

# Household Water and Energy Use: An Experimental Analysis of Decision-making under Uncertainty and Penalty Rate Structures

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## ABSTRACT

Faced with rising costs of supply expansion, water and energy utilities are increasingly relying on demand-side management (DSM) policies to close the gap between forecasted demand and available supplies. At the same time, current advancements in metering technology – “smart meters” – are allowing utilities to provide real-time feedback on use and prices directly to customers. It is anticipated that consumption patterns and policy responsiveness of informed customers will differ from that of the uninformed, which has also been identified by national initiatives: the Energy Independence and Security Act of 2007 states “for the United States to realize its full demand response potential, customers must have access to, and a better understanding of, information about real-time or near-real-time prices”. While many anticipate that more frequent feedback will reduce consumption and enhance the effectiveness of existing policies, the evidence to date is mixed. This study develops a better understanding of the effects of increased feedback frequency on household decision-making.

In using water and energy, households make multiple consumption decisions prior to receiving a bill. As a result, they face two types of quantity uncertainty over the course of a billing period: (1) “backward uncertainty”, since it is difficult or inconvenient to track previous consumption up to that point in the period, and (2) “forward uncertainty”, because the household is unlikely to know how much they will consume throughout the remainder of the period. In addition, households often face complex penalty-pricing structures where consumption beyond a threshold level results in a higher marginal price or an extra fee. Smart meters eliminate backward uncertainty by providing more frequent feedback; this gives households the ability to track electricity and water use throughout a billing period and know where their use is relative to pricing thresholds. It is unclear, however, how these types of programs will impact consumption and responsiveness to pricing policies.

Previous literature yields mixed results on how additional information impacts consumption patterns. Research is currently limited because real world data on the behavior of consumers with access to real-time information is scarce. To address this, we create a computerized experiment where feedback frequency varies causing participants to make choices with and without backward uncertainty. We investigate this behavior under two pricing schemes: a constant marginal price structure and an increasing block rate structure. We aren’t aware of any previous studies that have considered backward uncertainty in a controlled experimental setting or the impact of information under alternative pricing schemes. This experiment is a useful way to study behavior before incurring the risk and expense of a real world application, and to shed light on potential unintended consequences. Results indicate that additional feedback increases total consumption levels and variation of within-period consumption. While some participants are able to use the feedback to improve their performance in the experiment, others are not. Furthermore, we find participants to be less responsive to prices when facing penalty-pricing structures. We discuss implications for technology trends, water and energy use, and effectiveness of DSM policies.

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