Appalachian State University

Department of Economics Working Paper

Number 13-01 | February 2013

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Abstract: In an effort to improve efficiency of electrical markets the U.S. government hopes to encourage changing household use patterns, such as dishwasher and clothes dryer use, to off-peak times. One strategy has been to subsidize the installation of smart meters. In addition the government has encouraged electrical energy conservation by providing incentives for energy saving technologies such as the purchase of energy star appliances or increased insulation in the home. Households have sometimes been slow to respond. Using a survey of public opinion, we explore which individuals are more likely to adopt energy saving technologies and smart meters. We also explore the incentives required to adopt smart meters in the home.

"Climate change, security of supply, and fuel poverty are the three main areas where a more active demand-side has the potential to have both significant and cost-effective impacts" (Ofgem 2006).

Section 1: Introduction

Policymakers are searching for ways to make households more active participants in energy conservation. The American Recovery and Reinvestment Act of 2009 made available close to $300 million for states to subsidize households' cost of replacing older appliances with Energy Star certified models. According to the Department of Energy (DOE) 1.6 million rebates totaling $239 million were paid out between December 1, 2009 and March 31, 2011.[1] The DOE estimates that the annual savings from the purchase of these appliances will be approximately 1.5 trillion Btu (or 440 million kilowatt hours).[2] At the 2009 US average rate of 11.51¢ per kWh this energy savings translates into approximately $50.6 million per year. Additionally, $4 billion was set aside for smart grid development, including funding for the installation of 15.5 million smart meters (FERC, 2012).[3]

Demand side contributions to energy conservation combine behavior and technology. A number of instruments are available to promote conservation. Linden et al. (2006) describe these instruments as: information, economic (i.e., prices, taxes and subsidies), administrative (i.e., regulations) and physical improvements (i.e., more efficient appliances). Replacing inefficient appliances and installing programmable thermostats are choices household consumers can make. Yet, technology alone does not solve the problem of inefficient energy use unless combined with attitudes directed toward a reduction in overall consumption. As economic theory illustrations, a non-satiated consumer's welfare increases with consumption; an unfortunate consequence sometimes occurs when consumers switch to more efficient appliances – they use the appliance more. This so-called 'rebound effect' creates a dilemma for promoters of technological advancement as a mediator of inefficient energy use as well as for policy makers attempting to use regulatory measures to achieve conservation goals.[4]

For some households the incentives to make behavioral or technological changes are either lacking or ill understood. For some, however, their *inertia* may be rooted in a bias for the status quo. The status quo is typically the option that requires no action, which may be part of its attraction. Samulson and Zeckhauser (1988) show the existence of a status quo bias in the experimental lab as well as in field experiments of professionals'

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[1] US DOE, "State Energy Efficient Appliance Rebate Program. Program Impact: December 1, 2009 through March 31, 2011.

[2] The EIA reported electricity retail sales for 2009 to be approximately 4656 trillion Btu (*Annual Energy Review, 2011*, Table 2.1b "Residential Sector Energy Consumption, Selected Years, 1949-2009"), so the savings is about .03% of 2009 residential energy use. We would prefer to make a direct comparison with appliance energy use, but 2001 is the latest available data from the EIA.

[3] According to FERC (2012) two-thirds of these meters were installed as of September 2012.

[4] There is a large literature on the rebound effect in the field of energy economics and a debate over its magnitude. For a recent discussion see Sorrell and Dimitropoulos (2007).

choices of retirement and health plans. They discuss a number of areas where inertia has real world implications (e.g., periodic decisions such as contributions to charities or savings accounts, searching for competitor prices, public policy, etc.). They conclude, "[A]ssuming the status quo bias proves important, rational models will present excessively radical conclusions, exaggerating individuals' responses to changing economic variables and predicting greater economic instability than is observed in the world, (p. 47-8)." If household inertia is significant, response to incentives to improve conservation efforts may be weak. Therefore, short lived campaigns and subsidies to increase the penetration of more efficient appliances and encourage weatherization will have discouraging effects. To increase conservation efforts sustained endeavors must be undertaken to raise awareness and motivate behavioral change.[5]

