

MAXIMISING CONSUMER ABILITY TO MANAGE ELECTRICITY DEMAND

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Time-varying rates

Time-varying electricity charges can encourage people to shift the timing of their electricity demand to match the timing of electricity supply

These rates may be a useful tool in supporting energy transition

Time of Use (TOU) rates are a common type of time-varying rate, where people pay more for electricity in on-peak periods

However, some sociodemographic groups can face worse health and cost outcomes on TOU rates (White and Sintov, 2020)

White, L. V, Sintov, N.D., 2020. Health and financial impacts of demand-side response measures differ across sociodemographic groups. Nat. Energy 5, 50–60. <https://doi.org/10.1038/s41560-019-0507-y>



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Does building efficiency matter for time-varying rates?

Differing energy efficiency could underlie differences in cost and health impacts described on TOU

- In Australia, households experienced a wide range of comfort impacts when turning off AC during peak-pricing events (Strengers 2010)

Pre-cooling/pre-heating:

- is often recommended as a way to shift use to off-peak without experiencing discomfort
- but poorly insulated buildings are less able to retain thermal comfort without continual flow of energy

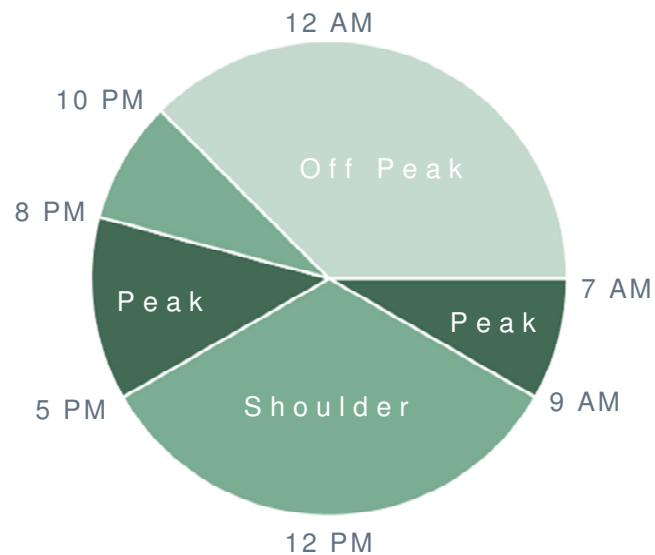
Strengers, Y., 2010. Air-conditioning Australian households: The impact of dynamic peak pricing. Energy Policy 38, 7312–7322. <https://doi.org/10.1016/j.enpol.2010.08.006>



There is a need to understand whether the energy efficiency of homes plays a role in residential ability to manage costs on time-varying electricity rates

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Flat: 22.76 c/kWh

TOU:

- On-peak: 29.56 c/kWh
- Shoulder: 21.25 c/kWh
- Off-peak: 16.94 c/kWh

What we examine

Sample of several thousand residents in the Australian Capital Territory (ACT)

- ACT mandates disclosure of Energy Efficiency Rating (EER) upon sale or rental
- Temperatures in winter require heating (drops below freezing)

Coarsened Exact Matching (CEM) to select a control group

- households that remained on flat rates and are demographically comparable to households that switched between flat and TOU rates

We use two-way fixed effects to examine whether switching to a time-of-use (TOU) rate has a heterogeneous treatment effect on quarterly household bills as a function of EER



Data

1. Data aggregator (for real estate) provided us with the 86,267 households in the ACT (out of approximately 200,000 households total) with EER data
2. Utility provided a list of potential “treatment” households that had been address-matched to the EER data (N=3,874 households that had been on a TOU rate at some point between 2015q1-2020q4)
3. We used coarsened exact matching (CEM) to identify 20,000 potential control households that were not in the “treatment” list. A total of 11,390 potential control households were returned by the utility following matching
4. Removed households that had ever been on rates other than flat or TOU, and other data cleaning (left with N=6,476 households total)
5. 880 households were excluded from CEM due to missing demographic variables. CEM was run with the remaining 5,596 households (5,252 control and 344 treatment), not all of which could be matched.
6. In running analyses, we dropped the quarter of switch and one lead, because visual inspection indicated that there were frequently irregularities in these time periods (consistent with meter tracking being disrupted during the rate switch)



Coarsened Exact Matching (CEM)

