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The Hawthorne Effect and Energy Awareness

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Abstract

The feeling of being observed or merely participating in an experiment can affect individuals' behavior. Referred to as the "Hawthorne Effect," this inconsistently observed phenomenon can both provide insight into individuals' behavior and confound the interpretation of experimental manipulations. Here, we pursue both topics in examining how the Hawthorne Effect emerges in a large field experiment focused on residential consumers' electricity usage. These consumers received five postcards notifying, and then reminding, them of their participation in a study of household electricity usage. We found evidence for a (study participation) Hawthorne Effect, seen in a reduction of their electricity usage even though no action was required on their part and no change was made in the conditions of their service. Responses to a follow-up survey suggested that the effect reflected heightened awareness of energy consumption, especially among those already more engaged with the topic. Consistent with that interpretation, the treatment effect vanished when the intervention ended.

The Hawthorne Effect and Energy Awareness

"How to substitute human responsibility for futile strife and hatred –this is one of the most important researches of our time." (Elton Mayo, in Roethlisberger and Dickson, 1939)

Beginning 1924, the Western Electric Company Hawthorne plant was the site of some of the most influential studies in the formative years of the social sciences: the *Illumination Experiments*, examining the effects of artificial lights on worker behavior. Although workers appeared to increase their productivity when lighting regimes changed, the researchers eventually concluded that those changes actually reflected psychological factors, such as workers' responses to receiving special attention, or being aware of the experiment. Subsequent studies at Hawthorne reached similar conclusions (*1*). Such changes came to be called the *Hawthorne Effect* (*2*, *3*), although, ironically, secondary analyses concluded that there was no effect in the original studies or, more precisely, that the studies' design was too flawed to establish whether the effect was, in fact, observed there (*4–7*).

The mythical status of the initial observation notwithstanding, the Hawthorne Effect is a fundamental concern for scientists studying any program designed to change human behavior, given that they must distinguish the effects of the program from those of being in the study. As a result, the Hawthorne Effect has been examined in many areas, including worker performance (*8*), education (*9*, *10*), health (*11*), and voting (*12*). The evidence from these studies is mixed. Some of the variability in their results may reflect differences in how they operationalized the concept of "being in a study." At one extreme lie such minimal manipulations as telling people no more than that they are in a study. At the other extreme, it includes treatments known to have their own effects, such as directly monitoring a specific behavior (*13*), providing performance

feedback (*14*), inadvertently communicating a research hypothesis (*15*), and providing new resources or instruction (*16*). Here, we add to the small set of experiments that have examined the effects of study participation per se with a field experiment examining the electricity usage of several thousand consumers. Our results reveal evidence of a pure Hawthorne Effect, the psychological mechanisms shaping its size, and its implications for field studies of policy interventions.

In addition to its economic and environmental importance, household electricity consumption offers several attractive features as a research domain. It is routinely measured for many households. It is such a small part of most Americans' budgets that it typically receives little attention, meaning that participating in a study might be enough to make it salient. Finally, most people know how to save electricity, if they think about it. Thus, if participating in a study increases the salience of electricity consumption, people should know what to do without further instruction – which could confound the pure participation manipulation.

Although there are many studies of interventions seeking to affect energy consumption, few have assessed the contribution of Hawthorne (study participation) effects in them (*17*). Among those few, some used an opt-in design that compromised their results by eliciting a public commitment to participate, had small samples, used weak manipulations, or omitted essential details in the research report, making it hard to tell what they did and found (*18–20*). As a measure of the importance of even small changes in energy consumption, states have set goals ranging from 0.1% to 2.25% annual savings (*21*).

Our experiment sent five weekly postcards to a random sample of electricity customers, notifying them about their participation in a study about household electricity usage. Monthly electricity usage was collected before, during, and after the experimental period for the treatment

group and for a similarly selected control group. One month after the last postcard was sent, we surveyed a random sample of participants, asking about their response to the study.

Experimental Design

Participants were randomly selected from residential customers of a mid-Atlantic electricity utility to be in treatment or control groups. Households in the treatment group received their first notification a few days before the start date through a postcard stating that they had been selected to be in a one-month-study about electricity usage in their home, and that no action was required on their part. They then received four weekly postcards reminders about the study. Thus, its sole stated goal was measuring electricity consumption. The control group received nothing. The observation period approximately spanned the interval between successive monthly readings. Table 1 summarizes household characteristics for the treatment and control groups. A subsample received a survey one month hence. The *Methods* section provides details on the postcards, survey, sampling, and data structure.

