Exploring Deep Savings: A Toolkit for Assessing Behavior-Based Energy Interventions

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ABSTRACT

While research assessing behavior-based energy interventions shows great promise, results vary widely and much is still unknown about the specific variables that impact program effectiveness. As utilities and regulatory agencies focus more attention on behavior-based energy interventions, it becomes critical to ensure that evaluations of such programs are rigorous and accurate. While the metric used to measure *whether* these various programs work (kWh) is fairly standard and easy to compare between studies, the metrics used to measure *how* and *for whom* they work have been left to individual researchers and evaluators. Standardization of assessment methods is common in related fields such as education and psychology, but has yet to take hold in energy program evaluation. This paper argues for a more systematic and comprehensive approach to the evaluation of behavior-based energy interventions, and describes a preliminary toolkit that is currently being developed and validated in conjunction with the International Energy Agency Demand Side Management Programme (IEA-DSM) Task 24 on Behavior Change as well as two large investor-owned utilities. Our approach is informed by theories and empirical research on behavior change as well as a content analysis of 85 behavior-based energy interventions. It includes questions on: context (demographics), user experience (ease of use, engagement), material culture (what people have), energy practices (what people do), and beliefs around energy use (what people think). Sample items for each construct and suggestions for implementation are presented. Broad use of such an instrument can improve and aggregate our overall knowledge across the countless additional studies expected to be conducted in the coming years.

Introduction

Household behavior has been identified as an efficient and effective source of energy savings, with up to 20% potential savings in the residential sector using currently available technology (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009). Many changes in household energy use can be made in the immediate term, without economic sacrifice or loss of well-being on the part of consumers (Dietz et al., 2009; Gardner & Stern, 2008). A variety of public and private programs have targeted such behavior in recent decades. Abrahamse, Steg, Vlek, and Rothengatter (2005) categorize programs that target household energy conservation as "involving either antecedent strategies (i.e. commitment, goal setting, information, modeling) or consequence strategies (i.e. feedback, rewards)" (p. 273). The State and Local Energy Efficiency Action Network (2012) use the term *behavior-based energy efficiency programs* and define them as "those that utilize strategies intended to affect consumer energy use behaviors in order to achieve energy and/or peak demand savings" (p. 1). Their list of such programs includes "outreach, education, competition, rewards, benchmarking and/or feedback elements" (p. 1). These programs are all based on the idea that consumers can be encouraged to use less energy if the underlying determinants of their behavior change in some way. Overall, the research on these programs shows potential for energy savings, but results vary significantly (from negative effects to over 20% in energy savings just for energy feedback) and much is still unknown about the variations both between- and within-studies that impact program effectiveness (see Ehrhardt-Martinez et al., 2010; Lutzenhizer et al., 2009).

Part of this limited understanding is due to the way that such behavior-based energy interventions (programs that seek to create energy savings by changing consumer behavior) are typically evaluated. Most program evaluations use the amount of energy use (measured in kWh) as the dependent variable for measuring effectiveness. Although this is an ideal measure of *whether* behavior-based energy interventions work, additional information about the participants' subjective experience could add significantly to our understanding about *how* and *for whom* they work. In their review of intervention studies aimed at household energy conservation, Abrahamse et al. (2005) found that "underlying determinants of energy use and energy-related behaviors have hardly been examined." Although this situation has improved in recent years with the proliferation of behavior-based programs that have subsequently been evaluated, significant variation remains in the variables collected and specific questions used during evaluation, making comparisons across studies difficult. Often these measures are developed by the program evaluator, and have not been validated to ensure that they effectively measure what they are designed to measure. The consistent use of well-validated measures would improve our overall ability to compare across studies and understand patterns or similarities. This would dramatically speed up the process of identifying best practices in behavior-based energy interventions, and allow programs to be streamlined to include only the most essential components.

This paper proposes a systematic approach to program assessments, and describes the development of a modular toolkit for comprehensive evaluation of behavior-based energy interventions. The proposed approach includes items to test key mediating and moderating variables needed to move "beyond kWh" and towards a more holistic understanding of how and for whom behavior-based energy interventions work best. This paper first articulates the value of a fully validated, consistent instrument to evaluate interventions and discusses the theoretical and empirical rationales behind the inclusion of questions to explore context, material culture, energy practices, beliefs around energy use, and user experience. The subsequent section introduces the preliminary toolkit, which is comprised of three independent phases (baseline, user experience, post-treatment), each of which can be completed in 10-15 minutes via computer, paper or phone in 10-15 minutes. Sample items for measuring each variable are described and suggestions for administration and analysis are presented. Broad use of such an instrument can improve and aggregate our overall knowledge across studies and contribute to a more robust understanding of behavior change as a resource. Such an understanding is necessary to maximize the effectiveness of existing programs, to inform the development of new programs, and to ensure that programs are designed to reach all sectors of the consumer market.

