Prices Versus Social Nudges for Motivating Energy Conservation

By Laura Grant*

Saving energy is supposedly easy: switch off the light when leaving a room, unplug idle device chargers, keep the thermostat at moderate settings, and shut windows when the air conditioner is running. And doing so reduces both personal expenses and the pollutants from energy production while moderating the burden on generation and transmission capacity. Yet many households fail to act, even when action seems rational based solely on private incentives.

Much like a parent instructing a forgetful child, policymakers and public utilities routinely remind consumers to conserve energy through messages and other non-price programs. Literature documents reductions in energy use when consumers are nudged using information of the 'normal use' of their neighbors as a social reference point (Allcott, 2011; Ayres, Raseman and Shih, 2013; Allcott and Rogers, 2014; Jessoe, Rapson and Smith, 2014; Ito, Ida and Tanaka, 2015). Opower's well known and well studied home energy reports cause a one-to-two percent reduction.

The U.S. military is going a step further, by implementing a novel program to encourage service members and their families living on base housing to conserve energy. The utility bills are a feebate design, using marginal pricing with total charges adjusted linearly, based on average usage of similar homes in the resident's neighborhood. The idea is that these endogenous charges make explicit the social-norm information. As a result, between-household competition makes the information more potent for energy conservation. This context contrasts from Opower, where the information is provided but lacks external consequences.

Using 385,000 observations of monthly electricity use spanning more than four years, I assess a set of treated households compared to two other bases as control groups. I measure the effects of changing the billing reference point to a social norm. For several months in between the old and new policies, residents are given free electricity but are provided bills with neighborhood 'social-norm' usage, as a practice period. Given these changes, the research design exploits the differences of the same household through time as a difference from control households. I find a significant increase in electricity use when electricity is free followed by a decrease when charged again; the estimated net effect of the social-norms policy is 4.8 percent reduction in electricity usage. This study provides an introduction to a unique scheme to reduce electricity use and an assessment of said program, which can provide policy implications for a large segment of the renter population.

I. Military Housing Energy Conservation Program

The Department of Defense has required the military branches to work with each of their U.S. housing locations to develop incentives for energy conservation.[1] With

* Grant: Robert Day School of Economics and Finance, Claremont McKenna College, 500 E. Ninth Street, Claremont, CA 91711, lgrant@cmc.edu. I am grateful for feedback at the 4th Annual Association of Environmental and Resource Economists Summer Conference and 15th Occasional California Workshop on Environmental and Resource Economics. Kathy Baylis, Sumeet Gulati, Sarah Jacobson, Jonathan Kadish, Corey Lang, and Lucija Muehlenbachs provided useful comments and advice.

[1] Executive Order (EO) 13423 required energy intensity reductions in Federal buildings by 3 percent/year from the 2003 baseline to total 30 percent by 2015. EO 13514 mandated federal entities to identify GHG emission reduction targets for 2020 relative to their 2008 baseline. On March 19, 2015, EO "Planning for Federal Sustainability in the Next Decade" revoked EOs 13423 & 13514; it outlines alternative goals for federal agencies in the area of energy, climate change, water use, and other aspects. In response, military administration

TABLE 1—SUMMARY STATISTICS.

Location	Obs N	Homes J	Tenants I	Tenure (mo/tenant)	DailyUse, kWh (mean)	Daily Use, kWh (SD)
Treated, TX	281,940	6,425	19,741	17.25	35.72	20.76
Control 1, TX	42,043	948	2,845	17.66	53.24	33.73
Control 2, NM	60,707	1,301	3,595	19.18	22.69	11.28

Note: The panel is nearly complete: 8,674 homes over 53 months from August 2010 to December 2014, providing 384,690 total observations with 26,181 residents. Tenure is underestimated because residents at the beginning and end of the data set are cut off.

properties contracted throughout the U.S., the U.S. military is a large and representative sector of residential population. The aims are saving money and natural resources while reducing pollution and dependence on foreign energy.

Instead of standard marginal pricing, the households receive a monthly allocation of electricity, then deviations above the allocation are charged a constant rate and deviations below are refunded – a feebate.[2] The rate is $0.076 per kilowatt-hour (kWh), so if, for example, a household is allocated 1000 kWh for the month but only uses 900 kWh, her rebate is $7.60. The marginal pricing incentivizes all households to reduce energy while the allocations subsidize service members for their energy use.

