What's Missing in Theories of the Residential Energy User

Mithra Moezzi and Loren Lutzenhiser, Portland State University

ABSTRACT

Residential energy use has been envisioned in varied ways, each highlighting different factors and capturing a partial truth. This paper outlines assumptions of core theories about household energy use. It gives an abbreviated list of major empirical findings framed by these theories. It then identifies a new set of "blind spots" created by overly-simple reliance on models and by data shortcomings that in combination may block development of a more sophisticated understanding of energy use. Policies and program strategies, in turn, can become oriented toward simplistic approaches to change. We point to the need for improved interpretation and elaboration of existing theories, and accordingly toward richer comprehension of energy users and the dynamics of energy use, suitable to the wider policy world of climate change and sustainability that the energy use research field now faces.

Introduction

This paper examines some principal assumptions and theories of household energy use, and asks how the simplifications in these theories may mislead in the energy efficiency field's everyday modes of thinking and strategizing about how to reduce energy use. As the formerly relatively confined world of energy efficiency research, which spoke in restricted terms and within a limited number of institutions, confronts the wider world of climate change and sustainability science and policy, developing capacity to recognize and transcend conventional boundaries of these theories becomes critical to the development and application of "good ideas" to reasonably vetted strategies.

The argument proceeds as follows. First we provide a "big picture" of the energy efficiency field, noting consequences of the shift of attention from the rationale of efficiency for its own sake to the goal of reduced carbon emissions on a grand scale. Second, we review some of the major theoretical approaches to residential energy use and the basic policy solutions that follow. Third, we address the subject of knowledge and knowability by providing an abbreviated list of major topics and "facts" by discipline. Next, we provide examples of how theoretical approaches – both the core approaches and some commonly-pursued correctives to them – become too bluntly cast, missing the real-world considerations that may be critical to success. Finally, we offer suggestions on how this state of affairs might be improved. To bound the analysis, we cover only work on residential energy use. The same observations do not necessarily apply to work on commercial or industrial energy use.

A word about method: our observations are not based on specific analytical techniques or rigorous field work. Rather we draw from our long experience in the field of U.S. energy efficiency, as well as from a literature review dedicated to sorting out how the social is treated in the many divergent approaches to residential energy use (Lutzenhiser and Moezzi 2010). The patterns and conditions we note are propositions, offered not as a final word but instead to stimulate debate on science, practice, and policy and their relationships. Other studies have pointed to research and discourse restrictions in the energy efficiency field (Archer et al. 1992;

Lutzenhiser and Shove 1999; Moezzi and Bartiaux 2007; Stern 1986; Wilhite et al. 2000), and the general problem is well-recognized in the sociology of science and knowledge (Brewer 2007; Greenwald et al. 1986). People and organizations become committed to particular theories and notions of solutions, shaped and reinforced by common languages, institutional structures broadly speaking (e.g., funding mechanisms, official definitions, political climates), data and methodological limitations, historical trajectories, perceived lack of viable alternatives, and tacit agreements to leave certain considerations out of the picture. We turn now to a brief summary of the energy efficiency field vis-à-vis the "problem" of residential energy use.

Big Picture

For over a hundred years, utilities and supply planners have wanted to know when people and their buildings will use given amounts of energy, and have sought to influence this usage upward (Deumling 2004) and downward. The policy-oriented research field of understanding energy use began about forty years ago, with the 1970s energy crises, and through the years has been addressed to a variety of different policy goals, including economic efficiency, supply security, resource conservation, and climate change. Much of the field's knowledge has been wrapped around questions of how to get things and the people who use them to be more energy efficient and to a lesser extent, to change when energy is used. Both of these are questions about how to create change, a different mission than understanding existing consumption patterns.

Statistical and sociological studies have revealed dramatic variation in household energy use. In the U.S., energy use in neighboring houses may differ by a factor of three (Lutzenhiser and Bender 2008), and the most consumptive quarter of households account for a full half of residential electricity use (EIA 2009a; authors' analysis). The variability of energy use has remained a challenge to statistical modeling, where observed factors explain limited portion of this variability (e.g., Hirst et al. 1982, Sanquist et al. 2010) and often in terms that cannot be directly addressed much by policy (e.g., weather, income) or that so far have not been addressed much by policy (e.g., house size, architectural forms). The sources of variation of current household energy use remain largely unknown, whereas even in idealized form, most purposeful interventions have very small effects relative to this huge variability. For pursuing absolute emissions reductions goals, the poor quality of this knowledge has consequences.

In the beginning, energy consumption research and policy concentrated on improving the technical properties of equipment stock and structures, along with some attention to behavior as discrete conservation actions. As it became clear that society was not as enthusiastic about purchasing energy efficiency or avoiding waste as top-down logics suggested they should be, attention turned to finding ways that people could be convinced to do more, especially to purchase energy efficiency at prescribed levels and for prescribed reasons. These suggestions and the conceptual models behind them – e.g. efficiency as a premium add-on to "normal" goods – were translated into program design and information campaigns. As challenging as the problem has been (Lutzenhiser 1992; Lutzenhiser 1993) the scope of efforts was fairly restricted throughout the 1980s and 1990s. Relatively simple logics did well enough to keep efficiency, which could show some clear successes, a funded concern.

