

Testing for crowd out in social nudges: Evidence from a natural field experiment in the market for electricity

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Abstract

This study considers the response of household electricity consumption to social nudges during peak load events. Our investigation considers two social nudges. The first targets conservation during peak load events, while the second promotes aggregate conservation. Using data from a natural field experiment with 42,100 households, we find that both social nudges reduce peak load electricity consumption by 2 to 4% when implemented in isolation and by nearly 7% when implemented in combination. These findings suggest an important role for social nudges in the regulation of electricity markets and a limited role for crowd out effects.

Acknowledgments:

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1. Introduction

Economists have traditionally advocated for market-based regulation to promote the conservation of natural resources (1–4). However, an important series of studies shows that interventions based on insights from social psychology and sociology, so-called social nudges, can be more cost-effective than market-based regulatory instruments (5, 6). Yet, existing work on social nudges has exclusively evaluated their effectiveness in isolation. While this research has led to tremendous insight, it is unclear whether and how one can use the results from such studies to inform the decisions of a policymaker tasked with selecting a portfolio of regulatory instruments to achieve multiple policy objectives. There is little empirical evidence exploring the effectiveness of nudges within this broader context of multiple instruments and objectives.

In this study, we explore whether social nudges succumb to crowd out effects. Such effects have important consequences for policy. For example, if social nudges are susceptible to crowd out effects, then earlier studies may overstate the effect of social nudges when included as part of a portfolio of regulatory instruments based upon behavioral insights. Despite the policy importance of this question, existent research offers little guidance on the nature and extent of crowd out in prosocial behavior. For example, research in social psychology finds that prosocial behavior can increase (7) or decrease (8) if the researcher has already made a request of the decision maker. Similarly, another strand of research in social psychology finds that prosocial choices in one time period can cause decision makers to behave more or less selfishly in subsequent time periods (9, 10).

With an eye toward policy consequences, we set forth to explore whether the effectiveness of a social nudge is attenuated by the earlier receipt of a distinct social nudge. Using a natural field experiment, we assess the question of crowd out by estimating the effect of two social nudges in isolation and combination. Both nudges use the psychological concept of a social comparison, where the choices of a nudge's recipient are compared with the behavior of other households (11). Although we focus on energy conservation, social comparisons have been applied across a broad spectrum of behaviors, including voter

participation (12), charitable giving (13, 14), and tax compliance (15), among others. The first nudge, which we call the peak energy report (PER), targets household electricity consumption during peak load events that periodically occur when demand for electricity is high. The closest analog to the PER that has been studied is the nudge examined in ref. 16, which utilizes moral suasion instead of social comparison to promote conservation during peak load events. Efforts to curb peak load feature prominently in energy policy because there generally is a mismatch between wholesale and retail prices within and across days in the energy sector, and moving consumption temporally can have large effects on emissions and social welfare (17–19). Studies targeting peak load typically focus on the consequences of price changes (20–22). The second nudge, the home energy report (HER), targets aggregate household electricity consumption and has been studied widely (23–29).

Conducted in Southern California during the summer of 2014, the experiment randomly assigned 42,100 households to receive either no communications, the HER, the PER, or both the HER and PER. Combining information on treatment assignment with more than 30 million observations of hourly household electricity consumption, we identify the conservation effect of each social nudge in isolation and in combination.

Our analysis focuses on estimating the extent to which the HER crowds out the effect of the PER during three peak load events that occurred over a 2-mo period in the summer of 2014. To assess crowd out, we relate the effect of receiving both social nudges during these peak load events to the sum of the conservation effects caused by the HER and PER treatments in isolation. If the combined effect is less than the sum of the isolated effects, then receipt of a social nudge crowds out the effectiveness of a subsequent social nudge.

We find that receipt of the PER causes a 3.8% reduction in electricity consumption during a peak load event and receipt of the HER causes a 2.1% reduction. When received in combination, the two social nudges cause households to reduce their electricity consumption by 6.8%. To put these effects into perspective, the price of electricity would have to be increased by nearly 70% during peak load events to achieve the electricity

savings of receiving both the HER and PER. Experimental variation in the price of electricity during peak load events finds an own-price elasticity of -0.1 (16, 20–22). Thus, to achieve the same reductions in consumption caused by the isolated effect of the HER and PER, prices during peak load events would have to be raised by 20 to 40%. To achieve the reductions caused by the combined effect of the HER and PER, electricity prices would have to be increased by nearly 70%. Furthermore, these findings suggest that the effect of the PER is not crowded out when households are already assigned to receive the HER. While we make no claim that these estimates will generalize across locations and domains, they provide evidence on the dynamics of nudging to achieve multiple policy targets in the market for electricity.

The remainder of this study is organized as follows. First, we discuss the experimental design in greater detail and assess balance. Second, we present results, after which we conclude.

2. Experimental Design

Our data come from a natural field experiment designed and implemented by Opower with 42,100 households serviced by a water and power utility in Southern California. The experiment was implemented in two phases, which are summarized in Fig. 1. In the first phase, households were randomly assigned to a treatment or control group, where the treatment group periodically received a HER. In the second phase, the same households were cross-randomized into a treatment group that received a social nudge called the PER that mimics the HER but targets consumption during peak load events or into a control group. Thus, each household was assigned randomly to one of four mutually exclusive groups:

- i) HER+PER group: received both the HER and PER
- ii) HER group: received only the HER
- iii) PER group: received only the PER
- iv) Control group: received no correspondence

Henceforth, we refer to the reports themselves as the HER and PER and households that received these reports as members of the HER group, PER group, or HER+PER group.

The timing of the experiment is summarized in Fig. 2 and went as follows. Households in the HER group and HER+PER group received the HER bimonthly beginning in either 2009 or 2011. Then, at the start of August 2014, households in the PER group and HER+PER group received a notification about peak load event days in the future, which can be seen in SI Appendix, Fig. S1. Thereafter, households in the PER group and HER+PER group received the PER on peak load event days that occurred during August and September of 2014.

The contents of the HER are illustrated in Fig. 3 with an example report. In the report, electricity consumption by the recipient is compared with the average usage of households in the recipient's neighborhood group and with the average consumption of the efficient homes in that same group, where efficient homes are defined as homes in the bottom 20% of usage in a neighborhood group. The HER also contains several other components, such as historical usage data, conservation tips, and information about utility rebate programs. An example of a complete report is provided in SI Appendix, Fig. S3.

An example also helps illustrate the contents of the PER in Fig. 4. To allow for content generation and delivery on short notice of a peak load event day, households received the PER via an automated telephone call to the main account holder. Some customers also received an email version that contained similar content. The email was delivered to the main contact email address if an email address was on file at the beginning of August 2014. In our analyses, we control for whether a household received both a telephone call and an email. If the customer did not pick up the telephone, the automated call was left as a voice mail. Unfortunately, we do not observe whether a call was answered or if the voice mail was accessed by a customer. Around each event day, Opower made two calls containing information that mimics the HER's social comparison module. On the afternoon of the day immediately preceding a peak event, customers were notified of the upcoming event, the hours to conserve electricity, a social comparison of their electricity consumption, and

conservation tips. [Customers in the top five of their comparison group received calls in which this achievement was specifically highlighted (SI Appendix, Fig. S4). All other content was identical. Furthermore, because the social rank was based on past peak event behavior, social rank information was unavailable for the first call.] Then, on the day immediately following the peak load event, customers received another call that provided a social comparison of their electricity consumption behavior during the peak load event. Fig. 4 provides example scripts for these calls. In the summer of 2014, peak load events were called from 1300 to 1800 hours on August 28, September 5, and September 16.