At first, the allocation was pre-set monthly for each home, using an engineering model, and announced ahead of time. But military administration wanted the allocations to better reflect behavior. So they moved to a social allocation: the average of a peer group's monthly electricity use, but the $/kWh-charge remained constant. A peer group is composed of similar houses at the same base. The group size is large, typically 90 or more homes, and peers are anonymous. In addition, a 'practice' period occurs so the billing company could transition accurately. During the practice, informational bills are sent using social reference points but rates are not actually charged; this is to verify that the system is accurately calculating feebates. The households receive paper bills through the mail with identical formats through the periods except, for the addition of social-norm information. To reiterate, the timing of the programs for the treatment group is (1) preset allocation and marginal feebate pricing, (2) social-norm information with free electricity, and then (3) social-norm allocation with marginal feebate pricing.

II. Research Design & Data

The research design uses difference-in-differences through the three distinct allocation periods of treatment. The treatment group is an army base in central Texas.[3] Control group 1 is also an army base and in central Texas, directly to the south. Control group 2 is an air force base to the northwest, located in New Mexico, the contiguous state. Both control groups also face feebate pricing and their allocation calculation remains fixed throughout. Like the treatment group in the treated period, households in Control 1 pay relative to the social norm over the entire time. For Control 2, the allocation is pre-set as the average of the previous 5 years of the same month at the same house.

I construct a panel of homes' electricity use from August 2010 to December 2014. The panel is nearly complete because the vacancy rate is low. However, I drop

plans to maintain and expand the programs described in this research.

[2]A feebate — a portmanteau of fee-rebate — is a sliding scale financial incentive that is added to, or subtracted from, the purchase price of a good, as a function of some attribute of that good. Feebates can be applied to any good, on any attribute. Johnson (2007) provides an overview.

[3]The identity of the data provider and exact locations are withheld to maintain a confidentiality agreement.

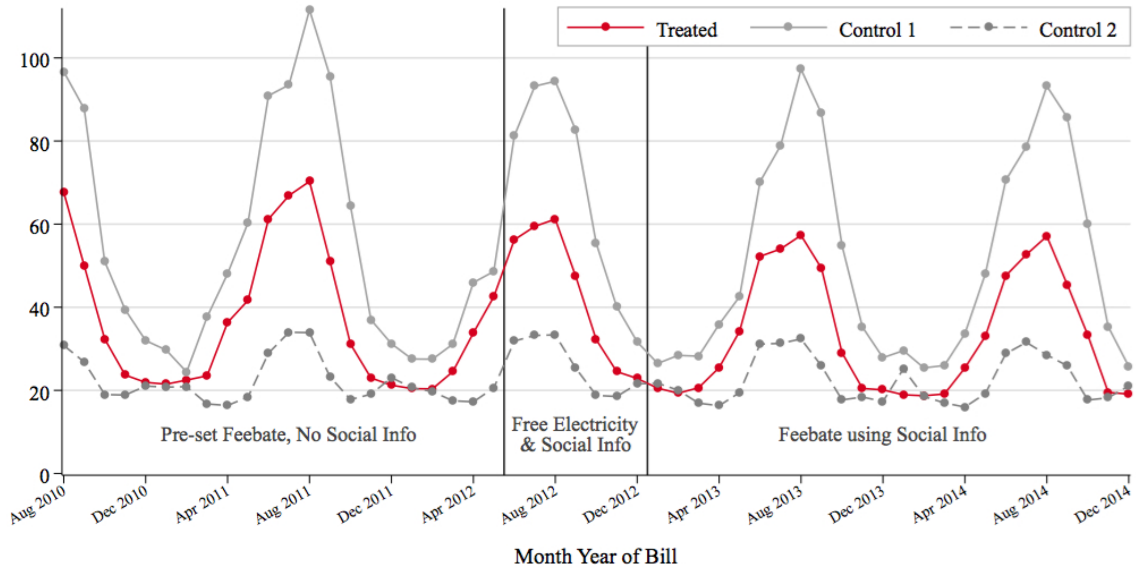

Figure 1. Average Daily Electricity Use (kWh), averaged by month and location.