As climate change and sustainability have risen in policy prominence, the energy efficiency field – as many others (Brewer 2007) – has been pushed to engage more holistically with the lived world in broader view, as well as with other disciplines. Policy power addressed to energy use is now more intense and broader in scope than it has been for decades. The questions are different too, in ways that the field is still adjusting to: reducing energy use and reducing emissions are different problems than increasing efficiency as conventionally defined (Harris et al. 2008; Moezzi and Diamond 2005). The shift has also brought more attention to how much behavior matters and how it can be influenced. Yet marginal improvements in energy efficiency or increased uptake of conservation behaviors seem little match for aggressive emissions reductions goals, especially given questions about how even these modest changes can be achieved.[1] The shift to absolute emissions goals and the wider engagement with “the world beyond devices and structures” makes the boundaries of the traditional disciplinary and pragmatic approaches used in the energy efficiency field increasingly suspect. In short, the complexity of climate change and sustainability as physical and policy problems exceed the data quality, methods, and knowledge the field has at hand.

Household energy use is not a physics problem, e.g., with stable principles across time and place, conditions that can be clearly articulated, and laboratory experiments that readily apply to the real world. Of course not; but since analysis in the energy efficiency field is so steeped in physics, classical economics, and quantification, it is easy to mistake the “variables” of theories and statistical analyses as levers that can be manipulated, rather than as clues to more complex and dynamic processes. What matters in one situation may not matter in another, and even in experiments, sources of variation are not easily controlled. Despite the explosion of data enabled by improved computing and data-harvesting power, the necessary data is still hard, sometimes impossible, to collect or access. This reinforces the heavy influence that theories and mental models have had in envisioning how energy is used and how this use might change.

Varied Approaches to Understanding Household Energy Use

There are at least three major types of literature or knowledge bases in the field of residential energy efficiency: the gray literature, the academic literature, and the vast set of mostly-unwritten knowledge held by professionals and practitioners of many sorts (Lutzenhiser et al. 2009; Moezzi and Bartiaux 2007). These literatures and knowledge types have different reasons for existence, and do not necessarily mesh even where topics overlap. Many different problems are addressed within these three arenas, in each instance making particular sense of a particular situation and for a particular audience (Brewer 2007). We identify four broad perspectives within which most academic and gray literature fit: engineering/technology, economics, psychology, and sociology/anthropology/social studies of technology. Social scientists have long argued that the dominant Physics-Technology-Economics Model (PTEM) theoretical approach to how energy is used and how efficiency is purchased misses much of the realities of energy use and much of what social and behavioral sciences can potentially contribute (Lutzenhiser 1993; Shove 1998; Wilhite et al. 2000). We will not review these arguments here, nor is the ultimate point of this paper that more social science research is needed. Rather we want to consider the consequences of the core theories.

Table 1 distills these four perspectives. These basic explanations of energy use, disciplinary objectives, and strategies have been the prime models for action in the energy efficiency industry, with explanations for energy use serving (with the partial exception of the social sciences, fourth row) as policy levers. Engineering is the prime mover, economics has served to justify and direct engineering change, and psychology has served largely to support or

[1] The authors’ concern is with the logic and quality of the alignment of policies and these goals, and how research supports this alignment.

question economics-formulated direction in focusing on individual decision-making and discrete behaviors. Residential customers have tended to be seen as generic *consumers* who are either forced to adopt (standards and codes) or voluntarily adopt energy efficiency because of the engineering, economic, or psychological values doing so provides. Stepping away from this device-oriented view, sociology, anthropology and social studies of technology have looked at broader questions: cross-sector patterns of variation and change in energy use, explanations for these patterns, and interpretation of these changes with respect to society, culture, technology, and history. This social scientific work can support policy but has been less oriented to creating change than to understanding it.

Table 1. Policy Approach used in Three Core Domains

Perspective	Basic Explanation of Energy Use	Objective	Policy Strategy
Technology	Characteristics of buildings and technology determine energy use	Understand and increase device and thermal efficiency	Promote technological innovation and dissemination via regulation or appeals to market
Economics	Consumer as price-influenced utility maximizer	Understand and use price signals to influence consumer action	Change or communicate prices of energy or energy-using goods
Psychology	Individual expression through consumption choices: mental processes affect conservation behavior	Understand and influence individual perceptions about and actions related to energy use, energy services, or environment	Convince people that they will be better off (on a variety of dimensions) using less energy or using more efficient products
Sociology, Anthropology, and Social Studies of Technology	Socially-negotiated patterns of consumption: focus on groups, cultures, and influences of larger social systems	Understand variability and patterns of consumption and the social origins of these patterns	Target people's life circumstances, identify winners and losers, look for sources of constraint and outside influences that shape consumption

Each discipline acknowledges that other things matter. Arguments often proceed by attempting to control those elements or considering them exogenous. Engineering knows that how the equipment is installed and used makes a difference, and psychology knows that many elements shape and constrain actual behavior, outside of internal psychological "factors." It is easy to see why this bounding takes place. But the divide-and-control approach has serious limitations when multiple elements must be considered simultaneously, as in the dynamic and largely uncontrollable systems of the real world. This has led to calls for more integrated models (e.g. Lutzenhiser 1992), but been limited progress in constructing methods to do so (Crosbie 2006; Keirstead 2006). Recognizing these limitations, it is useful to consider how well these theories hold *in situ*.