In response to these two social nudges, we observe the hourly electricity consumption for all 42,100 households from August 1, 2014 to September 30, 2014. Following Opower's standard eligibility test, the experiment only contains residential customers who have at least 12 mo of preexperiment consumption data. This rule is intended to ensure that neighborhood comparisons can be constructed reliably, and preexperiment usage is used to balance treatment groups. While we observe a remarkably fine level of consumption data for households in our sample, we do not observe additional cross-sectional covariates that may influence energy usage, such as income or property size. However, given that households are randomized into one of the four treatment groups, we can still identify effects, and the high-frequency nature of the data allow us to control for time-varying and time-invariant effects in the empirical specifications.

We conclude this section by assessing the validity of the randomization conducted by Opower with a comparison of electricity consumption during the baseline period before the first peak load event. While we observe electricity consumption decisions before the PER is administered, we do not observe the choices of households before their receipt of the HER. As a result, our examination of Opower's randomization focuses exclusively on assignment to the PER. Fig. 5 presents results from this examination by plotting average electricity consumption in log kilowatt hours (log kWh) for each treatment group. Therein, we see that before the PER is administered, households assigned to the control group and PER group consume indistinguishable levels of electricity in terms of log kWh. Furthermore, we see the same relationship holds for households assigned to the HER group

and HER+PER group. While Fig. 5 just reports the SDs of log kWh for each treatment group, we point readers interested in a more formal test of balance to the results in SI Appendix, Table S1.

Additionally, Fig. 5 highlights the effect of the HER on electricity consumption during the baseline period. In particular, comparing the HER group and HER+PER group with the control group, we see the HER caused a 3–4% reduction in electricity consumption. SI Appendix, Table S1B presents a more formal series of estimates of the HER in these two groups, and for both groups, the HER effect is significant at traditional levels of statistical significance.

3. Results

We start our empirical analysis by considering the hourly effect of assignment to each of the treatment groups over the course of the three peak load event days in our sample. Fig. 6A plots these effects in log kWh. Several trends emerge. First, the PER appears to have its intended effect. Households assigned to the PER group and control group start and end their day indistinguishable from each other; however, during the peak load event window, the PER group consumes 2–4% less electricity than the control group. Second, the HER delivers electricity savings over the entire course of the peak load event day, with the HER group consuming about 1–4% less electricity than the control group. Third, combining the HER and PER leads to the best of both worlds, with a 2–4% effect for the HER+PER group at the start and end of a peak load event day and savings as large as 8% during the peak load event window. Fig. 6B presents a visual depiction of our test for crowd out by comparing the effect for the HER+PER group against the sum of the effects for the HER group and the PER group. The extent to which these two lines track one another is remarkable, suggesting little in the way of crowd out. Finally, we point readers to SI Appendix, Fig. S5 to see the same presentation of electricity consumption in the week leading up to the first peak load event.

To formalize the results that emerge in Fig. 6, we estimate the effect of assignment to each of the treatment groups using ordinary least squares. To conduct inference on these estimates, we utilize SEs that are robust to heteroskedasticity and arbitrary within household autocorrelations (30). Furthermore, to improve precision, these estimates control for each hour in the sample, the HER deployment wave, and the medium used to communicate the PER.

Fig. 7 plots the estimated treatment effects and their SEs. (The full set of estimates from our empirical model is provided in SI Appendix, Table S2. Furthermore, the estimated treatment effects with 95% confidence intervals are plotted in SI Appendix, Fig. S7.) Across the estimates, we see that the trends observed in Fig. 6 remain, with the HER group and PER group reducing their electricity consumption by 2.1% and 3.8%, respectively, and the HER+PER group consumption falling by 6.8%. The estimated effect of the HER lines up well with other estimates in the literature, which report HER effects ranging from 1–3% (23–29). While the PER has not been previously assessed, its effect is smaller than the peak load social nudge studied in ref. 16, which assesses a social nudge that utilizes moral suasion instead of social comparison. Over the first three peak load events in their sample (16), these authors find their nudge causes an 8.3% reduction in peak load electricity consumption; however, this effect rapidly attenuates after the first three event days.

Pricing experiments provide another useful benchmark upon which to relate the estimated effects in Fig. 7. For example, several researchers (16, 20–22) experimentally vary the price of electricity during peak load events and find an own-price elasticity around -0.1 . To mirror reductions in consumption caused by the isolated effect of the HER and PER, prices during peak load events would have to be increased by 20–40%. Furthermore, to match the reductions caused by the combined effect of the HER and PER, electricity prices would have to be raised by nearly 70%. Interestingly, these price effects implied by the effects of the HER and PER line up well with the price changes induced in critical peak pricing experiments (16, 20–22).

Fig. 7 also presents results of our investigation into the crowd out effects of social nudges. There, we see that the effect of the HER and PER for the HER+PER group exceeds the sum of the HER and PER effects for the HER group and the PER group. If anything, this comparison suggests crowd in, as opposed to crowd out; however, the difference between the two estimates is not statistically distinguishable from a null effect, suggesting no crowd out effect for households in our experiment.

Before concluding, we describe five additional results from our empirical investigation, which are featured in SI Appendix. First, we consider whether the effects described above are robust to changing the outcome variable to electricity consumption in kilowatt hours, excluding households that moved during the experiment, allowing our hour by hour control variables to vary by HER deployment wave, and including household fixed effects. Across these robustness checks, which can be seen in SI Appendix, Tables S3–S6, we see that our main conclusions hold. Second, we consider whether the PER causes overall reductions in electricity consumption or merely prompts households to intertemporally substitute their electricity consumption. Such substitution effects have been found in response to peak load pricing experiments (16, 20–22); however, columns 2 and 3 in SI Appendix, Tables S2C, S7C, and S8C show that no such dynamic exists with the PER group in our data. Third, SI Appendix, Table S8 considers whether the effect of the PER persists after the intervention ends. Therein, we find no evidence of the treatments effects persisting in our data. Fourth, we compare the treatment effects for households above and below our sample’s median baseline electricity consumption. SI Appendix, Table S9 reports that there is no heterogeneity driving our main conclusions. Fifth, we consider the heterogeneity over the peak load event days in our sample. SI Appendix, Fig. S6 shows that there is no clear trend that emerges, especially given the imprecision in estimates. (Additionally, these same estimates are plotted with 95% confidence intervals in SI Appendix, Fig. S8.)

4. Conclusion

In this study, we consider the role of two different social nudges in the market for electricity during peak load events. Our investigation focuses on the conservation effect of these social nudges in isolation and in combination. We find that social nudges play an important role in household demand for electricity during peak load events, causing a 2.1–6.8% reduction in consumption, depending on implementation. Furthermore, our investigation also considers the extent to which there may be hidden costs, or crowd out effects, that could arise among households that receive both social nudges. We find no evidence of crowd out. If anything, our data suggest a complementarity or crowd in effect, as the effect of the two social nudges in combination marginally exceeds the combined effect of the two social nudges in isolation. It would be naive, however, to assume that this dynamic would hold over any possible combination of nudges. Further research will be needed to uncover the scale at which social nudging leads to diminishing marginal returns and whether the types of behaviors that are being nudged influence how social nudges interact. Moreover, our results suggest that more research is warranted to understand the underlying mechanisms predicting crowding in and out, as they could have large implications relative to future policies aimed at securing a sustainable energy system. Finally, we have only considered crowd out in terms of treatment effects. Given the importance of welfare effects that are not captured by a treatment effect estimate, future work should consider extending the approach of ref. 31 for assessing crowd out in social nudges.

