THE APPLICATION OF SOCIAL SCIENCE TO ENERGY CONSERVATION: REALIZATIONS, MODELS, AND FINDINGS

Christine Egan

March 2001

Report Number E002

1001 Connecticut Avenue, NW, Suite 801, Washington, D.C. 20036
202-429-8873 phone, 202-429-2248 fax, http://aceee.org Web site

CONTENTS

ABSTRACT

This report reviews 25 years of literature in the area of human dimensions research on energy efficiency and conservation. Three general categories are used for organizing this work, including: sociological realizations that derive fundamentally from the application of social theory to energy use; models and theories for organizing and predicting behavior; and intervention strategies and programmatic results that are behaviorally based and linked to one or more social science disciplines. Highlights include: many of the realizations are still relevant and oft overlooked by policymakers; no overarching model for consistently predicting behavior has been developed; and there is a rich potential for future exploration of this area of research. Topics as far ranging as the social and cultural context of markets and technology to the continued pursuit of individual behavior and motivation are pursued. In conclusion, the future of human dimensions research depends on interdisciplinary cooperation and the ability of the research community to meld theory and policy pragmatism.

ACKNOWLEDGMENTS

This paper was funded by the U.S. Environmental Protection Agency. The author would like to thank Shel Feldman, Sy Goldstone, Willett Kempton, Rick Kunkle, Christopher Payne, and Jane Peters for their expert review of earlier drafts of this document. Thanks also to Renee Nida and Liz Brown of ACEEE for their work in massaging and polishing the final product.

INTRODUCTION

Energy conservation emerged on the national policy scene in the early 1970s with the confluence of two events—the oil embargo of 1973–74 and the birth of a broad-based environmental movement a few years earlier. Suddenly, the social consequences of energy use were at the heart of increasing public dialogue on topics as diverse as national security, rising imports, air quality, and nuclear safety. Prior to these events, energy was a domain occupied almost exclusively by engineers and physicists who developed and implemented technologies and infrastructures that harnessed primary energy resources to propel societal growth. As issues of scarcity and environmental impact came to the fore, energy use was framed as a social problem and a door was opened, or at least held ajar, to social scientists.

Lutzenheiser (1993) wrote that "although scattered across social science disciplines, a body of research concerned with human factors in energy use does exist [and] can be applied in energy analysis." The array of disciplines represented in this body of research includes economics, psychology, anthropology, and sociology. Conceptually, the disciplines can be viewed as containing a range of approaches to evaluating energy decision-making. At one end of the scale lies economics and psychology, where a causal model of behavior can be constructed with set factors of influence (e.g., price, utility, attitudes, and social norms). As for anthropology and sociology, consumer decision-making is seen as interwoven with a variety of social, institutional, and cultural systems. The number and non-linear nature of the relevant variables preclude a single, causal model. The core of the difference lies with the unit of analysis for studying energy use, which in economics and psychology is the individual and in anthropology and sociology are culture, institutions, and social groups.[1]

The purpose of this report is to review the key findings of human factors research on energy efficiency and to reflect on their application to the current policy context. This is no small task. The literature in this area is vast, spanning 25 years of work by a small but prolific community. It is also varied, reflecting the diversity of disciplines included in this work and the organic nature of social science in general. Three general categories are used for organizing this large body of research: (1) sociological realizations; (2) models and theories; and (3) intervention strategies and programmatic results.

Sociological realizations covers a set of reflections that, although not attributable to a single discipline, project or person, derive fundamentally from the application of social theory to energy

[1] These analytical differences lead in turn to methodological differences. More structured and experimental methods dominate economics and psychology. Findings are typically precise and quantifiable. By contrast, open-ended and field-based methods dominate anthropology and sociology. Findings are typically narrative and qualitative. To date, the differences in methods and findings among the various disciplinary approaches has likely affected their relative influence on policy. The preeminence of the economic approach in federal policymaking (e.g., cost-benefit analysis) is a case in point.

use. This category is intended to provide structure to a body of related ideas that fall outside of a technical, engineering paradigm and consider the energy-human interface.

The models and theories category includes the theoretical structures proposed by the social sciences for organizing and predicting human behavior. In particular, these structures emerge from a review of the literature of the late-1970s and the earliest application of general disciplinary theories to the problem of energy and conservation.

Lastly, intervention strategies and programmatic results looks at a more micro-level at the relative efficacies of the behaviorally based intervention strategies used over the years in energy efficiency programs. In some cases, these strategies are linked explicitly or implicitly to the disciplines and theories discussed. In other cases, they are not at all linked to theory or discipline.

SOCIOLOGICAL REALIZATIONS

Social scientific analysis has led to a loosely connected body of what, for lack of a better term, can be called "realizations" about the nature of energy use and its human interface. Perhaps the most obvious and yet profound realization is that in the home, energy use has become invisible.[2] When you turn on a light you don't see kilowatt hours, you see light. When you turn on the oven, you don't see cubic feet of gas: instead, you feel heat. In fact, it is impossible to see or touch a kilowatt hour of electricity or cubic foot of natural gas. This intractable reality complicates the human relationship with energy use as compared to more tangible environmentally impacting behaviors such as the production of waste or recycling. As Stern and Aronson point out, the invisibility extends not just to energy use itself, but also to the workings of many efficiency measures.

> Insulation in walls, flame retention heads on oil burners, aluminum in automobile bodies and extra windings on motors all save energy without being visible [to end-users]. Because people can't see them, they are less likely to believe they save energy (1984).

Systems to address or compensate for the invisibility of energy use are at the core of many energy efficiency programs even today. The best example of a strategy to overcome this invisibility is feedback, a technique popular in the late-1970s to early-1980s that draws from psychological theories. The efficacy of feedback programs will be discussed below in "Intervention Strategies and Programmatic Findings."

[2] As Stern and Aronson noted, this was not always the case. In the 19th century, homes were heated with wood that required chopping, stacking, and loading into stoves on the part of the user. Coal and oil are equally tangible, though typically the delivery and, in the case of oil, the use requires less personal effort (1984). It is only with the preeminence of electricity and natural gas in residential energy use that invisibility has emerged.

A second sociological realization is that technologies do not use energy without human initiation. Lutzenheiser writes...

> We have yet to design machines that are fully autonomous, so their consumption must be viewed as part of routines in which humans are also involved. The joint human/machine use has been variously labeled "energy services," "behavioral routines," "occupant use factors," "energy-related social habits," "residential behavior patterns," and metaphorically transforming the household into a factory, the household "production function." In the end, machines don't use energy: people and their machines do (1992).

Thus, refrigerators don't use energy in and of themselves; people storing and preserving their food in refrigerators do. Cars don't use energy, but people traveling to and from work in their cars do. This realization is fundamental to the value-added of social science research in that it is essentially the argument that people and their social systems matter, not just technologies. The realization's impacts are clearly evident in studies that demonstrate the variability in energy use in physically, technologically, and demographically identical homes. That variability is proof of the human element driving energy use.

A related concept is that energy use is not in and of itself a behavior but the outcome of behaviors. One does not embark on energy use as a task. Instead, one embarks on tasks with the result of using energy. You turn your computer on to read email and do work, *not* with the notion that you need to use up some kilowatt hours. You buy a dishwasher *not* with the notion that you are buying an energy-using device, but because you are tired of washing your dishes by hand. In this way, the use of energy is an indirect consequence of the everyday actions (e.g., behaviors and purchase decisions) of participants in society. This realization was at the heart of some of the earliest efforts to improve information campaigns. Simple exhortations to use less energy have largely been ineffectual. More tailored messages about the specific actions of individuals offer greater promise (Stern 1984; Stern and Gardner 1981).

Most recently, Shove et al. articulated the notion that energy use is not an action (1998), arguing that energy use is woven into the social, cultural, and institutional context of everyday life and that all social participants (not just end-users) embark on actions that indirectly use more or less energy. Shove et al. noted that technologies and practices have cultural and social significance all their own and separate from their role as energy-using devices. For example, cars are an indication of social status and say something about the lifestyle one lives. This notion of social status is largely derived externally by broad social and demographic trends, not on an individual basis. Shove et al. also pointed out that many of the choices regarding the energy use of a car, home, or building are made long before reaching the end-user, by many social participants (each with their own social, cultural, and institutional paradigm), not just individuals. They wrote:

> End-users live in a world in which much of their consumption is already given. In the domestic setting, as in the office environment, consumers are confronted with a certain number of socket outlets, a boiler of a certain size and a building fabric that is relatively difficult to alter. To understand more about the framing of energy decision-making, we need to move along the supply chain and investigate the worlds of building contractors, subcontractors and designers...we also need to consider the pressures, priorities, and opportunities affecting those who manufacture and sell insulation, heating and cooling technologies...and the rest (1998).