Income	Number of occupants	Education	Tenure Type	Number of bedrooms	Solar	Gas	EER
SA1 median	SA1 median	SA1 median number of years	Individual: rent or own	Individual: 1 bedroom, 2 bedrooms, 3 bedrooms, 4 bedrooms, 5 or more bedrooms	Individual: never had solar, sometimes had solar, always had solar	Individual: has no gas, has some gas but not for heating (<50% seasonal variance), has gas and uses for heating	Individual: less than 4, 4.0-4.9, 5.0-5.9, 6.0, and >6

SA1: Geographical area (census measurement) with 200-800 people

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Groups after matching

	Full sample	No gas	No solar
Treatment	228	122	201
Control	1028	631	993

Data for up to 24 quarters per household (2015q1-2020q4)

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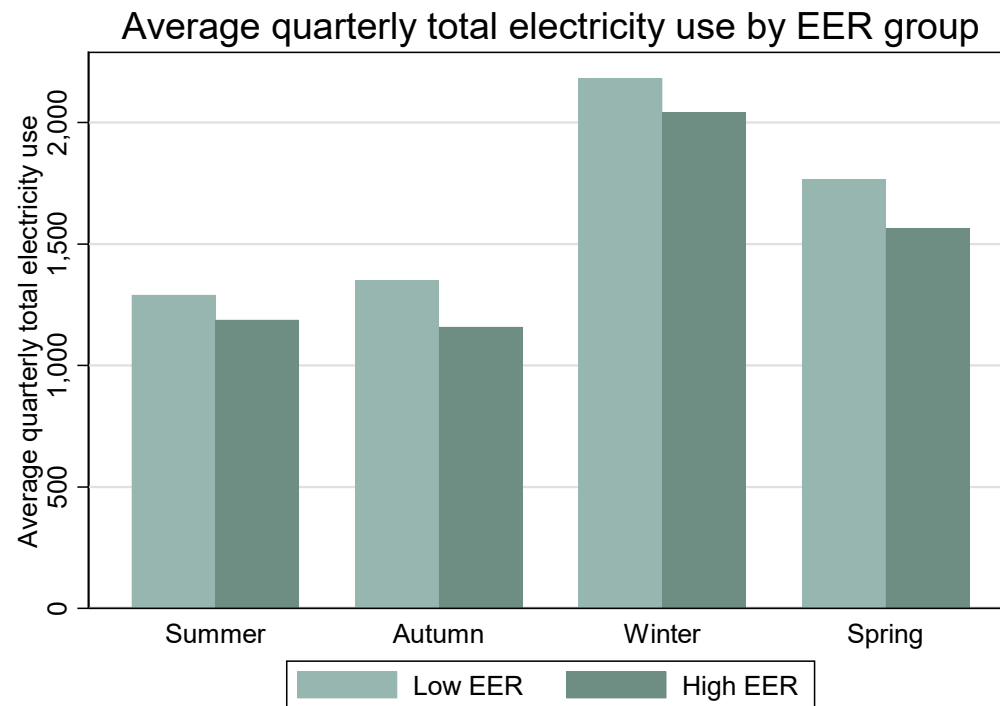


Impact of EER on energy use

First, we want to confirm that EER impacts usage in the way we would expect

Graph illustrates seasonal use by different EER groups

We check with regression analysis and confirm that high-EER homes use less energy compared to low-EER homes ($p < 0.000$; controlled for demographics, solar sales, and gas use)



Does EER impact how a switch to TOU affects household electricity bills?

Yes, but not in the expected way. Low EER households see decrease in bills. High EER households see no change (or slightly increase; not significant)

Treatment effects, for high and low EER homes, of TOU on log electricity bill

	Full sample	No gas	No solar
LowEER x TOU	-0.0202 (0.0551)	-0.209* (0.0843)	-0.00956 (0.0560)
HighEER x TOU	0.0392 (0.0450)	0.0216 (0.0680)	0.0283 (0.0441)
Solar Sales (log)	-0.0460 (0.0571)	-0.0386 (0.0610)	
Dichotomous Solar Use	-0.215 (0.359)	-0.256 (0.372)	
TOU x solar	-0.279* (0.118)	-0.0374 (0.146)	
Gas Use (log)	0.00642 (0.00595)		0.0146* (0.00712)
R ²	0.245	0.264	0.227
N	14294	8179	13445

* 0.05 ** 0.01 *** 0.001





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Bill findings

We find no evidence that low-EER households experience bill increases when on TOU

The low-EER households without gas have lower bills when on TOU

- Low-EER households may choose to turn heating in certain areas down or off, while high-EER households may be paying for the luxury of being able to “set and forget” their heating and cooling systems
- High-EER homes are more likely to have central heating controlled by a thermostat, while low-EER homes in the ACT typically have manually controlled heaters in certain rooms



Does EER impact how a switch to TOU affects household total electricity use?