Knowledge and Topics by Field

Table 2 selectively summarizes basic questions and current answers for the four disciplinary groups discussed above, covering only the academic literature.

Table 2. Problems and Allied "Facts" about Household Energy Use, by Discipline

Topic	Facts
	Physics and Engineering
Technical potential	Creating technical potential for energy savings and to facilitating its uptake has been a driving vision for the field. Some argue that conventional definitions of potential are too modest (Goldstein 2008; Reijnders 1998).
Efficiency in policy	Efficiency definitions used in policy are subjective even as they rest on physical criteria. "More efficient" does not mean lower energy use (Moezzi and Diamond 2005).
Non-energy benefits	Efficiency may deliver "non-energy benefits" beyond cost and energy savings, but there is limited ability to predict and account for such benefits. There may also be non-energy costs.
Performance	There is limited evidence on how well energy-efficiency measures deliver energy savings in practice (Geller and Attali 2005).
	Economics and Behavioral Economics
Energy efficiency gap	People under-invest in energy efficiency relative to levels presumed optimal in simple economic investment models, whether because of market barriers or failures or because costs and benefits are inadequately reflected (Hassett and Metcalf 1993; Golove and Eto 1996; Gillingham et al. 2009). There is limited work examining decision-making (Gillingham et al. 2009), and limited work in quantifying market barriers (IEA 2007).
Fuel price elasticity	Short-term and long-term price elasticities for residential electricity and natural gas are low, two of the most price-inelastic commodities in the market (Kristöm 2008). Elasticity may vary substantially by equipment present (Reiss and White 2005), and otherwise by population, time period, and methods used (Kristöm 2008).
Time-of-Use elasticity	Time-of-use price elasticity of electricity use is generally low, though measured results especially for residential TOU pricing, is scarce (Lijesen 2007)
Discount rates	Implicit discount rates for investment in energy efficiency vary widely and are usually higher than market interest rates, e.g. 5%-40% (Wilson and Dowlatabadi 2007).
Rebound	Direct rebound for electricity efficiency is usually considered at most moderate (Geller and Attali 2005). Its importance is disputed (Gillingham et al. 2009) and there are difficulties in estimation. Most cited estimates of rebound consider only direct rebound and not indirect and economy-wide effects (Herring 2006; Madlener and Alcott 2008).
Choice architecture	Various principles can be deployed to encourage people to make choices deemed desirable (Thaler and Sunstein 2008).
Crowding out	Monetary incentives may crowd out intrinsic motivations such as altruism (Stern 1999).
	Psychology
Norms	Norms are seen as important in shaping energy use (e.g. Schultz et al. 2007), but how norms or perceptions thereof are formed has been minimally investigated (Gifford 2008).
Attitudes and behaviors	Studies report moderate, weak, or non-existent relationships between attitudes and behavior (Owens and Driffill 2008; Stern 2007). Measurement issues are profound.
ABC Models	Psychology offers partial integration of individual actions and social structures as pertains to energy use through "ABC Models" where C stands for "context", "conditions", or "choice" determined exogenously (Shove 2009; Stern 2000). What context means in any situation, how it affects behavior, and how it might be used in research and policy is less clear.
Habits	Habits are seen as automatic behaviors trigged by cognitive structures and that can impede reasoned action (Steg and Vlek 2009).
Climate change	Reluctance to take action against climate change can be attributed to a variety of psychological barriers in addition to structural barriers, e.g., ignorance, uncertainty, mistrust, belief in alternative solutions, etc. (American Psychological Association 2009).
	Sociology, Anthropology, and Social Studies of Technology
Individuals as situated	Barriers framings of economics and psychology are generally rejected. A user-centered view of behavior and what shapes and constrains it contrasts with the top-down barriers-oriented framing (Lutzenhiser et al. 2002).

Topic	Facts
Needs and energy services	Needs and wants are socially constructed; distinguishing between these two is of limited value (Wilhite et al. 2000). Needs for energy services are created and can be changed, a more useful perspective than that of changing energy use itself (Wilhite et al. 2000).
Energy efficiency gap	The "energy efficiency gap" is a construction of a conceptual model that has limited ability to explain observed household energy use on its own. Over-emphasis on the "gap" constrains inquiry and policy strategies (e.g., Shove 1998, Wilhite et al. 2000).
Socio-demographics and consumption	Statistically significant relationships between energy consumption and income levels, lifecycle stage, and ethnicity have been identified (e.g., EIA 2009a; Hackett and Lutzenhiser 1991; Lutzenhiser 1993; O'Neill and Chen 2002).
Mega-trends	Social standards for "comfort, cleanliness, and convenience" are growing to higher levels (Shove 2003). These shifts are not matters of simple individual preference but instead of markets and intertwining socio-technical systems of provision (Shove and Warde 2002).
Micro-scale activity	Energy-using activities in the household are mostly habitual and inconspicuous, culturally complex and chained together in sequences that are part of shared social routines and shaped by cognitive dimensions of device control, symbolic uses of technologies as cultural communications devices, household negotiations such as around comfort and cooling, etc. (Lutzenhiser 1993).
Habits, practices, and models of change	Household energy use is mostly habitual and inconspicuous. Energy use results from practices which are engrained by social and technical structures, personal histories, and cultural interpretations (Carlsson-Kanyama and Lindén 2007; Maréchal 2009; Shove 2009a). Changing habits takes effort and has personal costs (Carlsson-Kanyama and Lindén 2007).