*** Table 1 ***

Results

The main dependent variable was households' electricity usage during the treatment period. Although meter readings are scheduled for monthly intervals, there is some variability in when they are actually performed. In order to accommodate this variability, we adjusted each household’s electricity usage by the number of days that fell during the postcard treatment

period. We used this as our estimator of the intervention's impact, comparing electricity usage in treatment and control households, before and after the treatment period:

$$y_{it} = \alpha + \beta \cdot X_{it} + \gamma \cdot treatment\_group_i + \delta \cdot treatment\_period_t + \mu_{it} + \eta_i + e_{it} \qquad (1)$$

where y_{it} is the log of the average daily electricity consumption for household i in month (billing period) t, $treatment\_group_i$ indicates whether household i is in the treatment (=1) or the control group (=0); $treatment\_period_t$ is the fraction of days in the treatment period included in monthly electricity usage for t. X_{it} is the interaction between the previous two terms, equal to the fraction of days in the treatment period for month t for households in the treatment group and 0 for households in the control group. As most of the variation in electricity use in this region reflects demand for heating and air conditioning, our statistical model included heating and cooling degree-days in each billing period: μ_{it} are the average cooling and heating degrees for month t, using the weather station closest to household i. η_i are household fixed effects controlling for time-invariant factors in our data (e.g., household size, electric heating); and e_{it} denotes the error term. β, is the *average treatment effect* of the intervention.

Table 2 presents ordinary least-squares (OLS) analyses, using robust standard errors clustered by household. Model I represents the treatment effect specified above (1). It shows that the average household in the treatment group used 2.7% less electricity during the month of the study (β = -0.027, P = 0.03), compared to the control group. These results are essentially the same when adjusted for observed days within the treatment month, as would be expected given the 97.9% overlap in the periods. Models II and III repeat the analysis for the following month and two months, respectively. There was no post-treatment effect in either the month after the last postcard (Model II, β = -0.007, P = 0.45) or the following two months (Model III, β = -

0.005, $P = 0.55$). The Supporting Information shows that these results are highly robust to changes in model specification and that including temperature data and household fixed effect markedly improve the fit of the regressions (*22*).

*** Table 2 ***

Survey

The survey was conducted a month after the field study ended. It followed the Tailored Design Method (*23*) and included a sub-sample of households in both the treatment and the control groups. Most treatment group respondents (68.1%) reported remembering at least one postcard, with a mean of 3.0 (SD = 1.3). When asked about the purpose of the study (open-ended), 29.2% of respondents cited variants of "save, learn, or be more aware about electricity," 28.1% offered variants of "study electricity usage" (as stated in the postcards), and 20.5% did not know. When asked structured questions about how the study had affected them, 22.2% agreed or strongly agreed that they had reduced their electricity consumption. In addition, 36.4% thought that the study had made them more aware of their electricity usage, and 30.2% that they had learned more about what things use electricity.

As seen in Table 3, respondents were more likely to report that they had reduced their electricity consumption when they saw themselves as doing more than their neighbors to save electricity (Model 1; $\beta = 0.171$, $P < 0.01$), and when they perceived the study as having heightened their awareness of electricity usage (Model 3; $\beta = 0.715$, $P < 0.01$). Whether they reported reducing their consumption was not related to whether they expressed concern about

privacy with new metering devices that would constantly track their usage, which could be seen as another form of awareness. Finally, even though perceived reductions were related to believing that the study was about reducing, learning or being aware of electricity usage (Model 2; $\beta = 0.245$, $P = 0.04$), that effect disappeared when reported electricity awareness was added to the model (Model 3). Thus, perceived reductions reflect heightened awareness of electricity use as a result of participating rather than beliefs about the study's purpose. Lack of statistical power precluded testing for significance of this relationship with actual electricity usage.

When asked how often they performed nine energy-saving actions (with "never"=1 and "always"=5), participants who reported reducing their electricity consumption were also more likely to report turning off their air conditioning, unplugging devices when not in use, and using electrical devices less, compared to respondents in the control group ($P = 0.07$, $P = 0.01$, and $P < 0.01$, respectively). There were no differences in reports of the other six actions, whether routine (e.g. turning off computers and lights) or sustained (e.g. buying energy efficient light bulbs or appliances). However, when comparing actions reported by participants who did not report reducing their electricity usage with those in the control group, the latter reported using electrical devices less ($P < 0.01$), with no other differences in these two groups' reported actions.

*** Table 3 ***

Discussion

We find evidence for a "pure" (study participation) Hawthorne Effect in electricity usage. Residential consumers who received weekly postcards informing them that they were in a study

reduced their monthly usage by 2.7% – an amount greater than the conservation goal currently mandated by any state. A follow-up survey found that participants who reported having responded more to the study also reported greater awareness of their electricity consumption, especially if they also saw themselves as already doing more than their neighbors. These results suggest that the Hawthorne Effect occurred here because participation in the study increased the *saliency* of the focal behavior – and interpretation supported by the fact that the treatment effect vanished when the intervention ended.