Yes, some groups curtail more (specifically low EER households with no gas). However most groups don't change total electricity use after switch.

Treatment effects for high and low EER homes of TOU on total electricity use

	Full sample	No gas	No solar
LowEER x TOU	25.90 (97.06)	-201.6* (94.34)	53.88 (97.06)
HighEER x TOU	87.40 (78.48)	71.49 (119.6)	56.68 (75.35)
Solar Sales (MWh)	-266.6 (191.8)	-920.8** (350.7)	
Dichotomous Solar Use	-394.5 (242.4)	234.4 (308.9)	
TOU x solar	-310.7 (165.5)	-69.88 (221.2)	
GasUnitsTJ	-2088.4 (1223.8)		-1210.9 (1231.3)
R ²	0.213	0.240	0.193
N	14294	8179	13445

* 0.05 ** 0.01 *** 0.001



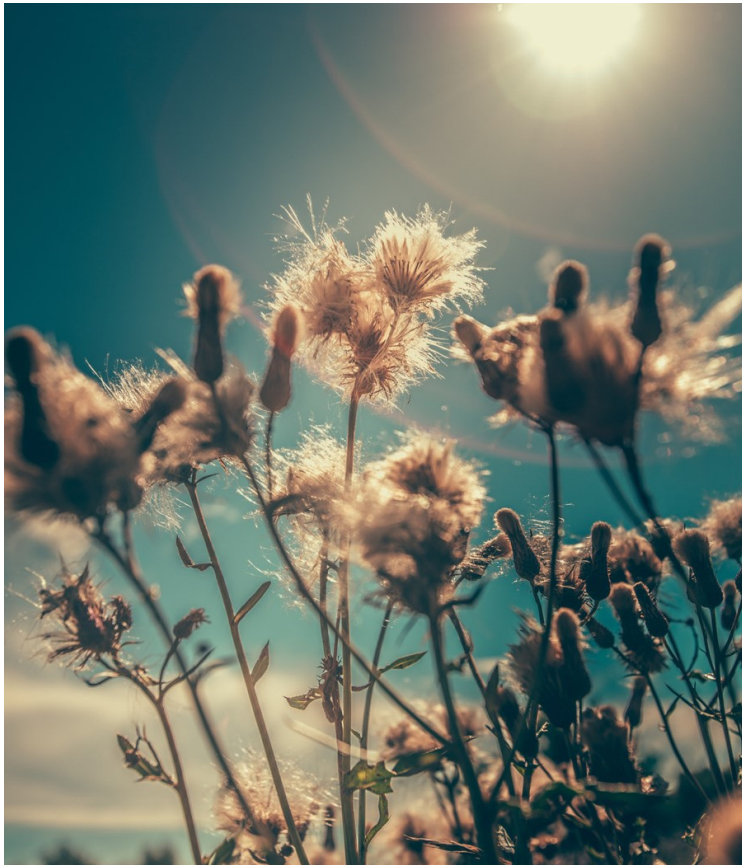


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Usage findings

- Low EER households without gas curtailed use overall, instead of retaining the same total usage distributed at different times of the day
- Households without gas must by definition rely on electricity for heating
- We expected that low EER households would be less able to make use of pre-heating, because the houses do not retain heat well
- It appears that they deal with this by curtailing total use, rather than by bearing higher energy costs



