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Dimensions of Conservation: Exploring Differences Among Energy Behaviors

Beth Karlin[1], Nora Davis[1], Angela Sanguinetti[1], Kristen Gamble[1], David Kirkby[1], and Daniel Stokols[1]

Abstract

Residential energy conservation is among the most efficient means of reducing emissions, yet behavior is lagging behind this potential, suggesting this is an area where psychology can contribute. Research suggests that conservation behaviors may cluster into distinct *dimensions*, and a greater understanding of these differences could improve intervention. This article explores this idea through systematic literature review and analysis of survey data. Content analysis of 28 articles showed strong support for two primary dimensions (curtailment and efficiency), with up to nine defining attributes. However, analysis also identified inconsistencies, leaving questions about their validity. Factor analysis of survey data identified two principal components along these dimensions; subsequent analyses revealed several differences in their predictors. Results provide support for a dimensional approach and suggest further research into underlying attributes. Although the curtailment versus efficiency dichotomy may be useful, it also has the potential to obscure high leverage maintenance behaviors, especially for renters.

Keywords

residential, energy, conservation, pro-environmental behavior, psychology

[1]University of California, Irvine, USA

Corresponding Author:
Beth Karlin, University of California, 202 Social Ecology I, Irvine, CA 92697-7075, USA.
Email: bkarlin@uci.edu

Introduction

Scientists and elected officials agree that human-induced climate change, with a focus on the combustion of fossil fuels to create electricity, is an issue that can no longer be ignored (IPCC, 2007; United Nations, 1992). Household energy conservation has been identified as an efficient and effective means of reducing emissions, with roughly 25% potential savings in the United States using currently available technology, yielding up to US$300 billion in gross energy savings through 2020. These changes can be made in the immediate term, without economic sacrifice or loss of well-being on the part of consumers (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009; Gardner & Stern, 2008). This savings potential, or "behavioral wedge," provides "both a short-term bridge to gain time for slower-acting climate mitigation measures and an important component of a long-term comprehensive domestic and global climate strategy" (Dietz et al., 2009, p. 18455). Although a variety of energy conservation actions are technically and economically viable, widespread adoption is lagging and policy makers are increasingly looking to psychologists for guidance (Lutzenhiser, 2009; Wilson & Dowlatabadi, 2007).

Traditional approaches to understanding and promoting conservation behavior have discussed energy use as either a holistic "behavior," suggesting that people "conserve energy" as if it were a single action, or focused on individual actions, and promoted them one at a time. Some psychologists have argued for the former, saying that proenvironmental behavior should be viewed and studied as an aggregate, undifferentiated construct rather than as a set of multiple distinct behaviors (Kaiser, 1998; Kaiser & Gutscher, 2003; Oskamp, 2000). The term *energy conservation*, however, encompasses a diverse set of specific behaviors, including those related to lighting, laundry, heating/cooling, and use of electronic devices. Even within a subset of actions, such as lighting, one can differentiate between turning off lights when leaving a room, installing energy-efficient lighting, or setting light timers. Because these behaviors can vary widely in terms of their relative financial cost, effort, and the knowledge required for implementing them, effective intervention strategies targeting these behaviors may also vary considerably.

The second approach, focusing on individual behavior, addresses the variation in behavioral context, but also has potential drawbacks. Possible negative outcomes of promoting individual energy behaviors include information overload, single action bias, and rebound effect. According to a growing body of literature, information is only positively correlated with performance to a certain point; beyond this point, people find it hard to identify relevant information and decision accuracy is reduced, a phenomenon known as information overload (Eppler & Mengis, 2004). In the case of energy conservation, this suggests that after a certain point, individuals are less likely to respond to messages promoting individual behaviors. A "single action bias" occurs when people respond to a need (e.g., climate change) by making just one corrective action and the feeling of having taken that single action actually deters future action (Weber, 2006). Of even more concern is the potential for a "rebound effect," whereby, after taking an action to increase energy efficiency, individuals may offset the environmental gain through increased use (Berkhout, Muskens, & Velthuijsen, 2000).

Understanding distinctions among hundreds of potential energy conservation behaviors is essential for developing effective interventions, but it may not be practical or even possible to take into account the specific circumstances and motivations underlying each relevant behavior when designing an intervention. Although a focus on "conserving energy" may be too broad to be effective, a focus on singular behaviors may be too specific to be efficient. A third possible approach promotes the differentiation of behaviorally distinct categories, or *dimensions*, of energy conservation behavior. This study, therefore, defines *dimensions* of behavior as conceptual distinctions at a level broader than discrete behavior, but more specific than the broad construct of "energy conservation."

This article explores the validity and use of *dimensions* of energy conservation through systematic literature review and statistical analysis of survey data. Its goals are twofold: (a) to conduct a systematic review and content analysis of past literature on energy conservation behaviors, identifying common dimensions, attributes, and predictive profiles, and (b) to evaluate previously hypothesized dimensions statistically through principal components analysis and an exploratory assessment of the differential predictive profiles of emergent dimensions.

Systematic Literature Review

Behavioral dimensions can be derived deductively based on characteristics of the behaviors themselves or they can be derived inductively through statistical testing based on self-report data. Recent research has focused on two main dimensions, generally referred to as curtailment and efficiency (Attari, DeKay, Davidson, & Bruine de Bruin, 2010; Dietz et al., 2009; Gardner & Stern, 2008). These two dimensions are widely referenced, despite limited empirical support and ambiguities in the theoretical distinctions between them; questions remain about their validity and utility in understanding energy conservation behavior and a synthesis has been lacking. The following section presents such a synthesis of literature on behavioral dimensions of energy conservation.

Method

Previous literature on dimensions of energy conservation was systematically reviewed using content analysis, which is a method of inferring patterns and themes from text by creating categories and coding the text into those categories based on specified criteria (Krippendorff, 1980; Stemler, 2001). Relevant articles were identified via (a) keyword search in PsycINFO, JSTOR, Web of Science, and Google Scholar, (b) backward and forward search of highly relevant (cited) articles, and (c) recommendations from personal contacts (and anonymous reviewers). This search identified 28 articles, books, or chapters that defined and/or tested dimensions of energy conservation.