The Hawthorne Effect has long been known as a potential experimental artifact. The present results suggest that in electricity usage field trials, reductions as large as 2.7% might reflect just being in the study, independent of the experimental manipulations. These results also suggest how these behavioral changes come about: By heightening awareness of electricity usage among individuals already concerned about it. That interpretation is consistent with the observation that the effects of sustained energy conservation programs appear to decay between quarterly usage reports (*24*). Thus, perhaps any socially acceptable way of increasing awareness will reduce consumption for those motivated to do so, for as long as the intervention continues, unless it creates habits or prompts structural changes (e.g., buying efficient air conditioning, upgrading home insulation). We cannot know what effects a sustained Hawthorne intervention (e.g., a steady stream of postcards notifying consumers about new studies) would produce. However, if awareness alone can improve performance, we might retire the "Hawthorne Effect" in favor of a "Hawthorne Strategy" (*25*), reminding people of things that matter to them, but can get neglected in the turmoil of everyday life.

Methods

Field Experiment. ***Participants.*** Participants (N = 6,350) were randomly selected from a dataset of residential customers who live in one of the regions served by a major mid-Atlantic electricity utility. Customers with meter reading dates close to July 20, 2011, and August 20, 2011, were eligible for the study – meter reading dates are scheduled in advance by the electricity utility. Other eligibility criteria were met by almost all customers: having an individual electricity meter and being a residential customer under a standard price scheme program (flat rate). From the 45,509 eligible customers, 6,350 were randomly split between the treatment and control groups. This sample size was determined through statistical power analysis using 2010 electricity usage data, considering effect sizes of previous energy conservation programs and budget constraints.

Procedure. The study was conducted from July 20, 2011 to August 20, 2011. Households in the treatment group received postcard notification of participation in the study a few days before its beginning, then they received three weekly postcards reminding them of their participation, and on the last week they received a postcard notification that the study was ending. All material said that the households were participating in a study conducted by researchers at Carnegie Mellon University, but with no other explicit goal of measuring the households' electricity consumption: "You have been selected to be part of a one-month study of how much electricity you use in your home. This study will start on Wednesday July 20, 2011, close to the day of your meter reading this month. No action is needed on your part. We will send you a weekly reminder postcard about the study. Thank you." Customer's names and addresses were included as well, using the post office format. On the front of the postcard was a picture of a house with appliances connected to an electricity meter and the Carnegie Mellon University logo. The materials were pre-tested with a sample of people recruited from an online national subject pool, to assess their

understanding and interpretations. Postcards were sent out on Fridays, so households would receive them on the following Monday or Tuesday. This was coordinated such that people were informed in a timely fashion of the beginning and end of the study. Two confederates from the area confirmed the arrival dates of the postcards. The control group did not receive any experimental material.

The field study used an opt-out design, in which customers (treatment group) could call a 1-800 toll free number or visit a Website to request not to be part of the study and not receive additional material. None of the communication channels provided more information than that shown on the postcards. Thirty-six (treatment group) participants (1.28%)[*] elected to opt-out. Although they received no additional postcards, they were included in the analyses.

Attrition. The sample was selected with 2010 data. By the start of the study (Summer 2011), 9.7% of households in the treatment group and 9.3% in the control group had moved or closed their accounts, hence did not receive the materials. Between August and October 2011, an additional 2.1% of households in the treatment group and 2.6% in the control group moved or closed their accounts. The postcards had a "sender request to be returned" stamp, with most returns indicating that customers had moved. As of October 2011, the final treatment and control groups had 2,802 and 2,796 participants, respectively. There were no significant differences between the treatment and control group attrition rates ($\chi^2(1) = 0.04$, $P = 0.84$). Although there are no data on electricity consumption for these participants in the study period, there is information about some characteristics, revealing that they had lower baseline electricity consumption and were more likely to be renting than those who received the study materials (*P's*

[*] This number includes participants who requested additional information that necessitated direct communication from the researchers. Most of the participants did not communicate any specific reason for their decision. A few stated no interest or confusion about the study.

< 0.05). Thus, participants in the study (N = 5,598) represented more 'settled' households in the area.

Electricity consumption data. All participants had two years of monthly electricity usage (133,545 observations), from November, 2009 to October, 2011. Of these, 6.7% had monthly electricity bills based on estimates, rather than actual consumption, as a result of scheduled meter readings not being performed due to weather conditions or meter inaccessibility. They were excluded, as were a few (<0.1%) with zero readings. These exclusions left 124,578 observations in the analysis.