Load profile

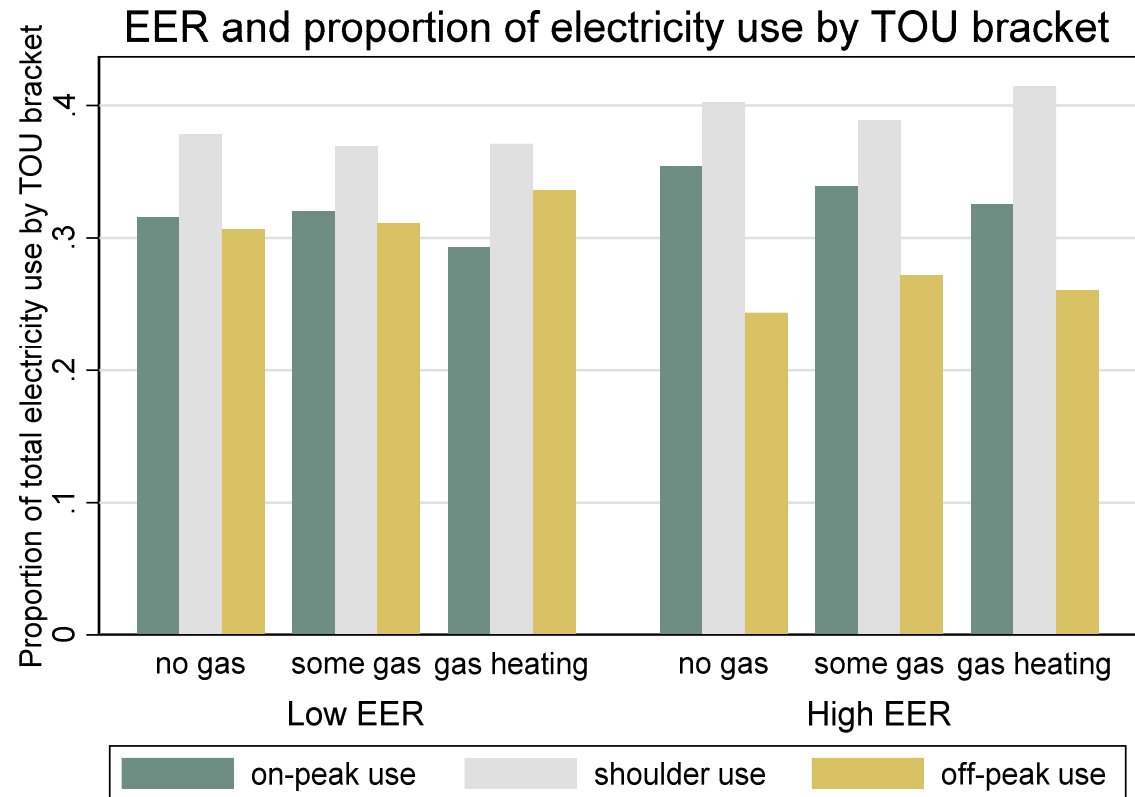
TOU quarters only

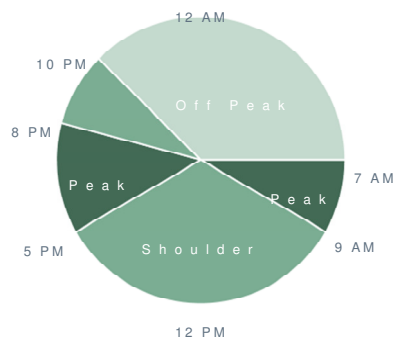
Low-EER households in general have more favourable load profiles, with a smaller proportion of total use falling on-peak

Low-EER households with gas heating have the most favourable profile, with the greatest proportion falling off-peak and the lowest falling on-peak

Households with gas may have less electricity use that is time dependent

For example, it is relatively easy to use dishwashers and laundry machines off-peak in a low-EER household, but electric heating may be needed most during peak times





11pm	12am	1am	2am	3am	4am	5am	6am		
7°	6°	2°	1°	0°	0°	-1°	-1°		
	7am	8am	9am	10am	11am	12pm	1pm	2pm	3pm
	-2°	0°	3°	6°	8°	10°	11°	12°	12°
		4pm	5pm	6pm	7pm	8pm	9pm	10pm	11pm
		11°	8°	5°	4°	3°	3°	2°	1°

June 4-5 2021 Australian Bureau of Meteorology predictions

Implications

Households do have different cost outcomes when switching to TOU, as a function of their home's EER

However, low-EER households do not appear to be at a disadvantage cost-wise

Some low-EER homes (those with no gas) curtail total usage after moving to TOU

For homes without gas, curtailing total usage after a switch to TOU suggests that these homes may be facing colder conditions indoors after switching

So lower bills on TOU for the low-EER+no-gas group are not necessarily an indication of better outcomes

If heating use is being curtailed, then these homes may be uncomfortably cold in winter



Conclusions

These findings suggest that those living in low-EER homes are not disproportionately financially disadvantaged by being on TOU rates (at least, not the design of TOU rate used in the ACT)

Future research should consider whether these findings regarding building energy efficiency are robust to other jurisdictions with different rate design, and should further investigate behavioural responses underlying the data

In particular, low-EER households engaging in greater behavioural response may be more likely face comfort impacts such as being too cold or too hot inside their dwellings



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