REDUCING GREENHOUSE GAS EMISSIONS THROUGH BEHAVIORAL CHANGE

An Assessment of Past Research On Energy Use, Transportation and Water Consumption

January 2009

Ezra M. Markowitz and Bob Doppelt
Climate Leadership Initiative
Institute for a Sustainable Environment

Table of Contents

REDUCING GREENHOUSE GAS EMISSIONS THROUGH BEHAVIORAL CHANGE

AN ASSESSMENT OF PAST RESEARCH ON ENERGY USE, TRANSPORTATION AND WATER CONSUMPTION

Behavioral changes are certain to be an important component in reducing greenhouse gas emissions (GHG) and combating climate change. However, relatively little research has been done to clarify what is known about the ability to motivate people to change their behavior in a way that reduces GHGs. This report provides a preliminary overview of the existing research on this critical question. It then provides a framework for thinking about how to plan and execute GHG reducing behavioral change interventions.

This is not a comprehensive assessment. Instead, it highlights some of the most readily available relevant research on behavioral change and GHG reductions in three domains: energy use, transportation, and water consumption. Our intent is to offer a clear, simple, basic guide that can serve as a starting point for implementation of behavioral change programs and for further research into the topic.

I. Defining "Behavioral Change"

The primary criterion this study used in gathering research reports and case studies is that the behavioral change must: a) be the result of conscious decision-making on the part of the individual; and, b) have an outcome (e.g., reduced energy consumption) that has a clear and direct link with reduced GHG emissions. Thus, any action that an individual *purposively* and *consciously* takes that represents a change from previous actions and that leads to a reduction in GHG can be considered a behavioral change.

II. Energy Use

Fossil fuels are the dominant source of energy in the U.S. and most other industrialized nations today, which means GHG emissions are endemic. Since the first round of oil crises in the 1970s, there has been a significant amount of time and energy spent by academic researchers, utility companies, business managers and others in an attempt to find ways to reduce fossil fuel use, particularly by households (see lengthier reviews by Abrahamse et al., 2005 and Stern, 1992 for more details). Some successes have been achieved. Although the majority of the research described in this section did not directly measure changes in GHG emissions as a result of behavioral changes (with a few notable exceptions), they all recorded changes in energy consumption, which we assume to be a surrogate for GHG reductions.

Because the vast majority of past research focused on energy reductions is oriented towards households and organizations, we examine these areas. Reducing GHG emissions via energy reductions in household and organizational settings encompasses a wide range of relevant interventions that stimulate behavioral changes.

A. Capturing Personal Time and Attention

An important initial step in motivating people to change their behavior intentionally is to capture their time and attention. Although what happens after someone gives their time and attention to an issue is the focus of many research topics, getting people to focus on and participate in an energy reduction program can be a significant behavioral change itself. At least five primary methods have been used by researchers to capture attention and secure a commitment of time: 1) door-to-door 'solicitation' (e.g.,

Winett et al., 1985); 2) mailed information about a project or campaign (e.g., Brandon & Lewis, 1999; Schultz et al., 2007); 3) talking with people via telephone (e.g., Becker, 1978; Department of Environment and Heritage, 2005); 4) placing ads (e.g., Hayes & Cone, 1981); and 5) utilizing existing social structures (e.g. Gardner & Stern, 2002).

Getting commitments of time and attention is important because, as discussed below, many of the interventions that have been developed to reduce GHG emissions via behavioral change require some level of conscious, cognitive processing of new information by individuals.[1] Although some interventions rely on subconscious processes or simple stimulus-response mechanisms, many require at least some cognitive "opening" for the researcher or practitioner to work with. Creating this "opening" is critical to get an intervention program off the ground.

B. Feedback

Once an individual has given his or her attention and time to a behavioral change program, the work of changing behavior can begin. Providing energy users with feedback (information) on their energy consumption has consistently been shown to be an effective way to alter a wide-range of relevant behaviors and reduce consumption (see Darby, 2006). The amount and type of feedback provided are important factors (Darby, 2006), and features of the target population should be taken into account when deciding what type of feedback to provide. In some cases feedback given multiple times a week (e.g., Seligman, Darley & Becker, 1978) and in other cases feedback given just bimonthly (e.g., Wilhite & Ling, 1995) has produced similar reductions in energy use (i.e., 10 percent energy savings).

Often feedback has been combined with other behavior change tools, including written information about how to reduce consumption (e.g., Benders et al., 2006: 8.5 percent savings over control groups), frequent visits with householders to provide information face-to-face (e.g., Gaskell, Ellis & Pike, 1982: 11-22 percent savings), and goal-setting, which refers to having individuals, households or organizations set specific reduction targets, e.g., "we will reduce our household energy use by 5 percent over the next month" (Seligman et al., 1978: 13 percent reductions).

Getting people to obtain their own feedback by reading their own meters has also resulted in decreased energy consumption. For example, Winett, Neale, and Cannon Grier (1979) achieved a 7 percent decrease equaling 270 kWh saved per household per month and Staats and Harland (1995) achieved 23-27 percent reductions. Teaching people how to get their own feedback may result in longer-lasting reductions than feedback provided by a researcher or external organization (e.g., Staats & Harland, 1995; Mountain, 2006).

In sum, research suggests that when people learn to seek and accept feedback, they are more effective at reducing energy consumption and GHG emissions.