After all articles were compiled, the following data were extracted from each: (a) names of proposed dimensions, (b) definitions and attributes for each dimension, and (c) examples of behaviors included in each dimension. Following extraction, dimension names and definitions were analyzed using emergent coding (Haney, Russell, Gulek, & Fierros, 1998). Interrater reliability was acceptably high ($\kappa > .700$) for all variables on four randomly selected studies (14%). However, because the coding process involved some degree of subjectivity, all data were analyzed and coded by two study authors, and discrepancies were resolved through discussion. Emergent codes were then reviewed to identify key attributes of each behavioral dimension and were compared against one another to identify inconsistencies.

In addition, a subset of these articles was identified that statistically assessed the validity of proposed dimensions. For these articles, additional data extracted included (a) variables collected and tested, (b) type of test conducted, (c) scales/measures used for assessment, and (d) results of statistical analyses. These results were compared with one another to identify patterns and gaps in findings across studies.

Results

Dimensions. Of the 28 articles reviewed, 7 directly referenced previous studies' definitions and 18 presented unique categories or did not directly reference any previous work. Although the actual terminology varied significantly, similarities across the reviewed literature suggest two primary dimensions. Table 1 presents a list of all analyzed studies with their provided dimensions grouped by analysis.

Table 1. Dimensions of Conservation Behavior Identified in Previous Literature.

Study	"Curtailment"	"Efficiency"	Other
Abrahamse, Steg, Vlek, and Rothengatter (2005) (Gardner & Stern, 1996)	Curtailment	Efficiency	
Attari, DeKay, Davidson, and Bruine de Bruin (2010)	Curtailment	Efficiency	
Ayres, Raseman, and Shih (2009)	Nondurable	Durable	
Barr Gilg and Ford (2005)	Habitual	Purchase-related	
Black, Stern, and Elworth (1985) (Stern & Gardner, 1981)	Curtailment	Efficiency	Curtailment -Ambient temperature -Minor curtailments Efficiency -Capital investment -Low-cost improvement
Butler and Hope (1995)	Noninvestment	Investment	
Cialdini and Schultz (2003)	Repeated	One time	
Curtis, Simpson-Housley, and Drever (1984)	Practices	Measures	
Dietz, Gardner, Gilligan, Stern, and Vandenbergh (2009)	Daily use	Equipment	-Weatherization -Maintenance -Adjustment
Dillman, Rosa, and Dillman (1983)	Home adjustment	Conservation action	
Gardner and Stern (1996)	Curtailment	Efficiency	
Gardner and Stern (2008)	Curtailment	Efficiency	
Kempton, Harris, Keith, and Weihl (1984)	Curtailment	Investment	Management
Kempton, Darley, and Stern (1992) (Kempton et al., 1984)	Curtailment	Investment	Management
Lehman and Geller (2004) (Gardner & Stern, 1996)	Curtailment	Efficiency	
Macey and Brown (1983)	Repetitive	Nonrepetitive	
McKenzie-Mohr (1994)	Curtailment	Investment	Management
Nair, Gustavsson, and Mahapatra (2010)	Noninvestment	Investment measure	Investment -Building envelope -High investment
Oikonomou, Becchis, Steg, and Russolillo (2009)	Frugality	Efficiency	
Opinion Dynamics (2011a)	Energy efficiency measures	Conservation behaviors	Efficiency -High-cost actions -Low-cost actions Conservation -Equipment Maintenance -No-cost actions
Opinion Dynamics (2011b)	Measure installations	Behavioral changes	Measure installations -High-cost installation -Low-cost installation -Building envelope

(continued)

Table 1. (continued)

Study	"Curtailment"	"Efficiency"	Other
Poortinga, Steg, Vlek, and Wiersma (2003) (Gardner & Stern, 1996; Samuelson, 1990)	Behavioral	Technical	
Samuelson (1990)	Curtailment	Device adoption	
Schultz (2010)	Curtailment	One time	
Stern (1992b)	Direct energy use	Technology choices	Policy choices
Stern (1992a) (Kempton et al., 1992)	Daily use	Purchase	Management
Stern and Gardner (1981)	Curtailment	Efficiency	
Van Raaij and Verhallen (1983)	Usage-related	Purchase-related	Maintenance-related

Note: Previous articles referenced are indicated in parentheses.

In the first category, the terms *curtailment, adjustments, usage-related, practices, direct energy use, frugality, repeated, noninvestment, conservation, behavioral, habitual actions, daily*, and *nondurable* referred to frequent and/or low cost (or free) energy-saving behaviors. Although they generally require no financial outlay, many authors suggested they entail a cut back on amenities or comfort and must be repeated to continue energy savings. Examples of these behaviors include turning off lights, unplugging appliances, or reducing appliance usage. Energy conservation behaviors in this category are referred to as *curtailment behaviors* in this article, as it is the most commonly used term in past literature.

In the second dimension, the terms *efficiency, equipment, conservation, purchase-related, device adoption, technical/technology choices, measure installations, one-time, non-repetitive, investments*, and *durable* referred to infrequent structural changes and/or those requiring investments or purchases. These behaviors generally require a financial outlay but result in no loss of amenities with longer-lasting energy conservation effects. Examples include purchasing energy-efficient equipment or products (e.g., compact fluorescent light bulbs [CFLs], energy star appliances) or investing in structural or building envelope changes to the home (e.g., installing double-paned windows). Behaviors in this category are referred to as *efficiency behaviors* in this article, as it is the most commonly used term in past literature.

Analysis of the definitions provided revealed nine major attributes of these two behavioral dimensions. A full list of these attributes, with frequency of occurrence, is provided in Table 2. The two most common attributes were frequency and cost. Additional behavioral attributes identified in analysis

Table 2. Primary Attributes of Curtailment and Efficiency Behaviors.

Attribute	Curtailment	Efficiency
Frequency	Repetitive / Daily / Habitual (14)	Infrequent / One-time (15)
Cost	No and/or low-cost (12)	Requires financial investment (13)
Actions	Behavior / Usage / Practices (9)	Technical / Structural / Purchases (9)
Permanence	Reversible / Non-durable (4)	Long-term / Permanent / Durable (7)
Lifestyle	Loss of amenities/comfort (6)	No lifestyle changes (2)
Cognition	Subconscious / Little effort (2) Conscious / Reliant on volition (5)	Conscious / Require effort (4)
Impact	Less impact/savings (2)	Greater energy savings potential (5)
Population	Anybody can do it	Harder for renters / low-income (3)
Motivation	Saving energy / Moral (2)	Saving money / Rational (3)

Note: Number of occurrences in literature (above one) are indicated in parentheses.

include actions, permanence, lifestyle, cognition, impact, population, and motivation.

