
Assessing Californians' awareness of their daily electricity use patterns

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authors and unedited

Supplementary Note 1: Data description and summary statistics

Supplementary Table 1 contains information about household electricity data and survey data provided by study participants. Supplementary Table 2 provides summary statistics for demographic and household characteristics as well as a comparison to estimates from the American Community Survey.

Supplementary Table 3 provides a comparison of participants with solar vs. those without solar systems across load shape perception measures.

Supplementary Table 1: Household electricity data and respondent survey data summary.

	Data sources		Sources of excluded data (n)				Analytical sample (n)
	Derived from electricity data	Derived from survey data	Households with missing electricity data ¹	Households missing survey data ²	Households missing survey & electricity data	Households with solar	
Study participants							242
Observed load shapes	Yes	No	18			26	198
Perceived load shapes	No	Yes		15			230
Observed load shapes & perceived load shapes	Yes	Yes	15	12	3	26	186
Demographic/ household characteristics	No	Yes		26			219
Observed load shapes & perceived load shapes & demographic/ household characteristics	Yes	Yes	13	21	5	26	177
¹ Insufficiency of hourly interval coverage across study period, sensor reading errors, instances of negative hourly demand, or evidence of no household occupancy							
² Participant did not respond to survey item on the questionnaire							

Supplementary Table 2: Sociodemographic and household characteristics for all study participants.

Measure	Description	Summary statistics	American Community Survey 2019 (1 year estimates) for California
Gender	Gender of the respondent	65.2% female Missing data=25	50.3% Female
Age	Age of respondent using the following categories: 1="18 – 24"; 2="25-34"; 3="35-44"; 4="45-64"; 5="65 or older"	Mean age=2.3 or between "25-34" and "35-44" Median category= "25-34" Missing data=24	Median age = 37
Income	Total household income in dollars on a scale from 1= "Less than \$10,000" to 16= "\$500,000 or more"	Mean=7.6 or between "\$60,000 - \$69,999" and "\$70,000 - \$79,999" Median category= "\$70,000 - \$79,999" Missing data=26	Median household income in 2019 inflation-adjusted dollars = \$80,440
Education	Highest education level achieved by the respondent	54.8% bachelor's degree or higher Missing data=24	Population 25 years and over with a bachelor's degree or higher: 35%
Occupants	Number of household occupants before SIP	Mean=3.1 Median=3.00 Missing data=24	Average household size = 2.9
Owner-occupied home	Respondent lives in a home that is occupied by the owner	54.3% live in an owner-occupied home Missing data=24	Owner occupied housing units = 54.9%
Electricity rate plan	Electricity rate plan of the household	24.5% on a time-based rate plan. Missing data=41	Not available

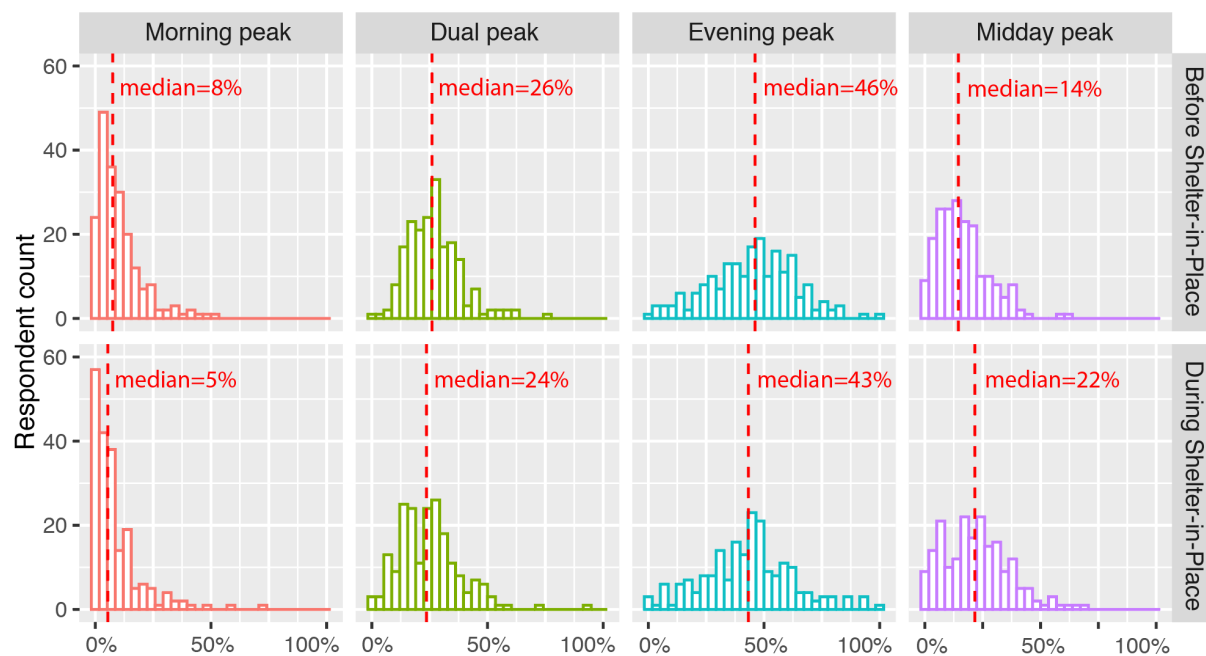
Supplementary Table 3: Comparison of solar vs. non-solar homes dominant load shape perceptions, before and during Shelter-in-Place (SIP).

