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Residential Water Use: Evaluating the Water Manager's Toolkit for Promoting Conservation

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Water resources in the eastern U.S. continue to be placed under growing stress as population growth has been combined with stagnant or dwindling water supplies. Periods of drought have resulted in southeastern municipalities facing periods of severe depletion of water reserves over the past decade. Management of water resources when there is competition for available supplies will undoubtedly include a focus on increasing efficiency in residential water use – that is, increased conservation on a per-capita basis. This issue of the *NC State Economist* describes studies evaluating three conservation tools aimed at reducing household demand for water.

The need for addressing residential water efficiency is highlighted by recent legislation passed in Georgia following years of severe drought. The 2010 Georgia Water Stewardship Act included aggressive residential plumbing codes requiring high-efficiency appliances be installed in all new construction, as well as requiring all local ordinances be updated to restrict outdoor watering for purposes of irrigation to the hours between 4p.m. and 10a.m.

From an economic perspective, the best solution would be to properly price water so that prices reflect the true supply and scarcity costs of water provision to households. However, this is rarely, if ever, the case. Water utilities are often governmental or semi-governmental organizations that have as their core mandate to provide safe and reliable potable water to households at an affordable rate. Politically, this translates into underpriced water that reflects only the standard business operating costs of supplying water to customers. The costs associated with depletion of a scarce natural resource, or costs associated with degradation of watershed ecosystems, are rarely considered in pricing decisions.

Given that prices are so rarely employed as a conservation tool, this leaves water managers with a toolkit that includes (i) changing behavior through prescriptive management (e.g., watering restrictions); (ii) changing behavior through information campaigns; or (iii) establishing incentives to adopt more efficient technologies. The 2010 Georgia law mentioned above focused on the first and third approach; however, water managers routinely use all of the above.

Historically, adoption of conservation tools was not based on evidence of efficacy, but usually on anecdotal data or mimicking of other programs. In recent years, however, utilities have partnered with researchers around the country to evaluate their conservation programs. These evaluations have in common careful analysis of observational data to shed light on how households have responded to conservation tools commonly in use today.

Prescriptive Management

Perhaps the most common response of local municipalities during times of severe drought is to impose watering restrictions that are aimed at reducing the amount of water applied to the household landscape. These programs often take the form of voluntary or mandatory limits on outdoor irrigation — for example, restrictions on the days of the week or times of day in which a household is allowed to irrigate their landscape. During the 2007 drought in North Carolina, many municipalities implemented a variety of voluntary and mandatory restrictions to limit water consumption until drought indicators returned to normal levels.

A recent analysis of water-restrictions across 1,800 households in six N.C. municipalities over the period 2006 to 2008 was conducted by NCSU and UNC researchers (Wichman, Taylor, and von Haefen 2012). Findings were that voluntary watering restrictions implemented during the period resulted in an average 3% reduction in household water use. However, there was quite a bit of variation in the response to voluntary restrictions, with reductions of up to 10% in Chapel Hill. Mandatory restrictions resulted in larger reductions, as might be expected. Households on average reduced water consumption by 8% to 13% when mandatory restrictions were in place. These reductions are substantial. In order to reduce consumption by the same amount through prices, the study suggests that the average price of water paid by customers during the study period would have had to increase by up to 25%.

While restrictions can be an effective means to reduce water consumption, they are costly to households. A recent study by researchers at Virginia Tech indicates that the way in which they are implemented is likely very inefficient (Moeltner et al. 2012). Those researchers partnered with a water utility in Reno, Nevada to examine the efficacy of their water restriction policies. An important feature of this study is that residential water meters in Reno record and transmit water consumption data continuously. So by analyzing the pattern of water use, the researchers could determine exactly when the household was irrigating its outdoor landscape.