Some of the definitions and behaviors provided in conjunction with these dimensions, however, varied across studies. Within the attribute of cognition, for example, there appears to be disagreement. When discussing "curtailment" behaviors, Barr, Gilg, and Ford (2005), for example, contend that "habitual" actions require little cognitive effort, and Nair, Gustavsson, and Mahapatra (2010) refer to "non-investment" measures as subconscious habits. However, Dillman, Rosa, and Dillman (1983) emphasize that "adjustments" are reliant on human volition, and Van Raaij and Verhallen (1983) refer to "usage-related" behavior as conscious energy use. Similarly, the specific behaviors discussed in relation to curtailment and efficiency dimensions are inconsistent across studies. For example, Macey and Brown (1983) offered caulking as an example of what they call repetitive behavior, defined as "repeated actions sometimes accompanied by inexpensive purchases" (p. 123; consistent with curtailment), whereas Ayres, Raseman, and Shih (2009) characterize caulking as a "durable, one-time action" (p. 12; consistent with efficiency).

There was also a lack of operational definitions for the meaning of several attributes, such as the "conscious" and "subconscious" adjectives discussed above as features of curtailment and/or efficiency behavior. Another example is the concept of loss of amenities and comfort as characteristic of curtailment behavior, as it is possible that efficiency behaviors can also limit amenities and comfort (e.g., dissatisfaction with the quality of light provided by CFLs). There seems to be a great deal of subjectivity in identified attributes, as clear definitions of what constitutes a "conscious" or "subconscious" decision or a "loss of amenities" or "comfort" are not provided in the literature.

Although the dominant discourse has revolved around a dichotomy of energy conservation behavior, as discussed above, some researchers have proposed additional dimensions of energy conservation (see Table 1). Van Raaij and Verhallen (1983) suggested maintenance and operating behavior as a third category of energy-related behavior. Although their definition for purchasing behavior as "a one-time investment in energy saving" (p. 125) is quite similar to other authors' definitions of efficiency behavior, they contend that this third category is similar to efficiency in that it leads to greater energy savings than curtailment, but similar to curtailment in that "the behavioral costs may dominate the cost-benefit tradeoff" (p. 133). One year later, Kempton, Harris, Keith, and Weihl (1984) suggested a similar dimension, labeled management, describing these behaviors as similar to curtailment in that both "require changing behavior patterns and continuously maintaining the changed behavior" (p. 1216), but similar to efficiency in that they lead to greater energy savings than curtailment behaviors. In the nearly two decades since, however, only a few additional studies have proposed or referenced this dimension (Dietz et al., 2009; Kempton, Darley, & Stern, 1992; McKenzie-Mohr, 1994; Opinion Dynamics, 2011a; 2011b; Stern, 1992a), and none appear to have statistically assessed its validity. Echoed today is what Van Raaij and Verhallen noted in 1983—that research on this behavioral dimension is practically nonexistent. Examples of maintenance (or management) behavior include setting the thermostat back each night (McKenzie-Mohr, 1994) or maintaining the energy-efficient operation of furnaces (Stern, 1992a).

Researchers have also proposed subdimensions of both efficiency and curtailment (see Table 1). Proposed efficiency subdimensions include a distinction between high and low cost (Black, Stern, & Elworth, 1985; Opinion Dynamics, 2011a, 2011b; Nair et al., 2010) as well as for building envelope measures (Opinion Dynamics, 2011a, 2011b; Nair et al., 2010). For curtailment, Black et al. (1985) distinguished between regulating home temperature (e.g., setting one's thermostat) and minor curtailments, which they refer to as "energy services that might not be perceived as sacrifice" (p. 9).

Dietz et al. (2009) recently proposed a five-pronged categorization of energy conservation behavior, WEMAD (Weatherization, Equipment, Maintenance, Adjustments, and Daily behavior). The equipment and daily behavior categories most accurately fit into the previously discussed dimensions of efficiency and curtailment, respectively, with equipment defined as "purchases to upgrade the energy efficiency of household equipment" and daily behaviors defined as "frequently repeated actions maintained by habit or repeated conscious choice" (p. 18454). Weatherization, generally included in the efficiency dimension, refers to "one-time investments in energy-efficient building shells and equipment" (p. 18454) and is similar to building envelope discussed above (Nair et al., 2010). Maintenance and adjustments both fit into the maintenance/management dimension proposed above, with both defined as infrequent and low cost, but maintenance specifically defined as *low or no-cost* and maintained by *habit* and adjustments as *no-cost* and maintained *automatically*. Dietz et al. (2009) specifically discuss the need for greater refinement than curtailment and efficiency:

> W and E both involve adoption of equipment, but the equipment differs in the salience of product attributes other than energy savings and cost. A and D both involve changes in equipment usage but differ in the ease of maintaining emission reductions: adjustments made once maintain their effects automatically, but D behaviors must be repeated over and over to achieve their potential. (p. 18454)

This approach begins to suggest, as indicated above, that analyzing behaviors in terms of specific attributes may yield categorization beyond the binary construction of curtailment and efficiency.

Predictors. In addition to analyzing behavioral attributes, researchers can also test behavioral dimensions through statistical analyses of self-report data. Although many studies have investigated the predictors of residential energy conservation as a whole or individual energy conservation behaviors, very few have analyzed the predictive profiles of dimensions of energy conservation behaviors; those that have done so have focused primarily on the dimensions of *curtailment* and *efficiency*. Among them, only a small number of variables (primarily demographic) have been evaluated in multiple studies; Table 3 presents a review of these findings. Although consistent results across studies have been found for income and gender, findings for age and education have been inconsistent across studies. Some studies have investigated housing-related variables in relation to dimensions of energy conservation behavior (Black et al., 1985; Nair et al., 2010; Opinion Dynamics, 2011a, 2011b; Sardianou, 2007). Housing-related variables found to positively predict efficiency behavior include building age (Nair et al., 2010), home type (detached; Opinion Dynamics, 2011a, 2011b), homeownership, home size, and home occupancy (Black et al., 1985; Poortinga, Steg, Vlek, & Wiersma, 2003). Home size (Black et al., 1985) and home occupancy (Opinion Dynamics, 2011a, 2011b) were also found to predict curtailment behavior.

Several psychological variables have been examined to assess whether they predict curtailment and/or efficiency behavior. Psychological predictors of curtailment behavior include concern for the energy situation (Black et al., 1985)

Table 3. Demographic Predictors of Curtailment and Efficiency.