C. Multifaceted Programs

Often, a number of interventions can be combined to motivate behavioral change. For example, in a detailed study, Abrahamse et al. (2007) achieved a 5.1 percent decrease in energy consumption by participants through a combination of tailored information, tailored feedback and goal-setting. This equated to 3320 kWh saved by all participants in the experimental group. All of the interventions were delivered to participants via a website that they had been directed towards via mailed invitations. The invitations asked households to participate in a study involving a new website aimed at providing custom information about household energy consumption. The authors found that participants decreased consumption through the following behavior changes: lower daytime thermostat setting; rinsing dishes in warm water; decreasing dishwasher use when not full; decreasing the number of showers per week;

[1] By 'information' we refer not only to specific pieces of knowledge regarding which behaviors we want people to change and how, but also to information regarding social norms, barriers to change, feedback, etc.

shorter showers; using washing machine when full; decreasing dryer use when not full; leaving lights on less; and, eating less meat. Unfortunately, the authors did not disaggregate energy savings by behavioral change.

An important feature of the Abrahamse et al. (2007) study was that the researchers provided participants with tailored information and tailored feedback. "Tailoring" involves utilizing data or knowledge about a specific individual or household (e.g., home energy audit) in order to provide the most relevant and potentially useful information and/or feedback to them (e.g., "Given what we know about your energy use patterns, the most effective change you can make is to replace your hot water heater..."). In contrast, many past attempts to change behavior have relied on providing individuals with relatively generic information (e.g., "Replacing incandescent light bulbs with CFLs saves energy"). Tailored information and feedback are generally more personally relevant to an individual and can be more effective behavior change tools than generic information. However, they are often considerably more time intensive to provide, as data must first be collected on individual participants.

In a similar manner, Staats et al. (2004) achieved energy reductions of 7.5 percent over a period of 3 years through an intervention program involving feedback, information and social support. Social support was provided by organizing individuals into 'EcoTeams,' which consisted of 6-10 people who met once a month to discuss personal experiences with environmental conservation, ideas for reducing consumptions, and achievements. Additionally, the groups served as a source of comparative information and feedback about successes and failures regarding various conservation goals set out by the program directors (e.g., amount of garbage produced in a month). The researchers reported significant reductions in household thermostat settings, turning unused lights off, setting TVs to 'off' instead of 'standby,' only using washing machines when full, and use of compact fluorescent light bulbs. Again, the report did not disaggregate energy savings by individual behavioral changes.

Keirstead (2007) found that UK households that had installed photovoltaic systems reduced their energy consumption by 6 percent and shifted their energy use to match peak energy generation produced by their PV systems. Although Keirstead does not discuss how the households he interviewed were convinced to install PV systems, he suggests that such a behavioral change can lead to dual-benefits: not only are households with PV systems producing GHG neutral energy, but they also began to use less overall energy than comparable households. Surveys of participants suggested that the observed energy savings could be explained, in part, by the presence of system performance monitors. These are devices located inside the home that provide real-time information to householders about energy generation and consumption. Thus, they provide a form of direct, immediate feedback on personal energy consumption.

D. Energy-Oriented Behavior Change in Organizational Settings

A few research projects examined behavioral changes leading to reductions in energy use in organizational settings. Siero, Bakker, Dekker and van den Burg (1996) provided workers at a metallurgical factory with energy conservation information (i.e., behaviors they could engage in to reduce consumption), had them set energy reduction goals, and provided either individual or group feedback. Although they did not quantify actual energy savings, they reported significant decreases in energy wasting behaviors by the workers. In particular, employees turned off computers at night, turned off lights when not in use, reported compressed air leakages, and disconnected electrical appliances. This project appears to have had essentially zero cost (except for minor costs associated with providing feedback). Importantly, employees in the comparative feedback condition saved more energy than did employees who received feedback only about their own group's behavior, suggesting an important role of social influences on energy use behaviors. [2]

[2] Group members in the comparative feedback condition received information both about their own group's energy use as well as about the energy use of the other experimental groups over the course of the intervention period.

Working in an office setting, Staats, van Leeuwen and Wit (2000) were able to decrease natural gas use by 6 percent and maintain such reductions by having office workers make two simple behavioral changes: uncovering radiator grates and maintaining office radiators at equal settings. To change behavior the researchers provided information to all office workers about the energy benefits of not using the grates as bookshelves and setting radiators at the same level. In addition, they used comparative feedback (graphic displays posted around the building showing percentages of offices complying) and individual feedback (telling workers how well they were doing maintaining grates uncovered and radiators within a given office set at equal heating levels).

More recently, a team of researchers and practitioners at Harvard produced significant reductions in emissions and energy use by the university's chemistry department via a program called, "Shut the Sash Contest" (Greencampus Initiative, 2008). Using a combination of information distributed via flyers, posters and emails (i.e., information on how much energy is wasted by variable volume chemistry hoods) and rewards (i.e., beer and pizza, cheese and wine parties for contest winners), the campaign reduced the CO_2 emissions of the Chemistry department by 350 metric tons per year, saving $130,000 per year in energy costs in the process.

Large monetary savings and GHG reductions have been found in a totally different setting as well. Working at two U.S. military bases, McMakin, Malone and Lundgren (2002) used focus groups (i.e., bringing small groups of potential participants together to discuss barriers to positive behaviors and locally feasible strategies for behavioral change), conservation oriented cartoons, diffusion techniques (e.g., using preexisting interpersonal relationships to increase participation), modeling (i.e., showing individuals performing desired actions via video programs) and targeting of certain behaviors (i.e., lowering thermostats at night) to reduce base-wide energy consumption by 10 percent or 4.23 million kWh and 8,300 mBtu at one of the bases (reductions at the other base are not as clearly quantified in the report). These changes resulted in $130,000 in energy savings at one base and $50,000 in savings at another. Self-reports by individual households on the bases suggested that behavioral changes (e.g., lowering thermostats) led to the observed reductions.

This overview suggests that many cost-effective interventions can motivate people to change their behavior and reduce energy use.