Meter reading dates. Meter readings are not always performed on the scheduled day, meaning that the treatment period did not fully coincide with a single billing cycle of participants. Overall, there was a 97.9% overlap between participants' bill cycle and the month of the treatment period. For the months before and after the treatment, the overlap was 9.5% and 3.6%, respectively. We adjusted our analyses to consider the days in the monthly billing cycle that overlapped with the study treatment and post-treatment periods.

Weather and household data. Cooling degree-days (heating degree-days) in the billing period for each household were calculated as the sum of the average daily temperature over (under) 65 degrees Fahrenheit, for a billing period, using the closest weather station to its zip code. Household data were obtained through the utility company data and 2010 Census data, for which we geo-referenced their address to their block and tract numbers. Table *S1* details all variables.

Survey. ***Respondents.*** Participants from the treatment (N = 600) and control group (N = 370) were sent a mail survey. Sixty-nine participants had moved or closed their account, hence did not receive the survey. From the 572 (treatment group) and 329 (control group) participants, the

overall response rate was 42.5%[†], with no significant differences between groups ($P = 0.97$). Table *S5* indicates respondents and non-respondents' characteristics, using census and electricity usage information, with a few seemingly minor differences.

Procedure. Participants received a package containing a cover letter explaining the goal of the survey, a 5-minute survey with questions about electricity, a $2-bill, and a postage-paid envelope. One week later, all participants received a thank-you-and-reminder postcard. Participants had the option of answering the survey online. In addition, some participants were randomly assigned to be offered participation in a raffle if they returned the survey before the end of September. Table *S6* details all questions included in the survey.

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[†] This response rate is greater than the response rate normally reached by the utility company that serves these customers, which is around 10%.

recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

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Tables

Table 1. Households' characteristics for control and treatment groups.

	Control Mean	*Treatment* Mean	*t*	*p*-value
Household size[†]	2.8	2.8	-0.72	0.47
% households renting[†]	13.7	13.9	-0.27	0.79
% households with electric heating[‡]	33.1	33.3	-0.27	0.78
Number of rooms[‡]	6.5	6.5	-1.71	0.09
Household income (in thousands dollars)[‡]	101.7	102.0	-0.32	0.75
% households with low payment history[*]	12.1	12.5	-0.50	0.62
% households with low income subsidy[*]	1.6	1.9	-1.01	0.31
% Whites[†]	47.2	47.4	-0.25	0.81
% Blacks[†]	31.1	31.0	0.08	0.94
% Asians[†]	13.5	13.1	0.90	0.37
% Hispanics[†]	11.5	11.7	-0.83	0.40
Summer 2010 electricity usage (kWh/day)[*]	42.0	41.8	0.36	0.72
Fall 2010 electricity usage (kWh/day)[*]	28.5	28.8	-0.74	0.46
Winter 2011 electricity usage (kWh/day)[*]	40.9	41.9	-1.19	0.23
Spring 2011 electricity usage (kWh/day)[*]	29.9	30.0	-0.32	0.75

[†]Source: 2010 Census Data (block level information)

[‡]Source: 2010 Census Data (tract level information)

[*]Source: data provided by utility company (household level information)

Table 2. OLS regressions and average treatment effects, indicating the percentage change (savings) in the treatment group compared to the control group during the study.

DV: ln(kWh/day)	Model I			Model II			Model III		
	Coef.	S.E.	t	Coef.	S.E.	t	Coef.	S.E.	t
Treatment effect (treatment period and treatment group)	-0.027**	0.012	-2.159	-0.026**	0.012	-2.151	-0.026**	0.012	-2.153
One-month-after effect (one-month-after period and treatment group)	-	-	-	-0.007	0.010	-0.751	-0.007	0.01	-0.697
Two-month-after effect (two-month-after period and treatment group)	-	-	-	-	-	-	-0.005	0.009	-0.592
Treatment group (=1; 0 if not)	0.006	0.014	0.47	0.007	0.014	0.48	0.007	0.014	0.488
Treatment period (=1; 0 if not)	-0.038***	0.008	-4.95	-0.038***	0.008	-4.966	-0.038***	0.008	-4.945
One-month-after period (=1; 0 if not)	-	-	-	0.033***	0.006	5.231	0.032***	0.006	5.075
Two-month-after period (=1; 0 if not)	-	-	-	-	-	-	-0.032***	0.006	-5.393
Cooling degree days	0.056***	0.001	107.622	0.056***	0.001	104.229	0.056***	0.001	103.964
Heating degree days	0.014***	<0.001	54.985	0.014***	<0.001	54.458	0.014***	<0.001	54.418
Constant	1.439***	0.054	26.484	1.460***	0.054	27.026	1.473***	0.054	27.38
Household fixed effects	Yes			Yes			Yes		
Adj. R-sq	0.220			0.216			0.218		
Households	5,598			5,598			5,598		
Observations	113,624			119,087			124,578		

Dependent variable is the log of household's average daily electricity usage.* p<0.10, ** p<0.05, *** p<0.01

Table 3. Surveys' measures associated with reported electricity reduction.