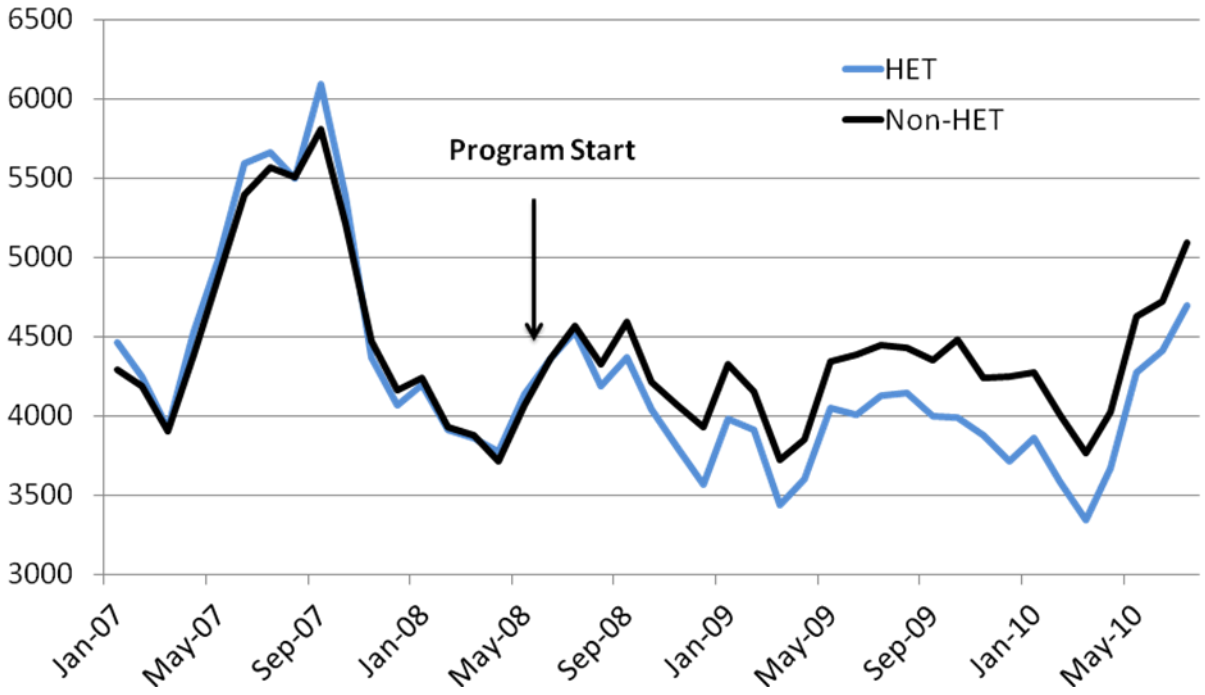
The water utility had instituted a watering restriction policy that allowed households only to water on certain days of the week, which is a common feature of watering restriction policies. The authors found important behavioral responses to watering restrictions. Households that followed the watering schedule prescribed by the utility used more water than those that "cheated" and watered somewhat more flexibly. The authors found that having a cap on the number of allowable irrigation days is important for reducing outdoor water consumption, but that if households were allowed to choose which days they water, conservation could increase up to 25% over an inflexible regime of assigned days and times.

Establishing the Incentives to Adopt Efficient Technology

Retrofitting the U.S. housing stock with more water-efficient appliances is a slow process given the long life of many appliances. For instance, toilets account for about 30% of residential indoor water use, but can work for over 40 years with minor maintenance. New toilets use no more than 1.6 gallons per flush (gpf), while toilets manufactured as recently as 1992 used 3.5 gpf, and earlier models can use as much as 7 gpf.

A common tool used by utilities managers to increase retrofits is to offer rebates on water efficient appliances, even though little information exists on the cost-effectiveness of these programs. In a recent partnership with Cary, North Carolina, researchers at NCSU and Duke University evaluated the effectiveness of the town's High Efficiency Toilet (HET) Retrofit

Figure 1. Mean monthly water use (gallons) of high efficiency toilet rebate recipients and a matched sample of their neighbors



Rebate Program (Taylor, Lee, and Bennear 2011). A survey was conducted of every household that received a rebate in the first year of the program and combined with data on each household's water use before and after installation of the efficient toilets. Importantly, the survey asked a series of questions that allowed researchers to determine why the household replaced the older toilet: If the rebate recipient was planning to replace an older toilet with a new one in absence of the program, the rebate would simply amount to a windfall gain to the household, and hence it would be inappropriate to attribute any additional conservation to the rebate expenditure.

