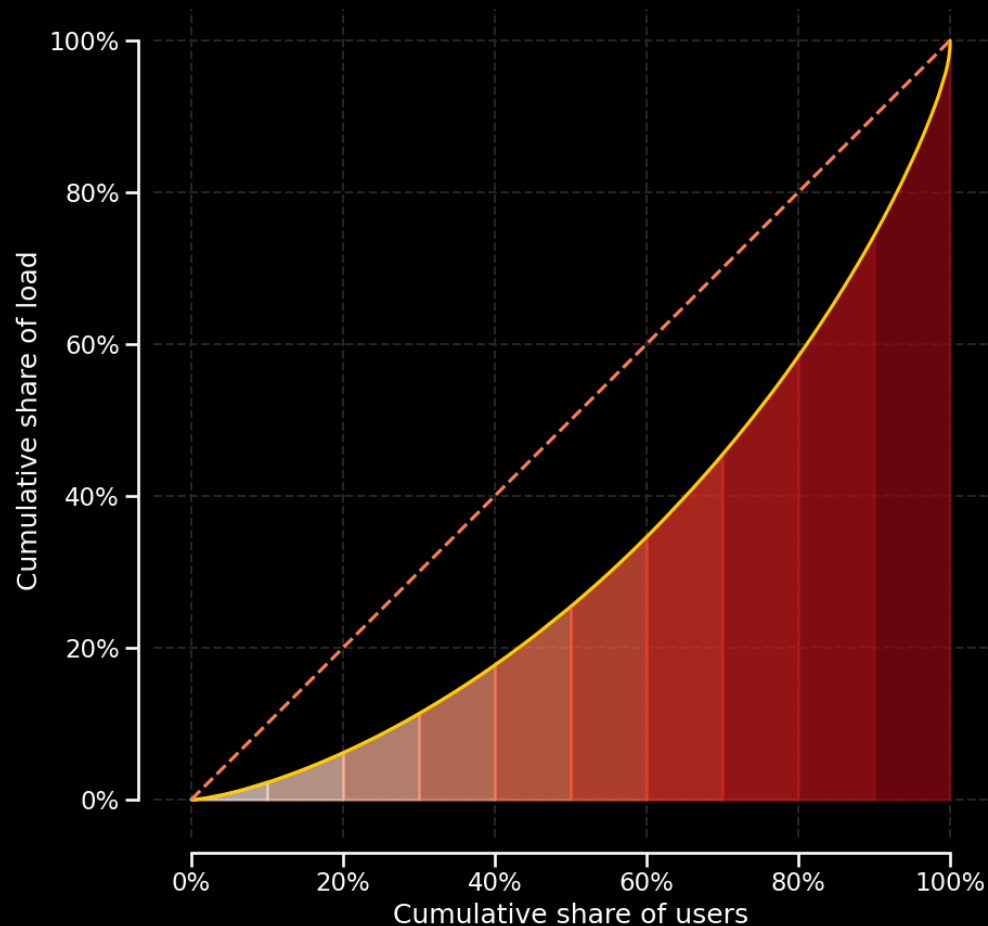
Weekday Average Residential Load Curves in Southern California by Season and Customer Electricity Use