Note: Average daily electricity use is calculated for each resident i in month t using their total use for each monthly billing period divided by the number of days in the period.

months of partial residency, as reflected in bills with fewer than 24 days. Table 1 gives the overall summary of the 384,690 observations, split by treatment and control groups.

The electricity usage of the two control groups sandwich the treatment group through time (Figure 1). Electricity use is largest in the summer months because the locations are in central Texas and New Mexico, where air conditioning is typical and accounts for 18 percent of residential electricity consumption. The average use for the treatment housing is 1055 kilowatt-hours per billing month (kWh/mo), which is lower than average residential use in Texas (1170 kWh/mo) and greater than the national average of 950 kWh/mo.[4] By location, the deviation between households within each month is very small: the 95% confidence intervals are narrower than the symbols marking the point estimates. The three groups follow a common, seasonal trend. An overall decrease of electricity use through time is apparent.

III. Empirical Findings

Because prices are \$0/kWh during the practice period, electricity use will likely increase. However, the allocation is simultaneously removed, which acts like income loss. Therefore, the direction and magnitude will depend on price and income elasticities.

I can estimate bounds on the price and income effects using a range of values from the literature. Price elasticity of demand for electricity is -0.12 to -0.24 in the short run.[5] Income elasticity for electricity is 0.5 to 0.8. The allocation when *Preset* is a value of \$84/month on average, about 2.5 to 3 percent of monthly income. Therefore, changing from pre-set to the practice period could feasibly increase electricity use in the range of 9 to 22 percent.

The average allocation when *Social* information is used is \$75/month. This represents a small income decrease, which could slightly lower use during social-norm period relative to pre-set. If electricity use is affected substantially, we can attribute

[4] http://www.eia.gov/consumption/residential/reports/2009/state_briefs/pdf/tx.pdf

[5] https://www.eia.gov/analysis/studies/buildings/energyuse/pdf/price_elasticities.pdf

TABLE 2—REGRESSION RESULTS.

Fixed effects:	Home-level			Tenant-level		
Control group:	Both	1	2	Both	1	2
Practice − *Preset*	0.096	0.128	0.075	0.102	0.130	0.085
	(0.007)	(0.009)	(0.009)	(0.006)	(0.007)	(0.008)
Social − *Practice*	-0.145	-0.135	-0.152	-0.140	-0.139	-0.139
	(0.007)	(0.008)	(0.008)	(0.006)	(0.007)	(0.007)
Social − *Preset*	-0.049	-0.007	-0.077	-0.038	-0.010	-0.054
	(0.008)	(0.010)	(0.010)	(0.007)	(0.009)	(0.009)
Observations, N	373,107	312,400	331,145	373,107	312,400	331,145
Homes, J	8,674	7,373	7,726			
Tenants, I				25,661	22,066	22,821
R-squared	0.574	0.648	0.566	0.649	0.726	0.642

Note: The outcome variable is the natural log of average daily electricity use for resident i in month t. Robust standard errors in parentheses, clustered on the home.

it mainly to the behavioral effect of social norms.

Using difference-in-differences provides an overall program evaluation of the social-norm program. The outcome variable is the natural log of average daily electricity use for resident i in month t. The semi-log linear form estimates effects that are approximately percent changes in electricity use. I vary the cross-section fixed effects between house and tenant to glean insight between overall effect and tenure.

Table 2 gives overall results: the effect of *Practice* relative to the baseline effect of the *Preset* allocation model and the effect of *Social* allocation relative to *Practice*. Then the linear combination gives the net change between *Preset* and *Social* allocation models. As predicted, I find a significant increase in electricity use when electricity is free followed by a decrease when charged again

The first set of three columns vary the control group (Both, 1, 2), and keep fixed the home-level effects, controlling for the home's energy consumption needs that remain constant through time. The *Practice-Preset* effect is larger based on Control group 1. *Social-Practice* is fairly consistent, ranging from -12.6 to -14.1 percent. On net, there is a decrease, though with Control group1, imprecisely measured. Using both groups as control, I find an overall reduction 4.8 percent.

