It's About Time: Transitioning to Time-of-Use Pricing and Consumer Demand for Electricity

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- "Block pricing" has been the predominant pricing scheme for electric utilities since the 1930s, though new dynamic pricing schemes have risen in popularity in the past decade
- Dynamic pricing is preferable to flat pricing for utilities because it can accommodate time-based differences in demand
- Measuring the degree of consumer response to a switch in the pricing schedule is confounded by variations in geography, climate, and idiosyncratic preferences

- How do residential electricity customers respond to changes in plan structure when automatically enrolled?
- What consumer habits impacted their likelihood to opt out of a change in the program?
- What are the implications for future electric utility changes?

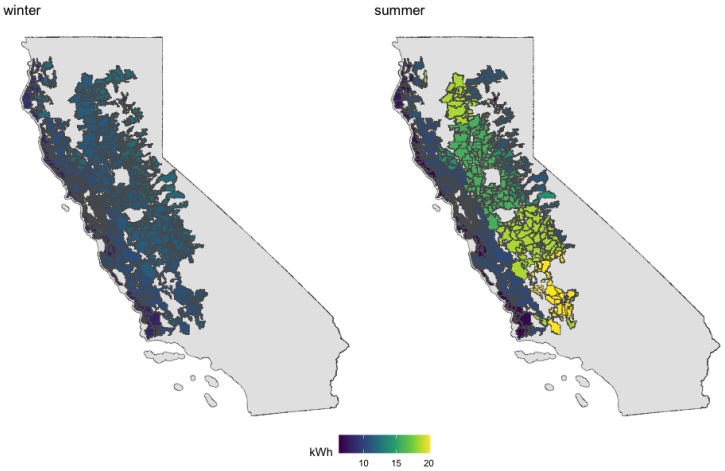
- Dynamic pricing in electricity: Boiteux (1960), Train and Mehrez (1994), Wolak (2010), Hinchberger et. al (2024), **Enrich et. al (2024)**, **Bernard et. al (2024)**
- Electric rate transition: Fowlie et. al (2021), Ito et. al (2023), **Cahana et. al (2023)**

- Most consumers face either flat tariffs or "block pricing" plans, where marginal price increases at specific usage thresholds
- Newer plans are dynamic in price: prices change in conjunction with demand
- Under "time-of-use" (TOU), price increases during high-demand hours set by the utility (usually the evening)
- The California Public Utilities Commission (CPUC) mandated that utilities transition their consumers to TOU from block pricing to TOU pricing, which began in 2021

- CPUC wanted to transition customers to TOU rates in order to promote energy conservation and lower aggregate peak-time consumption
- Approximately 40% of customers opted out of the program, leaving the other 60% as automatically opting in
- Rollout was done in 9 "waves," determined by groups of counties
- Rollout was implemented in April 2021 and ran through through April 2022
- PG&E promised "bill protection" for the first year that would reimburse consumers for bill increases for the first 12 months

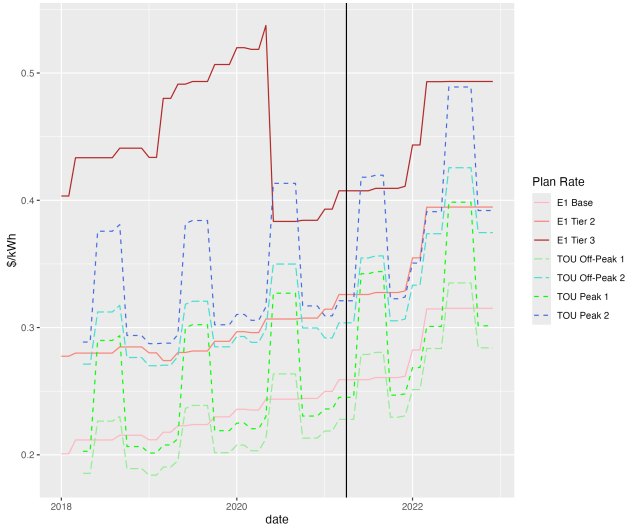
- Price tiers are set using local climate conditions and are calibrated to the median household's daily usage
- Applies to cumulative usage over the course of the month, using $baseline \times \#days$
- Baselines differ in summer (June - September) and winter (October - May)
- Baselines also differ for gas heat ($\sim$ 90% of customers) and electric heat

