Journal of Sustainability Education
Vol. 8, January 2015
ISSN: 2151-7452

Enabling energy conservation through effective decision aids

Shahzeen Z. Attari

Indiana University, Bloomington, Indiana, U.S.A.

Deepak Rajagopal

Indiana University Bloomington and University of California, Los Angeles, CA, U.S.A.

Note: First authorship is shared.

Abstract: Why don't people adopt energy efficient appliances and curtail their behaviors to decrease energy use? People may not know which behaviors are truly effective and may be insufficiently motivated to change their behaviors. We focus on one area of this problem by first analyzing existing decision aids, tools available to help users make effective decisions. We explore EPA's Energy Star program, DoE's EERE calculators, and LBNL's Home Energy Saver tool. We highlight their strengths and limitations and propose a framework to expand the functionality and uptake of the information through such aids. We suggest improvements along two broad areas. One area concerns the analytic capabilities and the information content of the decision aid, which focuses on (1) multiple goals and constraints, (2) hidden costs, and (3) heterogeneity in user characteristics. The other pertains to the framing so that users can easily process information through decision architecture by limiting choice overload and incorporating smart default options.

Keywords: energy conservation, decision aids, online tools, energy calculators, psychology, decision architecture

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Shahzeen Attari's research focuses on the psychology of resource use. Her work aims to identify factors that promote resource conservation and sustainability. She is an Assistant Professor at the School of Public and Environmental Affairs (SPEA) at Indiana University Bloomington. Previously, she was a postdoctoral fellow at the Earth Institute and the Center for Research on Environmental Decisions (CRED) at Columbia University. She holds a Ph.D. in Civil and Environmental Engineering & Engineering and Public Policy from Carnegie Mellon University, and a Bachelors of Science in Engineering Physics from University of Illinois at Urbana-Champaign. sattari@indiana.edu

Deepak Rajagopal's research focuses on life cycle assessment for public decision making, energy and environmental economics, multi-criteria analysis of energy and environmental policies, and impact assessment of climate change and climate policies.
He is a Visiting Assistant Professor in the School of Public and Environmental Affairs at Indiana University Bloomington and an Assistant Professor (on leave) at the Institute of Environment and Sustainability at the University of California, Los Angeles. He has a Ph.D. in Energy and Resources from University of California, Berkeley, a Master of Science degree in Agricultural and Resource Economics from UC Berkeley, a Mechanical Engineering from University of Maryland, College Park, and Bachelor's degree in Mechanical engineering from Indian Institute of Technology, Madras. rdeepak@ioes.ucla.edu

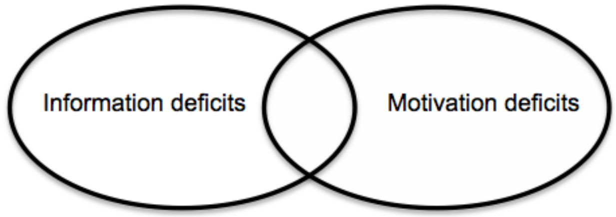
Introduction

Moment by moment we consciously or subconsciously make decisions about using resources. If we need to decrease our use of a resource, due to personal or societal constraints, do we know which changes in behavior are most cost-effective and save the most amount of the resource? Prior research has shown that public perceptions of energy and water use are rife with systematic and sometimes large inaccuracies. Notably, people tend to underestimate resource use on average and to underestimate (or compress) the relative differences between activities, especially for activities that use much of the resource (Attari, 2014; Attari, DeKay, Davidson, & Bruine de Bruin, 2010). Moreover, participants tend to believe that curtailing their activities (doing the same behavior but less of it, such as turning off lights or taking shorter showers) are among the most effective ways to decrease resource use as compared to adopting efficient technologies – for example, replacing incandescent light bulbs by Light Emitting Diodes (LEDs), or installing low-flow toilets. These beliefs contrast with expert recommendations in the domain of energy use and, to some extent, for water use (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009; Gardner & Stern, 2008; Inskeep & Attari, 2014). For instance, Gardner and Stern (2008) state that “the behaviors that are easiest to remember and perform, for example, turning out lights when leaving rooms, tend to have minimal impact on climate change”.