Yet another realization is that energy use is technologically complex. For example, the average user has little hope or interest in understanding the thermodynamic process by which primary energy is turned into home heating. This creates an inherent barrier to individuals' efforts to conserve energy in that they are not, in a technical sense, sure of the impacts of their efforts. It means also that the units with which energy is measured are alien and not used in everyday language. Discussion of the impacts of the technologically complex nature of energy abounds in the human dimensions literature — for example, in the folk models that people develop to make sense of energy-using devices (Kempton and Montgomery 1982). These folk models will be discussed in greater detail below in "Development of Theories and Models." Also, addressing technical complexity is the basis of some efforts to educate and inform consumers about energy.

Finally, billing and accounting of energy use is delayed and aggregated, adding another layer of muddiness to an already muddy picture. For the residential sector, Kempton and Layne compare this to the hypothetical case of shopping for groceries without being told the cost of individual items and being given only a single monthly bill rather than one for each shopping trip. Such a bill might read "US$527 for 2362 food units in April" (1994). Due to the delayed, aggregated nature of their energy bill, homeowners have little opportunity to learn the causes of their homes' energy use, nor are they offered any signal as to the relative success of any efforts they are making to conserve (Egan 1999).

Commercial and industrial (C&I) sector billing is generally also aggregated and delayed on a monthly basis as in the residential sector. An additional complication for C&I customers is the use of time of use rates, demand charges, and power factor billing. Payne found that this more complicated and/or supplemental information was limited in its effectiveness because of the lack of understanding of these charges by business decisionmakers (2000a). Based upon interviews with business owners, Payne observed the following:

> Just because C&I customers have more complicated bills doesn't mean they are receiving more information…more often the reverse is true. Many businesses don't know what a demand charge or power factor is. Many businesses see time of use rates as a means for the utility to gouge business consumers, as they don't see they have any choice about when they use their energy (2000b).

Various programs to improve and increase the transparency of billing have been implemented both in the United States and abroad. Some of these are discussed below in "Intervention Strategies and Programmatic Results."

In summary, the application of social science to the problem of energy use has lead to a series of fundamental realizations. First, in a modern society energy use and, by extension most energy-saving measures, are invisible to end-users. Second, technologies do not use energy without human initiation. Thus, a joint human/machine unit drives energy use, with each of the two parts playing a contributing role in the consumption dynamic. Third, energy use is technologically complex in terms of both the science behind it and the nomenclature used to organize it. This creates an inherent barrier to individuals' efforts to understand the contributing variables to consumption and conservation. These realizations could not have been derived from a strictly technical analysis. They have been incorporated to varying degrees in conservation and efficiency program design and, taken together as a body of work, have profound implications for public policy.

DEVELOPMENT OF THEORIES AND MODELS

As already noted, energy was in the beginning the domain of technologists. The need for social scientists was not evident since energy consumption was assumed to have little to do with people. Rosa, Machlis, and Keating noted that "very early research" in the area of reducing consumption...

> was guided by the singular assumption, derived from an engineering perspective, that household energy consumption could easily be explained by physical variables such as climatic conditions, housing design, and the stock and efficiencies of appliances and vehicles (1988).

The earliest theoretical work of social scientists on energy was in disproving this engineering model. A classic case was Princeton University's Twin Rivers Project. A five-year study of physically identical buildings in New Jersey that were occupied by demographically similar families, the researchers on the project found variations in energy use by as much as two-to-one. Even more astonishingly, the research showed little correlation between the total energy use of former and current residents of the same unit.[3] Rosa, Machlis, and Keating wrote that the study

[3] Twin Rivers stands out as one of the earliest examples of social scientists working together with the "harder" sciences on the problem of understanding energy consumption. The goal of the project was to "document, model, and learn how to modify the amount of energy used in homes" (Socolow 1978). An interdisciplinary research team (engineers, physicists, statisticians, mathematicians, psychologists, and an anthropologist) took on the task. The study concluded that the "observed variation in energy consumption for space heating (in townhouses with identical floor plans, furnaces, and appliances) is substantially assignable to the resident rather than structural features that persist independent of the resident" (Socolow 1978).

"clearly revealed the importance of lifestyles to energy consumption practices; these findings stimulated detailed investigations of how lifestyle shaped energy use and paved the way for justifying the importance of social science research to a skeptical policy establishment" (1988).

Once the point was made (and accepted) that people mattered, interest emerged in systems to predict, organize, and describe the complex dynamic of human and social behavior. Over the 25 years or so that social scientists have been involved in research on conservation and energy use, various social science-based models of energy use have emerged. These include: (1) the rational choice model based on classical economic theory; (2) the attitudinal model based on psychological theory; and (3) folk models based on anthropological theory. Following is a discussion of each of these models, the theory on which they are based, their scope, trends in their popularity, and their current standing. In addition, various other theories or organizing structures have been suggested, though less formally tested for the case of energy conservation. These include Stern's categorization of types of energy consumers and Rogers' theory of diffusion of innovation. This section will touch briefly on each of these.

The Rational Choice Model

Over the last twenty years, neoclassical economic theory gradually became enmeshed in energy and conservation analysis. At a macro-level, neoclassical economists forecast energy demand and model the various factors (e.g., price elasticity and market constraints to price responsiveness) that might impact demand. At a micro-level, the theory of market actors as rational, utility-maximizers gathering and weighing appropriate information has offered energy analysts a model for predicting and organizing conservation behavior. According to the rational choice model, producers and consumers will adopt conservation behaviors or efficient technologies if it is their best interest to do so (Archer et al. 1987). Furthermore, the rational model assumes that people will gather appropriate information in order to weigh the costs and benefits of their energy-related decisions. The rational choice model has been criticized widely (particularly by other social scientists) for its simplified vision of human behavior. Yates and Aronson wrote:

> Human behavior is too complex for existing economic models. Although the rational-economic model is able to predict behavior in many situations, it has limitations. This is not to say that human behavior is incoherent or unpredictable but to underscore that behavior is best understood as a coherent expression of personal desire, taking into account the cognitive, social and personal forces that, in addition to the economic realities, define a situation (1983).

Despite these limitations, energy efficiency policy and programs have relied implicitly (and in some cases explicitly) on this rational model, resulting in an early emphasis on information programs (to correct market imperfections in access to information) and leading later on to the use of financial incentives (e.g., to speed the adoption of new technologies with prohibitively high first costs). Lutzenheiser argued that the physical science, engineering, and economic models act together as an overarching model that has guided much energy analysis. He termed this model a "physical-technical-economic model" (PTEM), in which the behavior of human occupants of buildings is seen as secondary to building thermodynamics and technologies efficiencies in that "typical" or average consumer patterns of hardware ownership and use are assumed. Furthermore, PTEM assumes that changes to buildings and equipment are a systematic function of the cost of energy relative to consumer income, weighting consumer priorities for services, convenience, comfort, and time. This model, according to Lutzenheiser, "exaggerates the importance of energy prices and technological solutions" (1993).

In recent years, a new school of economic thought has developed that challenges the concept of rationality as assumed in neoclassical economics. Transaction cost and institutional economics, for example, have put forth the alternative concept of bounded rationality, which, according to Williamson (1985), is "a semi-strong form of rationality in which economic actors are assumed to be intendely rational, but only limitedly so." (See also Hodgoson 1997.) Goldstone noted that, under bounded rationality, "the mind is a scarce resource [and] economizing on its use…may frequently be warranted" (1995).

> The bounded rationality school is dedicated to putting behavioral realism into the economists assumptions…no longer assuming that all market actors will pay attention to, comprehend, retain and ultimately synthesize and use all relevant information (Goldstone 2000).

Goldstone further argued that the most important implication of bounded rationality for the field of energy efficiency is that it strengthens the affinity of economics with the research approach taken by other social science disciplines. For example, the folk models derived from anthropology (described below) fit within the theory of bounded rationality in that they are more cognitively efficient (e.g., a better use of scarce intellectual resources) for lay people than attempts to understand expert models. The emergence of such alternative economic theory may offer new perspectives for social scientific analysis of energy efficiency.