There is a high mid-day electricity use in the high consumption bins



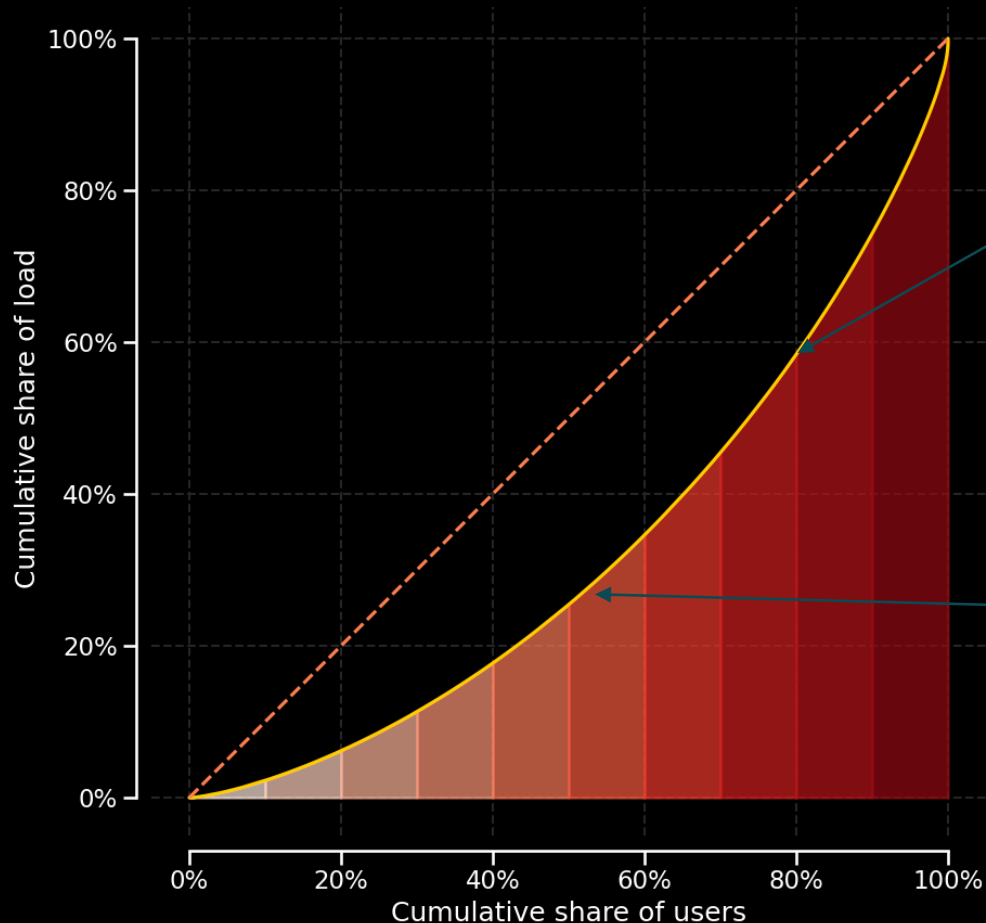
We can assess the inequality in electricity usage by showing the cumulative distribution of usage across the customers

Electricity Use Disparity: Cumulative Distribution Across Customers
Weekday in Hottest Months (July, August, September, October)



We can assess the inequality in electricity usage by showing the cumulative distribution of usage across the customers

Cumulative electricity usage by user
Weekday in Hottest Months (July, August, September, October)