The Power of Theories in Shaping Policies and Programs

Table 2 provides a series of "facts" but a limited sense of how these facts fit together. A few observations stand out. First, the policy levers are not shown to be very strong, insofar as observation has been able to detect. As to economics, energy prices make a difference, but most studies find low elasticities. Implicit discount rates are often much higher than market investment rates, as acknowledged in the substantial literature on the energy efficiency gap. While incentives and information are used to help close the gap, the nature of these barriers has typically been more a matter of speculation than close investigation. The gap and high discount rates can also be explained by the argument that the traditional framings miss certain consumer costs and preferences, but where to go from there? Psychology has provided partial explanations of why individuals over-invest or under-invest in energy efficiency, or choose to undertake conservation actions. However proving links between inner cognitive states and action has been difficult – as has proving links between campaigns dedicated to change internal states or behaviors (Abrahamse et al. 2005; Owens and Driffill 2008). Sociology, anthropology, and social studies of technology have noted interesting patterns in energy use and described various ways that individual action is shaped by relationships with other people and technical systems. But the academic work in social science has not left a strong trace in the orientation of energy efficiency policy (Wilhite et al. 2000). This is not condemnation, but instead a call to nuanced debate in consideration of what we know, what we do, what is knowable, what is doable, and where the "leaks" or "holes" may be found for each theory and for theories in combination.

Second, while efficiency policy strategies have by and large been judged successful within the energy efficiency industry, per capita residential sector greenhouse gas emissions in the U.S. have increased. Direct carbon dioxide emissions from the U.S. residential sector energy use increased 28% between 1990 and 2008 (EIA 2009b). Over the same period population increased 22% (US Census Bureau 2010). Various explanations are possible. Is this because efforts have been insufficient? Or is it because “standards of living” continue to increase (e.g., a 21% increase in the area of an average new single-family home [U.S. Census Bureau 2009])? If the latter, how fairly can the traditional defense of relative savings be assessed and how can researchers and policy makers better understand why consumption grows?

Some time ago, Stern (1986) called attention to policy “blind spots” resulting from the energy research field’s heavy reliance on economic models as the explanation for why people used energy as they did. He argued that the simplification offered by economic models of energy use was useful, but only as a partial explanation for energy use. Failure to explore what fell outside of these models’ narrow bounds, especially psychology’s potential contributions, can blind analysis and policy (Stern 1986). The simplification offered by a strong model hijacks attention away from what falls outside the model’s bounds, away from questions about the veracity of the model itself, the size of the effects captured, or what happens in the real world versus the halls of academic theory. A similar phenomenon applies to the models of technology, psychology, sociology, etc.

These core models and approaches reflect and reinforce how energy professionals see energy use and routes to changing it. Together they form a set of basic cognitive models used and shared among professionals, ways of talking even where not fundamentally “believed.” These reveal themselves as motifs about how to go about doing things, occurring repeatedly in everyday discussions. The grip of these models, and of the appealingly straightforward solutions (e.g., devices, prices, or information feedback) invited by them is strong, with a resulting tendency to fit evidence to models rather than vice versa.

The Old Ideas on Offer (and What’s Wrong with Them)

The core models have been internalized and put to work in policy and programmatic contexts in a variety of ways, with a variety of consequences. Limitations have periodically been noted, but the activities and perspectives that they support have proven quite durable. We consider five particularly important applications.

- **Developing more energy-efficient products and getting them into place is the ultimate mission.** This has been the main strategy of the energy efficiency field since its inception thirty-five years ago. It is not hard to see why: efficiency has policy hooks, can be specified in objective statements, is countable, and makes its mark largely through sales. What policy and social problems does this mission address, how well, in whose benefit, with what unintended effects, and what options and perspectives does it leave out? If the question is resource conservation or emissions reductions: higher efficiency does not necessarily translate to lower consumption or emissions, and houses (and “lifestyles”) with less efficient goods may use less energy than those with more efficient goods (Harris et al. 2008; Moezzi and Diamond 2005). Furthermore device- and structure-oriented strategies bypass bigger questions about the overall energy intensity of society (Wilhite et al. 2000). If the question is making consumers better off: consumers overall have been reluctant to adopt the efficient products that have been promoted, and once they have been adopted, it is not sure that they necessarily like them, use them as expected, or benefit from the promised energy and cost savings. Yet there is little research on what happens after the sale is made.