The Attitude-Behavior Model

Archer et al. (1987) wrote that the attitudinal model holds that favorable attitudes lead to energy conservation behavior and that "making people's attitudes more favorable will make them more likely to practice conservation." The work of psychologists Ajzen and Fishbein extended the simple attitudinal model by specifying that the immediate determinant of behavior is behavioral intention, not attitudes directly (1980). Behavioral intention in turn is seen as dependent on two factors — a person's attitude toward the behavior (i.e., favorable or unfavorable) and a person's subjective norm (i.e., the presence of favorable or unfavorable attitudes on the part of those of social importance to the person in question). Critical to the Ajzen/Fishbein model is that the attitudes and behaviors measured must have the same level of specificity. For example, general attitudes toward energy conservation would likely not be a good predictor of more concrete actions such as the likelihood of installing low-flow showerheads. Other researchers have proposed amendments to the Ajzen/Fishbein model, inserting variables such as past experience, habit, and facilitating conditions along the path from attitude to behavior (Macey and Brown 1983; Triandis 1975).

The concept that energy-related attitudes predict conservation intentions and/or behavior has been a point of great controversy. Social scientists spent significant time debating and testing this model, particularly in the late-1970s and early-1980s. An ORNL report noted:

> Since the early part of this century, the concepts of attitude and behavior have been linked by most social scientists under the assumption that an attitude is a predisposition to a behavior. Experts have disagreed, however, on the extent to which attitudes predict behavior. Currently, three schools of thought prevail. Some view attitudinal models as one important factor in producing a behavior. Other authorities...believe behavior can be predicted by attitudes toward a particular behavior with subjective norms...still others argue that behavior may change without a corresponding change in attitude (Collins et al. 1985).

To further complicate matters, there is some theoretical basis to believe that in fact the relationship between attitudes and behavior works in reverse, with behavior causing attitudes to change. This is, for example, consistent with the theory of cognitive dissonance that says that once a person takes an action, they often retrospectively take on attitudes that support that action so as to avoid internal conflict or hypocrisy (Stern 1992). This view of the behavior-attitude relationship led to efforts to elicit small commitments from individuals as a way of developing a conservation ethic and larger-scale pro-conservation behavior. The results of these commitment strategies will be discussed below in “Intervention Strategies and Programmatic Results.”

The attitude-behavior debate was never really resolved. Some studies found strong correlations between certain energy attitudes, behavioral intention, and resulting behavior (Seligman, Darley, and Becker 1978; Seligman, Hall, and Finegan 1983). Others found weak to no relationship (Costanzo et al. 1986). Lutzenheiser (1993) cited a test of the Ajzen/Fishbein model by Ester, noting that, although Ester’s is the most comprehensive application of the model to residential consumers to date, no correlation was found between attitudes and conservation behavior. Ester attributed the problem to the strong influence of “energy illiteracy” on a person’s willingness and ability to conserve. In the late-1980s, attitudinal research, as well as more general psychological research on energy, dwindled. It is not clear that this approach worked itself to completion. Another possibility is that the early results, being less consistent and more complex than expected, led a loss of interest (or funding) in the attitudinal model specifically and psychological research more generally. As recently as 1992, Stern argued for renewed psychologically based research on energy use and efficiency. He noted that a mistake of the early psychological studies was in focusing almost exclusively on the residential sector and too narrowly on individual behavior (Stern 1992; Stern and Oskamp 1987).

The Folk Model

Unlike the attitude-behavior and rational choice model, the folk model is not an all-encompassing, causal model of energy consuming behavior. Instead, it is a general theory that can be used to describe people's energy-related behavior. The core of this approach is that the models used by lay people or non-experts for interacting with and analyzing energy-using technologies or systems are often profoundly different from those used by experts. These represent folk models or lay concepts of how technically complex systems work and can be influenced. People in the same culture often create strikingly similar folk models of a particular concept and, as the word "folk" implies, these models are typically distributed widely in the world outside of specialists (Kempton 1986; Kempton, Boster, and Hartley 1995). The differences between lay and expert models have ramifications not only for individual energy consumption, but can lead to gaps between macro-level models of energy use and micro-level realities. However, these differences do not mean that the folk models are naive or stupid. To the contrary, they are often quite well thought out and based upon the transfer of similar or relevant experiences.

The classic illustration of a folk model of energy use was discovered by Kempton in interviews with homeowners about how thermostats work. Many respondents held what Kempton termed a "valve theory" of thermostat operation. A person with a valve theory believes that the house will warm up faster if the thermostat is set higher. Although this will waste energy if it leads to a higher thermostat setting overall, Kempton also showed that people who held this valve theory were also more likely to understand that the night setback saves energy (Kempton 1986). This is an illustration that a folk model that initially seems wrong to an expert may in fact work reasonably well. Kempton and Montgomery (1982) found similar folk methodologies in residents' analysis of their monthly utility bill. Specifically, they found that people tend to quantify their homes' energy use in the familiar units of dollars, rather than the technical and foreign units of kilowatt hours. Though cognitively efficient and consistent with monthly budgeting practices, this folk quantification leads to systematic errors in calculating home energy use, the choice of ineffective conservation actions, and underestimation of the benefits of conservation measures. Most recently, Kempton, Boster, and Hartley explored folk models relating to nature, weather, and climate change (1995).

There are likely other folk models relating to energy use, even outside the residential sector. Understanding these models can obviously lead to more targeted and improved energy efficiency programs, not so much to change these folk models, but to take them into account in communications with the public. To date, research in this area has been limited largely to the examples given. The lesson of this approach, that lay models do not correspond with those of experts, is often overlooked. Policies are typically designed assuming prevalence of the expert paradigm.

Categorization of Energy Users

Challenging the pre-eminence of a single, economic view of energy consumers, Stern and Aronson (1984) proposed five views of energy consumers, each true of some class of consumers at certain times and for certain energy-related decisions. These include: (1) energy user as investor; (2) energy user as consumer; (3) energy user as member of a social group; (4) energy user as an expression of personal values; and (5) energy user as problem-avoider. In each of these categories, different motivations are seen as driving energy-related decisions.

The "investor" views energy as a cost that should be carefully considered in making decisions such as the purchase of energy-sing equipment. This is largely consistent with the economic view of the energy consumer (though as Kempton's folk models demonstrate, consumer methods for weighing and analyzing costs can lead to unwise investment decisions). The "consumer" views energy-sing devices (e.g., cars) as consumer goods, providing some combination of necessity and luxury. This model may also be consistent with the economic model in that the value people find in the luxury aspects of their goods is consistent with the notion of "utility." The "member of a social group" views energy use and equipment as relating to his or her commitment to larger social groups. These social groups may encourage or discourage certain energy-efficient behaviors and technologies regardless of their cost-effectiveness. The "expresser of personal values" views energy use as related to their personal value systems and self-image. Personal values about comfort, for example, may lead to greater use of air-conditioning than for someone whose personal values are oriented toward voluntary simplicity. The "problem-avoider" takes energy use for granted and deals in energy-related matters only to the extent that it is required of him or her (e.g., because a furnace breaks down). This view is particularly useful in considering the family-level dynamics involved in energy use. A problem-avoider likely would not undertake actions that encountered family resistance (e.g., lowering temperature in the winter).

The five views are an interesting theoretical construct for organizing approaches to communicating about energy and efficiency. Each has support in the existing literature on human behavior. Intuitively, each also has some element of truth. Interestingly, these categorizations bear some analytical similarity to the approach taken by the marketing industry to segment customers. Additional research to test these five views and their relationship to marketing theory may be warranted particularly to test their validity in organizing and/or predicting real world energy-consuming behavior.

Diffusion of Innovations

The theory of diffusion of innovations holds that a new idea, practice, or technology follows a consistent path (represented by an S-shaped curve) toward its acceptance or rejection within a target population. The model emphasizes the importance of communication channels and social systems to the relative success of an innovation's acceptance (Rogers 1995). Also, time is highly variable with some innovations diffusing more rapidly than others. Five characteristics are linked to an innovation's rate of adoption, including: an innovation's relative advantage compared to the item it replaces; its compatibility with the values of the target population; its complexity and the perceived difficulty in use and understanding on the part of the target population; its "triability" and degree to which it can be tested prior to total commitment; and its observability or degree of visibility in its outcome (Komor and Wiggins 1988-89). The model notes that individuals will participate in the process at various points along the diffusion path depending on their "innovativeness." Innovativeness is defined as the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system (Rogers 1995). Five adopter categories, from most to least innovative respectively, are defined: innovators; early adopters; early majority; late majority; and laggards (Rogers 1995).