	Perceived load shape before SIP				Perceived load shape during SIP			
	Afternoon	Dual	Evening	Morning	Afternoon	Dual	Evening	Morning
Households without solar systems (15 NAs)	27 (13.2%)	46 (22.5%)	124 (60.8%)	7 (3.4%)	39 (19.1%)	88 (43.1%)	66 (32.4%)	11 (5.4%)
Households with solar systems	4 (15.4%)	4 (15.4%)	17 (65.4%)	1 (3.8%)	5 (19.2%)	10 (38.5%)	9 (34.6%)	2 (7.7%)

Supplementary Note 2: Observed load shape characteristics

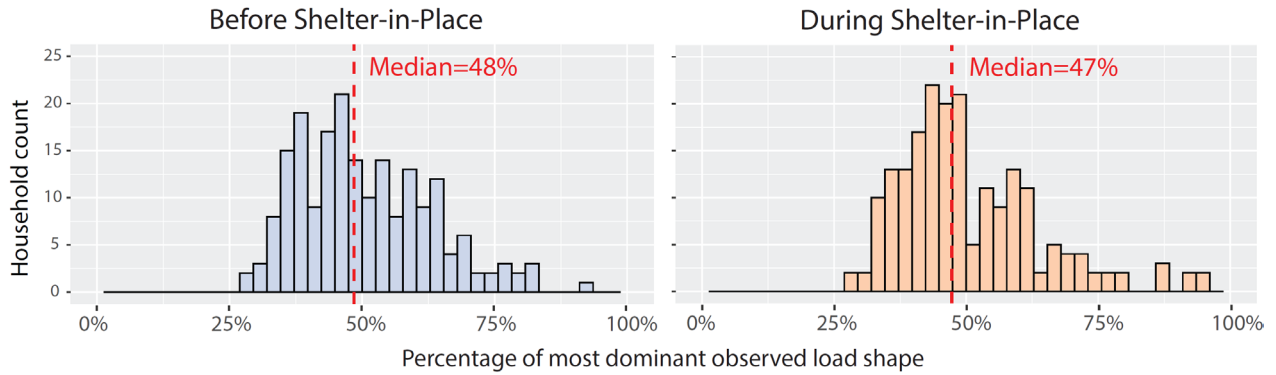
Below we consider the distribution of four load shapes (morning peak, dual peak, evening peak, and midday peak) identified using our participants' household electricity data. Supplementary Figure 1 displays the distribution of load shape percentages, as identified using normalization and a peak detection algorithm, before and during California's shelter-in-place (SIP) orders, which were first enacted on March 19, 2020. The most frequently occurring load shape in the before SIP period is Evening peak (median=46%), followed by Dual peak (26%), then Midday peak (median=14%), with the least frequently occurring shape Morning peak (median=8%). This pattern is similar for during SIP, however, with one notable difference: the Midday peak has a median of 22% of household load shapes (compared to 14% in before SIP), indicating a shift to afternoon usage that could be related to increased weekday occupancy due to pandemic restrictions on workplace and school attendance.

Supplementary Figure 1: Histogram displaying percentage of load shapes across households using electricity data before and during SIP orders. The red dashed line represents the median of these distributions.