Variable	Study	Curtailment	Efficiency
Age	Black et al., 1985	Positive	—
	Nair et al., 2010	—	[a]
	Poortinga et al., 2003	—	Negative
	Cialdini & Schultz, 2003	Positive	Positive
	Opinion Dynamics, 2011a	Negative	—
	Opinion Dynamics, 2011b	Negative	—
Gender (Male)	Nair et al., 2010	—	—
	Poortinga et al., 2003	—	—
	Cialdini & Schultz, 2003	Positive	Positive
	Opinion Dynamics, 2011a	Positive	—
	Opinion Dynamics, 2011b	Positive	—
Education	Black et al., 1985	Positive	—
	Nair et al., 2010	Negative	Positive
	Poortinga et al., 2003	Negative	Positive
Income	Black et al., 1985	—	Positive
	Dillman et al., 1983	—	Positive
	Nair et al., 2010	Negative	Positive
	Poortinga et al., 2003	Negative	Positive
	Cialdini & Schultz, 2003	Positive	Positive
	Opinion Dynamics, 2011a	—	Positive

Note: A dash (—) indicates the variable was tested but no significant finding was reported.
[a]Relationship varied among different subdimensions of efficiency behavior.

personal and social norms (Black et al., 1985; Cialdini & Schultz, 2003), environmental concern (Poortinga et al., 2003), and both environmental and financial motivation (Cialdini & Schultz, 2003). Psychological predictors of efficiency behaviors include perceived personal benefits (Black et al., 1985), financial motivation (Cialdini & Schultz, 2003), perceived cost (Nair et al., 2010), the importance of reducing energy use (Nair et al., 2010), environmental protection (Cialdini & Schultz, 2003), and social and descriptive norms (Cialdini & Schultz, 2003). Each of these results, however, was found by only one study and further research is needed to validate the reported findings.

Much less is known about the predictive profiles of other hypothesized behavior dimensions. No previous research has assessed maintenance (management) for predictive validity and only two have statistically evaluated subdimensions of efficiency (Black et al., 1985; Nair et al., 2010). Both studies tested high-cost versus low-cost efficiency behaviors and Nair et al.

(2010) also tested building envelope behaviors as a separate dimension. Although both provided some empirical support for differential predictive profiles of these various subdimensions, specific findings were singular and methodology for categorization relied on percent reported (Nair et al., 2010) and reliability analysis (Black et al., 1985).

Conservation Behavior Survey

This limited research suggests that people may engage in energy conservation "dimensionally" and that these dimensions may indeed have different predictive profiles, but the behaviors and variables tested as well as the findings reported have not been consistent across studies, preventing clear conclusions from being drawn. With the increasing importance of energy conservation behavior, such a prevalence of disparate and/or unique findings suggests the need for further research. The current study extends on past studies in its scope of dimensions and variables tested in an effort to further understanding of these relationships.

Method

Participants and Procedures. Data were gathered through an online survey conducted in Spring 2010. Participants were recruited via several common online recruitment tools (email, Facebook, Craigslist, and professional listservs). Online sampling is still a relatively new method, though a number of studies have found that Internet samples are as diverse as more traditional samples and that their response rates and findings are consistent with traditional methods and generalizable across presentation formats (Gosling, Vazire, Srivastava, & John, 2004; Kaplowitz, Hadlock, & Levine, 2004; Smith, 1997).

Survey design was based on Dillman's (2007) Tailored Design Method in which progress indicators, multiple screens, and a simple layout were used to maximize survey completion. The survey took approximately 15 min to complete, and respondents were entered into a raffle for a US$50 gift certificate to Amazon.com. All respondents were asked to forward the survey via email to their own contacts after completion, and a reminder email was sent 30 days after the initial contact email to maximize survey completion.

Of 838 respondents, 540 (64.4%) completed the entire survey; analyses were performed on complete cases only (analyses with missing data were tested against complete cases and no significant differences were found). Table 4 presents summary data on demographic and housing characteristics for the survey sample compared with U.S. Census Bureau (2010). The table

Table 4. Demographic Characteristics of the Sample (N = 540) Compared With U.S. Census Data.

	Study sample	Census data	JPSP 2002 samples
Gender[a]	66.3% female	51.0% female	77% female
Age[a]	41.0 years	36.8 years	25.1 years
Race[a]	85.6% White	79.4% White	80% White
Marital status	54.6% married	51.3% married	—
Education[a]	17.4 years	13.3 years	—
Income[a]	US$96,083	US$67,609	—
Home occupancy	2.5	2.6	—
Homeownership	63.5% own	68.0% own	—

Note: JPSP = *Journal of Personality and Social Psychology*.
[a]Sample and census significantly different based on independent t test (p < .01).

also presents average reported gender, age, and race statistics for all correlational studies published in *Journal of Personality and Social Psychology* (JPSP) in 2002 (from Gosling et al., 2004). The sample, although not fully representative, proved sufficiently diverse to address the research questions proposed by the study.

As our sample was self-selected, we also tested for the hypothesis that it was more "environmental" than traditional samples. In their meta-analysis of the New Environmental Paradigm (NEP; the environmental measure used in the present study—see below), Hawcroft and Milfont (2010) found that white-collar samples and environmentalist samples scored significantly higher on the NEP than representative samples. To test for this, we conducted a t test of our NEP sample mean with those of other representative U.S. samples. Analysis revealed that our sample is significantly lower than an average of the environmentalist ($t = -3.73$, $p < .001$), and significantly higher than an average of the representative ($t = -9.78$, $p = .008$) and white-collar ($t = -2.67$, $p = .07$) population means.

Measures. Data analyzed in this study were collected as part of a larger residential energy survey, which was designed to address three major topics: (a) energy conservation behavior and its predictors, (b) perceptions of energy use, and (c) impressions and use of residential energy feedback devices. This article presents results from analyses of the first part of the survey (i.e., energy conservation behavior and its predictors) as well as demographic data, which were collected at the end of the survey. The variables examined in this study are described below.

Demographic variables. Demographic questions were included in the survey to determine the characteristics and representativeness of the sample and to test for relationships with energy conservation behaviors. Traditional demographic data included gender, age, race, marital status, income, and education. As the study was concerned with home energy behavior, two housing-related demographic variables were also included: homeownership (own vs. rent) and home occupancy (number of people in the home).