Some types of curtailment actions could, in reality, prove highly effective depending on the situation. For instance, an occasional telecommute to work instead of a physical commute might reduce energy use much more than one could save by turning off a light bulb for a prolonged period of time. The longer the commute and more energy intensive the mode of transport (such as flying to a business meeting) the greater the impact of a single curtailment action, even when compared to an efficiency action. There are many uncertainties about which activities are effective to decrease resource use, and unfortunately, misperceptions of what is effective, such as turning off the light, tend to be sticky, an observation that seems to have changed little since they were first documented in 1985 (Kempton, Harris, Keith, & Weihl, 1985). Systematic misperceptions also provide one explanation for why individuals may underinvest in efficiency, a phenomenon termed the “energy efficiency gap” (Allcott & Greenstone, 2012; Dietz, 2010).

So far, the work described shows that people lack the needed information and literacy about resource use to effectively change their own behavior. However, there may be two main reasons why people may not act: (1) information deficits and (2) motivation deficits. Information deficits imply that people simply lack the knowledge required to act out effective behaviors, “I don't know what to do”, “I do not know what is effective”. Alternatively, motivation deficits imply that people may lack the correct motivations to change their behaviors, “it is not cost-effective to buy efficient appliances”, “my neighbors are not doing it”. These two deficits can also co-exist, such that people may lack accurate information and the correct motivators to facilitate behavioral changes, as shown in Figure 1. These deficits can occur throughout the decision making process, from pre-contemplation of the decision to final action and maintenance.

Figure 1. Informational and motivational deficits that prevent action.



In this paper, we focus on energy conservation and investigate ways to promote both energy efficiency and effective curtailment of activities through the use of decision aids. There are a variety of ways we use energy daily which make up our energy footprint. The term energy footprint refers simply to the total energy used in carrying out the day-to-day activities. The total energy consumed can be broken down into direct and indirect modes of energy use. By direct energy use, we mean that consumers purchase fuel or electricity to undertake an activity. In contrast, individuals consume energy indirectly as well because energy is used in the entire lifecycle of the product or service, including but not limited to processes such as manufacturing, transporting, retailing, installing, maintenance and disposal of goods. According to the U.S. Energy Information Administration, in 2013, residential energy use accounted for 26% of primary energy use (direct and indirect use) while transportation accounted for 23% (EIA, 2014a). Light automobiles (mostly personal vehicles), airways and bus travel accounted for 71% of the transportation energy use (EERE, 2014b). From this information, we infer that residential energy use and personal transportation combined account for 42% (= 26% + 0.71×23%) of total U.S. primary energy consumption and the remaining 58% being the indirect energy footprint. This provides a first order approximation of the share of direct energy use in the total energy footprint of the average individual in the United States.

At first glance this seems to suggest that decision aids ought to focus on the indirect energy footprint as it accounts for a larger share relative to the share of direct energy use in the total footprint. However, indirect energy use is distributed across a larger number of products and services compared to the number direct means of energy use. This is simply based on the number of different goods and services consumed. Therefore any single indirect energy activity is likely to comprise a much smaller share of the total energy footprint relative to that for any single direct means of energy consumption. Table 1 lists various major daily activities that directly involve energy use and the associated set of types of appliances and fuels. Gardner and Stern (2009) report that transportation accounts on average about 43% of the direct energy use by a U.S. household, and in-home uses accounting for the remaining 57%.

Table 1. A non-exhaustive list of various daily activities that involve an individual directly consuming energy.