One route to behavioral change is to make consumers more price sensitive. This problem is solved theoretically by introducing real-time energy prices. Currently, most *retail* consumers are on tariffs that do not change during the day. This pricing option is inefficient but convenient for people who do not want to reschedule their energy intensive household activities. To change a pricing policy that has always been the norm for most households creates questions of equity and political feasibility. Consumers on real time prices would face fluctuating prices during the day (e.g., hourly) depending on aggregate supply and demand conditions. Those with flexible schedules could potentially see significant reductions in their energy bills as a result of being able to shift their energy intensive chores to low demand periods of the day. For instance, a consumer willing to do the laundry at 5 in the morning or able to purchase a programmable washing machine would benefit while a consumer more constrained would likely see an increase in their monthly bill. Real time prices are becoming increasingly likely in a digital world, however, and many utilities in the U.S. have begun rolling out 'smart meters' in their service areas. Much of this roll out is funded under the monies set aside by the Recovery Act of 2009.[6] In the short run the smart meters are being used to assist the utilities in meter reading (which can be done remotely) and to provide consumers with more frequent and detailed information about their energy use. In the future they can be used to charge consumers dynamic prices that change frequently if that becomes politically feasible.

A motivating factor for adopting dynamic prices (such as real time prices) is the effect it will have on producers of electricity. Specifically, if consumers shift their demand during the day in response to changing prices, the shift in consumption would put less stress on generation capacity during high peak periods of the day. The effect would be to lower producers' costs (by utilizing capacity more efficiently and reducing the need for peak load capacity), but the overall impact on total consumption is ambiguous.[7] If higher electricity prices

[5] Some of the Recovery Act funds will support research on consumers' response to dynamic pricing, information technology and education (FERC, 2011).

[6] FERC (2012) reports the penetration rate of advanced metering was 23.9% for U.S. residential consumers in 2012 (Table 2-2). The report also outlines various states' plans for introducing dynamic pricing to residential consumers.

[7] Bornstein (2005) conducts a simulation exercise of possible generation costs savings. Bornstein (2005, 2012) elaborates on the benefits of dynamic pricing generally.

incentivized households to purchase more efficient appliances consumption would likely fall in the absence of significant rebound effects.

(Faruqui and Sergic 2010) review fifteen experiments in the U.S. of retail consumers' response to limited dynamic prices. The results varied widely, but suggested consumers reduced demand more when faced with critical peak pricing than time-of-use pricing. Time of use prices typically expose consumers to two different prices during the day, peak and off peak. Critical peak prices are similar but allow the utility to raise the peak period price (substantially) 10-15 days during the year. Consumers are given advanced notice by the utility before the critical prices begin. Equipping consumers with enabling devices such as automated demand response technologies reduced demand during critical periods further. In some cases results did not pass cost-benefit tests, such as Ecel Energy's time of use pilot program discussed by the authors. "While the demand reduction was significant, the meters implemented in the pilot were too expensive to make the offerings cost-effective," (p. 203). Currently in the U.S smart meters are being subsidized through the Recovery Act, so the utility's installation cost is lessened.

Pilot evidence suggests prices motive households to reduce and/or shift energy consumption. Shifting consumption reduces generation cost and increases productive efficiency. Reduced consumption can be achieved via technological and behavioral adjustments. This paper focuses primarily on the latter. For energy conservation technologies to reach their potential, households generally must make some behavioral adjustments. Using survey responses from two counties in Western North Carolina, Watauga and Forsythe, we try to determine which households are more likely to adopt energy saving appliances and technologies in the home and which suffer from inertia towards the status quo. Also, because dynamic pricing is not universally embraced, but increasingly feasible, we address consumers' interest or lack of interest in smart meters.