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Figures and Tables

Figure 1: Overview of Treatment Assignment in the Experiment

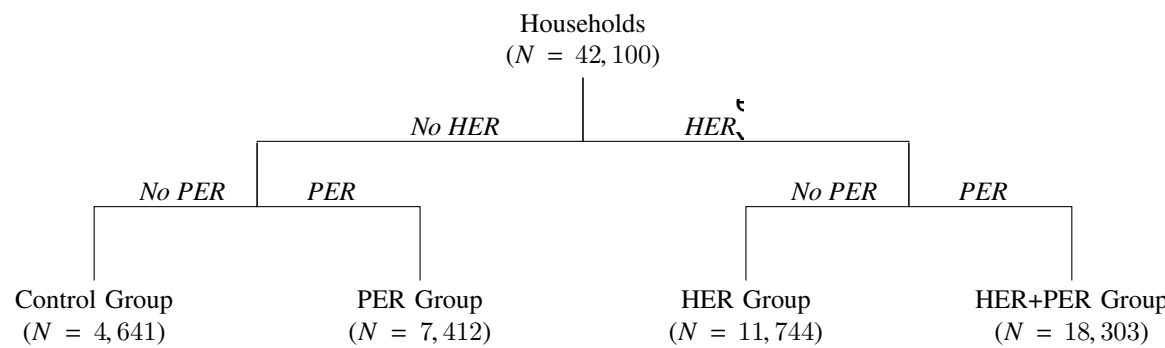
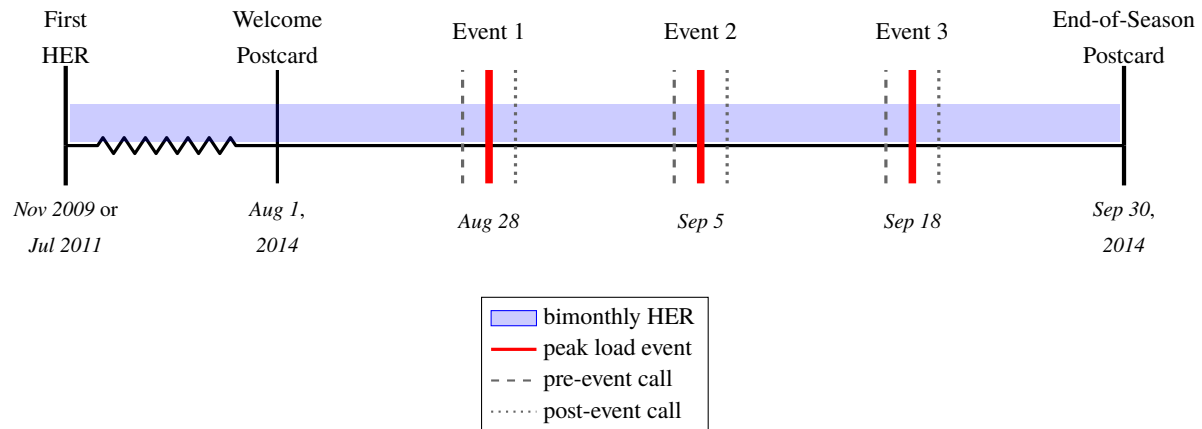
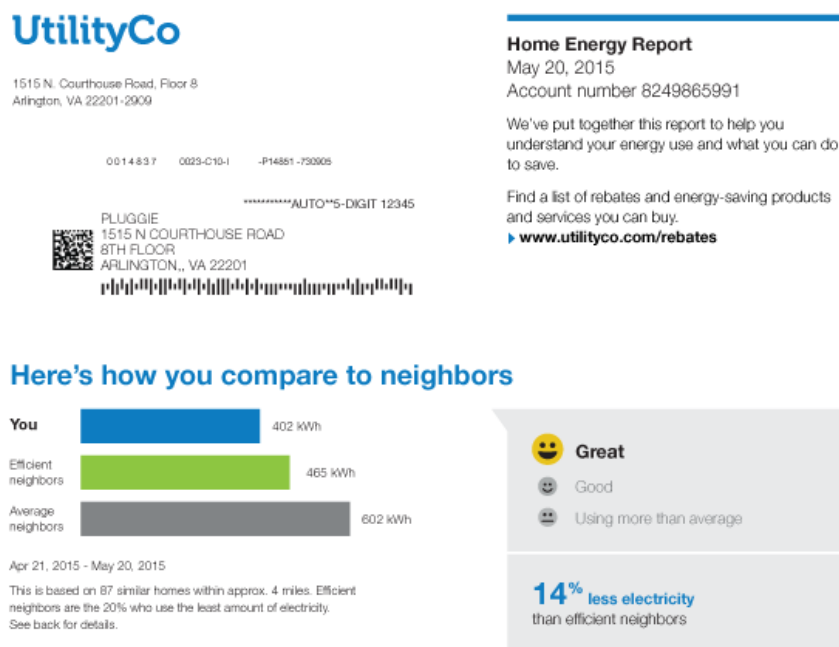


Figure 2: Overview of Timeline and Procedures in the Experiment



Notes: The random assignment to a bimonthly HER took place in November 2009 or July 2011. In the summer of 2014, households were randomly assigned to the PER within each treatment arm. The PER is delivered around the three days with peak load events in the summer of 2014. Each PER consists of three elements: (i) a pre-event call on the day before the event; (ii) the peak load event day itself; and (iii) a post-event call on the following day. Additional documents include a welcome postcard (*SI Appendix Figure S1*) on August 1 and an end-of-season postcard (*SI Appendix Figure S2*) on September 30. HERs are delivered bimonthly throughout.

Figure 3: The Home Energy Report's (HER) Social Comparison Module



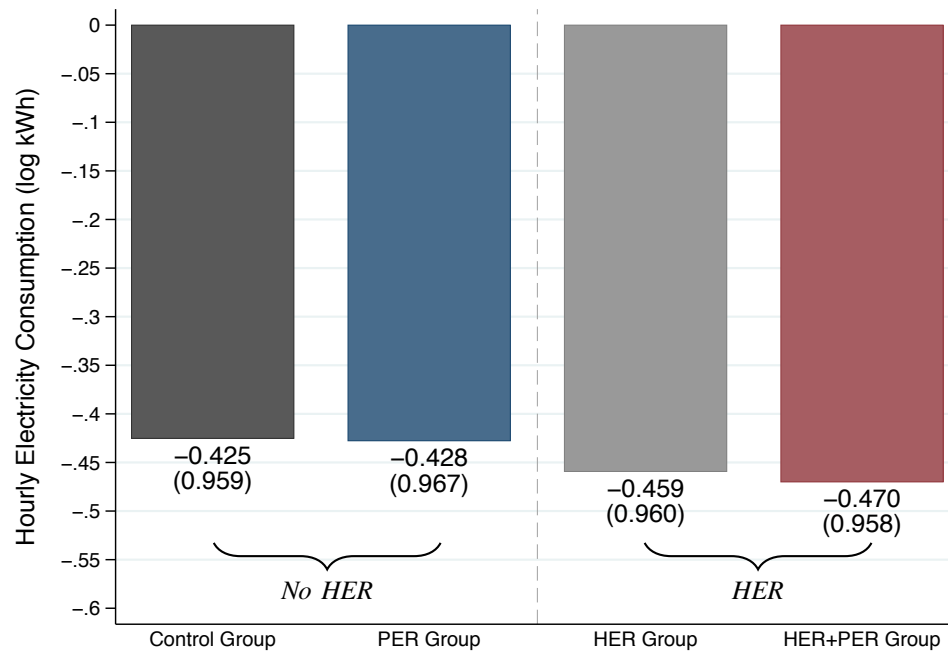
Notes: Example social comparison module of the Home Energy Report. See SI Appendix Figure S3 for a full report.