In Table 2, the second set of three columns use Tenant-level fixed effects, so effects are identified using residents that experience two or more of the treatment periods. This exploits the randomness of tenants moving in and out, which gives a sense of how much the results are driven by tenants rather than house. Within-tenants, free electricity with the social norms causes more increase in use and less decrease when reimplementing prices. The within-tenant net reduction is only 3.7 percent.

I also perform several robustness checks, finding consistent results: I drop the months January - March as the common trend seems imperfect; I use month and year fixed effects; I include the allocation amount as a covariate and instrument for it with own-lags because it is endogenous.

To provide assurance these results are valid externally, I also obtain an anonymous, random sample of renter data from the treated army base with approximately 11,100 tenants. The median household size for a military-family is four, with two adults and two children; the range is one to twelve persons. The average annual pay, based on rank (before bonuses) and net of housing expenses, is \$32,000. These data to not include age, but extrapolating from rank and speaking with the data provider, the ages are typically mid-20s to late 30s.

In the U.S., the share of households that rent is 36.5 to 41.1 percent, and the share is growing.[6] These numbers are nearly double for families with a head-of-household under 35 years of age. The share is also higher for families with lower-middle income. Therefore, the military families studied here resresent the population of likely renters – younger, less affluent families.

IV. Discussion

Modern society emits vast amounts of greenhouse gases that are causing rapid and potentially destructive climate change. The largest and fastest growing emitter of anthropogenic greenhouse gases is the energy sector.[7] So energy efficiency and conservation are essential pieces of the climate change mitigation puzzle. Many opportunities remain for reducing energy use toward more efficient levels (Gillingham, Newell and Palmer, 2009).

While many economists suggest implementing correct prices, based on the market values and social costs involved, behavioral economic theories show that alternative interventions can change behavior, be more cost effective and enhance welfare in some contexts; various papers provide supporting evidence (see Sunstein (2014) for an overview and Allcott and Kessler (2015) for a case specific to energy).

This analysis suggests that a price that incorporates social cues is more compelling for energy conservation than social cues and prices or prices alone. Furthermore, The program improves cost effectiveness in two dimensions, by motivating conservation for the same cost of billing (sending mail) and reducing the level of energy subsidization.

A relevant policy suggestion is that utilities offer a small monthly bonus based on peer usage; the bonus can be designed as revenue-neutral. Such a program may be particularly strong for new residents who are in the early stages of habit formation in a home; as an extension for further research and policy analysis, I am working with the program directors to test this.

[6]Based on U.S. census data and trulia.com surveys: `http://www.census.gov/housing/hvs/files/currenthvspress.pdf` and `http://www.citylab.com/housing/2016/02/the-rise-of-renting-in-the-us/462948/`.

[7]`http://www.iea.org/publications/freepublications/publication/Climate_Electricity_Annual2011.pdf`

REFERENCES

Allcott, H. 2011. "Social norms and energy conservation." *Journal of Public Economics*, 95(9): 1082–1095.

Allcott, H., and J. Kessler. 2015. "The Welfare Effects of Nudges: A Case Study of Energy Use Social Comparisons." NBER Working Paper Series 21671.

Allcott, H., and T. Rogers. 2014. "The Short-Run and Long-Run Effects of Behavioral Interventions: Experimental Evidence from Energy Conservation." *The American Economic Review*, 104(10): 3003–3037.

Ayres, I., S. Raseman, and A Shih. 2013. "Evidence from two large field experiments that peer comparison feedback can reduce residential energy usage." *Journal of Law, Economics, and Organization*, 29(5): 992–1022.

Gillingham, K., R. G. Newell, and K. Palmer. 2009. "Energy Efficiency Economics and Policy." *Annual Review of Resource Economics*, 1(1): 597–620.

Ito, K., T. Ida, and M. Tanaka. 2015. "The Persistence of Moral Suasion and Economic Incentives: Field Experimental Evidence from Energy Demand." NBER Working Paper Series 20910.

Jessoe, K., D. Rapson, and J. B. Smith. 2014. "Towards understanding the role of price in residential electricity choices: Evidence from a natural experiment." *Journal of Economic Behavior and Organization*, 107: 191–208.

Johnson, K. C. 2007. "Feebate Economics." Available at SSRN 995404.

Sunstein, C. R. 2014. "Nudging: a very short guide." *Journal of Consumer Policy*, 37(4): 583–588.