Section 2: Survey and Data Analysis

Two North Carolina counties were chosen for the survey. Watauga County is located in the mountains in the northwest part of the state with an elevation of over 3000 feet. The population is approximately 46,000 and peak energy use occurs in the winter. The town of Boone and Appalachian State University are in Watauga County. Forsyth County, about ninety miles from Watauga County, is more urban and warmer because its elevation is only about nine hundred feet. Forsyth has a population of approximately 360,000; Winston Salem is the largest city and Wake Forest and Winston Salem University both are in Forsyth County.

The mail survey was conducted in October and November 2009. The first mailing consisted of 2100 households, half in Watauga County and half in Forsythe County, North Carolina. Approximately 10% of the surveys were undelivered, leaving us with 891 delivered in Watauga and 991 in Forsythe. A follow-up postcard was sent to all households approximately one week after the initial mailing. Excluding bad addresses, a second mailing of the full survey was sent to all non-responders 3 weeks later. In total we received 372 responses from

Watauga households (42% of delivered surveys) and 357 responses from Forsyth households (36% of delivered surveys).

In Table 1, we report demographic information for both counties. The counties are rather similar in demographics with the average age of the respondent in both counties about 60 years old with essentially the same break down of education levels. Respondents in both counties are also predominately white and home owners. The average income is lower in Watauga County at about $63,000 while it is $73,000 in Forsyth County.[8] We also find that 19% of the respondents in Watauga and 12% in Forsyth County participate in the green energy programs where respondents pay a premium for energy from renewable sources such as wind and solar.

Table 1: Means of Variables

Variable	**Watauga Means**	**Forsyth Means**
Age	59	60
Income	$63,831	$73,301
Male (yes=1)	.58	.65
White	.97	.93
Education High School or less (yes=1)	.22	.19
Education College (Associates or Bachelorette) (yes=1)	.48	.58
Education Professional (Masters or more) (yes=1)	.29	.22
Green energy (yes=1)	.19	.12
Do you own your home?	.95	.97
Sample size	308	309

In Table 2, we establish a base line for energy use and conservation measures for both counties. Once again we find both counties similar for most measures with almost all respondents in each county having both a laundry facility and dryer in their homes. Also each county has about the same number of homes with dishwashers and programmable thermostat use.

The major difference between counties is that in Watauga County only 37 percent have air conditioning while in Forsyth 98 percent have air conditioning. This difference is due to the difference in climate between the two regions with Watauga County only having annual cooling degree days of 257 and Forsyth County with 1332. We also find that annual heating degree days differ between the two counties with Watauga having 6090 and Forsyth having 3848. When looking at total degree days Watauga has a total of 6347 and Forsyth of 5180 or only eighty two percent of Watauga County's degree days. This difference provides a unique case study to study incentives where two similar counties differ primarily by climate but not demographics. In the next section we analyze how this climate difference affects incentives to invest in energy saving techniques.

[8] Sample selection is an issue with most modes of survey research. Our respondents are older than the average adult in the two counties (approximately 44 years old) and richer (the average income for the counties is approximately $46,000 for Watauga and $52,000 for Forsythe).

Table 2: Energy usage and conservation

Question	**Watauga Means**	**Forsyth Means**
Do you have air-conditioning in summer?	.37	.98
Does your household use a dishwasher?	.83	.86
Does your household do laundry at home?	.97	1.00
Does your household use a clothes dryer at home?	.95	.99
Do you have double paned windows in home?	.80	.75
Do you have programmable thermostats in home?	.48	.43
Have you ever checked web site of your electrical provider to find out about energy saving tips?	.18	.26
Have you purchased a device that measures energy use on different appliances?	.03	.03
Sample size	308	309