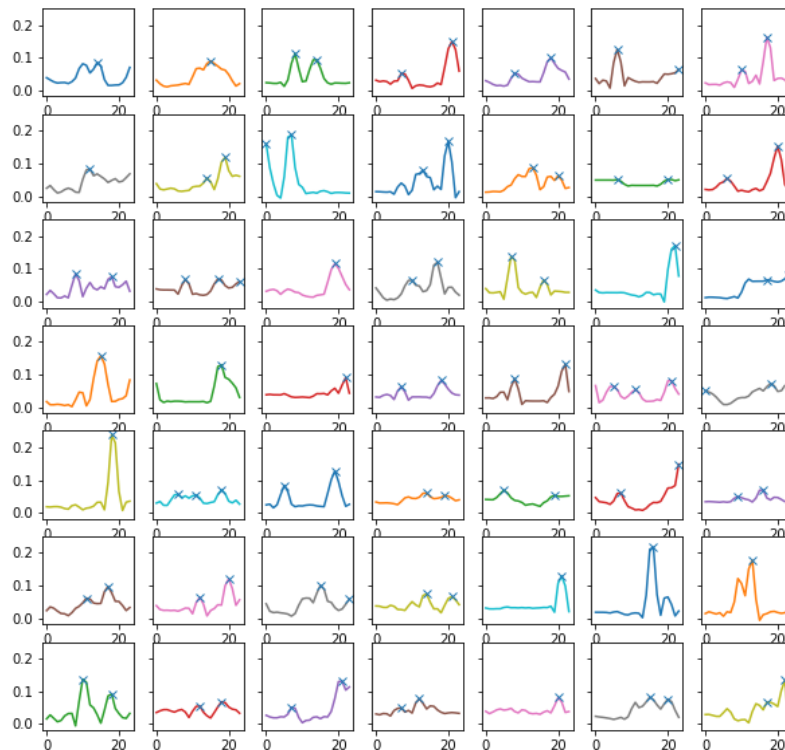
For comparison to the survey data (in which we asked respondents to identify their dominant load shape), we next consider the percentage of occurrence of a respondents' most dominant load shape, derived from electricity data before and during SIP (Supplementary Figure 2). We see that while the percentage of the most dominant load shape does descriptively display some variation in distribution when comparing before and during SIP periods, the median values are similar (48% vs. 47%). This suggests SIP did not dramatically alter load shape occurrences across our sampled households.

Supplementary Figure 2: Percentage of most dominant observed daily load shape across households using electricity data before and during SIP orders. The red dashed line represents the median of these distributions.



In Supplementary Figure 3, we display 49 randomly sampled smoothed daily load shapes from participant households. Smoothed daily load shapes are generated from the household's electricity data and are displayed on a 24-hour clock. Detected peaks are demarcated on these sampled smoothed daily load shapes.

Supplementary Figure 3. A sample of smoothed household load shapes with detected peaks demarcated by an "X". The y-axis is the normalized daily load and the x-axis is hours in a day starting at 0:00 (midnight) and ending at 23:59 (11:59pm).



Supplementary Note 3: Load shape awareness and participant characteristics

Supplementary Tables 4 and 5 contain results from bivariate analysis that estimates the relationship between load shape awareness and sociodemographic and household characteristics of participants. Supplementary Table 6 contains results from an alternative multivariate analysis that applies binary logistic regression.

Supplementary Table 4: Fisher exact test for binary household and sociodemographic measures, load shape awareness (0= Do not know load shape; 1=Know load shape).

Load Shape Awareness, before shelter-in-place				
Measure	Group comparison	Odds Ratio	95% confidence interval [lower, upper]	p-value
Gender	Female = 56.1% correct Male / prefer to self-describe = 38.6% correct	2.0247	[1.0221, 4.0773]	0.0371
Education	No bachelor's degree = 46.3% correct Bachelor's degree or higher = 54.1% correct	1.3613	[0.7263, 2.5628]	0.3693
Owner-occupied home	Not owner occupied = 47.8% Owner occupied = 48.4%	1.2490	[0.6682, 2.3418]	0.4608
Time-varying rate pricing	Non time-varying pricing=51.3% Time-varying pricing=48.6%	0.8965	[0.4005, 1.9989]	0.852
Load Shape Awareness, during shelter-in-place				
Measure	Group comparison	Odds Ratio	95% confidence interval [lower, upper]	p-value
Gender	Female = 32.5% correct Male / prefer to self-describe = 26.3% correct	1.3472	[0.6402, 2.9361]	0.4873
Education	No bachelor's degree = 29.2% correct Bachelor's degree or higher = 31.2% correct	1.1175	[0.5633, 2.2333]	0.7482
Owner-occupied home	Not owner occupied = 29.3 Owner occupied = 31.8.86%	0.9973	[0.5670, 2.2268]	0.7482
Time-varying rate pricing	Non time-varying pricing=30.3% Time-varying pricing=31.4%	1.0558	[0.4295, 2.4655]	0.999