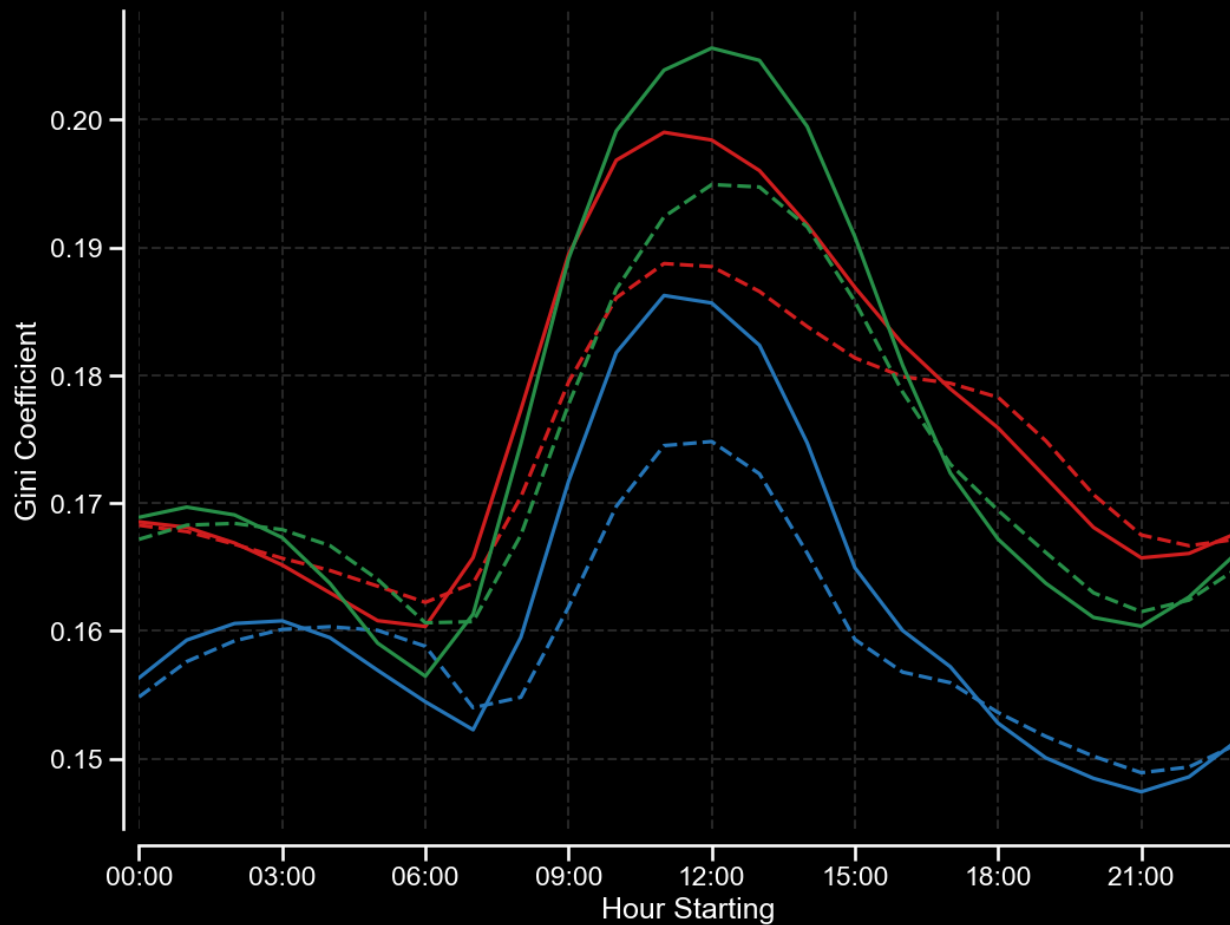


The top 20% of users consume more than 40% of electricity use

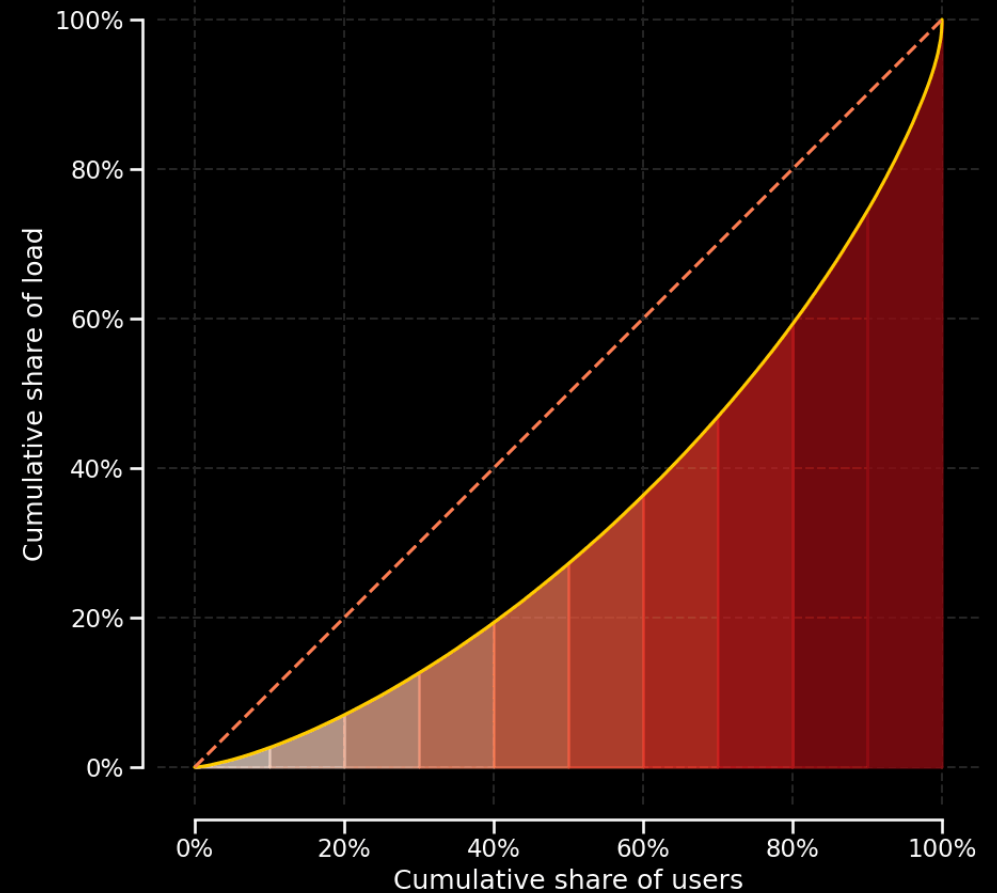
The bottom half of electricity use consume less than 25% of electricity use

We can see that customers who typically use more electricity are more likely