- **Technology and behavior are separable realms.** Traditionally, technology is seen to fulfill specific needs and requirements, with add-on efficiency measures that deliver savings if people behave "properly," in accordance with modeler or designer vision. Actual behavior is hard to observe, inconsistent, and varied across households, so the practice of assuming behavior saves time and simplifies. The problem is that assumptions about behavior are often based on unverified theories about behavior, broad averages, and overall optimism about the energy benefits of technological change (Moezzi et al. 2009). For example, the way people really use thermostats may be much different than assumed in current codes and models (Woods 2006) and in some regions many households may rarely use thermostats at all (Kordjamshidi and King 2009). These mismatches are not the fault of engineering or policy *per se*. They speak to current and even absolute data limitations as well as to difficulties in translating engineering to policy and vice-versa. But the result is a fictionalized playing field, one with limited mechanisms to evaluate how close assumptions match reality and the consequences of any differences.
- **Efficiency and conservation are the two routes to reduced emissions.** Separation of technology and behavior has contributed to a narrow view of the role of people in determining energy use. People are seen to "save energy" through undertaking a limited set of behaviors, namely, purchasing efficiency incrementally or undertaking conservation actions. The latter actions have been primarily defined as management or curtailment done with the intention of saving energy or money. This view misses much of what is important in how what people and society do affects energy use, e.g., the size and type of dwellings and their location, indirect energy use, and so on, as may also misunderstand why people manage energy as they do. Have research and policy focused too much on small stuff while bigger opportunities have gotten away (Moezzi et al. 2009; Shove 2003; Shui and Dowlatabadi 2005; Wilhite et al. 2000)?
- **Price signals are the best route to optimal energy use.** Optimal is defined within the confines of economic models. The translation to policy arguments has been that the price of energy should reflect the cost of delivering it, e.g., production costs and the value of environmental externalities of that production. People, in turn, should react to changes in price. This theory is intended to operate on the margin (changes in energy use from current levels) rather than to explain current consumption. Fine, but aside from difficulties of establishing and agreeing to float these prices, do marginal changes lead to universal optima in the long run, and if not, what would help there? Observed elasticities of energy consumption are quite low (Table 2), so that very large price increases might be required to get visible change. And average statewide electricity prices faced by U.S. households now vary by a factor of four (EIA 2010). How well can economic utility theory explain this variation? Time-of-use pricing is perhaps the most current energy price question in the U.S. The jury is still out on how elastic residences can be and the effects of this elasticity on individuals, households, and overall energy use. But research and policy attention has almost entirely focused on expected aggregate shifting created through price, rather than on the "who, what, why, and why not" comprising such effects.
- **Injecting information will help households consume energy at more desirable levels.** Providing information about the benefits of energy efficiency is one of the major strategies the energy efficiency industry uses to influence household energy use. There is no central agency controlling the messaging of energy efficiency nor assessing what

exactly households want to know. Instead, each program does what it can to meet its goals. The usual result is that the lens for conveying desired behavior is narrow and short-term. This can cause problems and conflicts. In communicating "normal" levels of temperature in demand response, households may learn to consume more rather than less (Strengers 2008). Energy efficiency marketing promises savings that are based on highly stylized assumptions – which may work okay for aggregate calculations but may often be misleading at the household level. Promoting efficiency over behavioral conservation, as popular in the 1990s, may have reinforced he idea that conservation is onerous and "about" saving money. The percentage of U.S. households reporting winter daytime temperature settings above 70 degrees when somebody was home increased from 17% in 1981 to 37% in 2005 (EIA 1983; EIA 2009a).[2] Could pro-efficiency marketing have played a role in increased set-points? In routinely promoting relative savings programs (e.g., 20/20 programs), the message is also that one's consumption is never low enough, a constant grade of "needs improvement." Metaphors equating small actions (e.g., "change a light bulb) with saving the earth are logically hard to defend, and may have negative long-run consequences (Crompton and Thøgersen 2009). The cacophony of voices and messages and attempts to cajole, convince, advertise, etc. can produce misleading information, confused people and (quite reasonably) reduced trust and a dulled attention.

Current Corrections and Cautions

In recognition of the problems above, there have been attempts to repair the mainstream paradigms for reducing household energy use with various new ones: in particular, behavioral economics, social marketing, and what one reviewer called "feedback frenzy." Nobody claims that the new paradigms are complete answers. But they have been received with such great enthusiasm that little space has been devoted to making cautious assessments of their scope, promises, and limitations. And all are based in an individual-centered view of how energy is used and saved, rather than attending to the collective nature of consumption and the parts played by larger systems and constraints, such as identified by social sciences (Table 2).

- **Behavioral economics: To the extent that price signals don't work with sufficient vigor, consumers can and should be cajoled or coerced into making the desired choices, and there are no adverse effects in doing so.** Behavioral economics has sought to inject psychological insights derived from experiments and observation into economic theory, for a better applied science. This helps break the tension symbolized in the energy efficiency gap framing and avoids problems of standards-making, including political difficulties, long lag times, and economic inefficiencies. Instead, energy users might be prospectively guided to desired actions in "nudges" by "libertarian paternalism" (Thaler and Sunstein 2008). But isn't it dangerous to embrace this route whole-heartedly, without ways to consider the quality of information used to determine "correct" choices and a sufficiently broad view of what "correct" means? By raising this concern, we are not claiming that the government has no role here, nor are we calling to delay until some unspecified time when enough is known. Rather we ask to what decisions, exactly, should these choice architectures should apply? Who decides what is "good" and with

[2] Over this period, however, natural gas consumption per household dropped strongly (EIA Natural Gas Sales data, http://www.eia.doe.gov/dnav/ng/ng_cons_top.asp, accessed February 2010).

what sorts of review? How precisely can “good” be determined? And, though Americans may be well-versed in marketing, what might be the consequences of the government applying or backing tricks and nags?