How is it measured? Why instrument validation matters

Data are only as good as the tool used to collect them; a measurement tool that is imprecise, unreliable, or – worst of all – does not measure what it is designed to measure will produce results that do not accurately reflect reality. Measuring attitudes, beliefs and even behavior in humans is not as straightforward as measuring energy consumption and the flow of electrons through wires. Behavioral scientists have devoted decades to developing strategies for ensuring that measures of psychological characteristics are as accurate as possible. Part of this strategy includes the use of properly validated measurement tools that have been tested to ensure that they accurately capture constructs of interest (e.g., that it is measuring an individual's attitude, rather than an individual's guess about what the researcher wants to hear) and that they do so in a reliable way (i.e. that if the same person completed the measure on two different days, we would get the same answer).

The process of validating a tool involves testing the measure with different subpopulations to ensure that all respondents interpret the language of the questions in the same way, and that this interpretation matches the intended meaning of the researcher. Although not overly difficult, scale validation is an investment that does take some time and expertise. However, once a tool has been validated with a particular population, it can be used and shared over and over.

How and For Whom? Why mediators and moderators matter

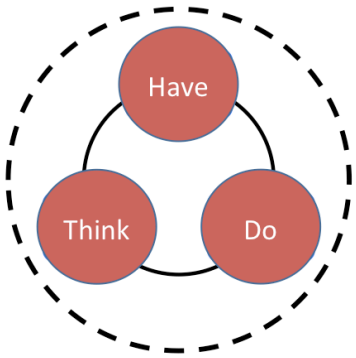
As the marketing industry has come to recognize, one size does not always fit all. Increasingly, advertisers are turning to niche marketing – tailoring messages and offers to particular segments of the population – which is proving to be more efficient and more successful. The promotion of energy efficiency can similarly benefit from a more nuanced approach to understanding market segments. Different subpopulations have different barriers to overcome and are motivated by different rewards; what works in a low-income community may fail in a middle class area. This is known as moderation: the effect of the energy intervention is different, depending on the subpopulation. Collecting information on moderators can inform program development for particular audiences. Potential moderating variables include demographics (e.g. age, gender), psychographics (e.g. motivation to save energy), and context (e.g. homeownership). Measuring these variables in a consistent way will improve the accuracy of findings in any given study, and also allow for easy comparison across studies.

Understanding how a program works – or doesn't work – is also important. Identifying the most important mechanisms through which the intervention works (mediators) helps program designers to generalize their success to other settings and behaviors. When a program doesn't work, measuring the most likely mediators of behavior will allow program administrators to more quickly identify where their program has broken down and why it has failed to achieve the desired effect.

Understanding Energy Behaviors

Energy behaviors are repetitive, heterogeneous, and embedded within the physical and social contexts of everyday life. The way in which energy is used within a home is determined in part by a household's material culture, including the building characteristics and the appliances owned (what householders *have*), but also by their practices that shape the way in which householders interact with these technologies (what they *do*). These interactions can both shape and be shaped by a household's beliefs around energy (ways in which householders *think*). These three interlinked elements of behavior (what households have, what they do, and how they think) determine a household's energy culture, which is embedded within a particular context of wider systemic influences that can both shape and constrain behavior (Stephenson et al., 2010). This is depicted in Figure 1.

Figure 1: The Energy Cultures Framework



Household energy culture can change over time; the purpose of energy interventions is to create a shift in one or more aspects of the customers' energy cultures. As such, this framework can be applied across scales and contexts, help understand heterogeneity, and depict opportunities for systemic change (Stephenson et al., 2015). It explains behavior change according to the interactions between material culture, energy practices, and beliefs within context, as changes to one element (e.g. installing new technology) may result in changes in the way householders think about energy and act, which may result in further changes.

Furthermore, it is important to understand how people respond to an intervention (e.g. the installation of a smart thermostat or the provision of information), because people will not use technology or information that they find confusing, uninteresting, and/or unhelpful. Therefore we also suggest that measuring user experience and response to the technology is important.

What Have Past Studies Collected?

A review of 85 empirical studies of behavior-based energy interventions from the past 10 years spanning commitment, goal setting, audits, media campaigns, feedback, and incentives was conducted to assess what types of data had been collected and how it was collected (Karlin, Ford, Wu, Nasser, & Frantz, 2015). Of the 85 studies reviewed, 69 collected data about at least one of the following measures: context, material culture, energy practices, energy beliefs (e.g. attitudes, social and personal norms, etc.) and user experience. Most (62 studies) did this using survey instruments; however, only 4 authors actually documented the instrument used in their paper. In addition, few collected data about all relevant variables; 28 asked about context, 19 about material culture, 45 about behaviors, 51 about beliefs, and 47 about user experience.

