

One size does *not* fit all: Applying the Transtheoretical Model to Energy Feedback Technology Design

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ABSTRACT

Global warming, and the climate change it induces, is an urgent global issue. One remedy to this problem, and the focus of this paper, is to *motivate* sustainable energy consumption *behaviors* by people. The development of *feedback technologies* providing real-time, continuous feedback of one's energy usage has been used to motivate sustainable energy consumption behaviors. However, there is one important problem - they tend to use a "one-size-fits-all" solution, providing the *same* feedback to *differently* motivated individuals at different stages of readiness, willingness and ableness to change. In this paper, we synthesize a wide range of motivational psychology literature to develop a *motivational framework* based on the Transtheoretical (*aka* Stages of Behavior Change) model. We state the motivational goal(s) of each stage, followed by our recommendation(s) for designing feedback technologies in order achieve these goals. Each recommendation is supported by a rationale based on motivational literature, followed by a simple textual example to illustrate one way to apply the recommendation.

Author Keywords

Sustainability, feedback, motivational theory, design.

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI)

INTRODUCTION

Global warming, and the climate change it induces, is an urgent global issue. Moving towards an environmentally sustainable lifestyle is recognized as a partial solution to this problem. Within the technological perspective, much focus is on creating energy-efficient technology: cars, homes appliances, etc. This is a necessary step, but is only a *partial* solution as people do not always use this technology in energy-efficient ways [46]. While energy-efficient technologies enable sustainable usage, we must also focus on a *people* solution: understanding the fundamentals of how and why people use energy [46], and apply this knowledge to develop technologies that can motivate sustainable energy behavior.

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Within both products and HCI, one common approach to motivating sustainable energy consumption behaviors is to develop technologies that provide real-time, continuous feedback of one's energy usage. This feedback is often presented as raw energy use (e.g., watts), as personal cost (e.g., money), or as environmental impact (e.g., CO₂). While providing energy feedback is somewhat effective [4], most of these technologies are limited as they use a "one-size-fits-all" solution. That is, they provide the *same* feedback to *differently* motivated individuals, with different willingness, ableness and readiness for change. Unless the energy consumer already holds a strong *goal* to use energy in a sustainable way [36], feedback only *informs*, but does not necessarily *motivate* any sustainable energy action.

Motivating behavior change (within the context of sustainable energy consumption or otherwise) is a *psychologically, socially, and culturally* complex problem [46]. While all three perspectives offer valuable and important insights, in this paper, we approach this problem primarily from the *psychological* perspective.

From this perspective, we explore the following question: ***How can energy feedback technologies leverage existing techniques and theories within motivational psychology to more effectively motivate sustainable energy consumption behaviors?*** In approaching this question, we argue that designers of such technology need to consider two important points:

1. Different people hold different *attitudes, beliefs* and *values* [5], and are motivated by different things. As such, designers need to develop a *range* of strategies in order to account for the complexity of human behavior.
2. Intentional behavior change does not occur as an event, but rather, as a *process* in a series of stages as defined by the Transtheoretical Model [38]. Individuals move from being unaware or unwilling to acknowledge the problem, to considering the possibility of change, then preparing to make the change, then taking action, and finally, to maintaining the desired behavior over time [38].

We make three contributions in this work. First, we frame motivational psychology literature as key notions for designers of technology that aim to motivate sustainable energy behavior change. Second, we show how these notions can be used to assess existing feedback technologies from a motivational perspective. Third, we

offer a motivational framework based on the Transtheoretical Model in which we propose strategies that target individual *attitudes*, *beliefs* and *values* held at each stage of behavior change.

DEFINING MOTIVATION

Motivation is “an inquiry into the *why* of behavior” [15]. It is “an internal state or condition (sometimes described as a need, desire, or want) that serves to activate or energize behavior and give it direction [29]. Motivation is closely tied to emotional processes [27]. Emotions may be involved in the *initiation* of behavior, for example, the emotion of loneliness might motivate the action of seeking company. Alternatively, the desire to *experience* a particular emotion may also motivate action [27], for example, the decision to run a 10km race may be motivated by the desire to experience a sense of accomplishment.

CONSTRUCTS OF MOTIVATION

Attitudes, *beliefs* and *values* are “learned psychological constructs that motivate and influence behavior” [5]. Within these constructs, attitudes are the *least enduring* (most likely to change), and values are the *most enduring* (least likely to change) [5]. We discuss these constructs within the context of sustainable energy behavior.

Attitudes are “learned predispositions to respond to a person, object, or idea in a favorable or unfavorable way” – reflecting what one likes or dislikes [5]. For example, a person might hold a favorable attitude towards water conservation: in particular, taking short showers.