III. Transportation

Moving people from point A to point B requires a great deal of energy and, when fossil fuels are used, produces significant GHG emissions. Over the past 30 years, researchers, practitioners, business-owners and others have investigated numerous ways to answer a basic question: how do you get people out of their cars or at least convince them to share their cars with others? We found only a limited number of research studies that measured actual changes in transport behavior and associated energy reductions.

One area that has been studied is methods for reducing the number of miles driven by commuters. One of the earliest studies aimed at reducing driving to campus by college students (Foxx & Hake, 1977). By offering students a combination of reinforcement and prizes, including cash bonuses and free oil changes for making set levels of reductions in miles driven, the researchers were able to reduce the daily mileage of the experimental group by 20 percent over the course of a month. However, it is important to note that the researchers used a very small sample of student drivers (all of whom were signed up for the study in a classroom setting).

Working with an adult population, Foxx and Shaeffer (1981) used a combination of a lottery (i.e., monetary prize dependent on amount of driving reductions realized) and feedback (individual and comparative provided via poster) to decrease mileage driven by employees of an R&D consulting firm by 11.6 percent, saving 108 gallons of gasoline over a four-week period. This study involved a very

small number of participants, although perhaps that makes the gasoline savings that much more impressive. The project was nearly cost-neutral in that the price of the prizes was almost offset by savings in fuel.

Some attempts have also been made to encourage energy reducing driving techniques and behaviors (e.g., driving more slowly). Working with the Dutch Postal Service, Siero, Boon, Kok and Siero (1989) used a combination of information (e.g., how to drive more efficiently), feedback (e.g., installing a tachometer in delivery trucks) and goal setting (5 percent reduction) to change three primary driving behaviors among postal workers: shifting gears earlier, driving more slowly, and anticipating braking (starting to brake at an earlier point, thus reducing unnecessary acceleration). Information on the requested behavioral changes was provided to delivery drivers via an instructional film (modeling) and booklet. Goal setting was initiated in a top-down fashion; that is, local supervisors met with all of their drivers in a single meeting to ask them to help "cooperate in cutting fuel consumption by 5 percent." The researchers obtained 7.3 percent in energy savings and, importantly, the savings were maintained after 6 months. The program seemed especially effective in getting postal drivers to shift at lower engine speeds and anticipate braking more often (self-reported).

One study has 'taken a step back' and focused on a major life decision that young adults make that has vast implications for their transportation-related GHG emissions: whether or not to get a driver's license. Fujii (2007) provided different forms of information related to negative consequences of becoming a driver (e.g., cost, safety, stress) to young college students who did not yet have driver's licenses. Relative to a group of comparable students that did not receive such information, these students were significantly less likely to have obtained a license 18 months after receiving the information. Participants spent approximately 3 minutes reading the information. The study suggests that car-use decisions can (at least indirectly) be strongly affected via simple, pertinent information.

A recent review of travel feedback programs (TFPs: Fujii & Taniguchi, 2006) suggests that it is possible to decrease transport-related CO_2 by up to 35 percent in this manner. TFPs are campaigns to change transport behavior that utilize personalized communications, usually focusing on providing information about how to change behavior (e.g., drive less, use public transportation) and sometimes encouraging people to make travel implementation plans (i.e., specific plans on how to change transport behaviors). TFPs often involve intensive face-to-face contact with participants, including visits by "experts" (e.g., bike carriers talking with commuters about bike travel; bus driver talking about using public transportation). They are generally aimed at changing residential, workplace or school transport behaviors. Fujii and Taniguchi (2006) review past TFP programs, primarily from Japan, in more detail. The average reductions in CO_2 emissions as a result of decreased car use over the studies they reviewed was 19 percent; average car use decreased by 18 percent and public transport use increased 50 percent across 10 TFP studies. Asking participants to create implementation plans appears to be an important factor in producing positive results via TFPs.

To provide just one specific example of a TFP: Fujii and Taniguchi (2005) compared traditional feedback (i.e., information about past transport behaviors and ways to reduce car-use) with feedback combined with implementation plans (i.e., having households develop plans for actually reducing car use). They found that traditional feedback alone did not reduce self-reported trips by cars whereas the group that created plans did in fact decrease their time spent traveling by car by over 25 percent, overall decreasing CO_2 emissions by 35 percent. Studies by Jakobsson, Fujii and Garling (2002), Matsumura (2004), and Doi et al. (2004) also demonstrated the positive effects of driving reduction plans.

Many studies have focused not so much on changing behavior as on discovering the barriers to public transportation use. A few, however, have successfully combined the two approaches. A number of studies have examined the effectiveness of public transport "trial" periods on reducing car use, although these studies do not seem to quantify actual energy saved or GHG emissions reduced via the behavioral changes. A recent study by Thogersen and Moller (2008) conceptualized transport behavior as a habitual action and used a one-month incentive (free public transportation) to encourage drivers to

break their habits and use public transport. Using a sample of 1000 Danish drivers, the researchers found that providing one month of free public transportation (in addition to providing individualized transport schedules) did significantly increase transportation ridership among previous non-users, however, four months after the free month expired, car use increased back to baseline.[3]

Providing a small group of drivers with a free one-month bus pass, Fujii and Kitamura (2003) found results similar to Thogersen and Moller, although they found that public transportation ridership was still higher one month after the free pass expired. These studies suggest that it may be possible to break habitual car-use behaviors (for example, by reducing the relative and absolute costs of non-car travel modes), but without better measures, it is difficult to assess the potential GHG savings of such programs (and thus their relative cost of reducing emissions compared to other techniques and behavioral domains).