This review of 10 years of empirical research identified a set of key variables that reflect the theoretical literature on predictors of pro-environmental behavior, but little consistency in questions used to analyze participants' behaviors, attitudes, knowledge, and user experience. The measures used were also rarely refined through any kind of validation process. By consistently using the same set of well-validated measures, researchers would be able to more easily trust their results, compare data and understand patterns across interventions.

Toolkit Introduction

This project was first presented as an internal concept paper to the International Energy Agency Demand Side Management (IEA-DSM) Program in 2013, where it received a positive response as well as a great deal of constructive feedback. Based on suggestions from member countries and an invitation from the leadership of Task 24 (Closing the Loop – Behavior Change), we conducted a methodological review of behavior-based energy intervention data collection methodology, which is summarized above and can be found on the IEA-DSM Task 24 website (Karlin et al., 2015). Reviewing these findings along with an extensive review of past literature on behavioral theories and predictors of energy behavior, we developed the toolkit framework as well as draft instruments for testing.

The toolkit builds on past literature to create a framework for uncovering how and for whom behavior based energy interventions work. Its modular nature allows for easy adaptation to a wide range of circumstances, and allows for the assessment of both mediation and moderation of program effectiveness in a consistent format that can be used across evaluation studies (see Figure 2). Moderators enable the model to account for individual level differences and identify those groups within the general population for whom the energy intervention works best. Mediators identify the mechanism by which the intervention works, to allow an understanding of which components work (or not). A better understanding of these effects will lead to more targeted and considered design of energy interventions.

We are currently preparing to undergo two preliminary rounds of testing. The first is a set of online experiments and surveys designed to test for four key aspects of psychometric quality commonly utilized in the HCI community: factor structure, reliability, validity and sensitivity. The second is a field test on a 4,000 household smart thermostat study. Following these two preliminary studies, we will bring the revised instrument back to the IEA-DSM community for review and additional testing in multiple geographic contexts. It is hoped that this process will ensure a wide buy-in for such a standardized measurement as well as improve the toolkit so that it can successfully be used across cultures.

The toolkit is structured to include measures of context, material culture, energy practices, beliefs around energy use, and user experience. The constructs included in each domain are informed by theory and research in behavior change and energy behavior, and the individual items are drawn from previous studies. Below we briefly review the literature supporting the inclusion of each construct. Sample items for each construct are provided in the Appendix.