Beliefs are “the ways in which people structure their understanding of reality” – in other words, “what is true and what is false” [5]. Most beliefs are based on previous

experience [5], e.g. recycling helps the environment.

Values are “central to our concept of self” [5], and can be conceptualized as “behavioral ideals” or “preferences for experiences” [38]. As *behavioral ideals*, values function as “enduring concepts of good and bad, right and wrong” [38], e.g. it is wrong to litter. As *preferences for experiences*, “values guide individuals to seek situations in which they may experience certain emotions” [38], e.g. I compost because it makes me feel good. Throughout this paper, we discuss values by drawing upon a *subset* of values defined by social psychologist Rokeach and values defined by psychologist Maslow (See Table 1). Both proposed that people hold *value systems* – “a value hierarchy or priority structure based on the relative importance of the individual values” [21]. Rokeach believed that differences in behavior occur due to differences in the *ranking* of value importance [42] – e.g. Bob, an energy auditor, values being “logical” more than he values being “imaginative” during an audit. Maslow’s value system consists of a hierarchical structure, where he believed humans seek to satisfy the lower level values (i.e. physiological, safety) before the higher (i.e. love/belongingness, esteem, self-actualization) [35].

HOW BEHAVIOR CHANGE OCCURS

The Transtheoretical Model (TTM), also known as the Stages of Change model, is an established theory of behavioral change processes [38]. It states that intentional behavior change is a *process* occurring in a series of *stages*, rather than a single event [38]. *Motivation* is required for the focus, effort and energy needed to move through the stages [38]. The stages progress as follows [38]:

Precontemplation. The individual may be unaware, uninformed, unwilling or discouraged to change the problem behavior. They do not believe the negative aspects of the current behavior outweigh the positive.

Contemplation. The individual acknowledges that their behavior is a problem and begins to *think* seriously about solving it. While they can be open to information about the problem behavior, they still may feel ambivalent, and as such, may be far from making an actual commitment.

Preparation. The individual is ready to change. They aim to develop a plan they can commit to in the near future.

Action: The individual takes action by overtly modifying their behavior.

Maintenance, Relapse, Recycling: The individual works to sustain the behavior change, and struggles to prevent relapse. If relapse occurs, individuals regress to an earlier stage and begin to progress through the stages again.

CRITIQUING FEEDBACK TECHNOLOGIES - WHY ONE SIZE DOES NOT FIT ALL

We now show the value of the above constructs and models by critiquing several existing feedback technologies from this motivational perspective. First, however, we discuss the goals of sustainable behavior change, introducing terms and

Behavioral Ideals (Rokeach)	Preferences for Experiences (Rokeach)	Preferences for Experiences - Low to high level (Maslow)
<p>Capable: Competent, effective</p> <p>Helpful: Working for the welfare of others</p> <p>Honest: Sincere and truthful</p> <p>Imaginative: Daring and creative</p> <p>Independent: Self-reliant; self-sufficient</p> <p>Intellectual: Intelligent and reflective</p> <p>Logical: Consistent; rational</p> <p>Obedient: Dutiful, respectful</p> <p>Responsible: Dependable and reliable</p>	<p>A comfortable life: a prosperous life</p> <p>Freedom: independence and free choice</p> <p>Health: physical and mental well-being</p> <p>Inner harmony: freedom from inner conflict</p> <p>A sense of accomplishment: a lasting contribution</p> <p>Social recognition: respect and admiration</p> <p>Wisdom: a mature understanding of life</p> <p>A world of beauty: beauty of nature and the arts</p>	<p>Physiological: Homeostasis and appetites</p> <p>Safety: Security of body, employment, resources, family, health, property</p> <p>Love/belonging: Affection and belongingness, be accepted</p> <p>Esteem: Self-respect, self-esteem, esteem of others</p> <p>Self-actualization: To find self-fulfillment and realize one’s potential</p>

Table 1. Values

techniques found in the sustainability literature. We then introduce commonly used techniques that aim to motivate sustainable energy behavior. Finally, we draw upon a sample of existing work in feedback technologies and classify them according to their best fit to particular motivational theories (this is *our* classification - the actual systems were not necessarily designed with these explicit theories in mind). From this, we discuss the technology's effectiveness in motivating sustainable energy behavior.

Goals of sustainable energy behavior change

When motivating sustainable energy behavior, two important goals are *durability* and *generalizability* [11]. *Durability* refers to behavior that is “self-sustaining without the need for repeated interventions” [11]. *Generalizability* refers to “the degree to which a target behavior ‘spills over’ to related but untargeted conservation behaviors” [11].