Home related activities	Appliance examples	Fuel choice
Space cooling	Air-conditioning (central or window unit)	Electricity*
Space heating	Furnace or Heat Pump	Electricity, Gas, Oil
Water services	Water heater, Faucets, Toilets, Swimming pool	Electricity (for heaters), Gas
Food storage	Refrigerator	Electricity
Food preparation	Stove, Oven	Electricity, Gas
Lighting	LED, CFL, Incandescent bulb	Electricity
Cleaning	Dishwasher, Clothes Washer, Dryer	Electricity, Gas (for dryer)
Communications and Entertainment	Computers, Phone, Television, Printers, Cable box	Electricity
Indoor Recreation	Exercise equipment	Electricity
Outdoor maintenance	Lawnmower	Gasoline, Diesel
Transport related activities	**Travel mode examples**	**Fuel choice**
Commuting to work	Walk, Bicycle, Motorbike, Train, Bus, Carpool, Automobile, Telecommute	Gasoline, Diesel, Biofuel (for personal automobiles only)
Leisure travel**	All above plus air travel with telecommute excluded	All above + Jet fuel (for air travel)

* Choice with respect to electricity is in the form of an option available to most consumers to purchase any given share of their electricity from renewable sources.
** Although leisure travel and some residential activities may in reality occur occasionally, one could derive average daily energy consumption for each activity.

A brief overview of existing decision aids

We use the term “decision aid” to refer to any information that a consumer can access to help them make decisions about energy use. Some decision aids simply provide a list of presumed effective behaviors for people to incorporate into their lives, without providing any specific information on effectiveness or cost-savings. For example, the Natural Resources Defense Council (NRDC) has a list of tips that are arranged by ‘habits that are free’ to ‘long-term efficiency’ actions that are costly. A few examples include unplugging devices and changing the sleep setting on the computer (free tips) to insulating the home and buying renewable energy (long-term efficiency tips) (NRDC, 2014). Other decision aids are designed to help individuals ‘do the math’ behind switching to more efficient technologies that use less energy for the same end-use, which are the focus of our discussion. These online decision aids usually employ spreadsheet based or web-based calculators that provide consumers with information regarding potential direct (i.e., at the point of use) energy savings and cost savings for alternative energy use decisions. Even when focusing only on direct energy use, consumers face a staggering array of alternative ways to reduce their energy footprint. For example, to decrease my energy footprint, which incandescent lights should I replace? Should I just keep switching off the light as much as possible? If my incandescent light is still working, should I still replace it with a LED light? Should I even focus on lighting or should I replace my windows?

For each activity in Table 1, we can identify two broad approaches to reducing total energy consumed – improving the efficiency of an individual activity by switching technologies and curtailing the activity by decreasing duration and frequency of the activity. The decisions we make about energy use can be classified as one-time decisions (such as an appliance purchase) or day-to-day decisions (such as adjustment behavior for lighting or heating and fueling options for operating appliances). Alternative classifications exist in the literature, for an example, see Dietz *et al.* (2009). Improving energy efficiency is usually a one-off decision, such as investing in a technology at one time, which mainly involves replacing old technology with new technology, and again, one might face a suite of choices, which all involve different tradeoffs between efficiency and initial cost, specifically, higher efficiency in return for higher initial cost. Curtailment is usually a repeated decision, which involves reducing the frequency or duration of an activity or both without a switch in technology. It usually does not involve a monetary cost, but does usually involve other costs such as time, effort, and possibly sacrifices in comfort. With the advent of smart appliances, which enable electric load shifting to low energy cost hours of the day or automatic scheduling of appliances to turn on or off, the time and effort involved with curtailment may decrease with new technologies. The number of choices to reduce energy use is still staggering given (a) the range of different activities across use categories, (b) the range of choices in terms of the number of different brands and models of efficiency equipment for any given application, and (c) the range of possibilities for curtailment, which is a continuous variable. Thus decision aids should be designed to help users make decisions based on the most important information and attributes to the user. We briefly review a select set of currently available online decision aids designed to help users make informed decisions about energy use. These decision aids have all been developed by government research institutions or agencies in the U.S. We highlight their strengths and some common limitations.