Figure 4: The Peak Energy Report's (PER) Social Comparison Phone Scripts



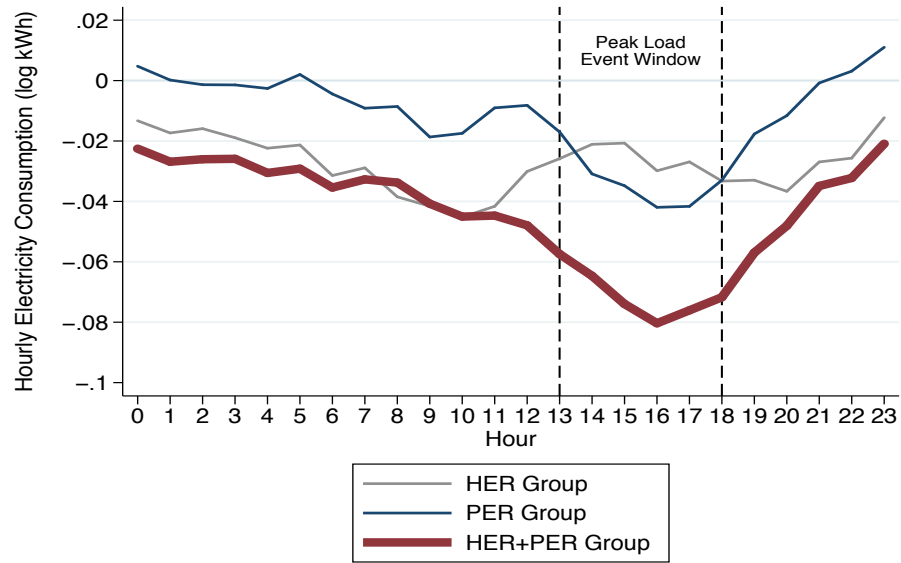
Notes: Example phone scripts of the Peak Energy Report (PER). Households receive a pre-event phone call on the day before the peak load event and a post-event phone call on the day after the peak load event. See *SI Appendix* Figure S4 for the scripts of phone calls households received on the day of the first peak load event and for households in the top 5 of their comparison group.

Figure 5: Treatment Balance in Baseline Electricity Consumption during Peak Hours

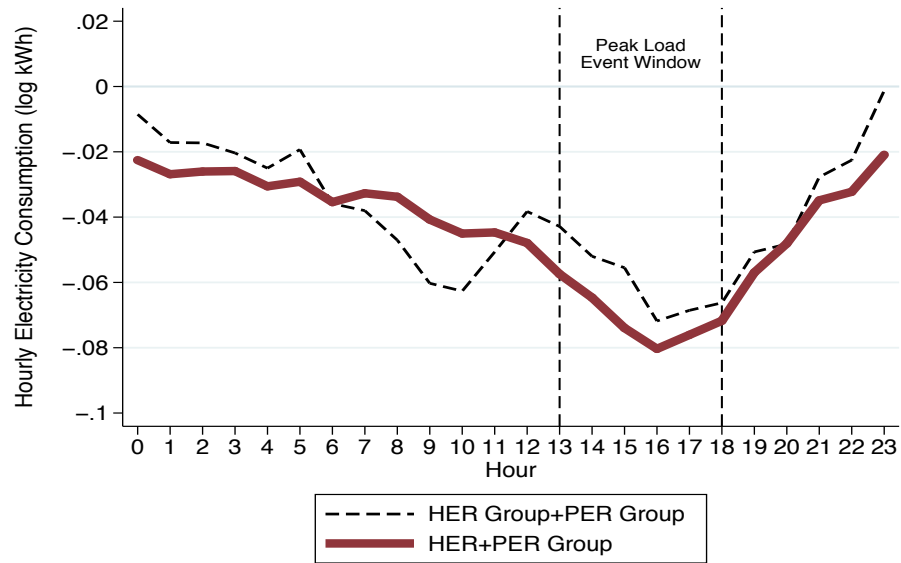


Notes: Log electricity consumption in the baseline period, from Aug 1 to Aug 27, 2014, for the peak hours from 1-6 pm. Bar labels represent the averages and we report corresponding standard deviations in parantheses. *SI Appendix Table S1* presents a more comprehensive set of summary statistics and balance tests.

Figure 6: Treatment Effects in Electricity Consumption on Days with Peak Load Events



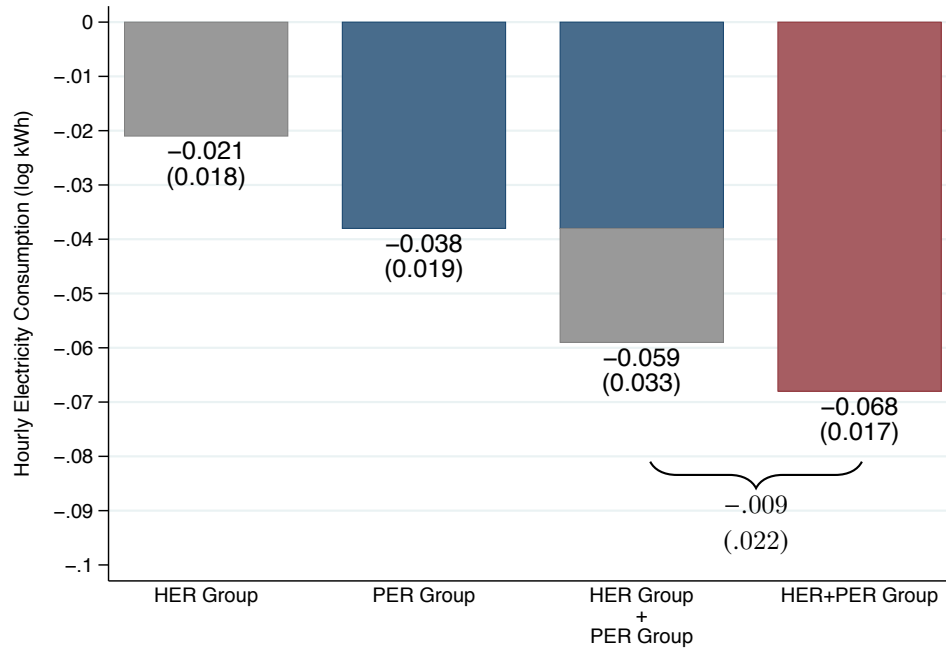
(a) All Treatment Groups



(b) Visual Test of Crowd-Out

Notes: In panel (a), we plot the differences in the log of electricity use between each treatment group and the Control Group on the three days with peak load events. In panel (b), we compare the difference between the Control Group and the HER+PER Group with the summation of the individual differences between the Control Group and the HER Group and PER Group. Vertical lines indicate the peak hours from 1-6pm.

Figure 7: Treatment Effects in Electricity Consumption during Peak Hours



Notes: Average treatment effects during peak hours (1-6pm) from a regression of log electricity use on treatment indicators and controls for each hour in the sample, the HER deployment wave, and the medium used to communicate the PER. We plot the total treatment effects on the three days with peak load events in the summer of 2014. Bar labels represent the point estimates and we report corresponding standard errors in parentheses. We also test the hypothesis of no crowd-out by comparing the treatment effect of the HER+PER Group and a summation of the treatment effects of the HER Group and the PER Group. We report the difference and corresponding standard error.