To achieve these goals, *intrinsically* motivated behavior is ideal [11]. *Intrinsic motivation* is “the doing of an activity for its inherent satisfactions rather than for some separable consequence” [17]. Inherent satisfactions include interest [41], curiosity [41], enjoyment [41] and competence [2]. *Extrinsic motivation* is “the doing of an activity in order to attain some separable outcome” [17]. Examples include material or social incentives.

Commonly-used motivation techniques

The *Attitude Model* assumes that “pro-environmental behavior will automatically follow from favorable attitudes towards the environment” [46]. This model appeals to the Rokeach value of “a world of beauty”, assuming that if one values nature, then they will act to protect it.

The Rational-Economic Model (REM) assumes “people will make pro-environmental decisions based on economically-rational decisions” [46]. In other words, monetary cost is the primary motivator. This model appeals to Maslow's value of “safety” - specifically, “security of resources”, and the Rokeach values of being “logical” and “responsible”.

The Information Model provides information to the problem, why it is a problem, and the steps required to solve the problem [46]. It appeals to the Rokeach value of being “responsible”, assuming once you know *what* to do, you will do it.

Positive reinforcement is “a situation in which a response is followed by the addition of a reinforcing stimulus” which “increases the likelihood that the response will be repeated in similar situations” [27].

The *Elaboration Likelihood Model (ELM)* [39] proposes two routes of cognitive processing. The central route processes arguments according to logic and rationale, where one is sensitive to the quality of the argument. The peripheral route uses emotional persuasion, where one is influenced by factors unrelated to the argument's validity such as emotional responses.

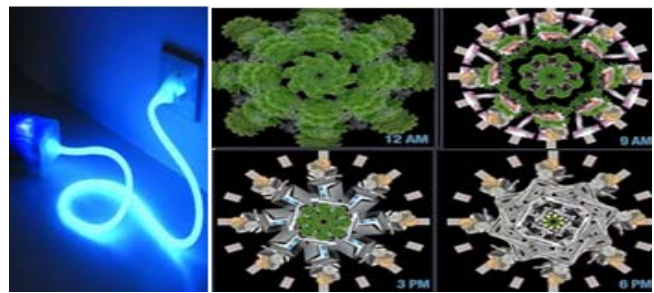


Figure 1. *Left:* Power-Aware Cord. *Right:* ‘7000 Oaks and Counting’: 4 snapshots over the day

A motivational perspective assessment of feedback technologies

Attitude Model: Almost all current feedback technologies employ the Attitude Model. To illustrate, we draw upon two examples. The ‘Power-Aware Cord’ [26] (Figure 1, left) is an electrical cord that visualizes electricity consumption by varying the pulse, flow, and intensities of light using three electroluminescent wires. It assumes that the visualization of electricity alone suffices in motivating individuals to reduce their consumption. ‘7000 Oaks and Counting’ [28] (Figure 1, right) visualizes a building's energy consumption by equating trees to carbon dioxide emissions. The lower the energy usage, the more trees in the visualization. The higher the energy usage, the more buildings and appliances shown in the visualization. Again, the visualization assumes that providing information of energy use suffices to motivate action.

There are two limitations to this model. First, it does not consider the stages of behavioral change. Specifically, the assumption of a pro-environmental attitude does not hold for *precontemplators* who have not yet acknowledged their behavior is problematic. For *contemplators*, feelings of ambivalence may indicate that a pro-environmental attitude does not lead to commitment or action. While the Attitude Model may be effective in the *preparation* stage, it does not provide individuals with specific energy actions they can take [46]. In the *action* and *maintenance* stages, individuals have already acted, and thus motivations based on attitude alone may have no further effect. The second limitation to this model is its lack of consideration of other factors, such as situational circumstances (time, convenience, comfort, aesthetics), social influences, government regulations, and so on that often override the decisional influence of a pro-environmental attitude [46].

REM and Attitude Models: The Attitude Model is often used in conjunction with the REM. Early works employing these models include textual LCD displays that present energy usage in relation to cost. Examples include the ‘Energy Detective’, ‘Power-Cost Monitor’, ‘Kill-A-Watt’ (Figure 2). Other systems add persuasive prompts (through changes in color or graphics) encourage less energy usage during peak hours when costs are high. Examples include the ‘Wattson’, ‘Energy Orb’, and ‘Energy Joule’ (Figure 3).



Figure 2. (Clockwise) Kill-A-Watt, Power Cost Monitor, Energy Detective, Energy Joule, Energy Orb, Wattson.