Section 3: Incentives to use energy saving techniques

To answer the question "Do consumers respond to incentives to conserve energy?" we asked respondents a series of questions on energy usage and conservation measures. In Table 3 we report how respondents use energy saving techniques. We find that respondents in Watauga County are more likely to increase the insulation in their homes (36 percent versus 30 percent in Forsythe County), are more likely to install energy efficient doors (31 percent versus 20 percent) and are somewhat more likely to install double paned windows (42 percent versus 40 percent) and to seal or insulate the duct work in their homes, (23 percent versus 21 percent). Watauga residents are also more likely to purchase more efficient heating systems (30 percent versus 22 percent). Forsyth County respondents are more likely to purchase Energy Star appliances for their homes (44 percent for Forsyth and 38 percent for Watauga).

These results suggest consumers do respond to incentives. Watauga County has more annual heating degree days and total degree days then Forsyth County suggesting a greater benefit to Watauga residents for actions that reduce energy needs for heating. Forsyth residents not receiving as great a benefit from techniques that reduce energy needs from heating or total degree days are more likely to look for savings from reduced energy use from more efficient appliances. Surprising only a little over ten percent of respondents in both counties receive tax credits for utilizing energy saving techniques.

Lastly when it comes to heating water both counties are about the same with only 26 percent purchasing more efficient water heaters and almost no one in either county using solar water heating. In the next section we ask if respondents are willing to change energy usage during the day to lower peak time use.

Table 3: Energy Saving Techniques

Techniques	Watauga Means	Forsyth Means
Increased the insulation	.36	.30
Energy efficient doors	.31	.20
Double paned window	.42	.40
Sealed and/or insulated ducts	.23	.21
Energy Star Appliances	.38	.44
More efficient water heater	.26	.26
More efficient heating system	.30	.22
Solar water heater	.01	.00
Receive tax credit	.12	.11
Sample size	308	309
Annual Heating Degree Days	6090	3848
Annual Cooling Degree Days	257	1332
Annual Total Degree Days	6347	5180
Percentage of Degree Days Watauga	100%	82%

Section 4: Incentives to install smart meters energy use patterns

To answer the question "Do consumers respond to incentives to change energy use patterns?" we developed a scenario where respondents were offered a smart meter that could potentially reduce their electrical bill. Respondents in both counties were offered the following scenario. For illustrative purposes we include the Watauga County scenario[9]:

> *The cost of producing electricity changes throughout the day, but most households pay the same rate for electricity all hours each day of the week. For example, in Watauga County households pay approximately 7.5¢-8.6¢ for each unit (called a kilowatt hour) of electricity they use. Paying a flat rate is convenient, but some customers might be able to lower their bill if their rate changed throughout the day. Some households in other counties already pay different rates for times of day when demand for electricity is high (peak hours) versus times of day when demand is low (off-peak hours). Peak hours in Watauga usually include 2pm – 7pm Monday-Friday in summer (June – October), and 7am to noon in winter (November – May). Evenings and weekends are off-peak hours.*

[9] Survey questions are available from the authors by request.

Customers with these rates pay one price during peak hours and one lower price during off-peak hours.

Some industry customers have rates that change each hour. The federal and state governments are studying how to make these rates available to residential customers like you. To have a rate that can change each hour households need a new meter. If you had one of these smart meters and an hourly rate, you would sometimes pay more than you currently pay and sometimes less. The smart meter would show you the price you were being charged for electricity and how much electricity you were using. Your monthly electricity bill might be higher, lower or even remain the same depending on when you use high energy electric appliances (such as dishwashers, clothes dryers, air conditioners, heaters, hot water heaters, and large televisions). The effect on your monthly bill would depend on your willingness to use them primarily during off-peak times when prices were lower. To answer the following questions think about how flexible your schedule is and how likely you would be able to change the time at which you use these appliances.