Energy Star Program: The U.S. Environmental Protection Agency's Energy Star program is a voluntary labeling program for consumer products that meet a minimum standard for energy efficiency and provides an online tool to analyze potential energy savings from over 60 various actions at the household level (Energy Star, 2014). There also exists a companion Energy Star program for the European Union, which emerged from an agreement between the Government of the US and the European Community (EU) to co-ordinate energy labeling but is currently confined only to office equipment (EU Energy Star, 2014). The Energy Star Program provides options for a given household, which includes recommendations for general home improvement as well as recommendations for appliances, electronic devices, and lighting systems. The aid focuses on both curtailment and efficiency actions to decrease energy use. However, while it provides estimates of energy savings it provides little financial guidance or easy to understand comparisons of the effectiveness of undertaking different investments. There are many positive aspects of this decision aid. It provides links to real product models available in the market and also helps locate contractors, both of which minimize search costs and other such transaction costs that are not easily observed and therefore tend to be ignored when designing public policies to promote energy efficiency. Exclusion of such costs is one reason why engineering-based assessments tend to underestimate the true cost and overestimate the economic potential of energy efficiency and conservation. This decision aid also employs some recommendations from psychological studies on motivating users to undertake action. For example, the aid asks users to “take the pledge”, where signing up with one’s zip code also allows the user to receive rebate information and coupons for efficiency purchases. Public pledges have been shown to be successful in motivating people to decrease energy use and maintaining the decrease over a period of time, however private pledges, such as the one used by this aid, are found to be less effective (Cialdini, 2001; Pallak, Cook, & Sullivan, 1980).

EERE calculators: The U.S. Department of Energy’s office of Energy Efficiency and Renewable Energy (EERE) has developed a spreadsheet-based calculator for each of several major types of household appliances such as refrigerators, air conditioners, clothes washers etc. (EERE, 2014a). Using these spreadsheets one can compare initial capital costs, the “life cycle” energy use and cost, emissions, as well as the payback period of a high efficiency appliance relative to a low efficiency appliance. The user is free to choose from a default set of models of an appliance, which vary in energy efficiency, upfront costs, and operating cost or input his or her own values for any of the inputs used in the spreadsheet calculations including cost, efficiency, expected life, and energy price. The EERE also maintains a separate web-based calculator for comparing the cost-effectiveness of energy efficiency alternative choices of automobiles (DOE, 2014). The automobile comparison tool, however, does not compute the payback or the internal rate of return for the more efficient vehicle choices, assuming they are costlier than the less fuel-efficient vehicles. Note, however, that the EERE calculators allow for comparisons within a given appliance category rather than between appliance categories, so the user would need to know *a priori* which category they want to spend their money on.

Home Energy Saver: One of the more advanced calculators is the Home Energy Saver, developed by the Lawrence Berkeley National Laboratory (LBNL), which is intended for users with varying levels of skill and motivation, including individual consumers and larger organizations (LBNL, 2014). With this tool, users can input information in wide ranging detail based on the level of motivation, expertise and information available to them. The decision aid then provides point estimates for the monetary cost of action, the savings in energy, and GHG emissions impact from upgrades to six broad category of appliances: heating, cooling, hot water, small appliances, large appliances, and lighting, thus allowing for cross-category comparisons of efficiency switches. The decision aid also provides a point estimate of the simple payback period and the rate of return on investment. The aid focuses exclusively on home energy efficiency actions. It excludes energy efficiency improvements in transportation. Finally, the decision aid focuses primarily on efficiency improvements and the user is unable to compare efficiency actions to the potential savings of curtailment energy savings in each daily activity.

We also searched online and reviewed, only briefly, a few other calculators developed by non-governmental organizations such as Pacific Institute (WECalc, 2014), CoolCalifornia (CoolCalifornia, 2014), Energizing Indiana (Energizing Indiana, 2014) to name a few. Furthermore, suggestions for reducing energy use can be found on the website of almost every major energy utility company. When compared to the tools we discussed earlier, these tend to mainly be qualitative and generally do not provide comprehensive and quantitative comparisons of options for reducing energy consumption based on one or more criteria.