to constitute a higher proportion of electricity use in the mid-day

GINI Index of Electricity Use

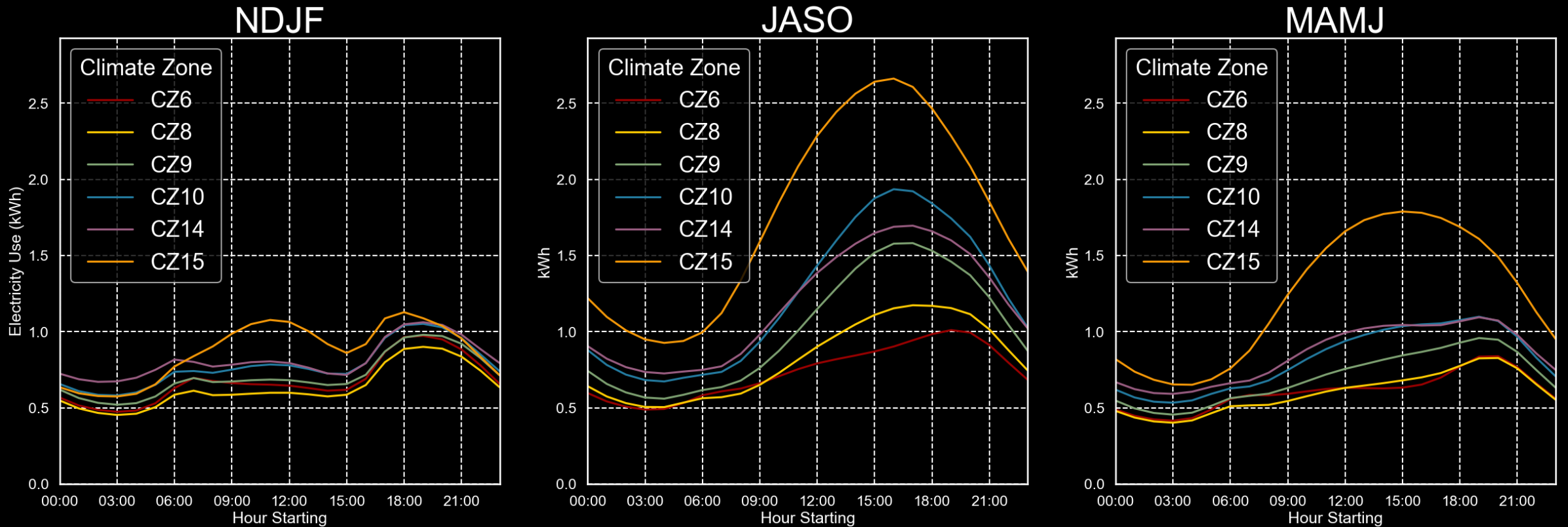


Lorentz Curve of Electricity at Hour 0
JASO - Weekday



Residents in warmer climate zones have more variability in their load profiles across days and seasons