Electric Utilities: Climate Zones

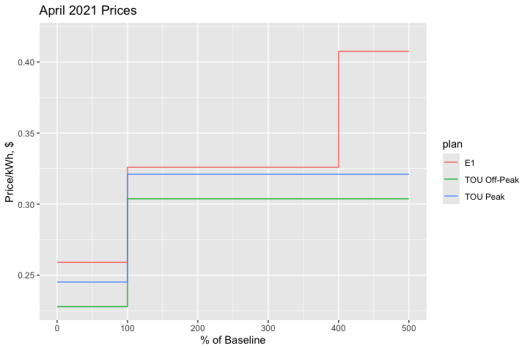


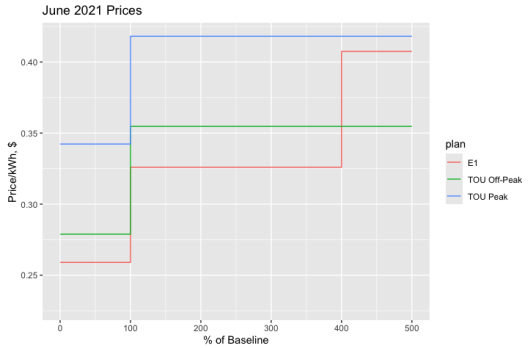
- Prices are set anywhere from one to six months ahead
- Relatively small changes when they do happen
- TOU prices are seasonal in addition to dynamic
- Consumers face strictly lower prices in winters (October—May)...
- But most face higher prices in the summer (June—September)
- Averaging across months and peak/off-peak usage, prices are nearly unchanged

Prices Over Time



Prices by Usage

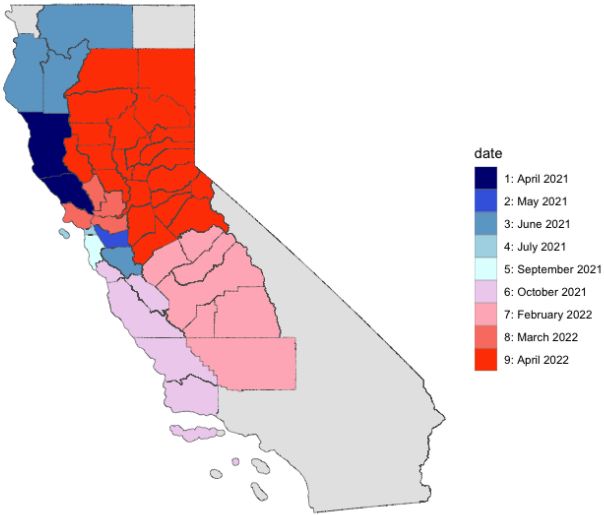




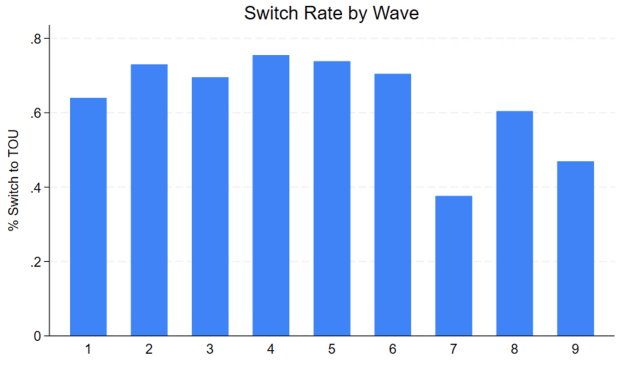
- Primary Dataset from Pacific Gas & Electric in California
- Sample of 75,000 single-family households, anonymized to zip code level
- Customers do not move during sample and must be active for entire period
- Hourly meter data from 2018-2021, monthly bills 2018-2022
- Includes: rate, hourly usage, home solar, income assistance indicators, climate zone, total bill amount
- Missing: addresses, household characteristics, demographics