Comparing existing decision aids: The strength of both the Energy Star and EERE appliance specific spreadsheet calculators relative to the Home Energy Saver is that they provide greater detail in appliance level estimation (in addition to the transportation energy saving calculator). However, both the Energy Star and the EERE decision aids have limitations in that they require significant effort on the part of the user to be able to compare the cost of energy efficiency and cost effectiveness of pollution reduction across appliance and energy usage categories (i.e., should I replace my lights or replace my windows?). Relative to both the Energy Star and EERE calculators, in our opinion, the Home Energy Saver calculator provides a more comprehensive analysis of alternatives and in an easier to comprehend manner for an individual user.

While the decision aids we reviewed provide estimates on specific benefits in terms of energy savings, and some even provide estimates of upfront and operating cost for different appliance choices for any given type of activity or service, the decision aids do not always help identify the most cost-effective actions that would maximize the impact for a given budget. For instance, given a baseline level of energy consumption, a decision maker with a given budget, might find the task easier with a customized recommendation of the top three to five actions based on certain criteria. Only the Home Energy Saver allows ranking of energy efficiency options based on a criterion such as additional cost, energy savings, simple payback period, and rate of return investment. Note that the costs in the Home Energy Saver decision aid are not the total cost of buying the new product, but more precisely the additional portion of the added cost of going with the more-efficient option compared with the least-efficient option. Although it does not automatically make recommendations that satisfy an individual's budgetary constraints, if he or she has one, a capable user could with a little effort identify the list of actions that would maximize the energy savings while staying within a given budget.

All the decision aids we investigated seem to focus exclusively on residential energy use, with fewer decision aids for transportation decisions. As mentioned earlier, actions related to transportation might potentially be the easiest and cheapest for certain types of individuals. Furthermore, none of the aids allow a systematic comparison of efficiency improvements to curtailment actions. That said, we do recognize that curtailment is not a one-time decision, in comparison to purchasing an appliance, and therefore quantifying the energy and cost savings for any specific user is challenging.

The aids described use limited behavioral insights and assume rational economic actors as their end-users. Behavior needs to be motivated by effectively framing the information such that a user can understand and act on the information that they are viewing. Humans have bounded rationality, which means our rationality is limited by information processing capacity, cognitive heuristics, time, and effort needed to make a decision (Hastie & Dawes, 2001; Simon, 1982). Given our limited resources, individuals may not always look for optimal energy conservation solutions or decisions, and instead may "satisfice". The process of satisficing implies problem solving and decision making that sets an aspiration level, searches until an alternative is found that is satisfactory by the aspiration level criterion and selects that alternative (Simon, 1957; Simon, 1972).

We thus conclude that the information contained in the typical decision aid available today forces decisions to be made in an ad-hoc manner with only partial knowledge of the range of actions, the available choices, and the cost-effectiveness of each option. While existing decision aids incorporate some lessons learned from the psychology and the marketing literature, framing of the information provided needs further improvement.

Desirable attributes of a better decision aid

In discussing attributes of more ideal decision aids, we assume that individuals are sufficiently pre-motivated to reduce energy use and that they either lack the necessary information or have difficulty in processing the information contained in existing decision aids, which limits their effectiveness. We do not discuss the problem of how to motivate a consumer to actually seek out the best available decision aid, given there exists any number of online resources that provide tips for reducing energy use (which can provide effective or non-effective tips). The issue of increasing mainstream use is left to advertising and marketing the decision aid, which is without a doubt an important topic but beyond the scope of this paper.

