Information and Price Variations to Reduce Residential Energy Use in the United States

Researchers:

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Sector(s): Environment & Energy

Fieldwork: Energy Institute at Haas, Center for Energy and Environmental Economics at Haas (UCE3)

Sample: 437 households

Target group: Adults Families and households

Outcome of interest: Climate change Climate change mitigation Conservation Energy conservation

Intervention type: Incentives Information Pricing Energy efficiency Monetary incentives Pricing and fees

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Research Papers: Knowledge is (Less) Power: Experimental Evidence from Residential Energy Use

Partner organization(s): United Illuminating Company (UI)

Increasing electricity prices could induce energy conservation by discouraging families from wasting energy, but electricity customers haven't been responsive to energy pricing policies. Information about how certain practices (e.g. cooling a house) translate into higher electricity usage may help customers track consumption and increase their responsiveness to price variations. Researchers evaluated the effects of introducing price increases during peak periods and also real-time information about electricity usage to residential customers in the United States. Households that received feedback about usage reduced consumption and individuals were more responsive to pricing events that happened with more advance notice. If sustained over time, the lower energy use could lead to meaningful reductions in carbon dioxide emissions.

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Energy conservation is one way to curb climate change, a policy priority worldwide. Utility companies have introduced different pricing strategies to encourage energy conservation and reduce strain on the capacity of electric grids. At the household level, raising electricity prices during peak usage periods could induce more efficient energy use and reduce overall consumption by discouraging families from wasting energy. Nonetheless, electricity customers haven't been responsive to price changes historically.

Low sensitivity to energy pricing could be due to consumers' strong preferences for a particular level of usage, but it could also result from the lack of information about how certain practices (e.g. cooling or heating a house) translate into higher usage and expenses. The uncertainty around consumption levels may be further exacerbated by the infrequency in electricity billing, which is a challenge for tracking usage and the energy requirements of each appliance. Additionally, electricity may comprise a modest share of household expenses and families may prefer to not invest time and effort to resolve this uncertainty.

Can information about residential electricity usage make customers more responsive to energy price variations and thereby induce energy conservation?

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At the time of the study, utility companies and federal agencies in the United States often relied heavily on social pressure and energy-efficiency standards for manufactured products to regulate electricity consumption. While these approaches have moderately improved conservation, other tools like price variation and information may further contribute to conservation efforts and increase efficiency in the electricity sector, an industry with over $420 billion per year in retail sales as of 2021 in the United States [1].

To shed light on the impacts of energy pricing and information policies, researchers conducted a study in the Bridgeport and New Haven areas of Connecticut from July to August 2011, the months during which peak electricity demand usually strained the capacity of the grid. Households that participated in the study had an average income of about US$72,400 and used on average 1.2 and 1.5 kWh per hour during off-peak and peak periods, respectively.



Women using app to control thermostat.

Photo: Monkey Business Images, Shutterstock

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Researchers partnered with the United Illuminating Company (UI), a regulated electricity utility, to evaluate the effects of introducing price increases during peak events and real-time information about electricity usage to residential electricity

customers. Researchers randomly assigned 437 households to one of three groups:

1. *Comparison group* (207 households): Households received an email that notified them that they were in the study, informed them of their group assignment, and contained an energy conservation pamphlet documenting "101 Ways to Conserve Electricity." Households assigned to the other two groups also received the same informational pamphlet.
2. *Price-only group* (130 households)*:* Households in this group could had their utility bill impacted by two types of pricing events that varied in the magnitude of the price increase and the timing of when households received the notification about an upcoming price change. Researchers simulated the price changes through an off-bill account credited with US$100—customers kept any remaining balance in the account at the end of the study, creating the same real-world incentive to conserve energy as billing directly while protecting participants from increases in their utility bills due to the pricing events. All events took place during peak hours, with variations in length (2 or 4 hours) and timing.

- The *day-ahead event* ("DA") provided one day's advance notice that the per-kWh price of electricity would increase by US$0.50 (a roughly 250-percent increase over the standard rate), mimicking a policy that utilities could use to incentivize energy savings if high temperatures were expected the following day. Households received notifications of pricing events by e-mail, phone call, and/or text message, depending on their stated preference.
- The *thirty-minute event* ("TM") sent a notification via households' preferred platform thirty minutes before a US$1.25 increase in the per-kWh price of electricity, a policy that could help reduce immediate risk in grid stability due to an unexpected decrease in generation.

3. *Full intervention group* (100 households): Households experienced the same pricing variations as in the price-only group in addition to receiving real-time information about their electricity use—specifically, they were able to track real-time usage, electricity prices, estimated monthly usage, and their bill-to-date. Participants received the information through an in-home display (IHD), a portable device that was installed in their home free of charge.

Between July 2011 and August 2011, three DA and three TM pricing events occurred. In both intervention groups, it was not clear that households would respond more to one of the two pricing events: while TM events raise prices more, households may not be able to respond to the price change within the short notification window. The information component in the full intervention was testing if households react differently to price changes if they have the opportunity to learn which appliances consume electricity more heavily in advance.

To evaluate the program, researchers relied on data on electricity usage provided by UI and data on demographic and housing unit characteristics from two household surveys (e.g., appliance ownership, frequency with which households checked their IHDs).

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Households that received feedback on their usage (full intervention group) reduced their electricity consumption in response to energy price increases, and were more responsive to price variations than those in the price-only group. Individuals in both groups responded more to pricing events that happened with more advance notice. Households changed their energy consumption habits, and reductions in energy usage could lead to meaningful reductions in carbon dioxide emissions if sustained over time.

Electricity usage: Households with real-time information about usage were more responsive to variations in electricity prices than those without. Participants in the full intervention reduced electricity usage by 14 percent relative to the comparison group, whereas households in the price-only group consumed a similar amount of electricity as the comparison group. Evidence

suggests that participants changed their behavior with the full intervention because the IHD device taught them how to map consumption choices to expenditures, rather than because it increased awareness of price changes—another avenue through which it could have induced responsiveness to pricing events.

Responsiveness to timing and size of price changes: Overall, individuals were more responsive to pricing events that occurred with more advanced notice—i.e., DA rather than TM events. During DA events, households in the full intervention and price-only groups reduced electricity usage by 17 percent and 7 percent relative to the comparison group, respectively. On the other hand, participants in both interventions were unresponsive to TM events, suggesting that individuals may not be able to react to financial incentives that come at a short-notice, even when incentives are strong.

Conservation implications: Lower electricity usage extended beyond the pricing events, leading to habit formation and meaningful conservation as a result. In the short-run (two hours preceding and following the event), households in the full intervention group reduced usage around the DA events by 10 percent, but did not change their usage in the two hours adjacent to TM events. Households in the price-only intervention did not change their behavior around the DA or TM events.

In the medium run (non-event days over the course of the summer), households in both the full and price-only interventions reduced consumption meaningfully, suggesting that recurring price events encouraged conservation among price-only households over time without needing access to the IHD information. Researchers estimate that if households across the US adopted similar new habits each summer, carbon dioxide emissions in the residential electricity sector would decline by approximately 1-2 percent.

Taken together, these findings suggest that pricing variations can change energy consumption habits beyond critical periods, in the short- to medium-run, and induce meaningful environmental benefits. While pricing events change habits in the medium-run irrespective of information on usage, information induces a response to short-run incentives.

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1. U.S. Energy Information Administration. Accessed on October 21st at: https://www.eia.gov/electricity/sales_revenue_price