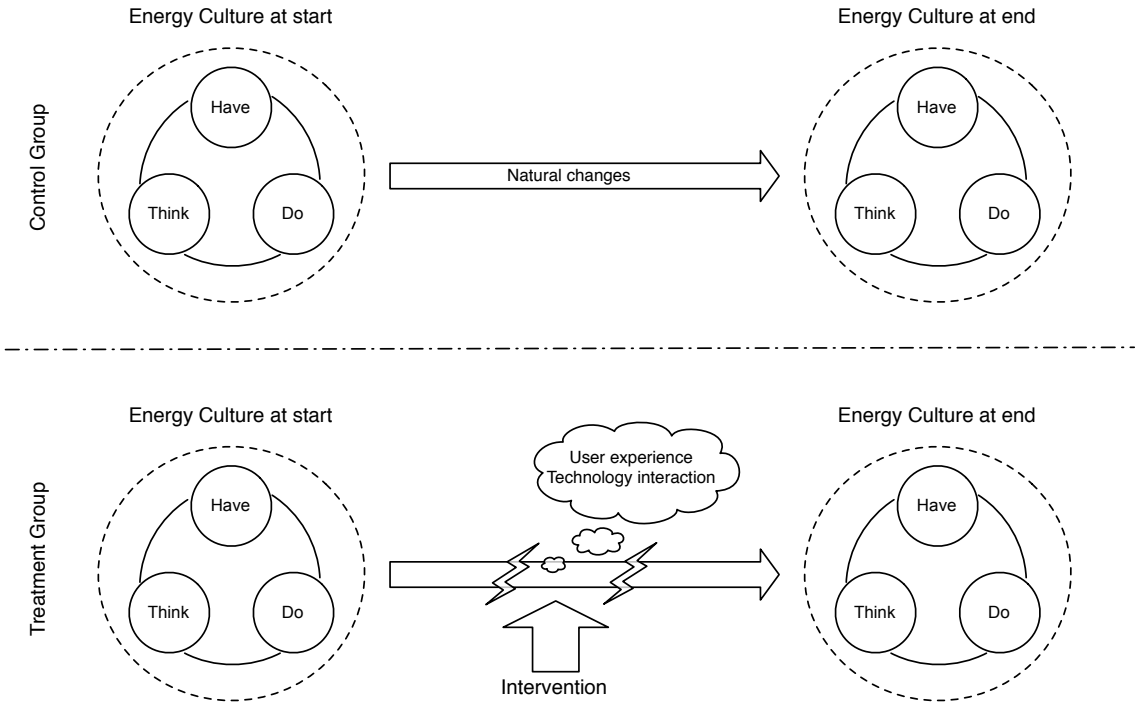


Figure 2: Changing Energy Cultures through an Intervention

Context

Context questions include demographic characteristics that relate to energy use or to the ways in which respondents might respond to a behavioral intervention. Although some contextual data can be acquired through secondary sources (e.g., census data), it is important to collect this information from respondents for between-subject moderator analysis (i.e., to identify *for whom* energy interventions work best). Relevant context variables identified in the literature include age (Curtis et al., 1984; Sardianou, 2007), homeownership (Gatersleben et al., 2002), income (Ritchie et al., 1981), education (Gatersleben et al., 2002), family size (Curtis et al., 1984), and home type (Sardianou, 2007). Physical location (enabling weather correction when comparing effects across geographic regions), whether or not occupants rent or own the home, the length of time they have been living in the home, and the length of time they plan to stay may also effect their decision to engage in some energy related behaviors.

Material Culture (Have)

The physical surroundings and objects owned by residents necessarily have a constraining impact on what energy-related behaviors are possible and on how willing residents are to engage in them (Stephenson et al., 2010). Housing characteristics that typically impact home energy use include type of dwelling (i.e. separate house vs. apartment), the size of the home, whether the home is insulated, how it is heated, and what appliances are present.

Energy Practices (Do)

The term "energy conservation" encompasses a diverse set of specific behaviors: there are over 200 separate behaviors related to residential energy efficiency alone (McKenzie-Mohr, 2011). Even within a category of behaviors, such as those related to lighting, there are differences between turning off lights when leaving a room, installing energy efficient lighting, and setting light timers. Each of these behaviors likely have a different set of situational predictors and barriers (McKenzie-Mohr, 2011), and have different environmental impacts. Therefore, conceptual distinctions among conservation actions may lead to greater predictive validity and improved interventions (Barr, Glig, & Ford, 2005;

Karlin et al., 2014). A review of recent literature was conducted to compile a list of specific behaviors that, when implemented, could lead to reductions in energy consumption. Articles were located using keyword searches in academic (e.g., Psychinfo) and general (e.g., Google) databases as well as backward and forward citation searches on relevant literature; this returned a total of 23 articles[1] for analysis. Data were collected about specific behaviors mentioned in each article. Similar behaviors were grouped together and consolidated into a single list, containing "purchasing" behaviors as well as behaviors relating to the use of appliances within the home, both of which are important to consider in evaluating behavioral based energy interventions. The current toolkit includes a broadly inclusive list of behaviors that can be customized to include only those that are relevant to each particular intervention.

Beliefs (Think)

While the physical surroundings and behavior undoubtedly impact energy use, what happens inside residents' heads is equally important. While some interventions attempt to create change through changes in material culture (e.g. through the installation of smart thermostats or insulation) many programs rely on changes in knowledge, attitudes, or norms to change energy use. Our literature review uncovered a small number of overarching psychological theories of behavior change that have been heavily researched, and a longer list of concepts and factors (not united by any theory) that have also been empirically tested. The Theory of Planned Behavior (TPB; Ajzen, 1991) is one of the most successful models for predicting behavior. TPB classifies the beliefs guiding individuals' rational decision-making processes as: (1) behavioral beliefs (attitudes towards the behavior), (2) normative beliefs (social norms), and (3) control beliefs (perceived efficacy over the behavior). According to TPB, these three sets of beliefs influence a person's behavioral intentions, which largely determine her/his behavior. The TPB has been used in hundreds of studies and has successfully predicted behaviors ranging from organ donation (Rocheleau, 2013) to smoking cessation (Norman et al., 1999). It has also been used to predict environmentally responsible behavior (Karppinen, 2005; Thompson & Hansen, 2013) and energy behaviors specifically (Harland et al., 1999; Lynch & Martin, 2010).

Stern's (2000) Value-Belief-Norm Theory is the second most common and heavily researched model of behavior change. According to this model, values influence beliefs, which in turn motivate and guide behavior. However, these values and beliefs are only activated when something a person cares about is threatened, and that person feels that they have both the responsibility and the ability to change it. Many values can influence pro-environmental beliefs (Schultz, 2001). Biospheric values—a concern for the environment; altruistic values, such as a concern for future generations; and egoistic values of saving money or being more comfortable can all lead a person to consider engaging in pro-environmental behavior. VBN theory has successfully predicted pro-environmental behavior in a number of contexts (Chen, 2014; Sahin, 2013; van Riper & Kyle, 2014). More recently, VBN and TPB have been directly compared and TPB has been found to be the better predictor of behavior (Kaiser et al, 2005; Lopez-Mosquera & Sanchez, 2012). However Han (2015) found a combination of the two to be the best predictor; this is the strategy we propose. In addition to these major approaches, a number of other variables have been found to predict conservation behavior in particular, including attitude accessibility (Ajzen, 1987), connection to nature (Mayer & Frantz, 2004); energy concern (Curtis et al., 1984), price sensitivity (Long, 1993), environmental concern (Poortinga et al., 2004), and personal and social norms (Nolan et al., 2008).