Supplementary Table 5: Difference in means for continuous household and sociodemographic measures, load shape awareness (0= Not aware of load shape; 1=Aware of load shape).

		Load shape awareness, before shelter-in-place			
Measure	Mean comparison	t-statistic	95% confidence interval [lower, upper]	Degrees of freedom	p-value
Age	Aware of load shape = 3.2527 Not aware of load shape = 3.4494	t=1.2455	[-0.1150, 0.5084]	174.68	0.2146
Income	Aware of load shape = 7.6557 Not aware of load shape = 6.9545	t=1.3139	[-1.7540, 0.3519]	175.68	0.1906
Number of occupants	Aware of load shape = 3.0439 Not aware of load shape = 2.8539	t=0.7879	[-0.6660, 0.2859]	176.88	0.4318
		Load shape awareness, during shelter-in-place			
Measure	Mean comparison	t-statistic	95% confidence interval [lower, upper]	Degrees of freedom	p-value
Age	Aware of load shape = 3.3273 Not aware of load shape = 3.6000	t = 0.19864	[-0.2936, 0.3591]	66.373	0.8429
Income	Aware of load shape = 7.6296 Not aware of load shape = 7.1694	t = 0.8027	[-1.5974, 0.6768]	73.353	0.4240
Number of occupants	Aware of load shape = 2.8364 Not aware of load shape = 3.0000	t = 0.6479	[-0.3367, 0.6640]	64.865	0.5184

Supplementary Table 6: Binary logistic regressions results predicting load shape awareness (0= Not aware of load shape; 1=Aware of load shape).

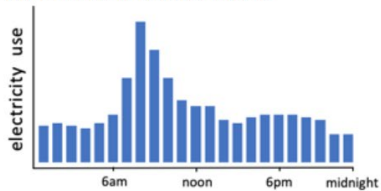
	Load shape awareness, before shelter-in-place			Load shape awareness, during shelter-in-place		
Predictors	Odds ratios	95% Confidence Interval [lower, upper]	p-value	Odds ratios	95% Confidence Interval [lower, upper]	p-value
Intercept	0.33	0.05 – 1.88	0.217	0.31	0.05 – 1.96	0.223
Female (vs. male/prefer self describe)	2.89	1.39 – 6.24	0.006	1.57	0.73 – 3.49	0.255
Age	0.85	0.61 – 1.16	0.307	0.94	0.67 – 1.32	0.736
Income	1.05	0.95 – 1.17	0.307	1.05	0.94 – 1.17	0.426
Bachelor's degree or higher (vs. else)	1.69	0.80 – 3.61	0.171	1.05	0.94 – 1.17	0.892
Number of occupants	1.06	0.87 – 1.31	0.554	0.93	0.74 – 1.15	0.514
Owner-occupied home (vs. else)	1.36	0.68 – 2.74	0.385	1.13	0.54 – 2.34	0.748
Time-varying rate pricing (vs. else)	0.90	0.41 – 2.00	0.801	1.05	0.44 – 2.35	0.917
AIC	248.17			231.14		
n	177			177		

Supplementary Note 4: Survey questions applied in the study

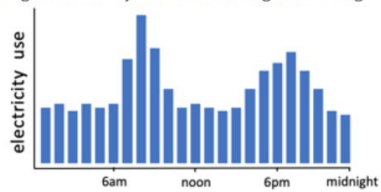
Q1. Before shelter-in-place perceived load shape

Choose the graph **most likely** to represent your home's electricity use on **weekdays** (Monday - Friday) **before** your household made any changes due to **shelter-in-place orders related to COVID-19 (coronavirus)**.