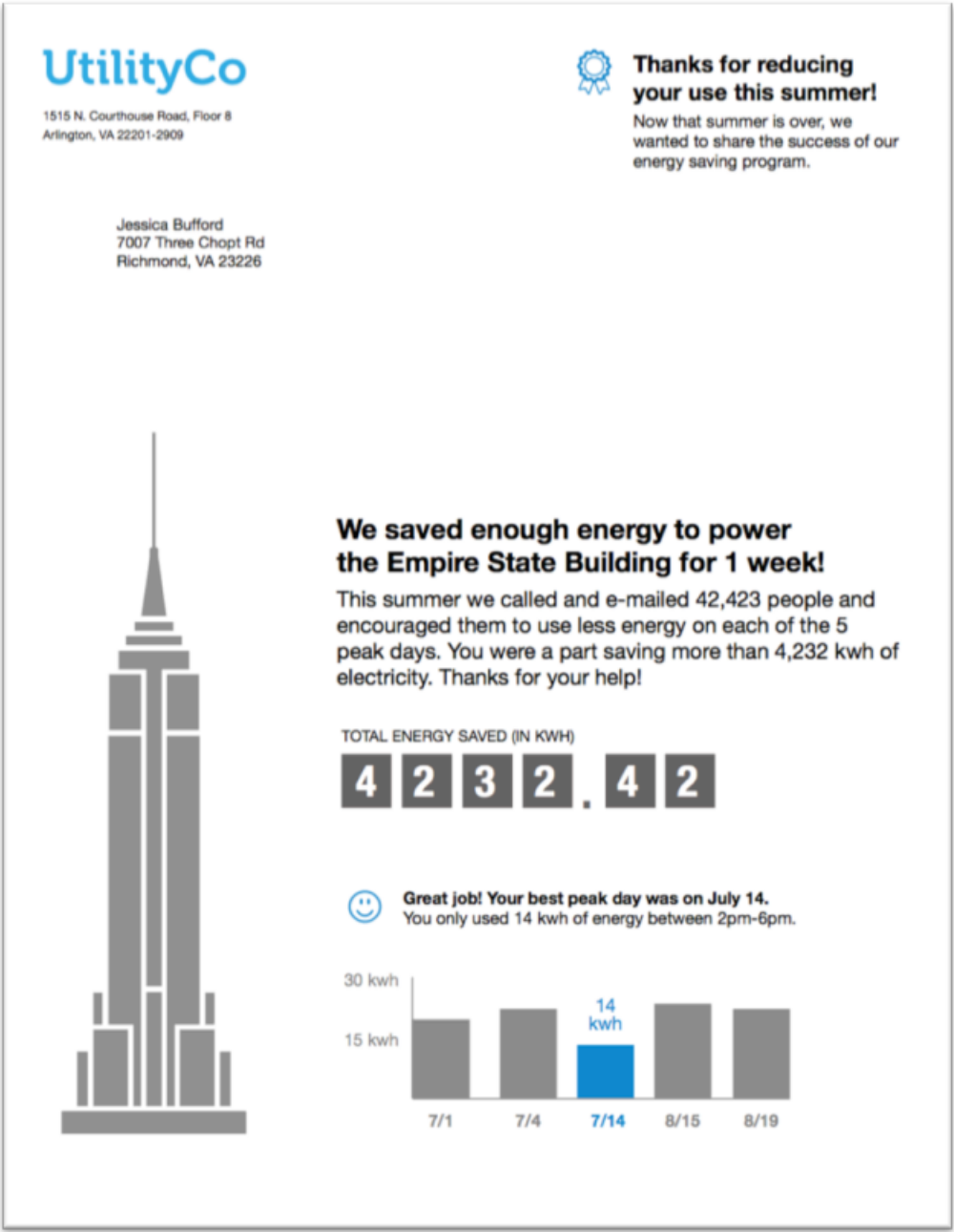
Supplemental Information (SI)

Figure S1: Welcome Postcard



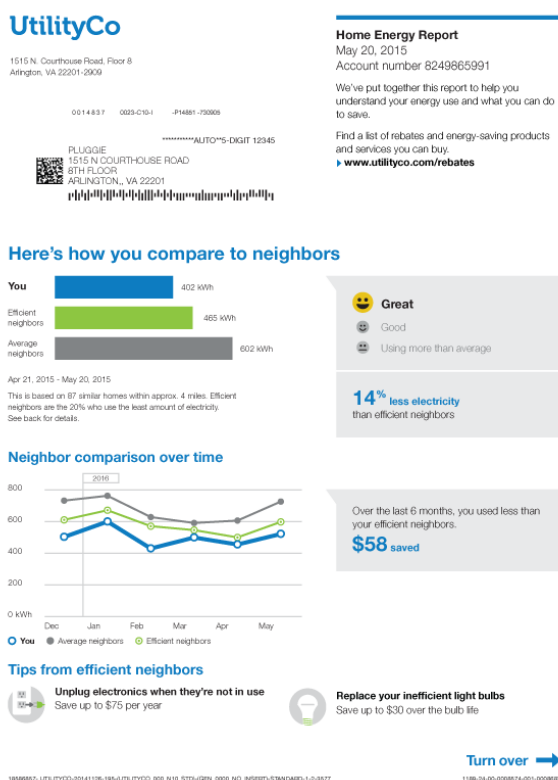
Notes: Customers in the the PER Group and the HER+PER Group receive this postcard prior to the 2014 summer season around August 1.

Figure S2: End-of-Season Postcard

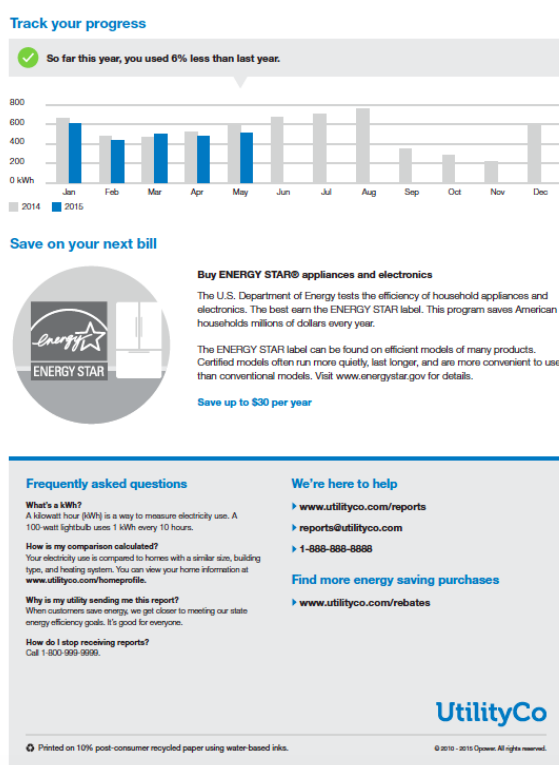


Notes: Customers in the the PER Group and the HER+PER Group receive this postcard after the 2014 summer season around October 1.

Figure S3: Home Energy Report (HER)



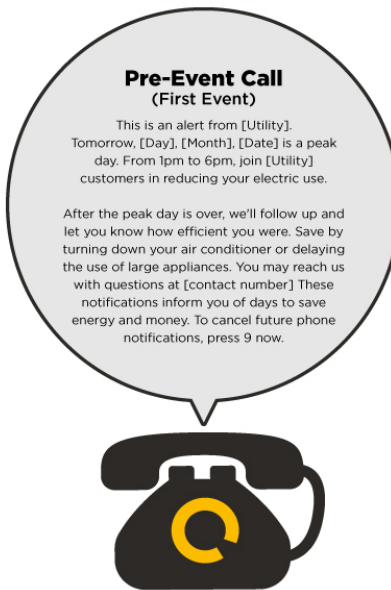
(a) Front



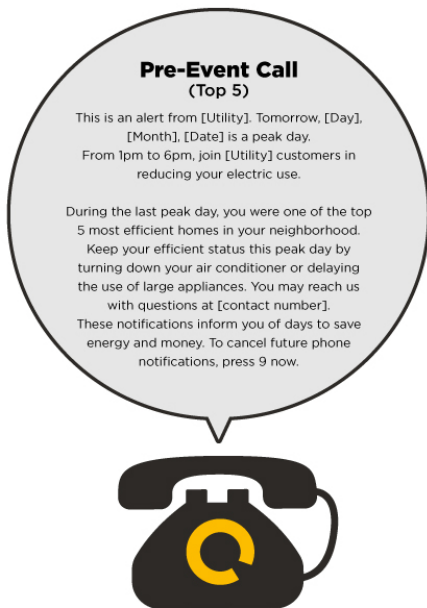
(b) Back

Notes: Example full Home Energy Reports (HER). HERs are delivered to customers in the HER Group and the HER+PER Group bimonthly by mail beginning in 2009 or 2011. The design of the mailers is identical across the two HER deployment waves and treatment groups.