- **Social marketing: Marketing principals can be applied to achieve behavioral change for the social good.** Price is not the only motivation for, and technical information is not the only barrier to, reduced energy use. Systems of encouraging altruism and symbolically rewarding “good actions” have emerged. While the marketing view has viewed people as “consumers” while the revised view sees them as “concerned citizens.” Again these strategies have merits, but looking beyond a program-by-program view, they also have limitations when the goal is reducing societal greenhouse gas emissions reductions. As in the case of behavioral economics, they raise serious questions about who decides what is good and for whom, and where to draw the line in producing normative pressure. Also, social marketing theory and campaigns invite restricted and idealistic views of what people are like and what people can be made to care about. An ideal consumer, in a social marketing sense, pays attention to their energy use and seeks information about it, believes in climate change, accepts responsibility to take the prescribed actions to combat it, feels that they can do so, and trusts the government, media, NGOs, and scientists. How many of these ideal consumers are there or how many can be created? Previous work suggests that this is only one slice of the population (Geller 2002; Pedersen 2008).

Conclusions

In strongly defending efficiency, the energy efficiency field has been left with rather limited means of debate and evolution. The problems are hard, the data support is weak, the politics are consequential, and the research funding has been limited. Acknowledging all this, for the new and currently well-funded context of greenhouse gas emissions, can the field do better in developing more sophisticated approaches to understanding residential energy use? Can researchers, analysts, policy makers, and practitioners better assess how well current and prospective strategies can actually work, and better identify and promote alternative strategies to the degree the current strategies cannot perform inadequately?

We think so, and that much of what is missing is not inaccessible or mysterious. We suggest, in particular, better recognition of the limits of knowledge, both current and absolute; making more rounded and multi-disciplinary assessments of technology and policy proposals routine, before large commitments are made (e.g., Time-of-Use pricing, Zero Net Energy Homes); promoting more open debate on the shortcomings, conditions, and boundaries of core theories and their applications; taking a more social view; being circumspect and analytical (vs. normative) about both “correctives” to the dominant views and newly emerging “movements”; trying to find out a lot more and in a deeper way about what people are actually doing/thinking/and consuming (differentiating this from “more market research” or “marketing research”); cultivating sophisticated policy conversations about alternative approaches and how they might complement one another (where do rebates crowd out something we want; why appliance manufacturers don’t want to make things that are really “off” when they say they’re “off”); creating not just “better informed ‘consumers’” but “better informed conversations among ‘humans’ or ‘citizens’ and policy institutions, technology developers, marketers, NGOs – conversations where the citizens are not just the objects to address and correct, but co-participants to listen to and observe.

References

Abrahamse, W., L. Steg, C. Vlek, and T. Rothengatter. 2007. "**The Effect of Tailored Information, Goal Setting, and Tailored Feedback on Household Energy Use, Energy-Related Behaviors, and Behavioral Antecedents.**" *Journal of Environmental Psychology* 27:265-276.

American Psychological Association. 2009. "Psychology and Global Climate Change: Addressing a Multi-Faceted Phenomenon and Set of Challenges." http://www.apa.org/science/about/publications/climate-change.aspx

Archer, D., T. F. Pettigrew, and E. Aronson. "**Making Research Apply: High Stakes Public Policy in a Regulatory Environment**." *American Psychologist* 47(10):1233-1236.

Brewer, G. 2007. "**Inventing the Future: Scenarios, Imagination, Mastery and Control**." *Sustainability Science* 2(2): 159-177.

Carlsson-Kanyama, A., and A. Lindén. 2007. "Energy Rfficiency In Residences--Challenges for Women and Men in the North." *Energy Policy* 35(4):2163-2172.

Crompton, T. and J. Thøgersen. 2009. **Simple and Painless. The Limitations of Spillover in Environmental Campaigning**. WWF-UK.

Crosbie, T. 2006. "**Household Energy Studies: the Gap between Theory and Method**." E*nergy and Environment* 17(5):735-753

Deumling, R. 2004. "**Thinking outside The Refrigerator: Shutting Down Power Plants with NAECA?**" In *Proceedings of the 2004 ACEEE Summer Study on Energy Efficiency in Buildings*. Washington, DC: American Council for an Energy Efficient Economy.

[EIA] Energy Information Administration. 1983. **Consumption and Expenditures: April 1981 through March 1982**. DOE/EIA-0321/1(81). Washington, DC: U.S. Department of Energy.

[EIA] Energy Information Administration. 2009a. R**esidential Energy Consumption Survey 2005** (microdata).

[EIA] Energy Information Administration. 2009b. **U.S. Carbon Dioxide Emissions from Energy Sources 2008 Flash Estimate**. http://www.eia.doe.gov/oiaf/1605/flash/flash.html

[EIA] Energy Information Administration. 2010. **Average Electricity Price by State.** http://www.eia.doe.gov/electricity/page/at_a_glance/sales_tabs.html

Geller, E. S. 2002. "**The Challenge of Increasing Proenvironmental Behavio**r" pp. 525-540 in R. Bechtel and A. Churchman, eds. *Handbook of Environmental Psychology* New York: John Wiley & Sons, Inc.

Geller, H. and S. Attali. 2005. **The Experience with Energy Efficiency Policy and Programs in IEA Countries: Learning from the Critics**. August. Paris: International Energy Agency.

Gifford, R. 2008. "**Psychology's Essential Role in Alleviating the Impacts of Climate Change**." *Canadian Psychology* 49(4):273-280.