The first question we asked addressed how flexible consumers are to changing electrical use pattern:

On a scale of 1 to 10 how likely will you be able to move some of your electric appliance use to off-peak times? This includes appliances such as dishwashers, clothes dryers, air conditioners, heaters, hot water heaters, and large televisions. (Please circle a number)

Not likely   Very likely
0 1   2   3   4   5   6   7   8   9   10

The mean answer to this question was 6.07 suggesting that most respondents are able to move some of their electrical use to off peak times.

We then asked about accepting smart meters in the home the first question was "*Suppose your electricity provider would install a smart meter in your home for no charge. If you could lower your electricity bill $A a month by changing the time at which you use your high energy appliances, would you want a meter installed?* The value of A was randomly assigned to respondents with three values $5, $10 and $15. As shown in Table 4 we found that fifty-eight percent of respondents would accept a smart meter in their home. This result further suggest that a majority of consumers are willing to adjust their energy use to save money on their electrical bill.

We then asked "*Now suppose the smart meter had a one-time cost to you of $100 for installation. Would you want a meter installed if you could lower your electricity bill by $A each month? Keep in mind you might have to change your current routines.* The value of A was the same value as in the question with the free meter. We find that only nineteen percent of all consumers or thirty three percent of the consumers who would accept a free smart meter are willing to pay $100 for the smart meters. The low percentage suggests that paying an upfront charge lowers consumer's willingness to participate in the program because they have to commit both money and time to acquire the savings.

To further explore the willingness to accept smart meters we estimate a bivariate probit model. Consider the following two equations:

1) $Y_1 = X\beta_1 + \varepsilon_1$

2) $Y_2 = X\beta_2 + \varepsilon_2$,

where ε_1 and ε_2 are distributed normally with 0 means and correlation ρ.

Y_1 is equal to one if a respondent answered yes to accepting a free smart meter and zero if the respondent answered no or don't know and Y_2 is equal to 1 if a respondent answered yes to paying $100 for a smart meter and zero for all other respondents. The vector X is the same for both equations. The independent variables include demographic variables, the portion of household's monthly budget spent on electric bill, the time flexibility measure, a dummy variable equal to one if a respondent participates or plans on participating in a green energy program. We also include the value of potential saving A as defined above. Table 4 shows the means of the non-demographic variables.

Table 4: Means of Variables

Variable	Mean	Standard Deviation	Max value	Min value
Free Smart Meter (yes=1)	.58		1	0
$100 Smart Meter (yes=1)	.19		1	0
Version of savings	$9.68		5	15
Ability to move electrical usage (0 to 10)	6.07		0	10
Electric bill as portion of monthly income	.03		.24	.003
Green energy (yes=1)	.15			

We use a bivariate probit model because unobservable characteristics that influence consumer's willingness to participate in the two programs could be captured in the correlation ρ. In Table 5 we report the results. In the probit model estimating the likelihood of accepting a free smart meter, we find that increases in age and income lower the probability of responding yes. Higher education, both college and professional degrees, increase the likelihood of responding yes in reference to an individual with a high school education, the excluded category. This may suggest higher educated individuals have more flexibility in their schedules than lower educated individuals, or that respondents with more education are more likely to believe they will benefit from a smart meter. We find that neither gender nor race affect the likelihood of responding yes.

We also find that respondents who participate in green energy programs are more likely to say yes as well as respondents who have greater ability to move electrical usage. Most surprisingly, we find that as the portion of a consumer's budget on electricity increases the *less* likely a yes response. The version of savings was found to be statistically insignificant.

In the probit model estimating the likelihood of accepting a smart meter that cost $100 the version of savings was positive and significant showing that the greater the potential savings per month the higher the likelihood of saying yes. Age and income, however, were both statistically insignificant while education shows the same pattern as in the free meter equation. We also find that participation in green energy and the ability to move electrical usage are positive and significant while the portion of the electric bill is negative and significant. The county dummy was insignificant in both specifications suggesting that although the two counties selected differ in climate the respondents have the same willingness to accept smart meters in their homes. Rho is positive and significant suggesting that unobservable characteristics that make a consumer less willing to accept a free meter also make a respondent less willing to accept a $100 meter.