Figure S4: Peak Energy Report (First Event and Top 5)



(a) Before First Event



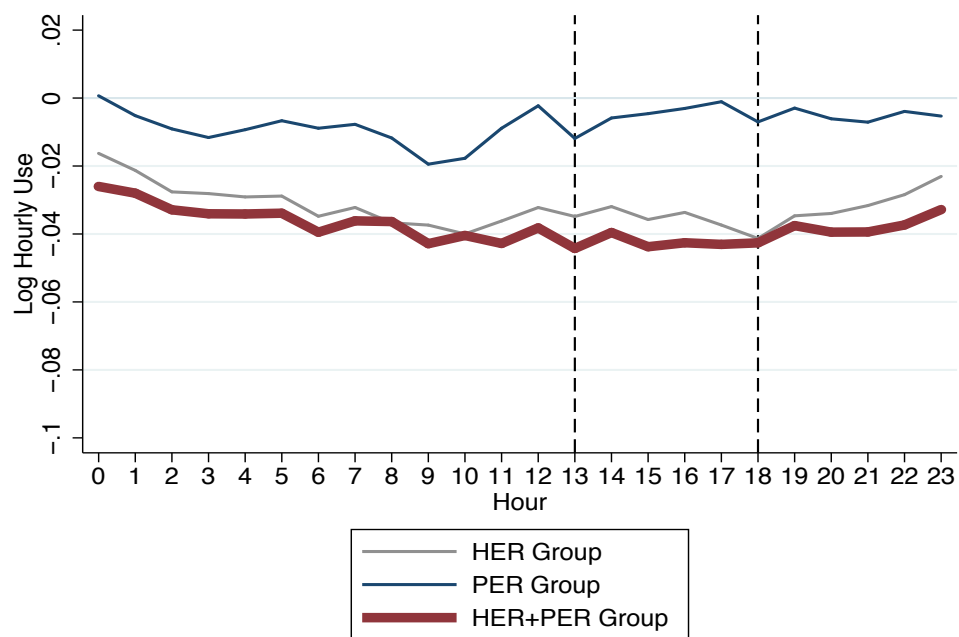
(b) Pre-Event Call (Top 5)



(c) Post-Event Call (Top 5)

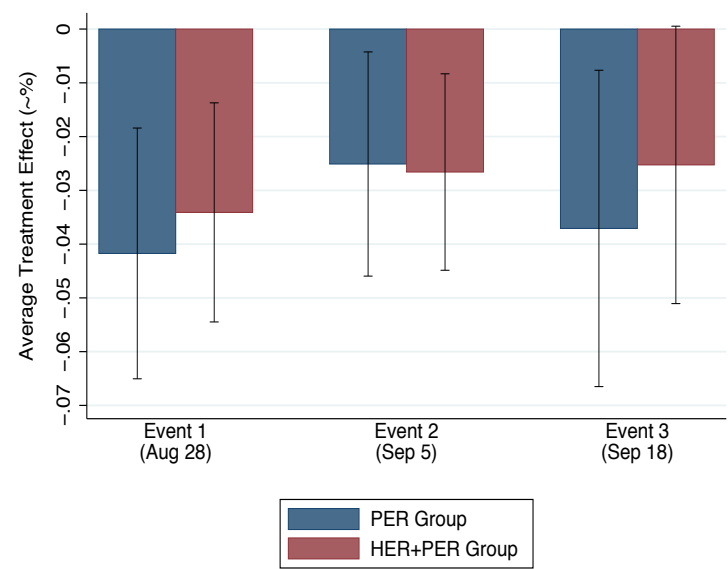
Notes: Peak Energy Reports (PERs) are delivered to households in the PER Group and the HER+PER Group by automated phone call around three days with peak load events in the summer of 2014. Households receive a pre-event phone call on the day before the peak load event and a post-event phone call on the day after the peak load event. Before the first peak load event day, households cannot receive a neighborhood comparison because the necessary data to generate the comparison are missing. Customers in the top 5 of their neighborhood comparison group receive a different call highlighting their accomplishment.

Figure S5: Treatment Effects in Electricity Consumption during the Last Baseline Week



Notes: We plot the differences in the log of electricity use between each treatment group and the Control Group during the last baseline week, from August 20 to August 26. Vertical lines indicate the peak hours from 1-6pm.

Figure S6: The Effect of the PER across Days with Peak Load Events



Notes: Effects of the PER during peak hours (1-6pm) on the three days with peak load events. We estimate our main specification for all three days with peak load events separately. 95% confidence intervals are presented based on clustered standard errors.

Table S1: Summary Statistics, Effect of the HER, and Balance

	Peak Hours (1pm-6pm)	Shoulder Hours (10am-1pm, 6pm-9pm)	Off-Peak Hours (12am-1am, 6pm-12am)	All Hours
<i>Panel A: Average Hourly Usage During Pre-Event Period [μ, (σ)]</i>				
Control Group	1.277 (1.196)	0.989 (0.845)	0.712 (0.573)	0.829 (0.673)
PER Group	1.276 (1.175)	0.980 (0.820)	0.702 (0.534)	0.822 (0.644)
HER Group	1.244 (1.182)	0.955 (0.823)	0.687 (0.537)	0.803 (0.649)
HER+PER Group	1.228 (1.155)	0.946 (0.804)	0.682 (0.529)	0.795 (0.636)
<i>Panel B: Effect of the HER During Pre-Event Period [Δ, (SE)]</i>				
HER Group	-0.033 (0.021)	-0.034 (0.014)**	-0.025 (0.009)***	-0.026 (0.011)**
HER+PER Group	-0.049 (0.019)**	-0.043 (0.013)***	-0.030 (0.009)***	-0.034 (0.011)***
<i>Panel C: Balance During Pre-Event Period [Δ, (SE)]</i>				
Control vs. PER Group	-0.001 (0.022)	-0.009 (0.016)	-0.010 (0.010)	-0.007 (0.012)
HER vs. HER+PER Group	-0.016 (0.014)	-0.009 (0.010)	-0.005 (0.006)	-0.008 (0.008)

Notes: Average electricity consumption in the baseline period from August 1 to August 27. In Panel A, we report the average hourly consumption in kilowatt hours (kWh) and the corresponding standard deviation in parentheses for each treatment group. In Panel B, we report the treatment effect of the HER, i.e., the difference between the Control Group and the two groups that received the HER (HER Group and HER+PER Group). In Panel C, we establish the balance in our sample by presenting differences in the average hourly baseline consumption across the treatment groups that did not receive the HER (Control Group and PER Group) and those that did (HER Group and HER+PER Group). Parentheses report the standard error of the difference in means for Panel B and Panel C. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table S2: Treatment Effects and Crowd-Out [Log Electricity Consumption]

	Peak Hours (1pm-6pm)	Shoulder Hours (10am-1pm, 6pm-9pm)	Off-Peak Hours (12am-1pm, 6pm-12am)	All Hours
<i>Panel A: Pre-Event Period (8/1/14-8/27/14)</i>				
HER Group	-0.029 (0.016)*	-0.032 (0.013)**	-0.029 (0.012)**	-0.029 (0.012)**
PER Group	-0.003 (0.017)	-0.011 (0.014)	-0.012 (0.013)	-0.010 (0.013)
HER+PER Group	-0.039 (0.015)***	-0.040 (0.013)***	-0.035 (0.011)***	-0.036 (0.012)***
<i>Panel B: Marginal Effect on Peak-Event Days (8/28/14, 9/5/14, 9/16/14)</i>				
HER Group	0.008 (0.008)	0.004 (0.006)	0.006 (0.005)	0.006 (0.005)
PER Group	-0.035 (0.009)***	-0.001 (0.007)	0.005 (0.005)	-0.003 (0.005)
HER+PER Group	-0.029 (0.008)***	-0.003 (0.006)	0.004 (0.004)	-0.003 (0.005)
<i>Panel C: Total Effect on Peak-Event Days (8/28/14, 9/5/14, 9/16/14)</i>				
HER Group	-0.021 (0.018)	-0.027 (0.015)*	-0.023 (0.013)*	-0.023 (0.013)*
PER Group	-0.038 (0.019)**	-0.012 (0.016)	-0.007 (0.014)	-0.013 (0.014)
HER+PER Group	-0.068 (0.017)***	-0.043 (0.014)***	-0.032 (0.012)***	-0.039 (0.012)***
<i>Panel D: Test of HER+PER Group vs. HER Group + PER Group [Δ, (SE)]</i>				
H_0 : No Crowd-Out	-0.009 (0.022)	-0.004 (0.019)	-0.001 (0.016)	-0.003 (0.017)