[1] Included articles were: Attari et al. 2010; Attari et al. 2011; Barr, Gilg & Ford 2005; Benders et al. 2006; Caird, Roy & Herring 2008; Desmedt, Vekemans & Maes 2009; Dietz et al. 2009; Ehrhardt-Martinez 2011; Ek & Söderholm 2010; Gadenne et al. 2011; Gardner & Stern 2008; Charles 2009; Karlin et al.2012; Leighty & Meier 2011; Mirosa, Lawson & Gnoth 2011; Poortinga et al. 2003; Poortinga, Steg & Vlek 2004; Stern 2010; Sütterlin, Brunne & Siegrist 2011; Thøgersen & Grønhøj 2010; Wood & Newborough 2007; Yan & Lifang 2011; Yohanis 2012.

It is important to note that the above approaches to predicting behavior are not mutually exclusive, but rather can and should be integrated (e.g., Turaga et al., 2010). Rather than limit evaluation to one theoretical approach, we propose incorporating multiple variables identified as predictors of behavior. As such, we include items drawn from the research reviewed above that have reliably predicted behavior. Key concepts measured are: energy literacy and awareness, awareness of adverse consequences of energy use, environmental concern, personal and social norms, performance and response efficacy, motivation, behavioral intention. Validation and field-testing will be undertaken to identify the most important predictors of behavior, and to eliminate redundant or ineffective items.

User Experience

User experience of energy interventions has most commonly been evaluated in informal laboratory based studies using qualitative techniques and small sample sizes (Froehlich, 2010). While this method is useful during an iterative design phase it is less useful for evaluation of energy interventions, particularly when sample sizes are large. Some scales (e.g. SUS, SUMI, UMUX) have been developed for this purpose, but most test perceived usability of systems or products, rather than information more generally.

The UPscale (Karlin & Ford, 2013), which builds upon decades of research in this space, has been developed to measure user experience with energy feedback displays but can be used with other technologies and information visualization as well. It employs four questions to evaluate perceived ease of use, and four to measure engagement. The UPscale questions developed and validated by Karlin and Ford (2013) are modified slightly to extend their relevance to energy interventions more broadly, and are incorporated into the Beyond kWh instrument.

Administration and Analysis

The toolkit is recommended to administer as a three-phase survey. A randomized controlled trial, in which households are randomly assigned to either the experimental or control group, is recommended for robust, unbiased evaluations of behavior-based interventions (State and Local Energy Efficiency Action Network, 2012). The first phase occurs prior to the energy intervention to: (1) describe the sample, (2) test for representativeness and subpopulations, and (3) obtain baseline measurements of energy culture against which subsequent changes can be evaluated. In phase one the context questions, as well as the energy literacy, attitudes, and behavioral questions are asked.

After phase one surveys have been completed, the intervention begins. Phase two can be deployed anytime after the start of the intervention. As the purpose of this instrument is to evaluate the participants' experience with the intervention in terms of ease of use and engagement, it is important to administer these surveys while the intervention materials are still fresh in participants' minds.

Phase three is designed to measure changes in household energy culture, as compared to the baseline measures collected in phase one. For some interventions (e.g. those that target practice changes, or that aim to increase energy literacy) it may be appropriate for phases two and three to coincide, in which case they are collapsed into a single post-intervention survey instrument. However for other interventions, e.g. home audit programs, which target behaviors that may take longer implement (e.g. installing insulation) the third phase of surveys should be delayed appropriately.

The toolkit is designed such that both moderation and mediation can be measured in order to better understand the overall effects of an intervention on energy use. The data collected in Phase 1 are used as moderating variables (see Figure 3), to determine for whom the energy intervention works best. The user experience responses, as well as the changes in material culture, energy practices, and beliefs about energy between phase one and three can be measured as mediator variables, answering the question of how the energy intervention works.