Gillingham, Kenneth, Richard G. Newell, and Karen Palmer. 2009. "**Energy Efficiency Economics and Policy**." Discussion Paper. Washington, DC: Resources for the Future.

Goldstein, David. 2008. "**Extreme Efficiency: How Far Can We Go if We Really Need To?**" pp. 10.44-10.56, *2008 ACEEE Summer Study on Energy Efficiency in Buildings*. Washington D.C.: American Council for an Energy Efficient Economy.

Golove, W. H. and J. Eto. 1996. **Market Barriers to Energy Efficiency: A Critical Reappraisal of the Rationale for Public Policies to Promote Energy Efficiency**. LBNL-38059. Berkeley, Calif: Lawrence Berkeley National Laboratory.

Greenwald, A. G., A.R. Pratkanis, M. R. Lieppe, and M. H. Baumgardner. 1986. "**Under What Conditions Does Theory Obstruct Research Progress**." *Psychological Review* 93(2):216-229.

Hackett, B., Lutzenhiser, L. 1991. "**Social Structures and Economic Conduct: Interpreting Variations in Household Energy Consumption**." *Sociological Forum* 6: 449-70.

Harris, Jeffrey, Richard C. Diamond, Maithili Iyer, Christopher Payne, and Carl Blumstein. 2006. "**Don't Supersize Me! Toward a Policy of Consumption-Based Energy Efficiency**." *Proceedings of the 2006 ACEEE Summer Study of Energy Efficiency in Buildings.* Washington, DC: ACEEE.

Hassett, K. A., and G. E. Metcalf. 1993. **"Energy Conservation Investment : Do Consumers Discount the Future Correctly?**." *Energy Policy* 21:710-716.

Herring, H. 2006. "**Energy Efficiency – a Critical View.**" *Energy* 31(1):10-20.

Hirst, E., R. Goeltz, and J. Carney. 1982. "**Residential Energy Use : Analysis of Disaggregate Data.**" *Energy Economics* 4:74-82.

[IEA]. International Energy Agency. 2007. **Mind the Gap**. Paris: OECD.

Keirstead, J. 2006. "**Evaluating the Applicability of Integrated Domestic Energy Consumption Frameworks in the UK**." *Energy Policy* : 3065-3077.

Kempton, Willett, Daniel Feuermann, and Arthur E. McGarity. 1992. **""I Always Turn it on Super": User Decisions about When and How to Operate Room Air Conditioners**." *Energy and Buildings* 18:177-191.

Kordjamshidi, M. and Steve King. 2001. "**Overcoming Problems in House Energy Ratings in Temperate Climates: A Proposal for a New Rating Framework**." *Energy and Buildings* 4(1):125-132.

Kristöm, B. 2008. "**Residential Energy Demand**," pp. 95-115 in *Household Behaviour and the Environment: Reviewing the Evidence.* Paris: OECD.

Lijesen, Mark G. 2007. ''**The Real-Time Price Elasticity of Electricity**.'' *Energy Economics* 29:249-258.

Lutzenhiser, L. 1992. "**A Cultural Model of Household Energy Consumption**." *Energy* 17(1):47-60.

Lutzenhiser, L. 1993. "**Social and Behavioral Aspects of Energy Use**," *Annual Review of Energy & Environment:* 247-289.

Lutzenhiser, L., and E. Shove. 1999. "**Contracting Knowledge: The Organizational Limits to Interdisciplinary Energy Efficiency Research and Development in the US and the UK.**" *Energy Policy* 27:217-227.

Lutzenhiser, L. and M. H Gossard. 2000. "**Lifestyle, Status, and Energy Consumption**," pp. 8.207-8.221, *2000 ACEEE Summer Study on Energy Efficiency in Buildings.* Washington, D.C.: American Council for an Energy Efficient Economy.

Lutzenhiser, L., K. Janda, R. Kunkle, C. Payne, and S. Bender. 2002. **Understanding the Response of Commercial and Institutional Organizations to the California Energy Crisis**. Sacramento, CA: California Energy Commission.

Lutzenhiser, L. and S. Bender. 2008. "**The 'Average American' Unmasked: Social Structure and Differences in Household Energy Use and Carbon Emissions**." In *Proceedings of the 2008 ACEEE Summer Study on Energy Efficiency in Buildings*. Washington, D.C.: American Council for an Energy Efficient Economy.

Lutzenhiser, L. et al. 2009. **Behavioral Assumptions Underlying California Residential Sector Energy Efficiency Programs.** February. Prepared for the California Institute for Energy and Environment (CIEE). Oakland, Calif.

Lutzenhiser, L. and M. Moezzi. 2010. **AREBA Integrated Theory Report.** Draft. Submitted to the California Energy Commission. Portland, OR: Portland State University.

Madlener, R., and B. Alcott. 2009. "**Energy Rebound and Economic Growth: A Review of the Main Issues and Research Needs**." *Energy* 34:370-376.

Maréchal, K. 2009. "**An Evolutionary Perspective on the Economics of Energy Consumption: The Crucial Role of Habits**," *Journal of Economic Issues* 42(1):69-88.

Moezzi, M. and R. Diamond. 2005. **Is Efficiency Enough? Towards a New Framework for Carbon Savings in the California Residential Sector**. CEC-500-2005-162. October. Sacramento, CA: California Energy Commission.