Notes: Regression of log hourly electricity consumption on treatment indicators and controls for each hour in the sample, the HER deployment wave, and the medium used to communicate the PER. We report regression coefficients and corresponding estimated standard errors in Panel A and Panel B. In Panel C, we estimate the total effect on days with peak load events, i.e., the summation of the baseline effect (Panel A) and the marginal effect on peak load events (Panel B) for each treatment group. Finally, in Panel D we test the null-hypothesis (H_0) of no crowd-out, i.e., we test whether the total effect in the HER+PER Group equals the summation of the total effects of the HER Group and the PER Group. For this test, we report the difference in means and the estimated standard error of the difference. Robust standard errors are clustered at the household level. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table S3: Treatment Effects and Crowd-Out [Electricity Consumption in kWh]

	Peak Hours (1pm-6pm)	Shoulder Hours (10am-1pm, 6pm-9pm)	Off-Peak Hours (12am-1pm, 6pm-12am)	All Hours
<i>Panel A: Pre-Event Period (8/1/14-8/27/14)</i>				
HER Group	-0.026 (0.020)	-0.030 (0.014)**	-0.022 (0.009)**	-0.023 (0.011)**
PER Group	-0.001 (0.022)	-0.011 (0.015)	-0.011 (0.010)	-0.009 (0.012)
HER+PER Group	-0.043 (0.019)**	-0.039 (0.013)***	-0.028 (0.009)***	-0.031 (0.011)***
<i>Panel B: Marginal Effect on Peak-Event Days (8/28/14, 9/5/14, 9/16/14)</i>				
HER Group	0.003 (0.012)	-0.004 (0.009)	-0.001 (0.005)	0.000 (0.006)
PER Group	-0.066 (0.013)***	-0.010 (0.010)	-0.001 (0.006)	-0.014 (0.007)**
HER+PER Group	-0.066 (0.012)***	-0.022 (0.009)**	-0.009 (0.005)*	-0.021 (0.006)***
<i>Panel C: Total Effect on Peak-Event Days (8/28/14, 9/5/14, 9/16/14)</i>				
HER Group	-0.023 (0.027)	-0.034 (0.020)*	-0.024 (0.013)*	-0.023 (0.015)
PER Group	-0.066 (0.029)**	-0.021 (0.021)	-0.012 (0.014)	-0.023 (0.016)
HER+PER Group	-0.109 (0.026)***	-0.061 (0.019)***	-0.036 (0.012)***	-0.051 (0.014)***
<i>Panel D: Test of HER+PER Group vs. HER Group + PER Group [Δ, (SE)]</i>				
H_0 : No Crowd-Out	-0.019 (0.034)	-0.006 (0.025)	-0.001 (0.016)	-0.005 (0.019)

Notes: Regression of hourly electricity consumption (in kWh) on treatment indicators and controls for each hour in the sample, the HER deployment wave, and the medium used to communicate the PER. We report regression coefficients and corresponding estimated standard errors in Panel A and Panel B. In Panel C, we estimate the total effect on days with peak load events, i.e., the summation of the baseline effect (Panel A) and the marginal effect on peak load events (Panel B) for each treatment group. Finally, in Panel D we test the null-hypothesis (H_0) of no crowd-out, i.e., we test whether the total effect in the HER+PER Group equals the summation of the total effects of the HER Group and the PER Group. For this test, we report the difference in means and the estimated standard error of the difference. Robust standard errors are clustered at the household level. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table S4: Treatment Effects and Crowd-Out [without Movers]

	Peak Hours (1pm-6pm)	Shoulder Hours (10am-1pm, 6pm-9pm)	Off-Peak Hours (12am-1pm, 6pm-12am)	All Hours
<i>Panel A: Pre-Event Period (8/1/14-8/27/14)</i>				
HER Group	-0.025 (0.016)	-0.031 (0.014)**	-0.030 (0.012)**	-0.029 (0.012)**
PER Group	-0.001 (0.017)	-0.009 (0.015)	-0.009 (0.013)	-0.007 (0.013)
HER+PER Group	-0.034 (0.015)**	-0.036 (0.013)***	-0.032 (0.011)***	-0.032 (0.012)***
<i>Panel B: Marginal Effect on Peak-Event Days (8/28/14, 9/5/14, 9/16/14)</i>				
HER Group	0.004 (0.008)	0.004 (0.006)	0.005 (0.004)	0.005 (0.004)
PER Group	-0.042 (0.008)***	-0.007 (0.006)	-0.001 (0.004)	-0.010 (0.004)**
HER+PER Group	-0.038 (0.007)***	-0.008 (0.005)	-0.002 (0.004)	-0.009 (0.004)**
<i>Panel C: Total Effect on Peak-Event Days (8/28/14, 9/5/14, 9/16/14)</i>				
HER Group	-0.021 (0.018)	-0.028 (0.015)*	-0.025 (0.012)**	-0.024 (0.013)*
PER Group	-0.043 (0.019)**	-0.015 (0.016)	-0.010 (0.013)	-0.017 (0.014)
HER+PER Group	-0.072 (0.017)***	-0.044 (0.014)***	-0.033 (0.012)***	-0.041 (0.012)***
<i>Panel D: Test of HER+PER Group vs. HER Group + PER Group [Δ, (SE)]</i>				
H_0 : No Crowd-Out	-0.008 (0.023)	-0.001 (0.019)	0.002 (0.016)	0.000 (0.017)

Notes: Regression of log hourly electricity consumption on treatment indicators and controls for each hour in the sample, the HER deployment wave, and the medium used to communicate the PER. We exclude households that moved out of their homes during the experiment. We report regression coefficients and corresponding estimated standard errors in Panel A and Panel B. In Panel C, we estimate the total effect on days with peak load events, i.e., the summation of the baseline effect (Panel A) and the marginal effect on peak load events (Panel B) for each treatment group. Finally, in Panel D we test the null-hypothesis (H_0) of no crowd-out, i.e., we test whether the total effect in the HER+PER Group equals the summation of the total effects of the HER Group and the PER Group. For this test, we report the difference in means and the estimated standard error of the difference. Robust standard errors are clustered at the household level. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table S5: Treatment Effects and Crowd-Out [FEs differ by Wave]

	Peak Hours (1pm-6pm)	Shoulder Hours (10am-1pm, 6pm-9pm)	Off-Peak Hours (12am-1pm, 6pm-12am)	All Hours
<i>Panel A: Pre-Event Period (8/1/14-8/27/14)</i>				
HER Group	-0.028 (0.016)*	-0.032 (0.013)**	-0.029 (0.012)**	-0.029 (0.012)**
PER Group	-0.003 (0.017)	-0.011 (0.014)	-0.012 (0.013)	-0.010 (0.013)
HER+PER Group	-0.039 (0.015)***	-0.040 (0.013)***	-0.035 (0.011)***	-0.036 (0.012)***
<i>Panel B: Marginal Effect on Peak-Event Days (8/28/14, 9/5/14, 9/16/14)</i>				
HER Group	0.008 (0.008)	0.005 (0.006)	0.006 (0.005)	0.006 (0.005)
PER Group	-0.035 (0.009)***	-0.001 (0.007)	0.005 (0.005)	-0.003 (0.005)
HER+PER Group	-0.029 (0.008)***	-0.003 (0.006)	0.004 (0.004)	-0.003 (0.005)
<i>Panel C: Total Effect on Peak-Event Days (8/28/14, 9/5/14, 9/16/14)</i>				
HER Group	-0.021 (0.018)	-0.027 (0.015)*	-0.023 (0.013)*	-0.022 (0.013)*
PER Group	-0.038 (0.019)**	-0.012 (0.016)	-0.007 (0.014)	-0.013 (0.014)
HER+PER Group	-0.068 (0.017)***	-0.043 (0.014)***	-0.031 (0.012)***	-0.039 (0.012)***
<i>Panel D: Test of HER+PER Group vs. HER Group + PER Group [Δ, (SE)]</i>				
H_0 : No Crowd-Out	-0.009 (0.022)	-0.004 (0.019)	-0.002 (0.016)	-0.003 (0.017)