In addition to the peer-reviewed literature on changing transport behaviors, there are a few case studies of transport-specific projects that should be briefly mentioned. These projects have websites and reports that can be explored for more detailed information. One set of projects that has received attention is the TravelSmart program in Australia (Department of Environment and Heritage, 2005). This set of transport behavior change campaigns, which encompasses a variety of specific projects, utilizes many different behavior change techniques to reduce car use by households, workplace commuters and school-related users. All of the TravelSmart projects utilize a community-based social marketing approach[4] and results indicate that personal engagement (i.e., talking with people face-to-face), providing useful information (e.g., bus tickets, maps, timetables), getting local support from community leaders (e.g., involving city council members), community involvement (e.g., scaling up projects to involve many individuals), and disincentivizing car use (e.g., removing downtown parking) can all be factors in changing transport behavior. The projects realized reductions in car use ranging from 0-60 percent and increases in public transportation use up to 50 percent. Resulting CO_2 emissions reductions for some projects (e.g., Perth, Melbourne, Brisbane) have been in the 0.12-0.39 tons per person per year range.

While there has been work on truck idling, most of it appears to focus on barriers to changing truck drivers' attitudes towards idling and not on what gains have actually been made in reducing unnecessary idling. However, a non-representative, small case study (of just two drivers) involving truck idling (Canadian Centre for Pollution Prevention, 2005) showed that installation of auxiliary power units reduced idling by 387.5 hours over a four month period for one driver and 162.75 hours for the other driver. These reductions led directly to GHG emissions reductions between 1.82 and 4.34 tons. More controlled and robust work needs to be conducted in this area.

Although there are a number of studies on transportation and transport decisions (at the household, commuter and organizational levels), many do not attempt to change behavior but rather describe various psychosocial and structural factors (e.g., access to public transport; physical impediments) that play a role in determining transport decisions. While these studies provide important information for practitioners, there does not appear to be substantial research on how specific behavioral changes lead to measurable reductions in GHG emissions.

---

[3] Many researchers have argued that incentives and rewards do not fundamentally and/or effectively change behavior in the long run (see Gardner & Stern, 2002 and Doppelt 2008).

[4] Community-based social marketing is a behavior-change technique pioneered by Doug McKenzie-Mohr and others (see www.cbsm.com) that involves five integrated steps: identifying barriers to change; designing interventions matched to bring down those barriers; piloting the strategy with a small community sample; implement across the entire community/organization; and, evaluate the impact of the program.

IV. Water Use

Although the energy required for heating, pumping, filtering and transporting water provides a clear link between water consumption and GHG emissions, this relationship does not appear to have been studied by many researchers. One of the reasons could be the obscurity of that relationship to individuals, practitioners and researchers interested in GHG emissions and behavioral change. While home energy use and transportation are clearly linked to GHG emissions, most of the diverse groups interested in water consumption and behavioral changes related to water use have focused on water availability and quality. However, many behavioral decisions regarding water use have direct implications for GHG emissions because of the energy required for transporting and heating water, including everything from drinking potable water to taking hot showers and leaving the water running while brushing one's teeth (Staats et al., 2004) to pumping water for lawn, garden or agricultural irrigation. Here we review just a few studies that focus specifically either on GHG emission reductions and water use and/or changing specific water-relevant behaviors.

Syme, Nancarrow and Seligman (2000) reviewed campaigns to reduce household water consumption, focusing on techniques used both to change water use as well as on methods used by previous reviewers. The authors report that past projects utilizing voluntary pleas for water use reductions by households have varied enormously in their results, with average reductions in the 10-25 percent range (although this number comes from an earlier review, Century Research Corporation, 1972).

In a 2005 study Kurz, Donaghue and Walker used a combination of information leaflets, attunement labels (i.e., labels indicating use of water by different appliances in the house), and comparative feedback to change water consumption in the household. The researchers found that the labels (e.g., a sign posted next to a shower telling a user how many gallons are used per minute), but not the feedback or information, aided in bringing about a 23 percent reduction in water use. The labels provided information about water use related to specific appliances or behaviors (e.g., showering) at the point of "interaction" between user and product (water). Over 50 percent of participants reported behavioral changes in the following domains: watering the garden less; shortening showers; using half flush on toilets more; and, setting water level for washing machine carefully. The researchers also measured changes in energy consumption but did not find any differences. It is unclear why this result was obtained.

In the Staats et al. (2004) study reported above (under Energy Use), the researchers also measured changes in water consumption as a function of a long-term social support intervention (see above for explanation) that also included feedback and information. The researchers reported significant positive changes in the following behaviors: using washing machine only when full; turning off faucets when washing hands, brushing teeth and doing dishes; taking shorter showers; installing low-flow showerheads; and, the number of toilets with toilet dams installed.[5] Over 3 years, water consumption decreased from 0.854 to 0.796 m^3 per person per week, a 6.7 percent decrease.

Dickerson et al. (1992) reduced shower times significantly by making people feel hypocritical when taking long showers. The researchers showed that getting people to make a verbal commitment to taking shorter showers, by itself, did not shorten shower times. Similarly, having people think about their past wasteful showering habits also did not shorten future shower times. Only when participants made a public commitment to take shorter showers after they had been reminded of their poor behavior did they change their behavior to save water. The authors explain their findings in light of cognitive dissonance theory (Festinger, 1957), which posits that when an individual holds (and is aware of)

[5] Toilet dams reduce the volume of water used per flush by taking up some of the space in the tank of a toilet with some sort of physical blocker.

contradictory beliefs, desires, etc., that individual experiences significant psychological discomfort (dissonance or tension). The authors suggest that people in their study took shorter showers in order to reduce the dissonance (reduce the tension) that was created by both stating support for water conservation and simultaneously being reminded of their own wasteful behaviors.