To make decision aids more comprehensive in the information they provide, more user friendly, and thereby, more effective, we suggest improvements along two broad areas. One area concerns the analytic capabilities and the information content of the decision aid, which focuses on (1) multiple goals and constraints, (2) hidden costs, and (3) heterogeneity in user characteristics. The other pertains to the framing of the information in a manner that is easily processed by the user by using decision architecture that limits choice overload and uses smart default options.

We suggest three major improvements related to the analytical capabilities and the information content of the decision aids. One improvement would allow the user to specify multiple goals and constraints. For an energy decision aid, decision architects could focus on three suggested attributes: (1) a user's monetary budget, (2) energy savings, and (3) payback period. The output would include the most effective actions to decrease energy use given the user's baseline use and cost constraints. (We do not focus on reducing GHG emissions per se, as decreasing energy use would inadvertently decrease GHG emissions. We also hope that improving decision aids will lead to an increased understanding about the trade-offs involved between the three suggested attributes.) For example, a user may face the following decision problem: reduce monthly energy expenditure by 10% while ensuring initial investment cost is less than $200 given a baseline. In case no potential solution other than curtailment is found (note that curtailment is always a technically feasible option to reduce energy use to any desired level), then the decision aid could make recommendations on how much any single goal or constraint needs to be relaxed such that at least one efficiency option becomes available, in case curtailment activities include high hidden costs, an issue we discuss next.

A second set of recommendations is aimed at minimizing various hidden costs associated with adopting energy efficient appliances and curtailment activities. Although our premise is that the "energy efficiency gap" is real, that people underinvest in economic efficiency opportunities, there is also a rich literature which argues that this gap is overestimated for a variety reasons, one reason being hidden costs (Gillingham, Newell, & Palmer, 2009; Golove & Eto, 1996; Levine, Koomey, McMahon, Sanstad, & Hirst, 1995). By hidden, we mean that an analyst or a researcher does not observe these costs, which might lead them to underestimate the true cost of energy efficiency. One example of hidden cost may be a perceived difference in quality of service from a more efficient device (e.g., difference in the color or warmth of light as reported for CFLs (Jaffe, Newell, & Stavins, 2004)) or the power of a device such as the slower rate of acceleration of efficient cars. Here we focus on a different set of hidden costs, which are not attributed to the product or service per se, and are referred to as transaction costs. Transaction costs are incurred both in the form of time required and money associated with making a choice. Examples include (1) locating one or more actual brands and models of an appliance for each improvement recommended by the aid and finding information on various attributes such as upfront cost, operating cost, installation cost, and payback period; (2) locating a retailer and, if needed, an installer (ideally, for each of the above two tasks, suggestions for multiple retailers would improve consumer confidence and reduce his or her search cost); and finally (3) gathering information about government subsidies such as tax credits and rebates from utility companies for trading in older appliances for high efficiency models. With regard to the last issue above, behavioral studies suggest that mere provision of information about financial incentives is insufficient unless coupled with clear messaging about the ease of collecting those incentives.

The huge success of the Consumer Assistance to Recycle and Save (CARS) Act of 2009, popularly known as the Cash for Clunkers program, has been attributed to the simplicity of the process for claiming the subsidy. In this case, automobile retailers served as a one-stop shop for consumers, by removing all paperwork burdens and providing instant rebates. This suggests that an ideal decision aid would be a one-shop stop for information on energy efficiency and curtailment. Currently, the EPA's Energy Star Program is the only decision aid that aims to provide some of the above information, specifically; it provides links to retailers of select high efficiency models of an appliance. A challenge with making such features available is the cost associated with maintaining all this information up to date in the database accessed by the decision aid. This can be accomplished by linking any web-based decision aid to a central online repository of information such as the Energy Star Program's database of appliances.