Notes: Regression of log hourly electricity consumption on treatment indicators and controls for each hour in the sample and the medium used to communicate the PER. We allow these control variables to vary by the HER deployment wave. We report regression coefficients and corresponding estimated standard errors in Panel A and Panel B. In Panel C, we estimate the total effect on days with peak load events, i.e., the summation of the baseline effect (Panel A) and the marginal effect on peak load events (Panel B) for each treatment group. Finally, in Panel D we test the null-hypothesis (H_0) of no crowd-out, i.e., we test whether the total effect in the HER+PER Group equals the summation of the total effects of the HER Group and the PER Group. For this test, we report the difference in means and the estimated standard error of the difference. Robust standard errors are clustered at the household level. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table S6: Treatment Effects and Crowd-Out [Household FEs]

	Peak Hours (1pm-6pm)	Shoulder Hours (10am-1pm, 6pm-9pm)	Off-Peak Hours (12am-1pm, 6pm-12am)	All Hours
<i>Panel A: Marginal Effect on Peak-Event Days (8/28/14, 9/5/14, 9/16/14)</i>				
HER Group	0.009 (0.008)	0.006 (0.006)	0.008 (0.005)*	0.008 (0.005)*
PER Group	-0.033 (0.009)***	0.000 (0.007)	0.007 (0.005)	-0.002 (0.005)
HER+PER Group	-0.027 (0.008)***	-0.002 (0.006)	0.004 (0.004)	-0.002 (0.005)

Notes: Regression of log hourly electricity consumption on the interaction between treatment and peak load event day. All models include controls for each hour in the sample and for each household. We report regression coefficients and corresponding estimated standard errors in Panel A. Robust standard errors are clustered at the household level. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table S7: Spillover of Treatment Effects to Days Between Peak Load Events

	Peak Hours (1pm-6pm)	Shoulder Hours (10am-1pm, 6pm-9pm)	Off-Peak Hours (12am-1pm, 6pm-12am)	All Hours
<i>Panel A: Pre-Event Period (8/1/14-8/27/14)</i>				
HER Group	-0.029 (0.016)*	-0.032 (0.013)**	-0.029 (0.012)**	-0.029 (0.012)**
PER Group	-0.003 (0.017)	-0.011 (0.014)	-0.012 (0.013)	-0.010 (0.013)
HER+PER Group	-0.039 (0.015)***	-0.040 (0.013)***	-0.035 (0.011)***	-0.036 (0.012)***
<i>Panel B: Marginal Effect on Non-Peak-Event Days from 8/29/14-9/15/14)</i>				
HER Group	0.011 (0.006)	0.004 (0.005)	0.002 (0.004)	0.004 (0.005)
PER Group	-0.002 (0.007)	0.003 (0.006)	0.004 (0.005)	0.002 (0.005)
HER+PER Group	0.006 (0.006)	0.007 (0.005)	0.005 (0.004)	0.005 (0.004)

Notes: Regression of hourly electricity consumption (in kWh) on treatment indicators and controls for each hour in the sample, the HER deployment wave, and the medium used to communicate the PER. We restrict the sample to the baseline period and days between the first and last peak load event, excluding peak load event days. We report regression coefficients and corresponding estimated standard errors in Panel A and Panel B. Robust standard errors are clustered at the household level. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table S8: Spillover of Treatment Effects to Days After the Intervention

	Peak Hours (1pm-6pm)	Shoulder Hours (10am-1pm, 6pm-9pm)	Off-Peak Hours (12am-1pm, 6pm-12am)	All Hours
<i>Panel A: Pre-Event Period (8/1/14-8/27/14)</i>				
HER Group	-0.029 (0.016)*	-0.032 (0.013)**	-0.029 (0.012)**	-0.029 (0.012)**
PER Group	-0.003 (0.017)	-0.011 (0.014)	-0.012 (0.013)	-0.010 (0.013)
HER+PER Group	-0.040 (0.015)***	-0.040 (0.013)***	-0.036 (0.011)***	-0.036 (0.012)***
<i>Panel B: Marginal Effect on Post-Peak-Event Days (9/17/14-9/30/14)</i>				
HER Group	-0.006 (0.007)	0.001 (0.006)	0.001 (0.005)	-0.001 (0.005)
PER Group	-0.009 (0.007)	0.004 (0.006)	0.005 (0.005)	0.002 (0.005)
HER+PER Group	-0.007 (0.007)	0.007 (0.005)	0.005 (0.005)	0.002 (0.005)

Notes: Regression of hourly electricity consumption (in kWh) on treatment indicators and controls for each hour in the sample, the HER deployment wave, and the medium used to communicate the PER. We restrict the sample to the baseline period and days after the last peak load event. We report regression coefficients and corresponding estimated standard errors in Panel A and Panel B. Robust standard errors are clustered at the household level. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.

Table S9: Treatment Effect Heterogeneity by Baseline Electricity Consumption

	Peak Hours (1pm-6pm)	Shoulder Hours (10am-1pm, 6pm-9pm)	Off-Peak Hours (12am-1pm, 6pm-12am)	All Hours
<i>Panel A: Pre-Event Period (8/1/14-8/27/14)</i>				
HER Group	0.006 (0.014)	0.001 (0.012)	-0.005 (0.011)	-0.003 (0.011)
PER Group	-0.002 (0.015)	-0.004 (0.013)	-0.007 (0.013)	-0.006 (0.013)
HER+PER Group	-0.009 (0.013)	-0.008 (0.011)	-0.012 (0.011)	-0.011 (0.011)
HER Group · High-User	-0.031 (0.021)	-0.032 (0.018)*	-0.020 (0.016)	-0.023 (0.016)
PER Group · High-User	-0.008 (0.022)	-0.018 (0.019)	-0.014 (0.018)	-0.012 (0.018)
HER+PER Group · High-User	-0.021 (0.020)	-0.029 (0.017)*	-0.019 (0.016)	-0.019 (0.015)
<i>Panel B: Marginal Effect on Peak-Event Days (8/28/14, 9/5/14, 9/16/14)</i>				
HER Group	-0.001 (0.012)	-0.009 (0.010)	0.001 (0.007)	0.000 (0.008)
PER Group	-0.025 (0.013)*	-0.007 (0.010)	0.003 (0.008)	-0.003 (0.008)
HER+PER Group	-0.025 (0.012)**	-0.009 (0.009)	0.006 (0.007)	-0.001 (0.007)
HER Group · High-User	0.018 (0.016)	0.029 (0.013)**	0.012 (0.009)	0.014 (0.010)
PER Group · High-User	-0.018 (0.017)	0.011 (0.014)	0.005 (0.010)	0.000 (0.010)
HER+PER Group · High-User	-0.007 (0.015)	0.013 (0.012)	-0.002 (0.009)	-0.003 (0.009)

Notes: Regression of log hourly electricity consumption on treatment indicators and controls for each hour in the sample, the HER deployment wave, and the medium used to communicate the PER. In addition, we interact all effects with a binary indicator for high-users in the baseline period, i.e., households with above-median average consumption before the first peak load event. We report regression coefficients and corresponding estimated standard errors in Panel A and Panel B. We omit the coefficients associated with the high-use indicators in the regression output. Robust standard errors are clustered at the household level. *** denotes significance at the 1 percent level, ** at the 5 percent level, and * at the 10 percent level.