There are also many studies that focus on 'hard' techniques aimed at reducing water consumption more broadly, primarily changing price structures and restricting use at certain times of the day (e.g., Kenney et al., 2008). For example, past research has shown that variable pricing (e.g., per use) promotes conservation while fixed-price systems do not (e.g., Van Vugt, 2001), primarily by providing financial incentives for conserving. Restricting water use (e.g., anti-lawn watering laws) obviously curtails behavior (by preventing water use), but is not of interest here as it does not involve conscious and deliberate (or unconstrained) behavior change by users.

V. Summary and Conclusions

A. What the Research Suggests Is Known

The purpose of this study was to bring together existing research on how interventions intended to motivate behavioral change have led to reductions in GHG emissions. A significant amount of research has been completed on this topic, and we have necessarily reviewed just a limited number of the best examples in three resource domains: energy use, transportation and water consumption. The results of thirty plus years of research seem clear: not only are theoretical reductions in energy, water and transportation use (and by extension GHG emissions) possible as a function of behavioral changes, actual reductions of between 5-30 percent have been achieved in every domain we investigated.

This conclusion has recently been reinforced by Gardner and Stern (2008), who reported that households could reduce energy consumption by at least 30 percent via behavioral changes that will not decrease their sense of well-being or comfort. However, their analysis relies on theoretical changes in behavior, and indeed, many of the behavioral changes those authors advocate (e.g., replacing inefficient appliances) are the ones behavioral scientists and practitioners have had much difficulty actually changing.

The behavioral changes that have been successfully achieved were accomplished through the use of a variety of techniques. The list below summarizes a few of the more widely used interventions that were examined in this report:

- Securing time/attention
  - Door-to-door solicitation (e.g., Winett et al., 1985)
  - Mailings (e.g., Schultz et al., 2007)
  - Telephone contact (e.g., Becker, 1978)
- Providing information to educate (distinct from feedback)
  - Why people should care/benefits of change (e.g., Staats et al., 2000; Fujii, 2007)
  - Which behaviors to change (nearly all studies/campaigns include this)
  - Information tailored to individuals[6] (e.g., Abrahamse et al., 2007)
  - Attunement labels (e.g., Kurz et al., 2005)
- Feedback on performance (see Darby, 2006 for review)
  - Self-generated via use and/or consumption monitors (e.g., Winett et al., 1979; Kierstead, 2007)
  - Provided by others or researchers (e.g., Seligman et al., 1978; Gaskell et al., 1982)
  - Tailored to individual (e.g., Abrahamse et al., 2007)
- Goal setting (e.g., Siero et al., 1996; Foxx & Schaeffer, 1981)

[6] As opposed to providing the same feedback or information to all participants

- Implementation plans (see Fujii & Taniguchi, 2006)
- Verbal commitments (e.g., Dickerson et al., 1992)
- Utilizing social support and interaction
  - Social support (e.g., Staats et al., 2004)
  - Social comparison/feedback (e.g., Staats et al., 2000;
  - Focus groups (e.g., McMakin et al., 2002)
  - Modeling (e.g., McMakin et al., 2002)
- Rewards and incentives (e.g., Greencampus Initiative, 2008; Foxx & Hake, 1977; Thogersen & Moller, 2008)
- Inducing cognitive dissonance (e.g., Dickerson et al., 1992)
- Disincentivizing unwanted behaviors, Substitution (e.g., Department of Environment and Heritage, 2005; Van Vugt, 2001)
- Modifying environments/infrastructure (e.g., Kierstead, 2007; see Gardner & Stern, 2002)

This list is by no means comprehensive. Many of these and other techniques have been described elsewhere in greater detail, including the Fostering Sustainable Behavior website (www.cbsm.com), the Tools of Change website (www.toolsofchange.com), and numerous review articles (e.g., Abrahamse et al., 2005; Darby, 2006). However, few of the other behavioral change techniques have been studied for their effects on GHG emissions.

Many of the techniques described in this report succeeded because they reduced the barriers to change, including attitudes about real and perceived benefits as well as knowledge-based and physical barriers. In addition, many of the most successful programs are cited multiple times in the summary above. This is no coincidence: considerable research clearly indicates the benefits of using "mixed-intervention" approaches to motivate change in GHG relevant behaviors (Gardner & Stern, 2002). In part these multiple intervention strategies work well because they focus on and address the needs of people that respond differently to various prompts, motivations, values, etc. That is, they address the needs of people regardless of their stage of readiness to change. More information on this issue is provided below. They also work effectively because the interventions build on each other, synergistically increasing the power of each individual intervention. Finally, most of the achievements of past research have been produced because researchers or practitioners successfully applied basic principles of psychology to the question of behavior change (e.g., identifying and employing importance of social comparison and support to change behavior).

B. Context for Behavioral Change Interventions

One of the key questions that researchers and practitioners seek to understand when designing a change strategy is which behavioral change mechanisms and techniques are most useful with different people at different times. To answer this question it is important to understand a theory of how people change.

Although no model of behavioral change is perfect, a useful way to describe the process that people move through when they make a major shift in behavior is the 'staged-approach' to change. This approach is based on the 'Transtheoretical' model of change (TTM) developed by Prochaska and his colleagues (1994), which resulted from extensive research that distilled 24 major approaches to cognitive and behavioural change into a single framework. The TTM approach was modified by Doppelt (2008) and applied to climate and sustainability issues to produce what he calls the '5-D Approach to Change.'

The basis of the 5-D approach to climate-focused behavioural change is the understanding that people go through a series of stages whenever they make a fundamental change in their behavior. Each of the stages is relatively predictable and people must complete a certain set of tasks to move from one

stage to the next. Different change mechanisms and different techniques are therefore helpful in each of the stages of change. Conversely, using the wrong mechanism or technique at the wrong time can set back change efforts.