DV: Perceived electricity reduction caused by the study	Model 1			Model 2			Model 3		
	Coef.	S.E.	t	Coef.	S.E.	t	Coef.	S.E.	t
Do more than neighbors to save electricity	0.171***	0.046	3.691	0.156***	0.047	3.342	0.066**	0.032	2.064
Concern about being observed with new metering devices	0.05	0.044	1.14	0.048	0.044	1.086	0.003	0.03	0.105
Study's purpose interpreted to save, learn, or be more aware about electricity (=1; 0 if not)	-	-	-	0.245**	0.118	2.075	-0.114	0.082	-1.383
Became more aware of their electricity usage because of the study	-	-	-	-	-	-	0.715***	0.038	18.911
Constant	2.101***	0.211	9.98	2.128***	0.21	10.14	0.467***	0.167	2.794
Adj. R-sq	0.038			0.048			0.554		
Observations	319			319			318		

For those who did not see any postcards, or those in the control group, responses of the effect and interpretation of the study were added as 'no effect' and 'no interpretation', respectively, to include them in the analysis. * p<0.10, ** p<0.05, *** p<0.01

Supporting Information

Electricity consumption. Changes in electricity consumption due to the intervention were examined by comparing usage before and during the study between the control and treatment groups. Table *S2* indicates the results for the following models (1, 2, and 3), using ordinary least-squares (OLS) analyses, with robust standard errors clustered by household.

$$y_{it} = \alpha + \beta_1 \cdot X_{it} + \beta_2 \cdot Y_{it} + \beta_3 \cdot Z_{it} + \gamma \cdot treatment\_group_i + \delta_1 \cdot treatment\_period_t + \delta_2 \cdot one\text{-}month\text{-}after\_period_t + \delta_3 \cdot two\text{-}month\text{-}after\_period_t + e_{it} \quad (1)$$

$$y_{it} = \alpha + \beta_1 \cdot X_{it} + \beta_2 \cdot Y_{it} + \beta_3 \cdot Z_{it} + \gamma \cdot treatment\_group_i + \delta_1 \cdot treatment\_period_t + \delta_2 \cdot one\text{-}month\text{-}after\_period_t + \delta_3 \cdot two\text{-}month\text{-}after\_period_t + CDD_{it} + HDD_{it} + e_{it} \quad (2)$$

$$y_{it} = \alpha + \beta_1 \cdot X_{it} + \beta_2 \cdot Y_{it} + \beta_3 \cdot Z_{it} + \gamma \cdot treatment\_group_i + \delta_1 \cdot treatment\_period_t + \delta_2 \cdot one\text{-}month\text{-}after\_period_t + \delta_3 \cdot two\text{-}month\text{-}after\_period_t + CDD_{it} + HDD_{it} + \eta_i + e_{it} \quad (3)$$

Where:

y_{it}: log of the average daily electricity consumption for household i in month (billing period) t.

X_{it}: the fraction of days in the treatment period for month t for households in the treatment group and 0 for households in the control group.

Y_{it}: the fraction of days in the month after the intervention ended for month t for households in the treatment group and 0 for households in the control group.

Z_{it}: the fraction of days in the second month after the intervention ended for month t for households in the treatment group and 0 for households in the control group.

$treatment\_group_i$: whether household *i* is in the treatment (=1) or control group (=0).

$treatment\_period_t$: the fraction of days in the treatment period included in the monthly electricity usage for *t*.

$one\text{-}month\text{-}after\_period_t$: the fraction of days in the month after the intervention ended included in the monthly electricity usage for *t*.

$two\text{-}month\text{-}after\_period_t$: the fraction of days in the month after one month the intervention ended included in the monthly electricity usage for *t*. This is the period we sent out the survey.

CDD_{it}: cooling-degree days for month *t*, using the weather station closest to household *i*.

HDD_{it}: heating-degree days for month *t*, using the weather station closest to household *i*.

η_i: households' characteristics (e.g., household size, electric heating).

e_{it}: error term.

Table *S3* applies the model using three and four years of data. Doing so increases the number of observations per household, while reducing the number of households for each year of data. All participants had electricity consumption data for the primary two years previous to the study, 97.2% for a three year baseline period and 87.9% for four years. As seen, the treatment and post-treatment effects are very similar.[‡] Lastly, to examine the heterogeneity of the treatment effect, we conducted OLS regression models using a standard fixed effects estimator (Table *S4*). We found that the treatment effect was larger for smaller households and those with higher income, although the latter effect moderates with household income above $130k.