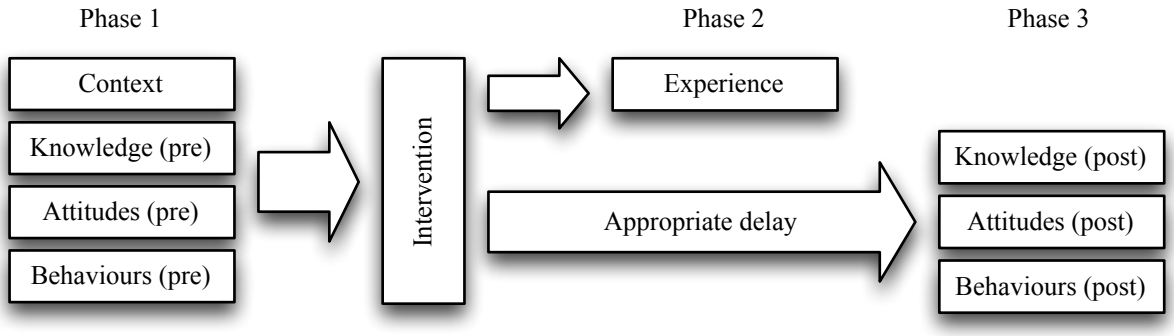


Figure 3: How to administer the toolkit

Conclusion

As more and more utilities and regulatory agencies focus their attention on behavior-based energy interventions, there is an urgency to ensure that evaluation of such programs is done in as rigorous a manner as possible. While the metric used to measure *whether* these various programs work is fairly standard and easy to compare between studies, the variables and metrics used to measure *how* and *for whom* they work have been left to individual researchers, with little attempts at creating a replicable model. Such standardization is common in related fields such as education and psychology, but has yet to take hold in energy program evaluation. The current paper proposes a an approach to assessment that can be used consistently with behavior-based programs including but not limited to eco-feedback, home audits, information and rebate programs, and social games.

The use of such a toolkit across multiple behavior-based energy efficiency programs can yield useful insights into effective program design. A standardized toolkit allows evaluators to cost-effectively and rapidly compare the relative effectiveness of different behavioral intervention options, and identify possible interactive effects that may make one intervention more effective for one customer segment and a different intervention more effective for another segment. Included measures delve into different dimensions of customer characteristics that may underlie customer receptiveness to different behavioral interventions, allowing utilities to make systematic and intentioned improvements in program design.

Widespread use of standardized tools to measure behavior intervention effectiveness across customer populations can help aggregate our overall knowledge across studies and contribute to a more robust understanding of the reliability of energy efficiency as a resource. Such an understanding is necessary to decrease the variability we currently see in savings from behavioral programs, so that utilities can begin to have greater confidence in consistent and reliable EM&V findings. It is only then that behavior-based energy interventions can begin to be valued as much as supply-side sources of energy.

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References

Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. Journal of Environmental Psychology, 25(3), 273–291.

Aguilar-Luzón, M. D. C., García-Martínez, J. M. Á., Calvo-Salguero, A., & Salinas, J. M. (2012). Comparative study between the theory of planned behavior and the value–belief–norm model regarding the environment, on Spanish housewives' recycling behavior. *Journal of Applied Social Psychology*,*42*(11), 2797-2833.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, *50*(2), 179-211.

Attari, S. et al., (2010). Public perceptions of energy consumption and savings. Proceedings of the National Academy of Science of the United States of America, 107(37), pp.16054-16059.

Attari, S. Z., DeKay, M. L., Davidson, C. I., & de Bruin, W. B. (2011). Changing household behaviors to curb climate change: How hard can it be?.*Sustainability: The Journal of Record*, *4*(1), 9-11.

Barr, S., Gilg, A. W., & Ford, N. (2005). The household energy gap: examining the divide between habitual- and purchase-related conservation behaviors. *Energy Policy, 33*(11), 1425–1444.

Benders, R. M. J., Kok, R., Moll, H. C., Wiersma, G., & Noorman, K. J. (2006). New approaches for household energy conservation—In search of personal household energy budgets and energy reduction options. Energy Policy, 34(18), 3612–3622.

Caird, S., Roy, R., & Herring, H. (2008). Improving the energy performance of UK households: Results from surveys of consumer adoption and use of low- and zero-carbon technologies. *Energy Efficiency, 1,* 149–166.

Charles, D. (2009). Leaping the efficiency gap. *Science, 325*(5942), 804-811.

Curtis, F. A., Simpson-Housley, P., & Drever, S. (1984). Communications on energy Household energy conservation. Energy Policy, 12(4), 452-456.

Desmedt, J., Vekemans, G., & Maes, D. (2009). Ensuring effectiveness of information to influence household behaviour. *Journal of Cleaner Production*,*17*(4), 455-462.

Dietz, T., Gardner, G. T., Gilligan, J., Stern, P. C., & Vandenbergh, M. P. (2009). Household actions can provide a behavioral wedge to rapidly reduce US carbon emissions. Proceedings of the National Academy of Sciences of the United States of America, 106(44), 18452–6.

Ehrhardt-Martinez, K., Donnelly, K. A., & Laitner, S. (2010). Advanced metering initiatives and residential feedback programs: a meta-review for household electricity-saving opportunities. Washington, DC: American Council for an Energy-Efficient Economy.