It is important to distinguish between change mechanisms and techniques. Change mechanisms constitute the overall approach to behavioral change and may incorporate a number of techniques. Education, for example, is considered a change mechanism and there are multiple ways to provide education to people. Securing a commitment is a change mechanism, and the techniques involved to achieve this goal may be written statements, verbal agreements, etc.

In order to design effective global warming change strategies, behavioral change practitioners must understand the stages of change and accurately assess the stage of change of their target individual or group. They must also utilize appropriate change mechanisms with each stage.

People usually begin in a stage of 'disinterest' about the climate, where they have little or no interest in changing their behavior. Disinterest is not necessarily a bad stage and it does not necessarily denote denial. All change starts with disinterest. The stage is sometimes caused by lack of information, fear of change, the belief that negative consequences will not occur, be minimal or not affect the individual, or other issues. Disinterested people do not feel a sufficient level of tension, or dissonance, to change their behavior. Because disinterested people are not ready to change, commitments, rewards, incentives, and even disincentives will do little to change their behavior. In fact, using these mechanisms and techniques may cause people to become further entrenched in disinterest.

Instead, the most helpful interventions for motivating people to move beyond disinterest tend to be experiential change mechanisms. They include: 1) using a disturbance or crisis to encourage an individual to think about whether their current behavior makes sense; 2) information that builds awareness of the downsides of existing behaviors and benefits of climate-positive alternatives; 3) emotional inspiration such as experiencing first hand the benefits of GHG reductions and the downsides of continued emissions; 4) choice expansion that allows the individual or group to see that a range of small and larger steps are available for making a change, thus helping them see that the change need not be overwhelming; and 5) having someone trustworthy to talk with about whether or not to make a change--that is, utilizing social support and interaction. The overriding goal of these interventions is three-fold:

1) To generate tension for change, or dissonance. A basic premise of behavioral change is: no tension, no change. Without tension for change (meaning that the individual or group desires either to achieve a deeply desired goal or value or avoid a negative), people have little motivation to behave differently;
2) To increase efficacy. Feeling tension for change is vital, but insufficient. People and groups must also believe that they have the capacity to successfully make the changes needed to reduce the tension; and
3) Build awareness of the benefits of change. In order to make a significant shift in behavior, individuals and groups must generally see significantly more benefits than downsides of changing their behavior. If the pros and cons seem relatively equal (or if the downsides appear larger than the upsides) people will not change their behavior.

If sufficient tension or dissonance grows between an individual or group's current state and a desired condition, they begin to develop some sense of efficacy and they believe that there may be benefits to changing their behavior, they move to the 'deliberation' stage of change. In this stage people deliberate about whether or not to make a change. The dominant internal dynamic is weighing the pros and cons of shifting to climate-friendly behaviors with the goal being to decide if the benefits sufficiently outweigh the costs. This type of cost-benefit analysis often includes a self-assessment by the

individual of their capacity to make a desired change (called efficacy), whether or not their social support network would support the change, and other factors.

The most helpful change mechanisms in the deliberation stage of climate-focused behavioral change include the five that are important for the previous stage of disinterest, plus self-appraisal. This involves helping an individual determine if their current behavior allows them to be the person they aspire to be (e.g., do they want their children or others to think of them as someone who failed to do their part to resolve global warming). Numerous techniques are available to help individuals and groups complete self-appraisals.

If an individual or group decides that the pros of change outweigh the downsides by about a 2:1 ratio (that is, they see two benefits for every one downside to changing), they enter what Doppelt calls the 'design' stage of change. In this phase, which can be short or long depending on the type of behavioral change involved and other factors, individuals design an initial plan for making the shift to new behaviors. The design stage allows the individual to 'try on' the new behaviors, make final determinations about their level of efficacy and their perception of the benefits of change, and decide if they want to make a firm commitment to new behaviors.

Making a public commitment is the most important change mechanism in the design stage of change. Previous to this point most of the change process has occurred internally and privately. To move beyond the design phase to action it is often important to make public the commitment to change. This may involve change techniques such as making a verbal commitment, setting goals, and making implementation plans.

If an individual or group commits to change, they enter the 'doing' stage where they act on their plans. This is usually an exciting stage where people feel charged up and pleased with themselves for their decision to alter their behavior. However, it is also easy to feel defeated because of the obstacles and resistance to the new behaviors that are likely to appear. To succeed in the ‘doing’ stage an individual must keep their commitment level high and learn how to overcome obstacles.

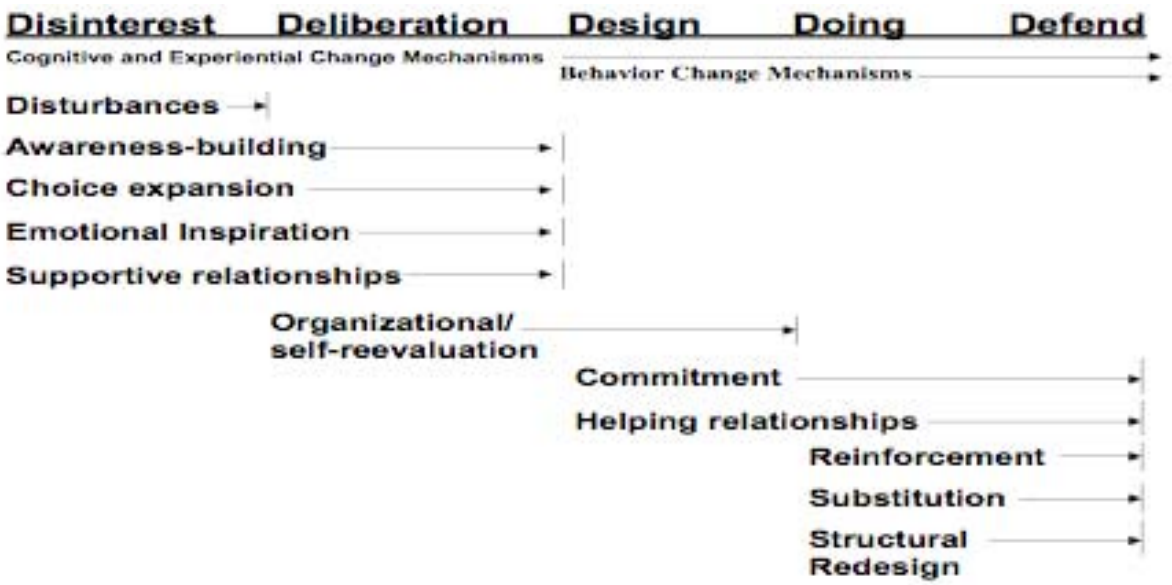
The most helpful change mechanisms in the doing stage therefore involve: 1) continued public commitment through goal setting, updating implementation plans, etc; 2) obtaining feedback on performance in a manner that allows an individual to improve and surmount barriers; 3) receiving rewards and incentives, which are also very important to provide a boost and keep people motivated; and, 4) removing factors that solicit high GHG emissions such as removing incentives for fossil fuel use and substituting low GHG options for high ones (e.g. easy access to public transportation or bike pathways as an alternative to single car use).