This model has been applied to the world of energy efficiency, though mostly in a descriptive or theoretical fashion. For example, Geller and Nadel (1994) used the model to explain the concept of market transformation (which seeks to accelerate energy efficiency's diffusion). Darley (1978) applied the diffusion model retrospectively to the experience of the Twin Rivers project in convincing a subset of the residents to adopt a clock-driven thermostat. The results were largely consistent with the model. One interesting result was that the pattern of diffusion was not spatial but sociometric, suggesting the greater importance of friends over neighbors in modern social networks. Earlier diffusion studies with technologies such as home air-conditioning and solar panels found clusters of diffusion in neighborhoods and even on certain streets (Komor and Wiggins 1988-89; Rogers 1995). Darley found "the second stage innovators were friends, colleagues, or office coworkers of the initial innovators, not neighbors" (1978). Komor and Wiggins (1988-89) cited a study by Leonard-Barton that found a strong predictor of solar adoption was the number of acquaintances with the equipment, along with a Puget Sound Energy study that found the adoption of wood heating and fireplace inserts followed an S-shaped curve.[4]

The diffusion-related studies mentioned are all in the vein of testing the theory (as in Darley 1978) or in using it to explain the current policy paradigm (as in Geller and Nadel 1994). In summarizing the state of understanding of diffusion research and its application to energy efficiency, Mast recently wrote:

> Further research needs to be conducted to fully realize the promise diffusion of innovation offers for energy efficiency market transformation…Most quantitative studies have been retrospective and have focused on successful innovations rather than failures. Thus we are still limited in our ability to estimate prospectively the likelihood of success for a particular innovation, the level of adoption needed to achieve sustainability, or the time required to reach that level (1999).

[4] The diffusion-related studies mentioned are all in the vein of testing the theory (as in Darley 1978) or in using it to explain the current policy paradigm (as in Geller and Nadel 1994). Some limited work has been done (for example, by EPRI) in testing the model's usefulness to the design programs (for example, with different outreach strategies for each category of innovator).

Though derived from an interdisciplinary mix of the social sciences (from anthropology to rural sociology to communications), the diffusion of innovation model is not without critics within the human dimensions of energy community. Shove et al. wrote:

> Analysis in terms of risk-taking propensities of early and late adopters seems to make sense... and to justify government programs designed to push individual consumers up the S-curves of energy efficient good practice as fast as possible. By implication, technology, especially cost-effective energy-saving technology, has a predetermined trajectory. Only the rate of change is in question. Social science researchers have been drawn into this framing of the problem as policymakers and others have looked to them...in the design and implementation of promotional campaigns and programs...Yet, [such work] rests upon, and in fact lends credence, to an essentially linear theory of technological development.

Shove et al. cited this model as one piece of a conventional paradigm of the human dimension of energy that has the effect of excluding questions about the social organization of energy consumption and related technologies.

In conclusion, no overarching model to predict, influence, or categorize human behavior on energy efficiency has emerged. Each of the models discussed above have been found to have merit in some though not all aspects of the human-energy relationship. A number of social scientists have concluded that even routine energy-using habits are too complex for simple models or organizing structures (Lutzenheiser 1992; Shove et al. 1998; Stern and Aronson 1984). More recently, applied models such as the diffusion of innovations and Sterns's categories of consumers place greater emphasis on social factors, such as the networks and social groups to which one belongs, than did earlier models (e.g., the rational-choice or attitude-behavior models). Lutzenheiser wrote that there seems to be a consensus in the literature that "adequate models of energy and behavior must be more directly concerned with the social contexts of individual action. This represents a...recognition...that because human behavior is inherently social and collective, its fundamental organizing principles cannot be discovered through the study of individuals" (1993).

INTERVENTION STRATEGIES AND PROGRAMMATIC RESULTS

Beginning with the first oil crises of the 1970s, programs to persuade consumers to conserve energy and adopt energy-efficient technologies have been undertaken by organizations at nearly all levels of social hierarchy (e.g., the federal government, state governments, municipalities, utilities, and community centers). Some of the earliest work was in simply documenting what people thought about energy, its use, and conservation. Over the last 25 years, public opinion polls have been sponsored, albeit sporadically, by government, utilities, and other entities.

These polls have consistently shown that the public believes businesses, industry, and government are responsible for energy crises and inefficiency, not individuals (Lutzenheiser

1993). Interestingly, energy was still considered a serious problem in the early 1990s with a majority of those surveyed indicating that future energy crises were likely. This was true despite the fact that earlier attitude studies showed low public understanding of the national energy situation (Lutzenheiser 1993). Farhar reported that "the pattern of preferences for using energy efficiency to decrease demand and renewable [sources] to supply energy has also been consistent in the poll data" (1996). Furthermore, 82% of those surveyed in 1990 reported that they had cut back significantly or somewhat in heating or air-conditioning to conserve energy (Farhar 1993).[5] Farhar (1996) concluded that the public is increasingly connecting energy use with environmental damage. This is encouraging because poll data have also shown that general concern for the environment is widespread and strong. In summary, over the years poll data show that (at least in principle) public sentiment supports energy efficiency.

In the late 1970s and early 1980s, the attitude behavior-model discussed above was at its peak in popularity. As already indicated, no clear relation between attitudes and behavior was proven. However, some interesting findings did emerge. "High levels of energy use for household heating and cooling were correlated with beliefs that home temperature was important for health and comfort" (Stern 1992). Belief in the urgency of the energy crisis of the 1970s, however, was not correlated with pro-conservation action (Stern 1992). Furthermore, people who cited conservation as the single most important strategy for improving the country's energy future were no more likely than others to engage in energy-conserving behavior (Costanzo et al. 1986). As noted, attitude studies largely ceased in the mid- to late-1980s, so it is not known if these correlations (or lack thereof) have persisted over time. In summary, attitudes leave a more murky picture of public commitment to energy efficiency than do public opinion polls.

The efforts of the energy efficiency community have gone far beyond simply documenting public opinion and correlating attitudes with behavior. Intervention strategies were and are undertaken with explicit goals such as creating pro-conservation attitudes, encouraging energy-conserving behavior, and promoting energy-efficient technologies. These strategies include information programs (mass information and targeted information) and incentives (financial and non-financial incentives). Lessons learned and results of these various approaches are discussed below.

Information Programs

A ORNL study (Collins et al. 1985) referred to information as a broad range of materials that are purposely designed to encourage energy-conserving behavior, including brochures, flyers, billboards/signs, workshops, television and radio ads, hotlines, interpersonal communications, and even monetary rewards. Today, computer-based materials such as tutorials and other software, along with Internet Web pages, would have to be added to the list. Several lessons can

[5] This self-report of behavior can be interpreted not so much as an indicator of the actual percentage of the population taking such measures but rather as an indication of level of interest.

be learned from a review of the literature on what makes for a "good" information program: information must be vivid and inviting, understandable and concrete, uncluttered, credible, personalized, and timed so that action by the consumer is convenient and possible soon after the information is received (Bettman 1979; Costanzo et al. 1986; Egan 1999; Stern 1992; Stern and Aronson 1984;Yates and Aronson 1983).

It is also clear from the literature, however, that all information is distributed in the larger context of everyday life and the social environment. The ORNL report (Collins et al. 1985) went to note that "information is not solely an objective set of words, pictures, numbers and symbols. Rather it is a social process by which knowledge is acquired, attitudes are formed or perceptions are reached." A review of the literature on what makes or breaks the success of information provision indicates that this "social process" includes external and internal influences. These influences appear to have as much to do with the success of information programs as does the quality of an information effort and its messages.