- Remove solar, subsidized/alternative cost plans, high/low usage households...
- Leaving $26,149$ households
- Approximately 90% have gas heating
- $16,668$ (63%) are on TOU pricing by the end of the transition program

Program Rollout



Switch Rates by Wave



	Switch			Stay			Difference
	Mean	Median	S.D.	Mean	Median	S.D.	
Pre-Rollout							
kWh	522.91	440	346.38	567.12	478	368.22	-44.21
$	139.65	112.06	107.17	145.92	118.75	106.18	-6.27
Peak kWh	146.26	118.32	109.27	165.92	132.34	123.53	-19.66
Post-Rollout							
kWh	476.99	407	304.36	489.77	428	292.93	-12.78
$	168.64	132.13	133.58	177.58	142.68	133.13	-8.94
Peak kWh	119.21	98.67	88.46	131.3	110.41	94.78	-12.09

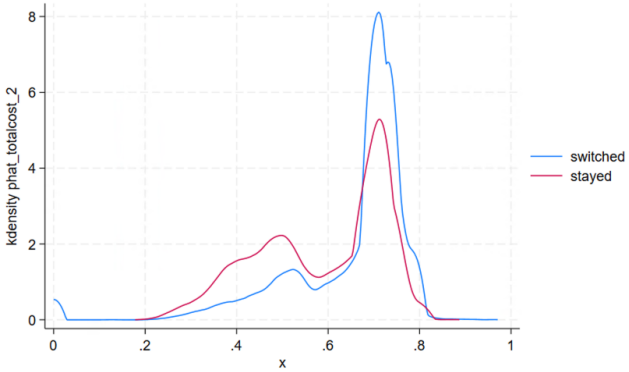
- Beginning 4 months prior to their county's transition date, consumers were notified of the transition program
- Nonresponse led to automatic opt-in
- Logging in to the portal would show a comparison of their past usage under the block and TOU prices

Possible reasons to opt out:

- The customer wants to avoid paying a premium on future peak-hour usage
- The customer saw (a) negative-value month(s) in the rate cost comparison provided by PG&E
- The customer is very elastic to changes in cost between bills
- The customer has more uncertainty about their usage and is concerned about their bill increasing

	Switched	**Switched**
Avg Bill Diff	-0.007	
	(0.005)	
Weekday Mean kWh		0.007
		(0.001)
Weekday Peak S.D.		-0.052
		(0.007)
Constant	-0.244	-0.163
	(0.053)	(0.071)
Month FE	Yes	
Year FE	Yes	
CZ FE	Yes	Yes

Pre-Rollout Sensitivity



Possible effects from the rate switch:

- Lower peak kWh usage
- Lower total kWh
- Substitution towards/away from peak

Summer Only	log(kWh)	log(bill $)	log(peak kWh)	Peak %
Post x Switch	-0.010	0.066	-0.012	-0.004
	(0.003)	(0.004)	(0.006)	(0.001)
Post	-0.006	0.000	-0.024	-0.002
	(0.004)	(0.005)	(0.006)	(0.001)
Constant	6.144	4.837	4.875	0.290
	(0.001)	(0.001)	(0.001)	(0.000)
N	511,500	511,500	399,726	399,726
R2	0.878	0.873	0.876	0.727
Wave x Month FE	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes
HH FE	Yes	Yes	Yes	Yes
Cluster	Zip	Zip	Zip	Zip

Winter Only	**log(kWh)**	**log(bill $)**	**log(peak kWh)**	**Peak %**
Post x Switch	0.000	-0.059	-0.005	-0.002
	(0.003)	(0.003)	(0.005)	(0.001)
Post	0.000	-0.020	-0.011	-0.001
	(0.007)	(0.005)	(0.010)	(0.001)
Constant	6.042	4.737	4.721	0.273
	(0.002)	(0.001)	(0.001)	(0.000)
N	971,623	971,623	764,173	764,173
R2	0.801	0.818	0.786	0.583
Wave x Month FE	Yes	Yes	Yes	Yes
Date FE	Yes	Yes	Yes	Yes
HH FE	Yes	Yes	Yes	Yes
Cluster	Zip	Zip	Zip	Zip

Currently Working On...

- Matching Estimation
- Counterfactual: Effects on Non-Switchers