After six months to a year of ‘doing’ the individual enters the final stage of change of ‘defending.’ The ‘doing’ stage involves implementation of the initial planned or perceived actions that were developed in the ‘design’ stage of change. After those steps are exhausted, the individual must continually defend their new climate-positive behaviors against a host of technical, economic, and social obstacles.

The four change mechanisms that are important in the ‘doing’ stage of climate-focused behavioral change continue to be important in the ‘defend’ stage. In addition, removing disincentives and taking other steps to restructure their environment become vital. The more that structural changes can be made that make it easier for the new behaviors to become routine, the greater the likelihood that the individual will persevere.

Table 1 depicts the stages of climate-focused behavioral change and the change mechanisms that are most helpful at each stage. This framework may provide a useful way for behavioral change practitioners to determine which GHG reduction behavioral change strategies and interventions make sense to use at different times in the change process.

Table 1 The '5-D Staged Approach' to Behavioral Change



C. Future Research

Future research would benefit by focusing more attention on the questions of *which* specific behavioral changes are most susceptible to change via behavioral change techniques and *what* the GHG emissions consequences of those specific changes are. Practitioners and project developers need to know which behaviors have been and can be changed and what they can reasonably expect to get out of such changes.

While it can be difficult to obtain measurements (or even reasonable estimates) of reductions in GHG emissions as a function of different specific behavioral changes, this is critical information to obtain. Working in interdisciplinary teams (e.g., Abrahamse et al., 2007) is a promising strategy to combat the tendency of researchers to 'leave it to someone else' to translate observed reductions in resource use (e.g., electricity, water) into GHG emission reductions. By bringing together behavior change experts, energy and GHG experts and individuals well-versed in outcome measurement, future projects will be able to provide an even greater level of detail regarding the relationships among different intervention techniques, specific behavioral changes and relevant outcome measurements (i.e., GHG emissions reduced).

D. Conclusion

The research reviewed in this report suggests that it is possible to motivate people to consciously and purposefully change their behavior in ways that decrease their energy, water and transportation use and thus by extension their GHG emissions. There is much we still do not know, but that should not prevent anyone from using known change mechanisms and techniques and testing new methods for stimulating behavioral changes.

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, 273–291.

Abrahamase, W., Steg, L., Vlek, C. & Rothengatter, T. (2007). The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents. *Journal of Environmental Psychology*, 27, 265-276.

Becker, L. J. (1978). Joint effect of feedback and goal setting on performance: A field study of residential energy conservation. Journal of Applied Psychology, 63(4), 428–433.

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, 3612-3622.

Brandon, G. & Lewis, A. (1999). Reducing household energy consumption: A qualitative and quantitative field study. *Journal of Environmental Psychology*, 19, 75-85.

Canadian Centre for Pollution Prevention. (2005). Truckers idling reduction program: Case study.

Century Research Corporation. (1972). *Social aspects of urban water conservation.* Report prepared for Office of Water Resources Research, U.S. Department of the Interior. NTIS PB-214 970.

Darby, S. (2006). *The effectiveness of feedback on energy consumption*. Prepared for DEFRA. Environmental Change Institute.

Department of the Environment and Heritage. (2005). *Evaluation of Australian TravelSmart projects in the ACT, South Australia, Queensland, Victoria, and Western Australia 2001-2005.* Australia: Australian Greenhouse Office.

Dickerson, C.A., Thibodeau, R., Aronson, E., & Miller, D. (1992). Using cognitive dissonance to encourage water conservation. J*ournal of Applied Social Psychology, 22,* 841-854.

Doi, T., Honda, Y., Fujii, S., Higuchi, K., Tsuji, N. (2004). Effectiveness of "a program for the wise use of automobiles in mobility management implemented in the Kawanishi and Inagawa areas." In: *Proceedings of Infrastructure Planning Study* (CD-ROM), p. 29 (in Japanese).

Doppelt, R. (2008). *The Power of Sustainable Thinking: How to Create a Positive Future for the Climate, The Planet, Your Organization and Your Life*. UK: Earthscan Publishing.

Festinger, L. (1957). *A theory of cognitive dissonance*. Palo Alto, CA: Stanford University Press.

Foxx, R. M., & Hake, D. F. Gasoline conservation: a procedure for measuring and reducing the driving of college students. *Journal of Applied Behavior Analysis*, 1977, 10, 61-74.