[‡] We also conducted a model using four years of electricity usage, and excluding winter data. Treatment effect was 2.6% reduction ($\beta = -0.026$, $P = 0.02$).

Survey. Respondents remembered having received more postcards when they had lived in their homes longer ($r(222) = 0.16$, $P = 0.03$) and lived with fewer people ($r(226) = -0.15$, $P = 0.02$). Table S7 and Table S8 detail the energy-saving actions performed by respondents who reported reducing their electricity usage during the study. The actions that they reported performing were mainly related to not wasting electricity with unused appliances. A smaller fraction reported actions related to air conditioning.

Tables (Supporting information)

Table S1. Variables in data set.

Variable	Comment
Study ID	Unique ID for participants
Treatment, Control*	Randomly assigned
Zip code†	
Usage bill cycle*	
Days bill cycle*	
Bill date*	
Bill type†	Whether bill is based on actual usage
Rate type†	Whether customer is on flat rate
Facility code†	Whether household is a residential customer
Credit code*	Whether customer has poor payment history
Paperless bill	Whether customer receives paper bill
Route number†	Route to read meters
Meter location	
Meter installation date	
AMI installation, notification	(There were no active smart meters)
Priority code	Whether household has individual meter
Poverty code	Whether customer receives subsidy
Status†	Whether customer is active
Cooling-degree days*	
Heating-degree days*	
% households rented*	
Average household size*	
Average family size	
Families w/children (<6, 6-18, <18)	
Median age	
% males, females	
% race (white, black, American Indian, Asian, Hispanic, Pacific Islander, other)*	
Total households (block, tract, zip code)†	
Year household built	
Median number of rooms*	
Heating (gas, electric, fuel, coal, etc.)*	
Value house	
Median household income*	
Mean household income	
Median family income	
Mean family income	

* Used in the analysis. †Used in building the analytical data base.

Table S2. OLS regressions and average treatment effects.

DV: ln(kWh/day)	(S_I)			(S_II)			(S_III)		
	Coef.	S.E.	t	Coef.	S.E.	t	Coef.	S.E.	t
Treatment effect (treatment period and treatment group)	-0.022*	0.012	-1.87	-0.025**	0.012	-2.037	-0.026**	0.012	-2.153
Post-treatment effect (post-treatment period and treatment group)	-0.006	0.01	-0.652	-0.007	0.01	-0.695	-0.007	0.01	-0.697
Post-post-treatment effect (post-post-treatment period and treatment group)	-0.005	0.009	-0.534	-0.004	0.009	-0.501	-0.005	0.009	-0.592
Treatment group (=1; 0 if not)	0.017	0.015	1.121	0.017	0.015	1.096	0.007	0.014	0.488
Treatment period (=1; 0 if not)	0.395***	0.008	47.348	-0.047***	0.008	-5.942	-0.038***	0.008	-4.945
Post-treatment period (=1; 0 if not)	-0.047***	0.007	-6.783	0.024***	0.006	3.877	0.032***	0.006	5.075
Post-post-treatment period (=1; 0 if not)	-0.264***	0.006	-43.165	-0.034***	0.006	-5.706	-0.032***	0.006	-5.393
Cooling-degree days	-	-	-	0.056***	0.001	103.18	0.056***	0.001	103.964
Heating degree-days	-	-	-	0.013***	<0.001	50.747	0.014***	<0.001	54.418
Constant	3.290***	0.011	300.086	2.905***	0.011	260.368	1.473***	0.054	27.38
Household fixed effects	No			No			Yes		
Adj. R-sq	0.02			0.091			0.218		
Households	5,598			5,598			5,598		
Observations	124,578			124,578			124,578		

Dependent variable is the log of household's average daily electricity usage. * p<0.10, ** p<0.05, *** p<0.01

Table S3. OLS regressions and average treatment effects. These models include households with two, three, and four years of electricity usage.