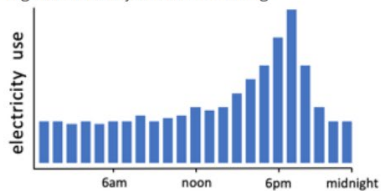
- ☐ Highest electricity use in the morning



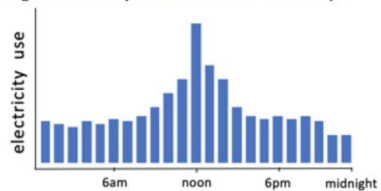
- ☐ Highest electricity use in the morning and evening



- ☐ Highest electricity use in the evening



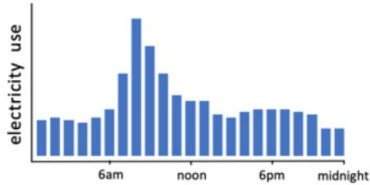
- ☐ Highest electricity use in the middle of the day



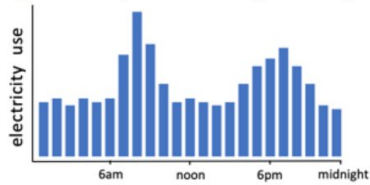
Q2. After shelter-in-place perceived load shape

Now choose the graph **most likely** to represent your home's electricity use on **weekdays** (Monday-Friday) **since** your household made any changes due to **shelter-in-place orders related to COVID-19 (coronavirus)**.

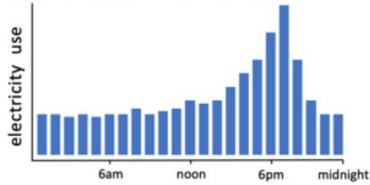
- ☐ My household has not made any changes due to shelter-in-place orders related to COVID-19 (coronavirus).
- ☐ Highest electricity use in the morning



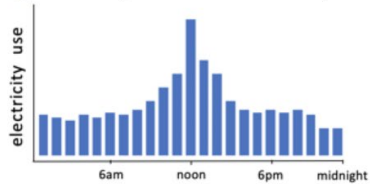
- ☐ Highest electricity use in the morning and evening



- ☐ Highest electricity use in the evening



- ☐ Highest electricity use in the middle of the day



Q3. Rate plan

Which of the following best describes the rate you pay for electricity?

- ☐ Flat rate. The price of electricity is always the same.
- ☐ Tiered rate. The price of electricity increases as I use more electricity during the billing cycle.
- ☐ Time-based rate. The price of electricity changes at different times of day. This is usually called "Time-of-Use" or "Time-of-Day" pricing.
- ☐ Other (please specify):
- ☐ I don't know.

Q4: Gender

What is your gender?

- ☐ Male
- ☐ Female
- ☐ Prefer to self-describe

Q5: Age

How old are you?

- ☐ Under 18
- ☐ 18-24
- ☐ 25-34
- ☐ 35-44
- ☐ 45-64
- ☐ 65 or older

Q6: Education

What is your level of formal education

- ☐ No high school degree
- ☐ High school graduate
- ☐ Some college, but no degree (yet)
- ☐ 2-year college degree
- ☐ 4-year college degree
- ☐ Postgraduate degree

Q7: Household size

Before shelter-in-place orders related to COVID-19 (coronavirus), how many people were living in your household?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5
- ☐ 6
- ☐ 7 or more

Q8: Owner occupied

Is your home...

- ☐ Owned by you or someone else who lives in the home
- ☐ Rented
- ☐ Occupied without payment of rent

Q9: Income

Including all income sources, which category best describes the total combined income of all members of your household for the last year, before taxes and deductions?

- ☐ Less than \$10,000
- ☐ \$10,000 - \$19,999
- ☐ \$20,000 - \$29,999
- ☐ \$30,000 - \$39,999
- ☐ \$40,000 - \$49,999
- ☐ \$50,000 - \$59,999
- ☐ \$60,000 - \$69,999
- ☐ \$70,000 - \$79,999
- ☐ \$80,000 - \$99,999
- ☐ \$100,000 - \$119,999
- ☐ \$120,000 - \$149,999
- ☐ \$150,000 - \$199,000
- ☐ \$200,000 - \$249,000
- ☐ \$250,000 - \$349,999
- ☐ \$350,000 - \$499,999
- ☐ \$500,000 or more
- ☐ Prefer not to say