Foxx, R.M. & Shaeffer, M.H. (1981). A company-based lottery to reduce the personal driving of employees. *Journal of Applied Behavior Analysis*, 14, 273-285.

Fujii, S. (2007). Communication with non-drivers for promoting long-term pro-environmental travel behaviour. *Transportation Research Part D, 12*, 99-102.

Fujii, S. & Kitamura, R. (2003). What does a one-month free bus ticket do to habitual drivers? An experimental analysis of habit and attitude change, *Transportation*, 30, 81-95.

Fujii, S. & Taniguchi, A. (2005). Reducing family car-use by providing travel advice or requesting behavioral plans: An experimental analysis of travel feedback programs. *Transportation Research Part D*, 10, 385-393.

Fuji, S. & Taniguchi, A. (2006). Determinants of the effectiveness of travel feedback programs- a review of communicative mobility management measures for changing travel behaviour in Japan. *Transport Policy, 13*, 339-348.

Gardner, G.T. & Stern, P.C. (2002). *Environmental Problems and Human Behavior*. Boston: Pearson Custom Publishing.

Gardner, G.T. & Stern, P.C. (2008). The short list: The most effective actions U.S. households can take to curb climate change. *Environment*, Sep/Oct.

Gaskell G., Ellis, P., & Pike, R. (1982). *The energy literate consumer: the effects of consumption feedback and information on beliefs, knowledge and behaviour.* Dept of Social Psychology, LSE.

Harvard Greencampus Initiative. (2008). *Shut the Sash Contest.* Online, http://www.greencampus.harvard.edu/fas.

Hayes S.C., & Cone, J.S. (1981). Reduction of residential consumption of electricity through simple monthly feedback. *Journal of Applied Behavior Analysis*, 14, 81-88.

Jakobsson, C., Fujii, S. & Garling, T. (2002). Effects of economic disincentives on private car use. *Transportation*, 29, 349-370

Keirstead, J. (2007). Behavioural responses to photovoltaic systems in the UK domestic sector. *Energy Policy*, 35, 4128-4141.

Kenney, D.S., Goemans, C., Klein, R., Lowrey, J. & Reidy, K. (2008). Residential water demand management: Lessons from Aurora, Colorado. *Journal of the American Water Resources Association, 44*, 192-207.

Kurz, T., Donaghue, N., & Walker, I. (2005). Utilizing a social-ecological framework to promote water and energy conservation: A field experiment. *Journal of Applied Social Psychology*, 35, 1281-1300.

Matsumura, N. (2004). Mobility management for residents. Presented at the one-day *Seminar Social Transportation Management: Travel Behavior Can Be Changed due to Communication,* Tokyo, Japan.

McMakin, A.H., Malone, E.L., & Lundgren, R.E. (2002). Motivating residents to conserve energy without financial incentives. *Environment and Behavior*, 34, 848-863.

Mountain, D. (2006). The impact of real-time feedback on residential electricity consumption: The Hydro One project.

Prochaska, J.O., Norcross, J.C, & Diclemente, C.C. (1994). *Changing for Good.* New York: HarperCollins Publishers.

Schultz, P. W., Nolan, J. M., Cialdini, R. B., Goldstein, N. J., & Griskevicius, V. (2007). The constructive, destructive, and reconstructive power of social norms. Psychological Science, 18, 429-433.

Seligman, C., Darley, J.M. & Becker, L.J. (1978). Behavioral approaches to residential energy conservation. *Energy and Buildings 1*, 325-337.

Siero, F.W., Bakker, A.B., Dekker, G.B., & van den Burg, M.T.C. (1996). Changing organizational energy consumption behaviour through comparative feedback. *Journal of Environmental Psychology*, 16, 235-246.

Siero, S., Boon, M., Kok, G. & Siero, F. W. (1989). Modification of driving behavior in a large transport organization: a field experiment. *Journal of Applied Psychology*, 74, 417–423.

Staats, H.J. & Harland, P. (1995). *The EcoTeam program in the Netherlands. Study 4: longitudinal study on the effects of the EcoTeam Program on environmental behavior and its psychological backgrounds.* Centre for Energy and Environmental Research, Faculty of Social and Behavioural Sciences, Leiden University.

Staats, H., Harland, P., & Wilke, H.A.M. (2004). Effecting durable change: A team approach to improve environmental behavior in the household. *Environment and Behavior*, 26, 341-367.

Staats, H., Van Leeuwen, E., & Wit, A.P. (2000). A longitudinal study of informational interventions to save energy in an office building. *Journal of Applied Behavior Analysis, 33*, 101-104.

Stern, P. C. (1992). What psychology knows about energy conservation. *American Psychologist, 47*, 1224-1232.

Syme, G.J., Nancarrow, B.E., & Seligman, C. (2000). The evaluation of information campaigns to promote voluntary household water conservation. *Evaluation Review*, 24, 539-578.

Thogersen, J. & Moller, B. (2008). Breaking car use habits: The effectiveness of a free one-month travelcard. *Transportation*, 35, 329-345.

Van Vugt, M. (2001). Community identification moderating the impact of financial incentives in a natural social dilemma: Water conservation. *Personality and Social Psychology Bulletin*, 27, 1440-1449.

Wilhite, H. & Ling, R. (1995). Measured energy savings from a more informative energy bill. *Energy and Buildings*, 22, 145-155.

Winett, R.A., Leckliter, I.N., Chinn, D.E., Stahl, B., Love, S.Q. (1985). Effects of television modeling on residential energy conservation. *Journal of Applied Behavior Analysis*, 18, 33-44.

Winett, R.A., Neale, M.S. & Cannon Grier, H. (1979). Effects of self-monitoring and feedback on residential electricity consumption. *Journal of Applied Behavior Analysis*, 12, 173-184.