DV: ln(kWh/day)	(S_IV: 2 years)			(S_V: 3 years)			(S_VI: 4 years)		
	Coef.	S.E.	t	Coef.	S.E.	t	Coef.	S.E.	t
Treatment effect (treatment period and treatment group)	-0.026**	0.012	-2.153	-0.029**	0.013	-2.323	-0.028**	0.013	-2.138
Post-treatment effect (post-treatment period and treatment group)	-0.007	0.01	-0.697	-0.009	0.01	-0.872	-0.004	0.011	-0.365
Post-post-treatment effect (post-post-treatment period and treatment group)	-0.005	0.009	-0.592	-0.007	0.009	-0.784	-0.004	0.01	-0.422
Treatment group (=1; 0 if not)	0.007	0.014	0.488	0.006	0.014	0.453	0.004	0.014	0.301
Treatment period (=1; 0 if not)	-0.038***	0.008	-4.945	-0.046***	0.008	-5.641	-0.052***	0.009	-5.98
Post-treatment period (=1; 0 if not)	0.032***	0.006	5.075	0.029***	0.007	4.389	0.018**	0.007	2.493
Post-post-treatment period (=1; 0 if not)	-0.032***	0.006	-5.393	-0.035***	0.006	-5.587	-0.047***	0.007	-6.99
Cooling-degree days	0.056***	0.001	103.964	0.057***	0.001	103.273	0.057***	0.001	94.438
Heating degree-days	0.014***	<0.001	54.418	0.015***	<0.001	57.366	0.015***	<0.001	55.779
Constant	1.473***	0.054	27.38	1.468***	0.055	26.57	1.571***	0.059	26.571
Household fixed effects	Yes			Yes			Yes		
Adj. R-sq	0.218			0.204			0.192		
Households	5,598			5,440			4,920		
Observations	124,578			183,094			218,058		

Dependent variable is the log of household's average daily electricity usage. * p<0.10, ** p<0.05, *** p<0.01

Table S4. OLS regressions and average treatment effects by households' characteristics, using a standard fixed effects estimator.

DV: ln(kWh/day)	(S_VII)		
	Coef.	S.E.	t
Treatment effect x household size	0.050356**	0.022	2.263
Treatment effect x income	-0.004338**	0.002	-2.200
Treatment effect x income^2	0.000016*	<0.001	1.943
Treatment effect (treatment period and treatment group)	0.083472	0.120	0.697
Treatment period x household size	-0.025902*	0.016	-1.600
Treatment period x income	0.005898***	0.001	4.215
Treatment period x income^2	-0.000028***	<0.001	-4.700
Treatment period (=1; 0 if not)	-0.237678***	0.083	-2.800
Cooling-degree days	0.057134***	<0.001	110.000
Heating degree-days	0.015243***	<0.001	60.000
Constant	2.887660***	0.004	710.000
Adj. R-sq	0.276		
Households	5,598		
Observations	113,624		

Dependent variable is the log of household's average daily electricity usage. * p<0.10, ** p<0.05, *** p<0.01

Table S5. Survey respondent and non-respondent characteristics.

	Respondent Mean	*Non-respondent Mean*	*t*	*p*-value
Household size[†]	*2.8*	*2.8*	-1.13	0.26
% households renting[†]	*14.4*	*13.8*	-0.56	0.58
% households with electric heating[‡]	*32.1*	*33.3*	1.09	0.27
Number of rooms[‡]	*6.5*	*6.5*	-0.53	0.60
Household income (in thousands dollars)[‡]	*106.0*	*101.6*	-2.17	0.03
% households with low payment history[*]	*6.8*	*12.7*	3.38	0.00
% households with low income subsidy[*]	*1.8*	*1.7*	-0.13	0.89
% Whites[†]	*51.7*	*47.0*	-2.84	0.00
% Blacks[†]	*25.4*	*31.4*	3.28	0.00
% Asians[†]	*14.0*	*13.2*	-0.98	0.33
% Hispanics[†]	*12.1*	*11.6*	-0.82	0.41
Summer 2010 electricity usage (kWh/day)[*]	*42.3*	*41.8*	-0.47	0.64
Fall 2010 electricity usage (kWh/day)[*]	*28.4*	*28.7*	0.34	0.74
Winter 2011 electricity usage (kWh/day)[*]	*39.6*	*41.6*	1.10	0.27
Spring 2011 electricity usage (kWh/day)[*]	*29.7*	*30.0*	0.29	0.77

[†]Source: 2010 Census Data (block level information)

[‡]Source: 2010 Census Data (tract level information)

[*]Source: data provided by utility company (household level information)