Ehrhardt-Martinez, K. (2011). Changing Habits, Lifestyles and Choices: The Behaviors that Drive Feedback-Induced Energy Savings. *In: Proceedings of the ECEEE Summer Study*.

Ek, K., & Söderholm, P. (2010). The devil is in the details: Household electricity saving behavior and the role of information. *Energy Policy, 38*(3), 1578-1587.

Froehlich, J., Findlater, L., & Landay, J. (2010). The design of eco-feedback technology. *In: Proceedings of the 28th international conference on Human factors in computing systems* (pp. 1999-2008). ACM.

Gadenne, D., Sharma, B., Kerr, D., & Smith, T. (2011). The influence of consumers' environmental beliefs and attitudes on energy saving behaviors. Energy Policy, 39(12), 7684–7694.

Gardner, G. T., & Stern, P. C. (2008). The Short List: The Most Effective Actions U.S. Households Can Take to Curb Climate Change. Environment.

Gatersleben, B., Steg, L., & Vlek, C. (2002). Measurement and determinants of environmentally significant consumer behavior. Environment and Behavior,34(3), 335-362.

Harland, P., Staats, H., & Wilke, H. (1999). Explaining pro environmental behavior by personal norms and the theory of planned behavior. Journal of Applied Social Psychology, 29, 2505–2528.

Kaiser, F. G., Hü bner, G., & Bogner, F. X. (2005). Contrasting the theory of planned behavior with the value-belief-norm model in explaining conservation behavior. Journal of Applied Social Psychology, 35, 2150-2170.

Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D., & Stokols, D. (2014). Dimensions of conservation: Exploring differences among energy behaviors. *Environment and Behavior*, *46*(4), 423-452.

Karlin, B., & Ford R. (2013). The Usability Perception Scale (UPscale): A measure for evaluating feedback displays. *In: 5th International Conference on Human-Computer Interaction.*

Karlin, B., Ford, R., Wu, A., Nasser, V., & Frantz, C. (2015). *What Do We Know About What We Know? A Review of Behaviour-Based Energy Efficiency Data Collection Methodology*. Report prepared for the International Energy Agency Demand Side Management Programme (IEA-DSM) Task 24 –Behaviour Change in DSM.

Karppinen, H. (2005). Forest owners' choice of reforestation method: an application of the theory of planned behavior. *Forest Policy and Economics*,*7*(3), 393-409.

Leighty, W., & Meier, A. (2011). Accelerated electricity conservation in Juneau, Alaska: A study of household activities that reduced demand 25%. Energy Policy, 39(5), 2299-2309.

Long, J. E. (1993). An econometric analysis of residential expenditures on energy conservation and renewable energy sources. Energy Economics, 15(4), 232-238.

López-Mosquera, N., & Sánchez, M. (2012). Theory of Planned Behavior and the Value-Belief-Norm Theory explaining willingness to pay for a suburban park.*Journal of environmental management*, *113*, 251-262.

Lutzenhiser, L., Cesafsky, L., Chappells, H., Gossard, M., Moezzi, M., Moran, D., Peters, J., et al. (2009). *Behavioral assumptions underlying California residential sector energy efficiency programs.* Prepared for the California Institute for Energy and Environment Behavior and Energy Program.

Lynch, D., & Martin, P. (2010). How energy efficiency programs influence energy use : an application of the theory of planned behaviour. In European Council for an Energy Efficient Economy Summer Study (pp. 2037–2048). Retrieved from

Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of Environmental Psychology*, *24*, 503-515.

McDougall, G. H., Claxton, J. D., Ritchie, J. B., & Anderson, C. D. (1981). Consumer energy research: a review. *Journal of Consumer Research*, 343-354.

McKenzie-Mohr, D., 2011. Fostering sustainable behaviour: An introduction to community-based social marketing. 3rd ed. ed. Gabriola Island, BC: New Society

Mirosa, M., Lawson, R., & Gnoth, D. (2011). Linking Personal Values to Energy-Efficient Behaviors in the Home. Environment and Behavior.

Nolan, J. M., Schultz, P. W., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2008). Normative Social Influence is Underdetected. Personality & Social Psychology Bulletin, 34(7), 913–23. doi:10.1177/0146167208316691

Norman, P., Conner, M., & Bell, R. (1999). The Theory of Planned Behavior and Smoking Cessation. *Health Psychology*, *18*, 89-94.

Poortinga, W., Steg, L., & Vlek, C. (2004). Values, Environmental Concern, and Environmental Behavior: A Study into Household Energy Use. Environment & Behavior, 36(1), 70–93.

Rocheleau, C. A. (2013). Organ donation intentions and behaviors: application and extension of the theory of planned behavior. *Journal of Applied Social Psychology*, *43*(1), 201-213.