Psychographic variables. A series of questions was included to test for psychographic variables identified in previous research as predictive of curtailment or efficiency behavior. Questions were grouped within three general categories: environmental, financial, and social. Environmental concern was measured using an abbreviated (six-item) version of the NEP (Dunlap, Van Liere, Mertig, & Jones, 2000; Zelezny, Chua, & Aldrich, 2000). For financial considerations, a single dichotomous item measuring bill consciousness (adapted from Wiener & Doescher, 1994) was included. Social norms were tested with two items (Cialdini, Kallgren, & Reno, 1991); the first item measures descriptive norms (perceptions of how others behave) and the second measures injunctive norms (perception of what others approve. Finally, 3 two-item scales (adapted from on Nolan, Schultz, Cialdini, Goldstein, & Griskevicius, 2008) were included to measure environmental, financial, and social motivations to use and/or conserve energy. For all measures, questions were reverse-coded when needed to ensure that all responses scored in the same direction. Psychological survey items along with their means, standard deviations, and alphas are presented in Table 5.

Energy conservation behaviors. Eight items were included to measure engagement in energy conservation behavior. Specific behaviors were selected based on the literature review to test for previously hypothesized dimensions (see Table 6 for list of behaviors with descriptive statistics). Categorization into curtailment and efficiency was based on behavioral frequency, as this was the most common defining attribute of these dimensions. For frequent behaviors (e.g., curtailment), participants were asked how often they engaged in each action and a binary variable was created to indicate which curtailment behaviors each participant *always* performs (the table presents the percentage of people that report they always engage in the action). For infrequent behaviors (e.g., efficiency), participants were asked to indicate whether they had ever engaged in the action. Efficiency behaviors were chosen to test for the previously hypothesized subdimensions of high cost versus low cost, management versus purchase-related, and building envelope versus appliance behaviors.

Table 5. Means, Standard Deviations, and Alphas for Psychological Variables (N = 540).

Psychological variables	*M*	*SD*	α
Environmental			
Environmental concern[a]	4.10	.57	.71
1. Although there is contamination of our lakes, streams, and air, nature will soon return them to normal.[b]			
2. The balance of nature is very delicate and easily upset.			
3. People must live in harmony with nature to survive.			
4. Courses focusing on conservation of natural resources should be taught in the public schools.			
5. Because government rules are so effective, it is not likely that pollution will become too bad.[b]			
Environmental motivation[c]	2.82	.99	.80
1. How much does decreasing your environmental impact decrease your home energy use?			
2. How much does environmental impact affect your home energy use?			
Financial			
Bill consciousness[d]	.64	.48	–[e]
1. I pay close attention to my monthly energy bill.			
Financial motivation[c]	3.09	1.01	.74
1. How much does saving money on your energy bill decrease your home energy use?			
2. How much does cost of energy bill affect your home energy use?			
Social			
Social norms[a]			
1. Most people are not willing to make changes or sacrifices to protect the environment. (Descriptive)	2.66	1.02	–[e]
2. People in my community expect me to do my part to conserve energy. (Injunctive)	3.29	.99	–[e]
Social motivation[c]	1.84	1.01	.62
1. How likely is comparing your energy use to your neighbors' use to encourage you to decrease home energy use?			
2. How much does your neighbors' energy use affect your home energy use?			

[a]Scale ranged from 1 = *strongly disagree* to 5 = *strongly agree*.
[b]Item was reverse-coded.
[c]Scale ranged from 1 = *not at all* to 4 = *a great deal*.
[d]Binary variable normalized to a maximum of 1.
[e]Single-item scale.

Analysis. Analysis was conducted in three phases. First, factor analysis was performed on the eight energy conservation behaviors using oblimin rotation with Kaiser normalization to identify how behaviors grouped together empirically based on all of the survey responses. Next, outcome variables were created based on the results of factor analysis and a series of bivariate correlations were performed with the demographic and psychographic predictor variables to determine which variables may predict different dimensions of

Table 6. Conservation Behaviors With Percentage Reported and Hypothesized Dimensions.

		Hypothesized dimensions			
Item	%	E/C[a]	Hi/Lo[b]	M/P[c]	B/A[d]
Turn off lights when leaving rooms	49.1	C	—	—	—
Wait until dishwasher is full to run	77.6	C	—	—	—
Shut down appliances at night	30.7	C	—	—	—
Add insulation in home	33.1	E	Hi	P	B
Purchase an energy-efficient appliance	61.3	E	Hi	P	A
Switch to energy-efficient light bulbs	80.9	E	Lo	P	A
Check toilet tank for leaks	47.8	E	Lo	M	A
Check home for thermal leaks	21.1	E	Lo	M	B

[a]Efficiency (E) or curtailment (C).
[b]High cost (Hi) or low cost (Lo).
[c]Management (M) or purchase (P).
[d]Building envelope (B) or appliance (A).

energy conservation. Finally, hierarchical linear regression analyses were conducted to identify which variables were most predictive of the identified dimensions.

Results

Factor analyses. Factor analyses performed on the eight energy conservation behaviors yielded a two-component solution, which accounted for 42.8% of total variance (see Table 7). The three curtailment behaviors clustered strongly as one component and the five efficiency behaviors clustered strongly as another component, with no cross-loading variables. The correlation between the two components was $r = .119$. Neither the initial factor analysis nor a subsequent analysis performed with only the five efficiency behaviors revealed distinct components for high versus low cost, management versus purchase, or building envelope versus appliance efficiency behaviors.

Because none of the subdimensions emerged as distinct components in factor analysis, subsequent analyses focused strictly on identifying predictors for the two identified components of curtailment and efficiency. As such, two outcome variables were created, summing the number of efficiency and curtailment behaviors, respectively. Distribution characteristics of these variables were evaluated and all were found to be normally distributed with no

Table 7. Conservation Behavior Items and Factor Structure.

	Rotated factor loading	
Item	Efficiency	Curtailment
Turn off lights when leaving rooms	.033	**.710**
Wait until dishwasher is full to run	–.008	**.632**
Shut down appliances at night	–.009	**.660**
Add insulation in home	**.631**	.013
Purchase an energy-efficient appliance	**.721**	–.188
Switch to energy-efficient light bulbs	**.553**	–.034
Check toilet tank for leaks	**.671**	.082
Check home for thermal leaks	**.584**	.155
Explained variance	.26	.17

Note: Values in bold indicate which items load to each factor.

significant skewness or kurtosis, thus meeting the requirements for ordinary least squares regression.