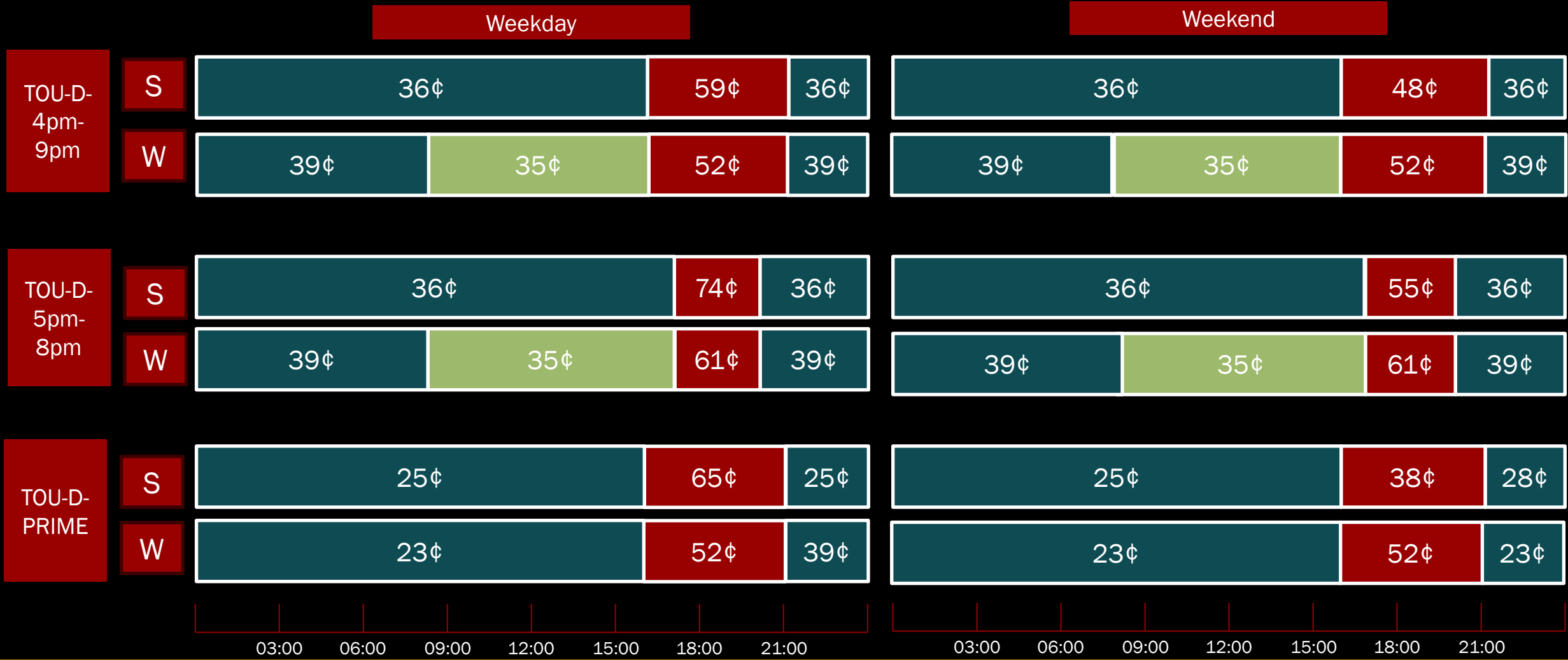
Average Weekday Load Curves in Southern California
By Season and Climate Zone



Based on previous consumption patterns, how could current time-of-use rate structures affect customer electricity costs?