Rogers, E.M., 1983. The Diffusion of Innovation (3rd Edition), New York: The Free Press.

Sahin, E. (2013). Predictors of Turkish Elementary Teacher Candidates' Energy Conservation Behaviors: An Approach on Value-Belief-Norm Theory. *International Journal of Environmental and Science Education*, *8*, 269-283.

Sardianou, E. (2007). Estimating energy conservation patterns of Greek households. Energy Policy, 35(7), 3778–3791. doi:10.1016/j.enpol.2007.01.020

Schultz, P. W. (2001). The structure of environmental concern: Concern for self, other people, and the biosphere. *Journal of environmental psychology*,*21*(4), 327-339.

Schwartz, S. H. (1977). Normative influences on altruism. In: L. Berkowitz (Ed.). Advances in Experimental Social Psychology, 10, 221-279. New York: Academic Press.

State and Local Energy Efficiency Action Network. (2012). *Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations.* Lawrence Berkeley National Laboratory: Berkeley, CA.

Stephenson, J., Barton, B., Carrington, G., Gnoth, D., Lawson, R., & Thorsnes, P. (2010). Energy cultures: A framework for understanding energy behaviours.

Stephenson, J., Barton, B., Carrington, G., Doering, A., Ford, R., Hopkins, D., & Wooliscroft, B. (2015). The energy cultures framework: Exploring the role of norms, practices and material culture in shaping energy behaviour in New Zealand. *Energy Research & Social Science*, *7*, 117–123.

Stern, P. (2000). Toward a coherent theory of environmentally significant behavior. *Journal of social issues*, *56*(3), 407-424.

Sütterlin, B., Brunner, T. a., & Siegrist, M. (2011). Who puts the most energy into energy conservation? A segmentation of energy consumers based on energy-related behavioral characteristics. Energy Policy, 39(12), 8137–8152.

Thompson, D.W., & Hansen, E.N. (2013). Carbon Storage on Non-industrial Private Forestland: An Application of the Theory of Planned Behavior. *Small-scale Forestry*, *12*, 631-657.

Thøgersen, J., & Grønhøj, A. (2010). Electricity saving in households—A social cognitive approach. *Energy Policy*, *38*(12), 7732-7743.

Turaga, R. M. R., Howarth, R. B., & Borsuk, M. E. (2010). Pro-environmental behavior. Annals of the New York Academy of Sciences, 1185(1), 211-224.

van Riper, C. J., & Kyle, G. T. (2014). Understanding the internal processes of behavioral engagement in a national park: A latent variable path analysis of the value-belief-norm theory. *Journal of Environmental Psychology*, *38*, 288-297.

Wiener, J. L., & Doescher, T. A. (1994). Cooperation and expectations of cooperation. *Journal of Public Policy & Marketing, 13*, 259-270.

Wood, G., & Newborough, M. (2007). Influencing user behavior with energy information display systems for intelligent homes. International Journal of Energy Research, 31, 56–78.

Yan, S., & Lifang, F. (2011). Influence of psychological, family and contextual factors on residential energy use behavior: An empirical study of China. Energy Procedia, 5, 910–915.

Yohanis, Y. G. (2012). Domestic energy use and householders' energy behavior. *Energy Policy, 41,* 654–665.

Appendix: Beyond kWh Toolkit Sample Items

Context:

- Gender, age race
  Note: categorical responses should be provided appropriate to the specific cultural context.

Material Culture (Have)

- What type of dwelling do you live in?
- Which of the following appliances do you own? (Space heater, dishwasher, central AC, etc.)

Behaviors (Do)

- How frequently do you: (Limit time in shower, turn off lights when not needed, etc.)

Beliefs (Think)

Energy Literacy and Consciousness

- Turning the thermostat up higher will make the room get warmer more quickly
- I don't think very much about ways of saving energy in my own home.

Awareness of Adverse Consequences

- My energy use has a negative impact on the environment

Environmental Concern

- I consider myself to be an environmentalist

Norms (Personal and Social)

- I feel a strong personal obligation to conserve energy.
- Most people are not willing to make changes or sacrifices to protect the environment.

Efficacy (Performance and Response)

- I can think of at least one thing that I can do to decrease my energy usage.
- If I conserve, it will have a positive societal impact.

Motivation

- How much does each of the following factors affect your household energy use?
  (Environmental impact, cost of energy bill, convenience, etc.)

Behavioral Intention

- During the next six months, I intend to (limit time in shower, turn of lights when not needed, etc.)

User Experience (UPscale)

Ease of Use

- I feel very confident interpreting the information provided to me.
- A person would need to learn a lot in order to understand this _____.

Engagement

- I do not find this _____ to be useful.
- I think that I would like to use this _____ frequently.