Correlations. Bivariate correlations between the outcome behavior and predictor demographic and psychographic variables revealed different profiles for the curtailment and efficiency dimensions (see Table 8). The variables correlated with each were almost completely independent; only 1 of the 15 predictor variables (bill consciousness) significantly correlated with both curtailment and efficiency. Although bill consciousness was the only psychographic variable correlated with efficiency behavior, all but 2 demographic variables (race and home occupancy) were significant. A converse pattern was revealed for curtailment behavior; both of the environmental variables as well as bill consciousness correlated with curtailment, but only the 2 demographic variables of race and home occupancy were significant. Neither the three social variables (descriptive social norms, injunctive social norms, and social motivation) nor financial motivation was significantly correlated with either curtailment or efficiency behavior. As such, they were not included in any subsequent regression analyses.

A correlation matrix for all of the predictor variables did not reveal any problematic collinearity. The only correlation above .500 was between homeownership and age (r = .540). However, both were retained in the model, as they represent distinct demographic characteristics.

Regression analyses. A four-step regression model was utilized to further analyze the dimensions of efficiency and curtailment (see Tables 9 and 10, respectively). The predictor variables in the model explained a total of

Table 8. Bivariate Correlations of Predictor and Outcome Variables.

	Efficiency behaviors	Curtailment behaviors
Demographic—traditional		
Gender[a]	−.099*	.031
Age	.370***	−.012
Race[b]	.028	−.086*
Marital status[c]	.272***	−.077
Education	.107*	−.019
Income	.172***	−.052
Demographic—housing		
Home occupancy	−0.006	−.108*
Homeownership[d]	.425***	.004
Psychographic—environmental		
Environmental concern	.074	.171***
Environmental motivation	.074	.196***
Psychographic—financial		
Bill consciousness	.192***	.134**
Financial motivation	.030	.038
Psychographic—social		
Social norm—descriptive	.071	.002
Social norm—injunctive	.026	.079
Social motivation	−.008	−.002

[a]Binary variable coded as Female = 1, 0 = Male.
[b]Binary variable coded as 1 = White, 0 = non-White.
[c]Binary variable coded as 1 = married, 0 = not married.
[d]Binary variable coded as 1 = homeowner, 0 = renter.
*$p < .05$. **$p < .01$. ***$p < .001$.

26% of the variance in efficiency and 9.6% of the variation in curtailment behavior.

For efficiency behavior, demographic variables predicted 23.9% of behavior ($p < .001$). No significant additional explanation was provided by the environmental psychographic variables, but bill consciousness added 1.6% variance ($p < .01$). The final efficiency regression model explained 26.0% of the variance in behavior and significant predictor variables included gender, age, marital status, homeownership, and bill consciousness. Homeownership was the strongest single predictor of efficiency behavior.

For curtailment behavior, the demographic variables were not significant (contributing only 2.6% explanation), but the psychographic variables contributed 7% explanation to the model ($p < .001$). The final curtailment regression

Table 9. Multiple Regression (Standardized Betas) on Efficiency Behavior.

Variable	Model 1	Model 2	Model 3	Model 4
Demographic—traditional				
Gender	−.080*	−.107**	−.113**	−.103**
Age	.326***	.178***	.173***	.154**
Race	−.054	−.051	−.051	−.065
Marital status	.187***	.143**	.144**	.141**
Education	.035	.045	.038	.036
Income	−.032	−.101*	−.090	−.081
Demographic—housing				
Home occupancy		−.059	−.057	−.059
Homeownership		.322***	.319***	.315***
Psychographic—environmental				
Environmental concern			.034	.033
Environmental motivation			.056	.058
Psychographic—financial				
Bill consciousness				.131**
R^2	.176	.239	.244	.260
R^2 change	.176***	.063***	.005	.016**

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 10. Multiple Regression (Standardized Betas) on Curtailment Behavior.

Variable	Model 1	Model 2	Model 3	Model 4
Demographic—traditional				
Gender	.024	.013	−.005	.007
Age	.029	−.020	−.035	−.058
Race	−.085	−.093*	−.094*	−.110*
Marital status	−.067	−.042	−.041	−.044
Education	.040	.031	.010	.014
Income	−.034	−.038	−.004	.007
Demographic—housing				
Home occupancy		−.102*	−.096*	−.099*
Homeownership		.064	.054	.049
Psychographic—environmental				
Environmental concern			.106*	.104*
Environmental motivation			.165***	.167***
Psychographic—financial				
Bill consciousness				.154***
R^2	.015	.026	.073	.096
R^2 change	.015	.010	.047***	.023***

*$p < .05$. **$p < .01$. ***$p < .001$.

model explained 9.6% of the variance in behavior and significant predictor variables included race, home occupancy, environmental concern, environmental motivation, and bill consciousness. The strongest single predictor of curtailment behavior was environmental motivation, followed by bill consciousness.

Discussion

This study sought to assess both the theoretical and empirical validity of a dimensional approach to understanding, predicting, and promoting energy conservation behavior. The two sections that follow present a review of findings with discussion of implications for use of these dimensions and suggestions for future research.

Theoretical Validity of Behavioral Dimensions

A review of previous literature revealed significant support for the division of energy conservation behaviors into distinct dimensions, most notably into a two-factor structure often referred to as curtailment and efficiency. Although these two dimensions have been widely used for more than 20 years, several authors acknowledge that the distinction between efficiency and curtailment is not always clear (Black, Stern, & Elworth, 1985; Cialdini & Schultz, 2003; Curtis, Simpson-Housley, & Drever, 1984; Samuelson, 1990; Stern & Gardner, 1981) and analysis of reported definitions revealed several validity concerns.

These two dimensions are generally presented as a dichotomy but categorization is based on multiple variables that may not always covary. For example, forcing categorization into two categories based on just the two most commonly discussed attributes—frequency and cost—allows for only two groups of behaviors: (a) frequent, low-cost behaviors (curtailment) and (b) infrequent, high-cost behaviors (efficiency). Each of these dimensions, according to the literature, asks something of us: Efficiency behaviors ask us to spend money and curtailment behaviors ask us to give up comfort or amenities (even the term *curtailment* refers to constraint or reduction). For some, this presents a difficult choice between suffering on one hand and spending on the other hand, and for others (e.g., those with limited financial means), this categorization implies that the only choice available is one of curtailment.