A third set of characteristics is aimed at recognizing heterogeneity in consumer characteristics to instill consumer confidence in the recommendations. To this end, recommendations of decision aids that are able to replicate the energy expenditures of a user based on the information he or she provides about characteristics of home, appliance and usage patterns, are more likely to be acted upon. Another aspect of consumer heterogeneity is variability in tolerance to investment risk. With regard to appliance performance, including information about warranty and reliable consumer reports along with appliance recommendation may mitigate this risk. Another source of risk is the longer-term trends in fuel prices, which has implications for payback and rates of return on investment for expensive capital. For instance, in late 2014, there has been a rapid and unexpected decline in current and expected price of crude oil (EIA, 2014b), which would have rendered energy efficiency investment calculations from early 2014 go awry. An option to analyze operating cost and payback periods under different assumptions of energy price would be a definite improvement to existing tools.

We next discuss how the information contained in the decision aid could be presented in a manner that an individual can (1) easily process and (2) be motivated to act on the most effective actions among the choices presented. As Allcott and Mullainathan (2010) suggest, although research in human behavior and energy-use decisions is not new, there is a missing link between researchers, policy-makers, and businesses to do the "engineering" work of translating behavioral science insights into practice.

To illustrate the power of framing information, research has shown that consumers' evaluations of beef labeled "75% lean" were far more favorable than beef labeled "25% fat" (Levin & Gaeth, 1988). Similarly, promoting pro-environmental messages can deter conservatives from adopting energy-efficient lighting, where Gromet, Kunreuther and Larrick (2013) find that more conservative individuals are less likely to purchase a more expensive energy-efficient light bulb when it is labeled with an environmental message than when it is unlabeled. Additionally, attribute framing also has a strong effect on choice. Self-identified Republicans and Independents are more likely to pay for a carbon offset than a carbon tax, although Democrats did not differentiate between taxes and offsets (Hardisty, Johnson, & Weber, 2009).

To give another example of framing, in the case of automobile efficiency, the "miles per gallon" metric is curvilinear, meaning that the gallons of gasoline used per 10,000 miles expressed as a function of fuel efficiency of a car is not a linear relation; switching from a 16 mpg car to a 20 mpg car actually reduces gasoline use far more than switching from a 34 mpg car to a 50 mpg car over 10,000 miles. Thus the mpg metric does not intuitively and correctly inform car buyers on the relative fuel savings between cars (Larrick & Soll, 2008). Additionally, people seem to prefer fuel-efficient automobiles when fuel economy is expressed in terms of the cost of gasoline over 100,000 miles, regardless of whether or not the vehicle pays for its higher price in gasoline savings (Camilleri & Larrick, 2014). Thus, tools from decision architecture (Johnson et al., 2012) should more clearly be studied and adopted in the energy domain to reduce consumer illusion about performance. Some of these recommendations have now been adopted by the EPA, where the new window sticker for automobiles includes information on gallons per 100 miles, annual fuel costs, and how much money is saved in fuel costs over 5 years compared to the average new vehicle. Similarly, the EERE fuel economy calculator also incorporates some of these lessons, where fuel economy is reported per 100 miles along with cost estimates for driving 25 miles. For an illustration, www.fueleconomy.gov allows the user to personalize the estimates for cost of driving by modifying the default setting for assumptions about their driving patterns and a single value for fuel price (DOE, 2014). That said, people might overtly focus on the mpg metric given the strong status quo, since the mpg metric is still the most prominent feature on the new EPA car label.

One troubling example, is that programmable thermostats have failed to save the energy that they were designed to save, as per the EPA Energy Star labeling site: "The Energy Star specification for programmable thermostats was suspended on December 31, 2009 and the Energy Star label is no longer available for this category. While EPA recognizes the potential for programmable thermostats to save significant amounts of energy, there continue to be questions concerning the net energy savings and environmental benefits achieved under the previous Energy Star programmable thermostat specification." The question that remains is why did the programmable thermostats fail to save energy? One reason could be the failure to recognize the importance of psychology, where smart efficient default settings were not always pre-set by the manufacturer before thermostats were sold to the consumer, thus they were left either un-programmed or programmed on incorrect settings. Thus pre-programming appliances with an energy saving efficient default would be a better default option in this case in comparison to no programming or incorrect settings.