Internal influences include one's existing beliefs and the extent to which the information given is consistent or conflicting with those beliefs. Another internal influence is one's existing knowledge base on the information topic and the extent to which the information is comprehensible. Finally, one's attention or interest in the topic of information is a factor of internal influence. External influences include what those people who make up one's social network do (e.g., family, friends, co-workers, and neighbors). Also, what those same social networks say about the topic of information can exert influence on the extent to which information is received or not. Models, such as leaders in the community or celebrities, are a source of external influence. Finally, the actions one has already taken to commit or not to the issue or related topic can exert influence on a person's likelihood to connect with and act upon information. Stern summed it up this way:

> Energy information is multi-dimensional. From a policy standpoint, what matters is not so much the amount of information contained in a label, advertisement, or other message but getting the audience to pay attention and take the message seriously. This depends on the way the information is presented, the way information users interact with the information sources, their trust in those sources, and the confirming or conflicting information that comes from friends and associates (1992).

Collins et al. referred to eight informational strategies including: (1) a strictly factual approach; (2) a persuasive approach; (3) a negative, arousal of fear approach; (4) perceptions of attributes approach that links the energy-saving features with more salient features such as enhanced safety or comfort; (5) a repetitive, reminder-based approach; (6) an elicitation of commitment or goal-setting approach; (7) the use of models (either for imitation or as a spokesperson); and (8) the use of incentives (Collins et al. 1985). This list contains degrees of interactivity. The first four are largely passive and oriented toward the messages that might be contained in a broad public information campaign. Lutzenheiser referred to such information efforts as "mass information" (1993). The remaining four are more interactive and lend themselves better to smaller-scale and localized activities. A discussion of these "targeted and interactive" information efforts follows a discussion of "mass information" strategies.

Mass Information

Looking beyond these general principles to evaluations of mass information campaigns, it becomes clear that the relationship between information provision and actual energy savings is complex and difficult to establish. First of all, mass information programs often go unevaluated. This reflects the naive assumption that information given is information received. An example is the more than twenty-year-old appliance labeling program in the United States. Until recently, only one evaluation of this program had been done and little was known about the program's efficacy in encouraging the purchase of more energy-efficient appliances (its legislatively mandated purpose). Recent work by duPont and the American Council for an Energy-Efficient Economy (ACEEE) indicated that the program is likely not having much impact in that key elements of the label are misunderstood and misused (duPont 1998; Shugoll Research 1999). Even more extensively tested programs, such as the automobile miles per gallon (MPG) label, have received little evaluation in terms of estimating actual savings. Instead, comprehension and awareness have been the focus. These are useful points of data and better than no evaluation at all. However, they do not measure the programs' effect on energy and the environment. Another evaluation problem is that when information evaluations are undertaken, they often use self-reported savings data to establish energy savings. Such self-reported data are notoriously inflated. In fact, in a review of 124 studies of state and local-level information programs, Collins et al. noted with suspicion that those using self-reported data always indicated energy savings (1985). Thus, even if these self reports approximate the upper bound of potential, their use has contributed to a lack of confidence in program efficacy.

Collins et al. found that the mass information programs reviewed reported savings of 0–9% with an average of 4%. Collins et al. also noted, however, "that these estimates are rough and do not take into account the quality or validity of each study reviewed...[and that] they may best be viewed as upper bounds" (1985). As an upper bound, 0–9% is quite broad. Certainly, a 0% savings would be deemed unacceptable. However, 9%, or even an average of 4%, could well be worthwhile depending on the scope and cost of the program. One can't escape the thought, however, that these numbers are disappointingly low, particularly if you were the entity sponsoring the information program. Stern et al. (1985) wrote that "overall, information programs seem to do less than their creators intended." Difficulties in energy information campaigns is not limited to the United States. de jongh and Captain wrote that in the Netherlands, the government has mainly approached consumers on environmental issues through educational campaigns. They noted that...

> Behavior has been successfully changed, for example, in getting residents to separate wastes for recycling but little progress has been made in regard to car-

> use and energy consumption because there is a perceived penalty for making changes [i.e., that something, such as comfort or convenience, is being given up] (1999).

In sum, the literature showed that a savings of 4–10% from mass information programs is good and that negligible savings are possible. However, it is important to note that absolute savings are not the only measure of success. Perhaps the greatest value of a mass information campaign is the signal it sends that an issue is of societal importance not only to the public but to policymakers. Also, cost per person and per unit of saving have to be taken into account. This is often an area of strength for information programs in that they can be relatively inexpensive to implement (as compared with other "mass" programs such as tax credits). Finally, many information programs have been undertaken without pre-testing of key messages and on the basis of expert rather than folk models. Therefore, a limited degree of success is not surprising. More recent efforts, such as the ENERGY STAR® labeling program, the ongoing work of ACEEE to improve the Federal Trade Commission's Energy Guide label, and the Alliance to Save Energy's multi-media campaign promoting energy efficiency, have incorporated a more sophisticated understanding of lay models and made use of pre-testing. To the extent that these programs can estimate program efficacy and resulting energy savings, they will offer a more refined estimate of the potential of mass information programs. In short, to conclude that mass information programs are completely lacking in worth would be a mistake.

Use of Mass Media. The following points from the literature reviewed on mass information regarding the use of mass media are detailed in order to point out their ongoing relevance. Collins et al. wrote that large-scale media campaigns about social issues are more likely to succeed if based on counter-advertising. An example is the case of smoking, where efforts to curb smoking run counter to advertising by cigarette manufacturers. They noted that the likelihood of success is also enhanced by sponsorship and funding via Congressional directives and by the presence of a grave (even life-or-death) hazard. Stern and Aronson wrote that a barrier to the success of governmental media programs is the limited array of methods they can access, particularly the limitations on using paid advertising.[6] They compared these limitations to the case of Canada, where not only can paid advertising be widely used but campaigns that are clearly promotional and directly in conflict with the interests of energy producers and manufacturers of equipment can be undertaken by government (1984). Not only government is restricted in its methods. As a practical matter, nonprofit organizations are limited in their methods as well by a lack of funding. Large-scale media campaigns are expensive and few entities have the funds to finance them. Certainly, the ENERGY STAR labeling program has pushed the limits of government's information role, as discussed by Stern and Aronson (1984). Results of the upcoming evaluation of that program may well demonstrate that a successful strategy for overcoming these limitations has been achieved. On a local level, evaluations of

[6] Similarly, Collins et al. concluded that public service announcements appear to only be worthwhile if the target population is the elderly. They found that for state and local-level programs, the required effort (staff time) was simply not worth the number of participants generated (1985).

label recognition in regions with active utility programs promoting ENERGY STAR are encouraging (Feldman 1999; Hewitt, Pratt, and Smith 1998).

Targeted and Customized Information Programs

The conclusion that broad-based information programs produce small (though not insignificant) energy savings has led to the implementation of more targeted and customized programs including feedback and the use of energy models.

Feedback. Feedback is a strategy based upon cognitive psychology that views energy conservation as a learned behavior (Socolow 1978). Wilhite and Ling defined feedback as "information which people receive on the consequences of their behavior and/or performance of things of their material environment" (1995). In the energy sector, feedback has been provided through diverse mechanisms such as written notes, regular/recorded meter reading, continuos displays on a monitor, and graphical displays of comparative energy use. Feedback directly attacks the invisibility of energy use by providing end-users a signal about their consumption patterns, thereby creating an opportunity to modify those behaviors to use less energy. Stern and Aronson (1984) cited a review by Winkler and Winett of 19 sets of data from feedback studies in which households were frequently informed (mostly daily) about how much energy they were using. Feedback led to saving of up to 20% compared to households without feedback. Interestingly, the study found that the effectiveness of feedback increased with the costs of energy. In a similar review of feedback programs, Collins et al. (1985) found that feedback resulted in 3–21% savings with an average of 11%.

Interestingly, the feedback literature shows little consensus on the frequency with which feedback is required. For example, Collins et al. concluded that daily feedback is most effective. However, a more recent and large-scale study in Norway found that monthly feedback resulted in savings of 10% (primarily accomplished through behavior changes in the home) compared to a control group receiving no feedback (Wilhite and Ling 1995). Komor and Kempton (1991) found that preferences on information frequency varied substantially among small businesses depending on business size and the role of the individual being interviewed (e.g., managers who are responsible for daily operations preferred daily feedback while owners preferred monthly, as this was consistent with bill paying).

The literature is also not clear on whether or not feedback is most effective as a stand-alone strategy or when combined with other strategies such as general information provision and incentives. Earlier studies found that it was best when used in combination with other approaches, but the Wilhite and Ling study found no statistically significant differences in groups that received only feedback and those who received feedback and energy savings "tips" printed on the bill. Another point of concern is whether or not savings persist after the withdrawal of feedback. In some of the early studies, this was not the case. In the Norwegian case, savings held for the three years they were measured (1995).