However, as can be seen in Figure 1, such a two-factor categorization, even with just two levels per factor actually allows for up to four groups, or dimensions, of behavior. Although curtailment does fit into one of these cells (high frequency, low cost), as does efficiency (low frequency, high cost), there are two additional potential dimensions of behavior (high frequency,

	Low Frequency	High Frequency
Low Cost	Maintenance	Curtailment
High Cost	Efficiency	(n/a)

Figure 1. Dimensions of energy conservation by frequency and cost.

high cost and low frequency, low cost). Although we could not identify any high frequency, high-cost behaviors (nor do they seem useful for the majority of energy consumers), there are several examples of behaviors—such as replacing light bulbs or cleaning the coils behind one's refrigerator—that are low frequency and low cost. These behaviors are consistent with previous definitions of management and/or maintenance and may be "best of both world" behaviors, such that they require neither significant spending nor suffering the curtailment of amenities.

It is important to note that this figure is not meant to represent a comprehensive categorization of all energy conservation behaviors. Cost and frequency could be viewed as a continuum with more than two levels or even as continuous variables (e.g., cost in dollars or frequency in number of occurrences per year), which could expand the number of behavioral dimensions. Likewise, the addition of the other seven attributes would also increase the potential number of dimensions. This figure is provided as a starting, rather than an ending point, an example provided to emphasize the complexity of these behaviors and the danger of dichotomizing them without careful attention to how they vary.

However, as evidenced by the example above, not all possible iterations within a factorial matrix are logical when looking for dimensions by attribute. If we included all nine attributes identified from content analysis with all potential iterations (even with only two levels per attribute), the resulting matrix would allow for up to 512 (2^9) dimensions, which may be more than the total number of possible energy conservation behaviors in the home. It is important to derive dimensions based on an analysis of attributes analyzed in terms of the behaviors themselves; such an approach allows for complexity without being constrained by it. Further research is needed to integrate multiple attributes into a reliable typology of behavioral dimensions that are mutually exclusive and mutually exhaustive. This study provides an important first step in identifying attributes from previous research and exploring their definitions and inconsistencies.

As such, similar issues of nonexclusivity may arise with other combinations of attributes, such as nonpermanent purchase behaviors or adjustment behaviors that result in loss of amenities. For dimensions to be reliably used, it is vital that behaviors can be reliably categorized within them. It appears that the dimensions of curtailment and efficiency are neither clearly defined nor mutually exclusive based on the definitions provided across studies. Although such concerns were introduced by various researchers in the 1980s and 1990s (e.g., Kempton et al., 1984; McKenzie-Mohr, 1994; Stern, 1992a; Van Raaij and Verhallen, 1983), very few have voiced them in recent years (e.g., Dietz et al., 2009), and none have attempted an approach that focuses on deriving dimensions based on a systematic analysis of behavioral attributes. Such an approach would enable accurate definitions that can be used widely and consistently across behaviors. At the very least, current findings strongly suggest the inclusion of at least one additional dimension of maintenance behaviors based on the two most frequent behavioral attributes (frequency and cost).

Statistical Validity of Behavioral Dimensions

Although theoretical questions about these two dimensions remain, statistical analysis suggests that individuals may *engage* in conservation behaviors in a way that is consistent with the dimensions of curtailment and efficiency. Statistical testing of energy conservation behavior did validate two unique dimensions for curtailment and efficiency behaviors (with maintenance behaviors included in the "efficiency" dimension), confirming previous findings by Barr et al. (2005). Subdimensions for management versus purchasing, high cost versus low cost, and building envelope versus appliance did not emerge as distinct. This could be due to the relative importance of certain attributes (e.g., frequency) in predicting conservation behavior. Management behaviors (which are generally infrequent and inexpensive) clustered as efficiency, implying that frequency (more than cost) may affect choice of conservation behaviors. As discussed previously, attributes such as cognition and lifestyle are not sufficiently operationalized to allow for related behaviors to be properly categorized among these dimensions, which make evaluating or testing them beyond the scope of this study.

Bivariate correlations revealed distinct profiles for curtailment and efficiency behavior, such that demographic and housing variables were primarily correlated with efficiency behavior, whereas environmental attitudes and motivation variables were primarily associated with curtailment behavior. This supports the suggestion made by Oikonomou, Becchis, Steg, and Russolillo (2009) that curtailment behavior may be related to a moral model of behavior and efficiency to a rational model. The final predictive models used explained 26% of the variance in efficiency behavior and 10% of the variance in curtailment behavior. These figures are consistent with previous regression models of energy conservation dimensions (R^2 of 10%-11% for high-cost efficiency, low-cost efficiency, and curtailment in Black et al., 1985; R^2 of 28% for curtailment and efficiency behavior in Cialdini & Schultz, 2003), but the disparity between the total predictive ability of the models is unique. The specific findings for each identified dimension are discussed below.

Efficiency. Demographic variables accounted for nearly a quarter of the variance in efficiency behavior, with little additional variance explained by psychographic variables. As efficiency behaviors largely involve structural or technical changes as well as financial outlays, this is an expected result and is consistent with one interpretation of the attribute—cost—of efficiency. However, the efficiency scale used in this study was designed to include nonstructural no-cost and low-cost behaviors (i.e., checking toilet tanks for leaks, checking for thermal leaks, installing CFL light bulbs) suggesting that some of these contextual barriers may be more psychological than logistical (e.g., perceived compared with actual ability). Further research testing this relationship might suggest new avenues for promoting efficiency behaviors across a wider variety of individuals than those currently engaging in them.

Possibly related to this is the strong relationship between homeownership and efficiency behavior. Homeownership was the strongest single predictor of efficiency behavior by a factor of two and significantly reduced the effects of age and marital status in the first step of the model. Black et al. (1985) also found homeownership to be a significant predictor of efficiency behavior, attributing the relationship to the association between renting and low-income with concomitant logistic and financial constraints. This explanation is less satisfactory for the present findings as the efficiency scale included no-cost and low-cost behaviors. Further exploration of psychological barriers for renters (e.g., low sense of agency, control, and efficacy) in relation to one's home may suggest new avenues for research as well as interventions focused on promoting no-cost and low-cost efficiency behaviors to renters.