[††]Source: 2010 Census Data (all region) and electricity usage for all region

Table S6. Survey questions

Question
Study ID (previously inserted)
What is your gender?
What is your age?
Who is primarily responsible for paying your monthly electricity bill? (I am, Another adult (spouse, roommate, family member, etc.), My landlord, Other)
How do you receive your monthly bill? (Online—I log in to view it, In the mail—I receive a paper bill, I don't get one—an automatic payment is deducted from my bank account, Other)
Who generally picks up the mail at your home? (I do, Another adult (spouse, roommate, family member, etc.), Other)
How many people live in your home?
How long have you lived in your current home?
How many of these postcards do you remember having seen? [a picture of a postcard was inserted next to this question]*
If you did not see all five postcards, why do you think that happened? (I wasn't at home throughout the study (vacation, moving, living somewhere else, etc.), I might have thrown a postcard away without noticing it, Someone else might have picked up a postcard, Other)*
What do you think was the purpose of the Smart Electricity Study?*
Are you aware of having done anything different after receiving the postcards?*
Please tell us how much you agree with the following statements about the study. I think the study … [1: Strongly disagree to 5: Strongly agree]*
made me more aware of my electricity usage
made me reduce my electricity usage
made me learn more about what things use electricity in my home
had no effect on me at all
How often did you do each of these things, during the month of the study? During the study … [1: Much less than usual to 5: Much more than usual; 6: Doesn't apply]*
I turned off my air conditioner (AC)
I set my AC thermostat higher
I turned off lights when not in use
I turned off computers and TVs when not in use
I unplugged appliances when not in use
I used electrical devices less
I replaced incandescent light bulbs with CFLs
I bought an energy-efficient appliance
If you changed any other aspect of your electricity use during the month of the study, please describe the change.
Please indicate how often you do these things to save electricity, in general. In general, to save electricity … [1: Never to 5: Always; 6: Doesn't apply]
I turned off my air conditioner (AC)
I set my AC thermostat higher
I turned off lights when not in use
I turned off computers and TVs when not in use
I unplugged appliances when not in use
I used electrical devices less
I replaced incandescent light bulbs with CFLs

I bought an energy-efficient appliance
I use an electricity tracking device (e.g. in-home display)
I insulate my home
If you do other actions to save electricity (not listed in the previous table), please describe them.
How much do you agree with the following statements? Compared to the average household in my city … [1: Strongly disagree to 5: Strongly agree]
My household uses more electricity
My household has done more to reduce its electricity consumption
My household cares more about the environment
About how much was your last monthly electricity bill?
About how many kilowatt hours (kWhs) did you use on your last monthly bill?
At what temperature do you usually keep your AC thermostat in summer?
How many of each of these appliances do you have? Please write a number in each space. Several appliances were listed (e.g. Central air conditioner, TV, and dishwasher)
Do you have a smart meter in your home? (A smart meter sends your electricity use to the power company continuously, rather than just once a month). (Yes, No, I don't know)
How much you agree with the following statements. Smart meters can …[1: Strongly disagree to 5: Strongly agree]
Make electricity more expensive
Violate your privacy
Let the electric company control your electricity use
What is your current employment status? (Employed full time, Employed part time, Unemployed, Looking for work, Student, Homemaker, Retired)
What is the highest level of education that you have completed? (Less than high school, High school/GED, Some college, 2 year college degree (Associates) 4 year college degree (BA, BS), Masters, PhD, MD, JD, etc.)
What is your annual household income($)? (0-15k, 16k-30k, 31-50k, 51-75k, 76-100k, 101-125k, 126-150k, 151-175k, 176k+, Prefer not to answer)
Would you describe yourself as: (American Indian/Native American, Black/African American, Asian, Hispanic/Latino, White/Caucasian, Other, Prefer not to answer)
Do you consider yourself to be: (Democrat, Republican, Independent, Other, Prefer not to answer)

* Only households in the treatment group

Table S7. Energy-saving actions reported by survey respondents who reported taking actions in response to the study.

Action performed more than usual during the study	% of respondents
I turned off lights when not in use	69.6%
I turned off computers and TVs when not in use	60.4%
I turned off my air conditioner (AC)	45.8%
I unplugged appliances when not in use	45.8%
I replaced incandescent light bulbs with CFLs	43.5%
I set my AC thermostat higher	38.3%
I used electrical devices less	28.3%
I bought an energy-efficient appliance	26.1%

Table S8. Energy-saving actions reported by respondents who did and did not report reducing their usage in response to the study, and those in the control group. Respondents used a scale anchored at 1 = "Never" and 5 = "Always."

Action	*Mean*		
	Treatment: Reported reduction (i)	*Control (ii)*	*Treatment: Didn't reported reduction (iii)*
I turned off my air conditioner (AC)*	3.13	2.81	2.96
I set my AC thermostat higher	3.43	3.52	3.31
I turned off lights when not in use	4.37	4.42	4.41
I turned off computers and TVs when not in use	4.24	4.13	4.09
I unplugged appliances when not in use**	3.23	2.66	2.67
I used electrical devices less***	3.25	2.64	2.25
I replaced incandescent light bulbs with CFLs	3.24	3.46	3.38
I bought an energy-efficient appliance	3.78	3.97	3.99
I insulate my home	3.38	3.73	3.65

* p<0.10, ** p<0.05, *** p<0.01, when comparing (i) vs. (ii). There were no significant difference between (ii) and (iii), except for using electrical devices less
Note: We also asked for the use of in-home displays (but only a very small number of participants used (or know) these devices