The researchers analyzed three-and-a-half years of monthly water consumption data of the households that participated in the rebate program, and compared their consumption to a large sample of nearby neighbors who did not participate in the program. The figure above graphs the monthly water use of these two groups and highlights the start of the rebate program in June 2008. As is clear in the figure, the water consumption of households installing high-efficiency toilets decreased after the toilets were installed. Analysis of the data indicated that water-use fell an average of 8% after the installation of high-efficiency toilets (the average number of installations was two toilets per household). At $150 per rebate, the cost to achieve the 8% reduction in water use by Cary is estimated to be $5 per 1,000 gallons reduced. This is competitive with the alternative to demand reduction: capacity expansion, which was estimated to be approximately $7 per 1,000 gallons at the time the study was undertaken.

However, after considering why the household's replaced their old toilets, a somewhat different picture emerges. The survey of rebate recipients revealed that approximately 63% of rebate recipients were planning to replace their toilets anyway. Of these, 44% were planning to replace their toilet with a high efficiency toilet, and thus the rebate was a windfall gain to the household. The other 19% were going to replace their toilets with a new, but not high-efficiency toilet. When considering the incentives of the rebates, and attributing water savings to the rebate only when the rebate actually motivated the household to replace the toilet, the cost of the program increases to approximately $11 per 1,000 gallons. In this case, the program does not appear to be cost effective relative to capacity expansion alternatives.

Affecting Preferences

Information campaigns are an integral part of almost every utility's conservation program. Perhaps the most common information campaign is the use of flyers placed within a customer's bill, or mailed separately, showing customers ways to increase their water efficiency. Often a set of "top ten tips" for water conservation are presented, along with cost-savings that can be achieved by increasing efficiency. Despite the popularity of such messages, systematic analyses of whether these programs have any effect on household consumption patterns have only just begun to be undertaken.

Recently, Ferraro and Price (2012) conducted a randomized field trial in which approximately 35,000 households in the Atlanta metropolitan area received one of three messages in a letter:

(i) Top-ten tips for saving water;

(ii) Top-ten tips for saving water + appeals to the common good; or

(iii) Top-ten tips for saving water + appeals to the common good + a social comparison.

The top-ten tips message was a list of ten common actions that can reduce water use and save the household money (e.g., finding and repairing leaks). The second treatment group received the exact same top-ten tips sheet, plus a discussion of how, in times of drought, everyone needs to do their part. Finally, the third treatment group received what is commonly referred to as a "social comparison" or "norm-based messaging." In this third treatment, each household receiving the letter had their average water use compared to the average water use of other households in the area.

Results indicated that the "top ten tips" message alone had no affect on household water use immediately after receiving the letter or in the future. Receiving the top-ten tips plus the appeal to the common good (treatment (ii) above) resulted in a 2.7% reduction in household water use directly following receipt of the letter, however, no lasting effects in the following summer could be detected. Finally, the norm-based messaging treatment resulted in significant reductions in water use — up to 5% immediately after receipt, nearly 3% one year later, and just over a 1% reduction two years later. The norm-based messaging would appear to be an important cost-effective means for reducing household demand, especially given that the reductions found in this study resulted from a single mailing to the household.

Summary

Both regulatory and voluntary, incentive-based management programs to increase water conservation require careful understanding of their efficacy if they are to be designed in a way that can achieve their goals without excessive costs. Water utilities have at their disposal a wealth of data on household consumption of water resources. In partnership with researchers, utilities managers can use these data to design programs that are based on quantitative evidence of their efficacy.

The four studies that have been briefly reviewed here all relied on household-level consumption data that were made available to researchers by the utilities in order to investigate how households responded to regulations or programs. These types of partnerships are important — not just for ex-post analysis of programs, but also so that new programs can themselves be designed with an eye toward later evaluation. This latter point is an important one. It is not sufficient to look to only one, or just a few, experiences when designing conservation programs. Water managers should design their own programs, based on the best evidences available to them, in a way that allows quantitative and rigorous evaluation of their efficacy and cost-efficiency. Research partnerships, such as those described in the four studies above, can be an effective means for achieving these goals.

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