Changing the default setting for a decision has been shown to make a large difference on the final outcome. For example, changing the opt-in to an opt-out can lead to large differences in organ donation rates (Johnson & Goldstein, 2003). Similarly increasing the default retirement savings contributions can also lead to more savings in the long run (Madrian & Shea, 2000). There are but a few examples of experiments in changing default settings in the energy domain. One such example, demonstrated by Pichert and Katsikopoulos (2008) provides evidence that people use the kind of electricity provided to them as a default, and more people use renewable electricity when it is the default option provided by the utility. These types of changes in default setting can be viewed as libertarian paternalism (Thaler & Sunstein, 2003), given the individual can still choose to decline being an organ donor, decrease their 401(k) contributions, or switch from renewable electricity to fossil fuels. Research has shown that people prefer changes in default (soft regulations) to harder regulations like bans, because freedom of choice is protected (Attari et al., 2009). However, there is a need to suggest caution in using these types of paternalistic defaults: To the extent that individuals do not to behave in their own best interests, paternalism may prove useful, but, to the extent that paternalism prevents people from behaving in their own best interests, paternalism may prove costly (Camerer, Issacharoff, Loewenstein, O'Donoghue, & Rabin, 2003). For example, overinvesting in retirement for individuals on a tight budget can hurt in the short-run. One recommendation is to provide smarter efficient default options for online and in-store appliance purchases, however more research is needed on how to present these options without being too costly for the consumer.

By simply presenting the facts without effective framing the information, consumers now have a long and somewhat overwhelming list of options to choose from, which may lead to choice overload and actually deter significant adoption of behaviors that decrease energy use (Iyengar & Lepper, 2000). We suggest that only limited choice options be provided to the end-user that is tailored to their existing goals and constraints (Miller, 1956). The Home Energy Saver tool partially addresses this concerns in that it allows a ranking based on a single criterion. However, while this can identify options that maximize the impact for a given budget or minimize cost for achieving a given target level of reduction in energy consumption, it does not allow a consumer to easily choose between multiple but imprecise and often contradictory goals.

Another issue that has received little attention in the past is evaluating the effectiveness of existing decision aids such as the LBNL's Home Energy Saver and the EERE spreadsheet calculators. While it easy to automatically generate statistics on the number of times an online decision aid is accessed and while users could be nudged to reveal more information about themselves and their experience with using this tool, evaluating how the decision aid actually influenced their decisions and behavior is a harder problem, requiring reliance on self-reported surveys or collecting information on a consumer's exposure to a decision aid at the time of purchase. A brief literature search yielded few publications on the topic of evaluating these online decision aids and how using these aids related back to actual energy use. Indeed, there is a growing literature of how providing information on social norms can decrease electricity use in the home. For example, companies like OPOWER are combining with academic researchers to conduct field experiments to assess the effect of social comparisons of household energy. Econometric assessment of such interventions demonstrate a 2% reduction in electricity use over the long-run (Allcott, 2011). However a limitation with these studies is that one cannot identify from the aggregate energy use data for a household which actions the household took to reduce energy consumption. Thus, developing strategies for evaluating the effect of using decision aids is a challenge for future research. We also need to know which individuals are currently using these decision aids, i.e., how accessible are these aids to the general public.

Summary

In this paper, we are proposing a call to action. We highlight that there are decision aids that are available to end-users. The current existing decision aids explored, namely, the Energy Star Labeling, EERE calculators, and Home Energy Saver, allow some choice comparisons that are usually hard to make. However, the current aids assume cost-calculating rational actors with few cognitive limitations. They are also limited in their analytic capabilities, information content, and the use of decision architecture to help consumers make better decisions. Here we suggest a framework of how to address these limitations, which needs further development. There are also limited systematic studies of who is actually using these aids to make real-world decisions. Thus, more work is also needed to actually see how these aids affect decision making in the wild and how we can improve them given the recent advances in psychology.

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