Feedback programs, though popular from the late-1970s to mid-1980s, are uncommon today. One area where feedback is still applied is in energy billing. For example, most utility bills include comparative data of some kind, usually self-comparison. The Wilhite and Ling study mentioned above was a test of improved utility billing in Norway. Improvements included increasing the frequency and accuracy of utility bills (from quarterly estimated to monthly actual) and the addition of a self-comparative graphic of energy use (this year compared with last). These Norwegian programs are ongoing and continue to be improved.

In the United States, the ENERGY STAR Billing program promotes a normative and graph-based comparison as part of the bill. These graphs compare an individual home with others in a similar grouping. Unfortunately, participation in the program has been limited to small municipal utilities and a large-enough sample has not yet been available to estimate savings from the program. Preliminary results of interviews with customers receiving the graphs are promising (Egan 1999). Programs that provide feedback via the vehicle of the utility bill not only improve the visibility of energy use (i.e., they attack energy invisibility), they also improve the accessability of billing information to customers (i.e., they attack the delayed, aggregated, and technically complex nature of the bill).

Models. Another behaviorally based approach to increasing individual energy efficiency action is the use of an energy-efficient role-model either as a source of imitation or as a source of credibility. Models are more targeted than mass information strategies in that the model is selected because of his/her ability to "speak" to the target audience. In the imitation vein, Stern and Aronson (1984) cited a study by Winett et al. in which a videotape showing a couple taking energy-saving actions in their home and acting as a model was used. The videotape was shown to a subset of participants, all of whom a attended an instructional meeting. Savings ranged 10–25% higher than the group that attended only the instructional meeting. Similarly, a study by Aronson and O'Leary found that placing an energy-conserving model in a university shower room held great promise. This person took shorter showers by turning off the water while soaping up. Aronson and O'Leary found that with one model, 49% of showerers imitated the energy-conserving behavior, and with two models, 67% did. However, these students had previously been sensitized to the issue with signs, which had resulted in participation of 6–19% depending on the signs' level of visibility.

Another form of model is one who is used as a source of credibility. Typically, a public figure or celebrity fills this role. An example of this approach was President Carter's characterization of the energy crisis as the moral equivalent of war, and subsequent request for homeowners to don sweaters and turn down their thermostats. Other environmental fields have used a "symbol" as a model—for example, Smokey the Bear for forest fire prevention and Woodsy the Owl for pollution prevention. The ENERGY STAR program used the celebrity approach with its use of the Beach Boys to promote qualifying equipment. However, no specific estimates of savings from these or similar programs are known.

Financial Incentives

The use of financial incentives derives directly from the rational choice model by placing the purchase of an energy-efficient technology more in line with one's economic interests. The efficacy of various financial incentive programs have been reviewed extensively elsewhere (e.g., Collins et al. 1985; Geller 1988; Stern et al. 1985) and will be reported here in only a summary fashion with an emphasis on those issues of social-behavioral relevance. Collins et al. reported that the financial incentive programs they reviewed reported savings of 4–28% with an average of 15%. They also concluded that larger rebates were more effective than smaller rebates in that the amount of savings increased with the amount of the rebate.[7]

Interestingly, Stern et al. (1985), in a more comprehensive review, did not arrive at a similar conclusion regarding the size of rebates. Rather than measuring success by level of savings, Stern et al. looked at program participation and resulting degree of retrofit activity. They found partial grants or rebates to have the highest rate of retrofit activity, followed by interest-free loans and lastly partial-loan subsidies. However, among the eight grant or rebate programs studied, they found those offering the *smallest* incentives had the highest participation rates. Even more amazingly, programs of the same financial values administered by different entities had participation rates with more than a ten-fold difference. Stern et al. concluded that this was because of the non-economic aspects of the programs (e.g., level of program marketing, credibility of implementing organization, and/or intrusiveness of implementation, etc.). Based on these results, Stern et al. concluded "that the stronger the financial incentive, the more important the non-financial factors, especially marketing, become to a program's success."

Also of interest is that Stern et al., in comparing analyses of financial incentives types (e.g., grants and or rebates, zero-interest loans, and partial-loan subsidies), found that "different types of households have different preferences with respect to incentives" due to differences in income, home ownership status, opinions regarding indebtedness, confidence in budget management, etc. For example, renters for obvious reasons had no interest in loan programs. Similarly, low-income participants were often unable to take advantage of programs with up-front costs regardless of long-term economic benefits. Also, regardless of income, those who were debt averse were unwilling to participate in even interest-free loan programs. Thus money has different value to different customers when presented in each of these forms. Stern et al suggested that offering customers choices among incentive types might increase participation.

In summarizing Stern et al., Lutzenheiser wrote that their review suggests "a number of reasons why persons who are targeted with incentives may fail to act in ways that economic analyses suggest are in their self-interest. These include: lack of accurate information, confusion, restricted choice, too much time and/or effort required (high information costs), lack of trust in information sources, lack of cash and the relative invisibility of conservation impacts" (1993).

[7] However, at the level of 20% savings, it became more expensive to achieve reductions in energy use.

Non-Financial Incentive Programs

Non-financial incentive programs are those that appeal to other than financial motives — for example, to altruism, social obligation, desired lifestyle, or even guilt. Such programs appear to be few and far between, perhaps because of the assumed preeminence of the financial motives. However, a similar theory of motivation lies at the heart of marketing. Lutzenheiser wrote that “the whole point of marketing is to induce purchase of appliances through appeals to non-economic motives” (1992).

A tangible example of an intervention that has taken a non-financial incentive approach is implementation of commitment-based strategies. Commitment strategies elicit an initial commitment (either verbal or active) from program participants to secure later and more substantive energy-saving actions. This approach is based on the theory of cognitive dissonance mentioned above. Stern and Aronson (1984) cited a 1980 study by Pallak, Cook, and Sullivan that tested this approach. A group of homeowners who had volunteered to save energy through behavioral changes were split into two groups. All were given equivalent information on energy-saving strategies, but one was informed that their names would be published in an article (the high commitment group) about the experiment, while the other was assured anonymity (the low commitment group. In two identical versions of this experiment (one for natural gas and one for electricity), the high commitment group saved 15 and 20% respectively over the low commitment group. Katzev and Johnson (1983) found similar results in their work on commitment-based strategies . Such strategies appear to have been virtually abandoned by the energy efficiency community and may warrant a second look.

The energy efficiency community’s lack of attention to programs to stimulate non-financial motives is likely due to the fact that to do so would lead directly into the culturally and politically taboo subject of lifestyle. Several members of the human dimensions community have argued that real progress in reducing energy use and meeting climate change targets will have to tackle this issue head on (Lutzenheiser 1992; Moezzi 1998; Shove et al. 1998). Some threads of human dimensions research, with its increasingly common conclusion regarding the importance of the social versus individual context of energy use, are moving in this direction. Regardless, it remains somewhere between a non-starter and a hot potato here in the United States. Given that consumers increasingly report willingness to change lifestyle (Kempton, Boster, and Hartley 1995), this innovation may well move slowly up the energy efficiency community’s S-curve, with social scientists as the early adopters.

In summary, this section has discussed the merits and application of a variety of intervention strategies including various information and incentive-based approaches. For the organizational purposes, each method was discussed independently. In reality, however, these programs are typically implemented jointly and the literature generally indicates that that is effective. For example, Geller (1988) cited the results of a NYSEG pilot refrigerator rebate program that showed that information in combination with advertising achieved a doubling of the penetration of efficient refrigerators in the target population while the addition of incentives increased that penetration to between 48.6 (for a $35 rebate) and 59.7% (for a $50 rebate).

CONCLUSIONS

As social scientists joined the energy research community, they contributed knowledge about the human-energy interface. Social-psychological realizations (such as the invisibility of energy and energy efficiency, the reality of the joint human/machine energy user, the indirectness of energy use, the technologically complex nature of energy use, and the aggregated and delayed nature of energy billing) have vastly improved our understanding of that human-energy interface. Even today, policymakers and program implementers would do well to occasionally ruminate on these realizations. As experts, we tend to forget their implications.