Table 5: Bivariate Probit for Free Participation and $100 Smart Meter Program

Variable	Coefficient Free	Coefficient $100
Constant	-.334 (.471)	-2.915 (.000)
Version of savings	.017 (.229)	.049 (.001)
Age	-.013 (.005)	-.002 (.778)
Income (in thousands)	-.006 (.014)	.0005 (.883)
Female (yes=1)	.169 (.183)	.291 (.046)
White	-.021 (.951)	-.042 (.886)
Education College (Associates or Bachelorette) (yes=1)	.442 (.005)	.488 (.025)
Education Professional (Masters or more) (yes=1)	.620 (.001)	.401 (.105)
Green energy (yes=1)	.524 (.002)	.373 (.021)
Ability to move electrical usage	.214 (.000)	.157 (.000)
Electric bill as portion of monthly income	-6.671 (.002)	-5.397 (.043)
County dummy (Watauga =1)	-.114 (.342)	.208 (.147)
Rho	.877 (.000)	
Log likelihood function	-545.68	

Bivariate Probit, n=617, (p-values in parentheses).

Using a follow up question we were able to identify why respondents said no to either both the free and $100 smart meter question or no to only the $100 smarter question. We found that for the respondents who said no to both 66% said that the savings ($A) were too low, 21% said they liked being able to use their appliances without worrying about price, 6% said they didn't have flexible schedules, and 3% said that they might have to give up some comfort. From the respondents who said no only to the $100 smart meter question, 30% said that the savings ($A) were too low, 46% said they liked being able to use their appliances without worrying about price, 13% said they didn't have flexible schedules, and 4% said that they might have to give up some comfort. These results suggest that respondent's value flexibility and require a fair amount of savings to induce them to accept smart meters.[10]

Using the Cameron and James (1987) technique we can calculate the mean savings required to accept a $100 smart meter. We report the results in Table 6 evaluated with different assumptions. The monthly savings required evaluated using the means of all variables is $30. The $30 estimated savings required for accepting a smart meter is twice the largest potential savings offered in the survey (A = $5, $10 or $15). Our results suggest a great deal of inertia with consumers preferring the status quo of constant pricing over a smart meter with time varying prices. The only consumers close to the savings suggested in the survey were those who find it easy to move electrical power usage, and their predicted savings is $18 a month to accept a smart meter.

Table 6: Savings required to accept $100 smart meter

Evaluated at all Means	$30
Education High School or less	$38
Education College (Associates or Bachelorette)	$28
Education Professional (Masters or more)	$30
Green energy (yes=1)	$24
Green energy (no=0)	$32
Ability to move electrical usage (Difficult = 0)	$50
Ability to move electrical usage (Easy = 10)	$18
Monthly Average Electric Bill—summer (standard deviation)	$112 (47)
Monthly Average Electric Bill—winter (standard deviation)	$123 (50)

Section 5: Conclusions

Using survey data from two Western North Carolina counties, we address the questions of whether households respond to incentives to conserve energy and what characteristics make them more likely to adopt energy saving technologies in their home. The demographic characteristics of the survey respondents were similar between counties, but their likelihood of adopting specific technologies differed. These differences can be attributed to the disparity in climate in the two counties.

[10] We should stress that smart meters were linked to time varying prices in our scenarios.

One technology of interest is the smart meter which could provide incentive for consumers to use energy during non peak times. Smart meters could be used to price electricity on a time varying scale in the (perhaps near) future. A household's benefit from time varying prices would depend on their willingness and ability to use the information and adjust their household schedules accordingly. Our survey results suggest that just over half of respondents in both counties would be interested in having a smart meter if it was provided by the utility without charge. However, only nineteen percent would pay $100 to have the meter. At the time of the study $100 was our best estimate of installation fees. Most respondents who were not interested in having the meter believed the expected monthly savings was not worth the change. Many did not want to give up the flexibility they now enjoyed from a single price.