Another interesting relationship between the demographic and housing variables in the efficiency results relates to income, which is a strong unique predictor of efficiency behavior at the bivariate level (see Table 8), but negatively and not significantly correlated when controlling for other traditional demographic variables (see Table 9, Model 1), and significantly negatively correlated when controlling for housing variables in the regression model (see Table 9, Model 2). Previous studies (Dillman et al., 1983; Poortinga et al., 2003) found a positive relationship between income and efficiency behavior, but Black et al. (1985) statistically identified homeownership as a potential mediator for this relationship. These findings suggest that other demographic variables (e.g., marital status, age) may also strongly influence the relationship between income and efficiency behavior and the change in direction (from positive to negative) strongly calls for future investigation of this relationship.

Curtailment. Psychographic variables accounted for about a 10th of variation explained in the curtailment model, whereas demographic variables alone explained very little variation and did not significantly predict curtailment behavior. This makes sense, as curtailment behaviors are less constrained by contextual factors (e.g., cost, home structure) and therefore are more likely to be influenced by attitudinal differences. Race, consistent with Opinion Dynamics results (2011a, 2011b), and home occupancy were the only demographic variables that significantly predicted curtailment behavior. Home occupancy was negatively related to curtailment behavior, though it has previously been found to be positively related to efficiency behavior (Black et al., 1985). Contrary to previous findings (Poortinga et al., 2003), education and income were not related to curtailment behavior.

Environmental concern and motivation had a greater influence on curtailment than efficiency behaviors. A possible explanation for this finding relates to the ease of engaging in curtailment (vs. efficiency) behaviors. These findings support Stern's (2000) suggestion for further attention to the distinction between attitudes and habits as causes of proenvironmental behavior as it relates to the dual-process model that distinguishes "between conscious and effortful behaviors and automatic or associative ones" (p. 419).

Policy Implications

Understanding dimensions of energy conservation has implications for what types of interventions may be most suitable for different behaviors as well as for different types of individuals. The finding that bill consciousness predicts both curtailment and efficiency behavior is especially relevant to current policy and practice in energy conservation. The provision of energy feedback has been widely promoted in recent years as a promising strategy to promote energy conservation (see Darby, 2006, and Fischer, 2008, for review) because it is based on the idea that increased awareness of the amount of energy being used (and the associated cost of that energy) will lead to more efficient use of energy. The finding that price consciousness predicts curtailment and efficiency suggests the potential of feedback as a conservation strategy that can be used effectively across both of these dimensions of behavior.

Although the use of feedback may be useful in targeting curtailment and efficiency behavior, this study suggests that other common intervention strategies, such as moral and informational appeals, will be differentially effective. Evidence suggests that highlighting the environmental benefits of engaging in conservation behavior may be more effective in reminding people to engage in curtailment behaviors, whereas appeals focused on overcoming real and/or perceived barriers to behavior (e.g., cost, self-efficacy) may be more effective in promoting efficiency behaviors.

Despite the empirical findings, the literature review exposed severe flaws in the widespread use of the curtailment versus efficiency distinction. Most notable is the omission of maintenance behaviors, which are infrequent and inexpensive, making them ideal for many energy consumers. Although promoting energy conservation in terms of behavioral dimensions may have clear benefits over either a holistic or a behavior-specific approach, it is important that dimensions are promoted in a way that is clear and that maximizes conservation behavior.

Limitations

The sampling technique and measurement of key variables used in the conservation behavior survey may limit the generalizability of its findings. As discussed in the "Method" section, online sampling is still a relatively new method, though studies have found diversity and findings to be consistent with more traditional samples (Gosling et al., 2004; Kaplowitz et al., 2004; Smith, 1997).

The length of the psychological scales may also constitute a study limitation. The survey included a 6-item subscale from the NEP scale. The complete scale has 15 items, but this subscale was previously tested for reliability by Zelezny et al. (2000) and has been used successfully (Hawcroft & Milfont, 2010). Environmental, financial, and social motivation were all measured with a 2-item scale, and price consciousness as well as descriptive and injunctive social norms were measured as single items. Although more robust measure may be desirable, an investigation of similar studies within the energy conservation behavior literature reveals a precedent for studies measuring such attitudes with as little as one item (e.g., Barr et al., 2005; Sardianou, 2007).

Finally, there was some noncompletion of survey items, particularly in the demographic section. This could be due to participants' preferences regarding disclosure of personal information or a potential fatigue effect, as demographics were presented at the end of the survey. Noncompletion was a problem for one behavior item, running a full dishwasher, likely among those participants who did not own a dishwasher. Analyses were run using a listwise and pairwise deletion with no significant differences between results therefore all final analyses were conducted with complete cases only.

Conclusion

These findings both synthesize and extend previous work in this area and also suggest future research and policy applications. Empirical findings support residential energy feedback as a universally effective strategy and indicate that policies aimed at addressing contextual constraints and promoting efficacy may encourage efficiency behavior, whereas programs designed to promote environmental motivation may increase curtailment behavior. However, theoretical analysis revealed key inconsistencies with the currently prevalent dimensions of curtailment and efficiency as well as potential practical and ethical concerns with their continued use. Further research is needed to tease out the important behavioral attributes of energy conservation behaviors, both individually and within broader dimensional constructs, and to better understand their predictive profiles. Such analysis may lead to the development of energy conservation dimensions that are simultaneously theoretically valid, empirically predictive, and most importantly, practically useful.

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*Indicates that the article was included in the content analysis.

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Author Biographies

Beth Karlin is founding director of the Transformational Media Lab within the Center for Unconventional Security Affairs at the University of California, Irvine. Her research interests include psychological dimensions of energy conservation, technology-enabled feedback, and film-based social action campaigns.

Nora Davis is a graduate student in social ecology at the University of California-Irvine. Her primary research area is environmental psychology though the motivation of environmental behavior, and the relationship between transcendent experiences in different environments and value salience.

Angela Sanguinetti received her PhD in planning, policy, and design at University of California, Irvine with an emphasis in design-behavior research. Her research interests include cohousing and other strategies for promoting personal and collective well-being through residential environments.

Kristen Gamble, MA, is a social ecology PhD student at the University of California, Irvine. Her research focuses on resource management in society, with a primary interest in disaster stricken areas.

David Kirkby is a professor of physics and astronomy at the University of California, Irvine. His research interests include the design of energy consumption monitoring and feedback devices. He also conducts observational studies to improve our understanding of dark matter and dark energy in the universe.

Daniel Stokols is chancellor's professor of social ecology at the University of California, Irvine. His research interests include environmental psychology and environmental design, social ecological approaches to improving public health, and the study of collaborative processes and outcomes in transdisciplinary action research teams.