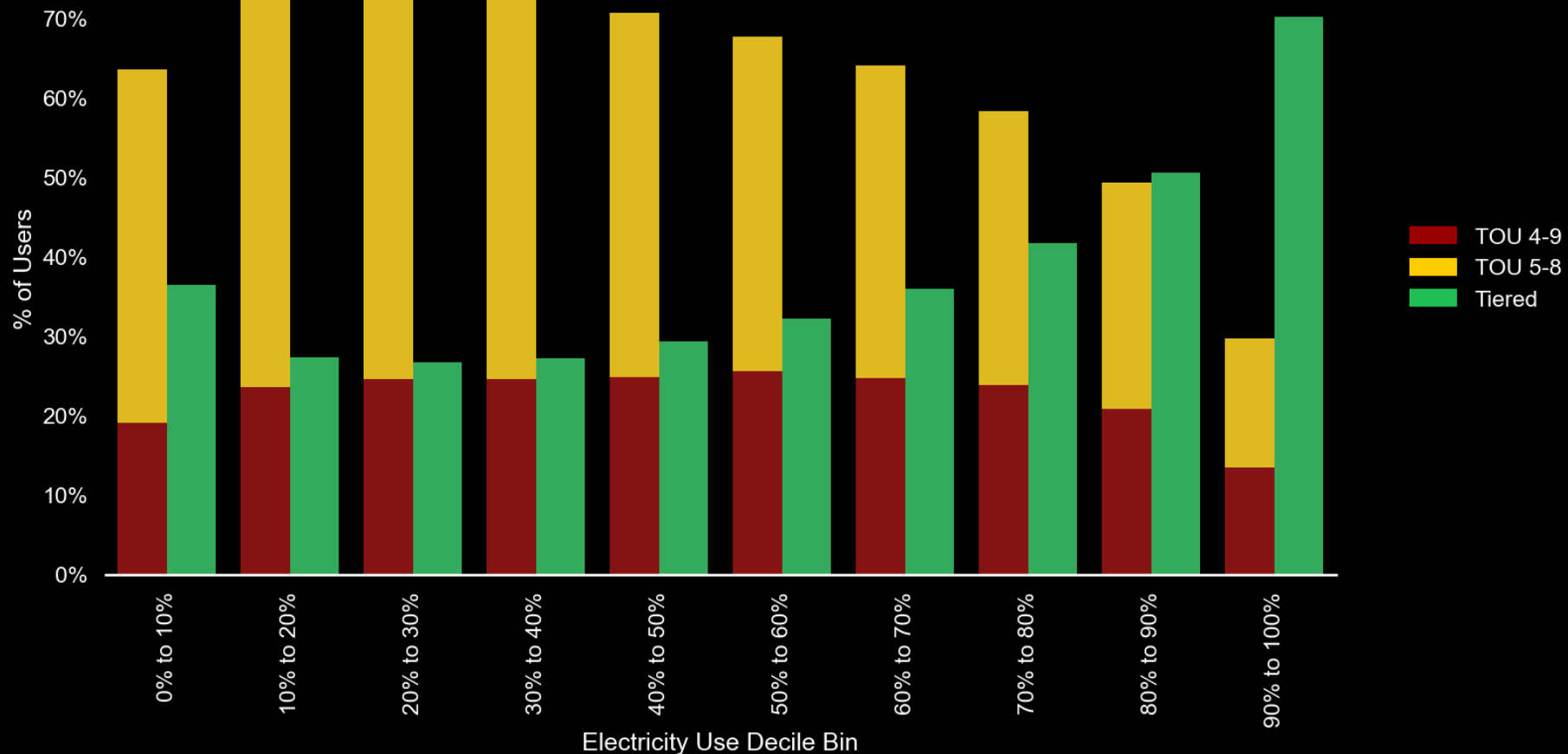


As the CEC has promulgated rules pushing time of use initiatives, SCE has offered new time of use rates to customer with the largest rollout in 2019.