Moezzi, M. and F. Bartiaux. 2007. "**Liberating Energy Analysis.**" In P*roceedings of the 2007 ECEEE Summer Study on Energy Efficiency*. St-Raphaël, France.

Moezzi, M., M. Iyer, L. Lutzenhiser, and J. Woods. 2009. **Behavioral Assumptions in Energy Efficiency Potential Studies.** May. Prepared for the California Institute for Energy and Environment (CIEE). Oakland, Calif.

O'Neill, B.C., and B. S. Chen. 2002. "**Demographic Determinants of Household Energy Use in the United States.**" *Population and Development Review* 28:53-88.

Owens, S., and L. Driffill. 2008. "**How to Change Attitudes and Behaviours in the Context of Energy.**" *Energy Policy* 36:4412-4418.

Pedersen, Marc. 2008. "**Segmenting Residential Customers: Energy and Conservation Behaviors.**" In *Proceedings of the 2008 ACEEE Summer Study on Buildings*. Washington, DC: American Council for an Energy Efficient Economy.

Reijnders, L. 1998. "**The Factor X Debate: Setting Targets for Eco-Efficiency**," *Journal of Industrial Ecology* 2(1):13-22.

Reiss, P. C. and M.W. White. 2005. "**Household Energy Demand, Revisited**." *Review of Economic Studies* 72:853-882.

Sanquist, T.F., B. Shui, and H. Orr. 2010. "**Integrated Assessment Modeling of Energy Consumption Behavior and Carbon Emissions**." In Proceedings of IEEE ISI. Vancouver, BC.

Schultz, P. Wesley, Jessica M. Nolan, Robert B. Cialdini, Noah J. Goldstein, and Vladas Griskevicius. 2007. "**The Constructive, Destructive, and Reconstructive Power of Social Norms.**" *Psychological Science* 18:429-434.

Shove, Elizabeth. 1998. "**Gaps, Barriers and Conceptual Chasms: Theories of Technology Transfer and Energy in Buildings**." *Energy Policy* 26:1105-1112.

Shove, E. 2003. **Comfort, Cleanliness, and Convenience: the Social Organization of Normality.** Oxford and New York: Berg Publishers.

Shove, E. 2009. "**Beyond the ABC: Climate Change Policy and Theories of Social Change**". http://www.lancs.ac.uk/staff/shove/transitionsinpractice/papers/BEYONDTHEABC.pdf

Shove, E. and A. Warde. 2002. ''**Inconspicuous Consumption: the Sociology of Consumption, Lifestyles, and the Environment**.'' Chapter 10 in R. Dunlap, F. Buttel, P. Dickens, and A. Gijswijt, eds, *Sociological Theory and the Environment*. Oxford: Rowman & Littlefield.

Shui, B. and H. Dowlatabadi. 2005. "**Consumer Lifestyle Approach to US Energy Use and the Related CO2 Emissions.**" *Energy Policy* 33:197-208.

Steg, L. and C. Vlek. 2009. ''Encouraging Pro-Environmental Behaviour: An Integrative Review and Research Agenda.'' *Journal of Environmental Psychology* 29:309-317.

Stern, P. C. 1986. "**Blind Spots in Policy Analysis: What Economics Doesn't Say About Energy Use**." *Journal of Policy Analysis and Management* 5(2): 200-227.

Stern, P. C. 1999. "**Information, Incentives, and Proenvironmental Consumer Behavior**." *Journal of Consumer Policy* 22:461-478.

Stern, P. C. 2000."**Toward a Coherent Theory of Environmentally Significant Behavior**."*Journal of Social Issues* 56:407-424.

Stern, P. C. 2007. "**Environmentally Significant Behavior in the Home**." In A. Lewis (Ed.), *The Cambridge Handbook of Psychology and Economic Behaviour* (Ch.15). Cambridge: Cambridge University Press.

Strengers, Y. 2008. "**Comfort Expectations: The Impact of Demand Management Strategies in Australia**." *Building Research & Information* 36(4):381-391.

Thaler, R.H. and C.R. Sunstein. 2008. **Nudge**. New Haven, CT: Yale University.

U.S. Census Bureau. 2009. **Characteristics of New Housing** (C25). Washington, DC.

U.S. Census Bureau. 2010. **Statistical Abstract 2010**. Washington, DC.

Wilhite, H., and L. Lutzenhiser. 1999. "**Social Loading and Sustainable Consumption**." *Advances in Consumer Research* 26:281-287.

Wilhite, H., E. Shove, L. Lutzenhiser, and W. Kempton. 2000. "**Twenty Years of Energy Demand Management: We Know More about Individual Behavior but How Much Do We Really Know About Demand?**" In *Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings.* Washington, DC: American Council for an Energy Efficient Economy.

Wilson, C., and H. Dowlatabadi. 2007. "**Models of Decision-Making and Residential Energy Use.**" *Annual Review of Environment and Resources* 32:169-203.

Woods, J. 2006. "**Fiddling with Thermostats: Energy Implications of Heating and Cooling Set Point Behavior**." In *Proceedings of the 2006 ACEEE Summer Study on Energy Efficiency in Buildings.* Washington, DC: American Council for an Energy Efficient Economy.