No overarching model for successfully predicting or influencing individual behavior has emerged, though many have been tried from academic disciplines as wide-ranging as economics, psychology, and anthropology. In some ways, this is no surprise. Human behavior and decision-making are complex on even the simplest of issues. And, as evident by the above realizations regarding energy, its use and conservation are in no way simple. This is not to say that the social sciences have had no success in the modeling or predicting of energy behavior but rather to say that success and failure have appeared on a more case-by-case basis. Simply put, no silver bullet has emerged. Maybe this is why simple, straight-forward (though limited) models such as those based on utility-optimizing, economically rational behavior have lingered so long. Likely it is also why the social sciences have had such a hard time securing consistent, stable research support, because we offer no easy answers. The precise and quantifiable nature of economics and to a lesser extent psychology has great appeal to policymakers who have to implement programs based on clear goals and with verifiable results. By comparison, sociological studies are easily labeled as too broad, theoretical, or academic. It is likely that the future of human dimensions research will depend on the ability of those inside and outside the human dimensions community to transcend this tension between pragmatism and theory, and work in an interdisciplinary fashion.

Findings from specific intervention strategies such as information programs and financial incentives show wide variations in their energy savings. Specific and targeted information programs have fared better than mass information strategies. However, the limited understanding of cognition and a lack of careful pre-testing have certainly negatively impacted mass information programs. Financial incentives generally garner larger savings than do information programs. The amount of savings possible from the use of non-financial incentives is not known as this strategy has rarely been used. In addition, energy savings is not a program's only measure of success or impact. Public information programs, for example, signal that energy efficiency is an issue of social importance, not only to the public but to policymakers. Moreover, the success or failure of incentive programs has much to do with non-economic factors such as the customer friendliness of the program and its marketing. Also, results of the NYSEG study mentioned above and other efforts indicated that these strategies are not mutually exclusive but mutually reinforcing. Today's energy efficiency programs typically include both information and financial components. Each has its own individual role in contributing to overall success in promoting energy efficiency.

Nearly all of the work of social scientists has arrived at the conclusion that too much time has been spent in focusing on the residential sector and individual behavior out of the context of social groups. This finding is consistent with public opinion, which has consistently placed the blame for energy problems with social groups such as businesses and industry. Organizational behavior literature is perhaps the best place to start for consideration of efforts within businesses and institutional networks. For other social groups, the trick will be finding research and programmatic mechanisms that can explore and influence social networks. This interest in institutional, social, and cultural groups is well-timed in that it is at least intellectually consistent with the broader energy efficiency community's move from technology-specific demand-side-management to the more sector- and market actors-driven approach of market transformation. Research and promotion strategies based upon the institutional, social, and cultural context of energy efficiency is a logical next step. The challenge for social scientists will be in defining exactly what that means and presenting their methods/findings in a practical, applied fashion. The challenge for the broader community will be in leaving the individualistic, rational-choice model in its appropriate place, as one of many drivers in decision-making.

This is not to say that work targeting individuals should be abandoned. Indeed, this work is highly valuable and contributes to the creation of broad social values necessary for social change. More consistent and large-scale messages need to be sent to the public regarding energy and its environmental impacts. For some years, energy has been able to languish as a non-issue on the political agenda and in public discourse. Climate change mandates that this change. More specifically, greater attention and exploration of individuals' non-financial motivations is an important area of future research and program implementation. For example, one thing missing from nearly all of the research, programs, and policies implemented to date on energy efficiency is the role of emotion in individuals' relationships to products and social issues. The average Americans' attachment to their vehicles is an illustration of "an emotional relationship" with products. This aspect of the human psyche is fundamental to marketing, which actively strives to create positive feelings toward the products it sells. Social marketing applies these concepts to issues of public concern. This field has been relatively untapped by social scientists and by the energy efficiency community in general.

Work on promoting energy efficiency through social networks and consideration of non-financial motives, when followed to its intellectual end, leads to the taboo issue of lifestyles. It is possible, however, to tackle lifestyle without the promotion of "blame" (e.g., with negative messages or the use of guilt about current consumption levels). Nor does it require a sacrifice in quality of life. As Lutzenheiser noted, Japan and Western Europe are about twice as energy efficient as the United States with similar quality of life. He noted that while settlement patterns have much to do with this, they are not the only cause (1992). Those settlement patterns are themselves lifestyle related and the promotion of resource-conserving, energy-efficient settlement patterns represents a growing, albeit minority, movement in community development and planning.

Finally, some “loose ends” were revealed in this literature review. Some may be rectified by further review of work already completed. Others are indicative of gaps in social science research on energy. These “loose ends” include:

- Psychologically based work has not been pursued to a clear intellectual conclusion. The results of attitude studies, for example, are inconclusive. While it is unlikely, based on results to date, that in fact a single model of behavior can be created, a better understanding of the relationship between attitudes and behavior would greatly enhance programs such as information and communications campaigns. Stern and Aronson’s (1984) five views of energy consumers are an even more promising and under-explored approach to organizing behavior.

- Exploration of folk models of energy has been limited to a few profound examples such as thermostats and energy bills. More recent work by Kempton, Boster, and Hartley (1995) indicated that folk models exist in a myriad of related areas such as nature, weather, and climate. Undoubtedly, folk models exist outside of the residential sector. Discovering these models and applying them to more targeted programmatic efforts is a major area of opportunity.

- The diffusion of innovation model is one that appears to warrant further exploration, particularly regarding its usefulness in guiding program development. Related work by EPRI warrants further review. However, the model appears to have been underexplored in terms of its *a priori* application to program design.

- Work to improve the quality and comprehensiveness of mass information program evaluations is needed in order to more accurately establish their potential. Additionally, the literature on mass media programs offers some guiding principles; it is unclear whether these have been considered or applied to current programs. Finally, it is worth considering whether the existing media and communications campaigns are broad enough in scope. For example, are sufficient messages being communicated to engender a broad pro-conservation ethic?

- Interactive information strategies such as the use of feedback and models may warrant a revival. A clearer sense of the extent to which these models are currently being used would be a first step. These programs achieved substantial savings but appear to have gone out of style. One intriguing approach to using a model is the creation of a national “symbol,” as has been done by other environmental communities.

- Most of the work of social scientists has focused on the residential sector. Additional exploration of the decisionmaking paradigms of businesses and the commercial and industrial sector is desperately needed for a market transformation paradigm to succeed. The literature on organizational decisionmaking, which was not reviewed for this report, is a good place to start.

- The social and cultural context of energy and related equipment needs to be addressed. Rather than beginning from the assumption that technologies and infrastructures are developed in a linear fashion and in response to consumer demand, such research would consider the impacts of changes in lifestyle and the organization of energy systems to garner savings.

- The role of non-financial incentives in mobilizing the human factor for energy efficiency has been underutilized. Lessons from social marketing may be of relevance for developing strategies in this arena.

In conclusion, the lessons from years of social science research are of value in improving programs to promote energy efficiency. More broadly, the literature contains much wisdom on strategies to achieve the ultimate goal of using less energy and avoiding climate change. The social science, evaluation, program implementer, and policymaking communities have worked together somewhat sporadically over the years. However, renewed interest in such collaboration has emerged. The ultimate objective of this report is to strengthen and re-energize such coordinated and interdisciplinary work in order to achieve more significant and lasting energy savings.

REFERENCES

Ajzen, I. and M. Fishbein. 1980. *Understanding Attitudes and Predicting Social Behavior.* Englewood Cliffs, N.J.:. Prentice Hall, Inc.

Archer, D., T. Pettigrew, M. Costanzo, B. Iritani, I. Walker, and L. White. 1987. "Energy Conservation and Public Policy: The Mediation of Individual Behavior." In *Energy Efficiency: Perspectives on Individual Behavior*. Washington, D.C.: American Council for an Energy-Efficient Economy.

Bettman, James R. 1979. *An Information Processing Theory of Consumer Choice*. Reading, Mass.: Addison-Wesley Publishing Company, Inc.

Collins, N.E., L.G. Berry, R.B. Braid, D.W. Jones, C.R. Kerley, M. Schweitzer, and J.H. Sorensen. 1985. *Past Efforts and Future Directions for Evaluating State Energy Conservation Programs.* ORNL-6113. Oak Ridge, Tenn.: Oak Ridge National Laboratory.