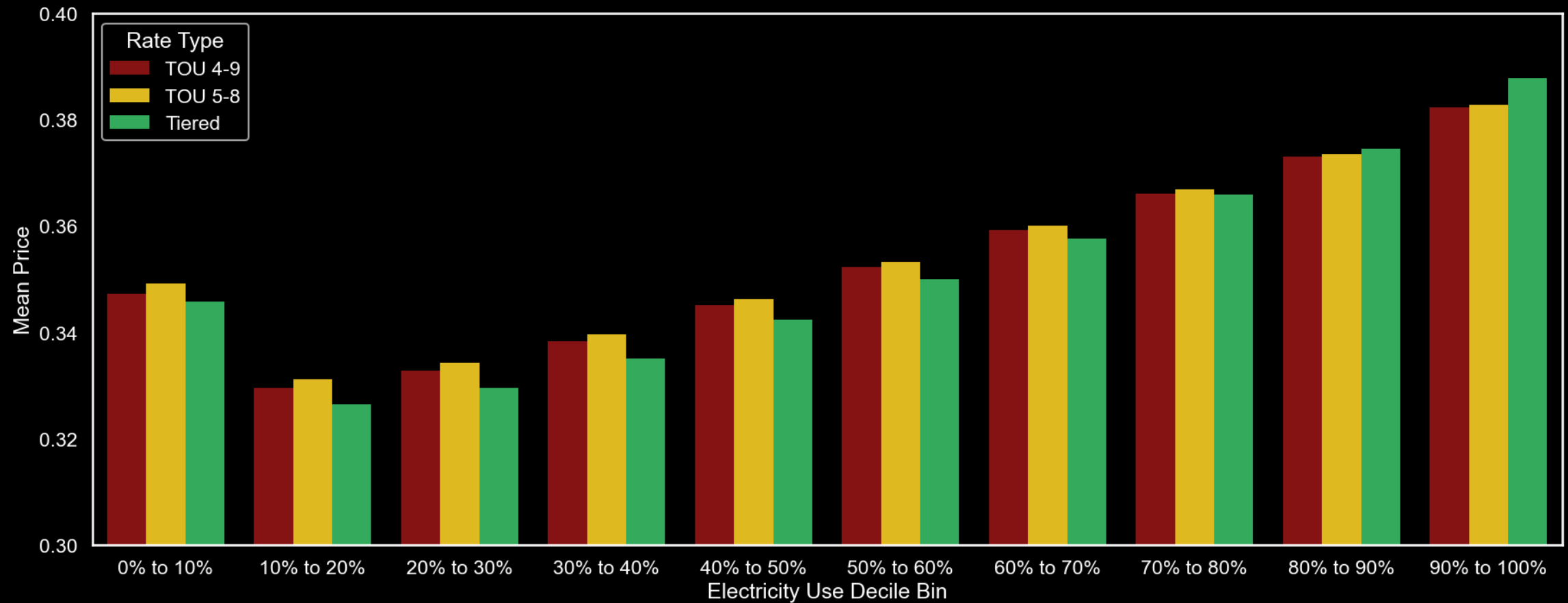


Customers who consume the most electricity benefit more from staying on the traditional rates if their behavior stays the same.

Cheapest rates for customers based on 2015, 2016 and 2018 data
By Decile Bin



Customers who consume the most electricity benefit more from staying on the traditional rates if their behavior stays the same.



Conclusions

- Smart meters can help to elucidate the strong seasonal and diurnal patterns in the residential load profile
- A small number of high electricity consumers are consuming a disproportionately large amount of electricity. The bottom half of users consumes less than 25% of the electricity load.
- Customers who typically use more electricity are more likely to constitute a higher proportion of electricity use in the mid-day
- Those same customers may be the ones targeted most by the time of use rates.

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