While many in our survey have made energy conserving choices for their home, including the purchase of Energy Star appliances, only 10% of respondents from each county had taken advantage of rebates. This likely suggests that most purchases were made at times when rebates were not available and that, even in the absence of subsidies, some households will make energy saving changes to their home. In general, however, less than half of respondents from either county reported purchasing more efficient heating systems or appliances. This result is in line with nationwide data on energy star appliance use in the U.S. The 2009 Residential Energy Consumption Survey by the U.S. Department of Energy showed that approximately 37% of residential consumers had energy star refrigerators. The percentages for dishwashers and clothes washers were 40 and 44 percent respectively.[11]

Our results are indicative of a world in which both incentives and inertia play a role in decision making. Households were more likely to want a smart meter the greater the potential bill reduction; they were more likely to install more insulation the colder the temperature, yet there was significant reluctance to change based in part on the lack of interest in altering routines. Consumers showing the most inertia were those with lower levels of education, of a higher age and those whose electric bills were a larger portion of their income.

A pessimistic conclusion from our survey is that many households are not prepared for the adjustments necessary to benefit from time varying prices. The lack of interest and preparedness could create political resistance to changing utility rate schedules. One policy proposal might be to introduce time varying prices via smart meters to consumers on a voluntary basis to reap the benefits from those customers who are more flexible and more price sensitive. Bornstein (2012) illustrates an opt-in program with an example of a default rate structure designed to maintain a flat rate for those customers. To circumvent inertia he proposes *shadow billing*; i.e., informing customers what their bill would have been (the last month or the last year, etc.) under the alternative rate structure.

On a final note, one problem often left out of the conservation debate is the need to incentivize landlords to upgrade their rental property, particularly landlords renting to very low income individuals. These households

[11] Table HC3.2 "Appliances in U.S. Homes, by Owner/Renter Status, 2009." Some respondents reported that they did not know if their appliance was Energy Star rated and some reported their particular appliance was over 9 years old.

often use more electricity than equivalent sized households because they have available the least efficient appliances and heating sources. Moreover, these households have neither the ability nor resources to weatherize their homes. Since fewer than 5% of our responders rented their homes, we cannot comment using our data on the disparities in conservation behaviors between renters and owners, but this is an important area for future research.

References

Bornstein, S. (2005). “The Long-Run Efficiency of Real-Time Electricity Pricing.” *Energy Journal* 26(3): 93-116.

Bornstein, S. (2012). “Effective and Equitable Adoption of Opt-In Residential Dynamic Electricity Pricing.” *Review of Industrial Organization*, forthcoming.

Cameron, Trudy Ann and Michele James (1987). "Efficient Estimation Methods for 'Closed Ended' Contingent Valuation Surveys," *Review of Economics and Statistics*, 69: 269-276.

Faruqui, A. and S. Sanem (2010). “Household Response to Dynamic Pricing of Electricity: a Survey of 15 Experiments.” *Journal of Regulatory Economics* 38: 193-225.

The Federal Energy Regulatory Commission (2012). *The National Action Plan on Demand Response*. July.

The Federal Energy Regulatory Commission (2012). *Assessment of Demand Response and Advanced Metering: Staff Report.* December.

Lindén, A., A. Carlsson-Kanyama and B. Eriksson (2006). “Efficient and Inefficient Aspects of Residential Behavior: What are the Policy Instruments for Change?” *Energy Policy* 34: 1918-1927.

Samuelson W. and R. Zeckhauser (1988). “Status Quo Bias in Decision Making.” *Journal of Risk and Uncertainty* 1: 7-59.

Sorrell, S. and J. Dimitropoulos (2008). “The Rebound Effect: Microeconomic Definitions, Limitations and Extensions.” *Ecological Economics* 65: 636-649.