Costanzo, M., D. Archer, E. Aronson, and T. Pettigrew. 1986. "Energy Conservation Behavior: The Difficult Path from Information to Action." *American Psychologist* 41: 521-528.

Darley, John M. 1978. "Energy Conservation Techniques as Innovations and Their Diffusion." In *Saving Energy in the the Home: Princeton's Experiments at Twin Rivers*, edited by R.H. Socolow. Cambridge, Mass.: Ballinger Publishing Company.

de Jongh, P. and S. Captain. 1999. *Our Common Journey: A Pioneering Approach to Cooperative Environmental Management.* London, England: Zed Books.

duPont, Peter T. 1998. "Energy Policy and Consumer Reality: The Role of Energy in the Purchase of Household Appliances in the US and Thailand." Ph.D. Dissertation. Newark, Del.: University of Delaware.

Egan, C. 1999. *Comparative Energy Information and Its Potential in Promoting Residential Energy Efficiency.* Washington, D.C.: American Council for an Energy-Efficient Economy.

Farhar, Barbara C. 1993. *Trends in Public Perceptions and Preferences on Energy and Environmental Policy*. NREL/TP-461-4857. Golden, Colo.: National Renewable Energy Laboratory.

———. 1996. *Energy and Environment: The Public View*. Washington, D.C.: Renewable Energy Policy Project.

Feldman, Shel. (Shel Feldman Management Consulting). 1999. Personal communication. October.

Geller, H. 1988. "Lessons from Utility Experimentation with Appliance Efficiency Incentive Programs." In *Proceedings of the 1988 ACEEE Summer Study on Energy Efficiency in Buildings*. Washington, D.C.: American Council for an Energy-Efficient Economy.

Geller, H. and S. Nadel. 1994. "Market Transformation Strategies to Promote End-Use Efficiency." *Annual Review of Energy and Environment* 19: 301-346.

Goldstone, Seymour. 1995. "Restructuring: A Stimulus to Improving Utility DSM, How Economists Might Help." Presented at the Western Economic Association's 70th Annual Conference, San Diego, Calif.

Goldstone, Seymour. 2000. "Memorandum: Feedback on Draft Paper *The Application of Social Science to Energy Conservation: Realizations, Models and Findings*." Submitted to Christine Egan. February 4.

Hewitt, D., J. Pratt, and G. Smith. 1998. "A Second WashWise Market Progress Evaluation Report." Prepared for The Northwest Energy Efficiency Alliance. Portland, Ore.

Hodgoson, Geoffrey M. 1997. "The Ubiquity of Habits and Rules." *Cambridge Journal of Economics* 21: 663-684.

Katzev, Richard D. and Theodore R. Johnson. 1983. "A Social-Psychological Analysis of Residential Electricity Consumption: The Impact of Minimal Justification Techniques." *Journal of Economic Psychology* 3: 267-284.

Kempton, Willett. 1986. "Two Theories of Home Heat Control." *Cognitive Science* 10: 75-90.

Kempton, Willett, James S. Boster, and Jennifer A. Hartley. 1995. *Environmental Values in American Culture*. Cambridge, Mass.: MIT Press.

Kempton, Willett and L. Layne. 1994. "The Consumer's Energy Analysis Environment." *Energy Policy* 22: 857-866.

Kempton, Willett and L. Montgomery. 1982. "Folk Quantification of Energy." *Energy* 10: 817-827.

Komor, Paul and Willett Kempton. 1991. "Maybe Somebody Forgot to Turn the Chiller On: Energy Information and Behavior in Small Businesses." *Environmental Systems* 20: 111-127.

Komor, Paul and Lyna Wiggins. 1988-89. "Energy Conservation Behavior: A Critique of the Cost-Minimization Model and a Review of Some Alternative Models." *Journal of Environmental Systems*, 18 (1).

Lutzenheiser, L. 1992. "A Cultural Model of Household Energy Consumption." *Energy* 17:47-60.

———. 1993. "Social and Behavioral Aspects of Energy Use." *Annual Review of Energy and Environment* 18: 247-289.

Macey, Susan M. and Marilyn A. Brown. 1983. "Residential Energy Conservation: The Role of Past Experience in Repetitive Household Behavior." *Environment and Behavior* 15: 123-141.

Mast, Bruce. 1999. "Why Can't We All Just Get Along? A Reconciliation of Economic and Innovation Diffusion Perspectives of Market Transformation." Energy Program Evaluation Conference, Denver, Colo.

Moezzi, Mithra. 1998. "The Predicament of Efficiency." In *Proceedings of the 1998 Summer Study Proceedings on Energy Efficiency in Buildings.* Washington, D.C.: American Council for an Energy-Efficient Economy.

Payne, Christopher. 2000a. "Utility Bill Comprehension in the Commercial and Industrial Sector: Results of Field Research." In *Proceedings of the 2000 Summer Study on Energy Efficiency in Buildings.* Washington, D.C.: American Council for an Energy Efficient Economy.

Payne, Christopher. 2000b. Email Communication submitted to Christine Egan. January 31.

Rogers, Everett M. 1995. *Diffusion of Innovations.* 4th Edition. New York, N.Y.: Free Press.

Rosa, Eugene A., Gary E. Machlis, and Kenneth M. Keating. 1988. "Energy and Society." *Annual Review of Sociology*. 14: 149-172.

Seligman, C., John M. Darley, and Lawrence J. Becker. 1978. "Behavioral Approaches to Residential Energy Consumption." In *Saving Energy in the Home: Princeton's Experiments at Twin Rivers,* edited by R.H. Socolow. Cambridge, Mass.: Ballinger Publishing Company.

Seligman, C., D. Hall, and J. Finegan. 1983. "Predicting Home Energy Consumption: An Application of the Fishbein-Ajzen Model." *Advances in Consumer Research.*

Shove, E., L. Lutzenheiser, B. Hackett, and H. Wilhite. 1998. "Energy and Social Systems." In *Human Choice and Climate Change,* edited by S. Rayner and E.L. Malone. Columbus, Ohio: Battelle Press.

Shugoll Research. 1999. "A Focus Group Study to Assess Consumer Reaction to the Current FTC Energy Guide Label." Washington, D.C.: Prepared for the American Council for an Energy-Efficient Economy.

Socolow, Robert H. 1978. "The Twin Rivers Program on Energy Conservation in Housing: Highlights and Conclusions." In *Saving Energy in the the Home: Princeton's Experiments at Twin Rivers*, edited by R.H. Socolow. Cambridge, Mass.: Ballinger Publishing Company.

Stern, Paul. 1992. "What Psychology Knows about Energy Conservation." *American Psychologist* 47: 1224-1232.

———. 1984. "Energy and Behavior: What Have We Learned? In *Families and Energy: Coping with Uncertainty*, Conference Proceedings, 39-48, edited by Bonnie Maas Morrison and Willett Kempton. Michigan State University, College of Human Ecology, Institute for Family and Child Study.

Stern, Paul C. and E. Aronson. 1984. *Energy Use: The Human Dimension*. New York, N.Y.: W.H. Freeman and Company.

Stern, Paul C., E. Aronson, John M. Darley Daniel H. Hill, E. Hirst, W. Kempton, and Thomas J. Wilbanks. 1985. "The Effectiveness of Incentives for Residential Energy Conservation." *Evaluation Review* 10: 147-176.

Stern, Paul and Gerald Garnder. 1981. "Psychological Research and Energy Policy." *American Psychologist* 36 (4): 329-342.

Stern, Paul and S. Oskamp. 1987. "Managing Scarce Environmental Resources." In *Handbook of Environmental Psychology*. Edited by D. Stokols and I. Altman, 28: 1043-1088. New York, N.Y.: Wiley Press.

Triandis, H.C. 1975. "Cultural Training, Cognitive Complexity, and Interpersonal Attitudes." In *Cross-Cultural Perspectives on Learning*, edited by R.W. Brislin et al., 39-77. Beverly Hills, Calif.: Sage.

Williamson, O.E. 1985. "The Economic Institutions of Capitalism." Chap. 8 in *Contractual Man*, 43-63.

Wilhite, H. and R. Ling. 1995. "Measured Energy Savings from a More Informative Energy Bill." *Energy and Buildings* 22: 145-155.

Yates, Suzanne and E. Aronson. 1983. "A Social Psychological Perspective on Energy Conservation in Residential Buildings." *American Psychologist* 435-444.