In general, works employing these models have the following limitations. First, the motivating effect of material incentives (such as money) is non-durable; just as the behavior is quickly started using material incentives, their removal likewise terminates behavior change [11]. Second, when the cost of energy is low in proportion to one's income, feedback is not as effective [23]. Finally, similar to the Attitude Model, the REM does not consider the influence of situational circumstances that may override the logistics of cost, or the positive influences of pro-environmental attitude [50].

Information, Rational-Economic and Attitude Models: Some systems supplement these earlier models with an Information Model. 'EcoImagination' and 'Energy Tree' (Figure 3, top left and bottom) are two examples. They employ complex visualizations of feedback, summarizing trends over days to months, and providing information such as cost and CO₂ emissions, and action steps one can take for more efficient usage. This helps to explain why energy use is a problem and how more efficient usage can be achieved.

The combination of these three models improves upon the previous categories. Still, from a motivational standpoint, limitations remain. First, information *alone* rarely motivates action [46] as information is only effective if the user *already* holds a strong goal to act based on that information [36]. Second, humans have a psychological tendency to *avoid* non-supportive and *seek out* supportive information [6]. Specifically, individuals in the contemplation stages may still hold ambivalent feelings [38], and thus may psychologically discount information that contradicts with their current energy behaviors. In contrast, the Information Model can be very effective in the *preparation* and *action* stages, improving upon the Attitude Model by providing specific actions one can take. In the *maintenance* stage, Information Models can be effective if the information provided deepens over time to match with the individual's deepening knowledge.

Positive Reinforcement, Emotional Persuasion through the ELM & Values: 'Ubigreen'[22] (Figure 3, top right) is

one work that employs these techniques. It is a mobile phone visualization that uses semi-automatic sensing technologies to provide feedback of transportation behaviors. It uses a series of *emotionally persuasive icons* [22] (i.e. a polar bear standing on an iceberg) as *positive reinforcement*. The more "green" one's transportation behaviors, the further in the progression of icons one gets (i.e. the iceberg grows and the ecosystem improves) until one reaches the final stage (i.e. sun sets and Northern Lights appear). Icons also represent "auxiliary benefits", including a piggy bank to represent money savings, a person meditating to represent relaxation, a book to present the opportunity to read and a weightlifter to represent exercise [22]. We classify these respective icons as appealing to the following *values*: Maslow's "safety", Rokeach's "inner harmony", "intellectual", and "health".

In 'Ubigreen', the relation of green transportation behaviors to other benefits of value is promising as it provides a *range* of personal benefits [46] while minimizing the individual's perception of personal cost [9]. An improvement would be to consider the *specific values* and *value systems* of each individual. For example, Person A holds a high value on exercise and keeping fit, but a low value on money savings. As such, the visualization could show *personalized* feedback of green transportation behaviors and their positive impact on keeping fit. In contrast, the visualization could highlight different benefits for Person B who (say) highly values money savings.

One important limitation of 'Ubigreen' from a motivational perspective is the possible *extrinsic* nature of the positive iconic reinforcement (polar bears). Specifically, some participants viewed the visualization to be a "game", where making it to the last screen was the "final level" [22]. This is problematic. If people are only in it to win, it has



Figure 3. (Clockwise) Ecoimagination, Ubigreen, Energy Tree.

negative impacts on their *intrinsic* motivation [16], and may lead to less durable and generalizable behavior change [11]. This work aimed to target “already very green individuals”, implying that participants are most likely in the *action* or *maintenance* stages, where *intrinsic* motivation is required for long-term success [38].

A MOTIVATIONAL FRAMEWORK: APPLYING TTM TO ENERGY FEEDBACK DESIGN

The TTM is often used in conjunction with motivational counseling, where specific intervention strategies are proposed to target people at different stages of change. Its goal is to motivate a move to the next stage [38]. In this section, we synthesize literature within psychology, motivational counseling, social psychology, and environmental psychology to propose a motivational framework based on the TTM to provide insights as to which motivational strategies may be most effective at each stage of change. At each stage, we present the motivational goal(s), as well as recommendation(s) for how feedback technologies may reach these goals. Each recommendation is supported by a rationale (based on existing motivational literature). To make the recommendations more vivid, we use a scenario of a particular energy user named Mary, who holds specific attitudes, beliefs and values. We simplify this example to focus on one appliance – the desktop computer. We draw upon this scenario to provide a simple textual example for each recommendation. We do not claim the examples we provide are ideally presented; rather, they serve to illustrate what information may be appropriate to fit a recommendation. Table 2 summarizes the goals of each stage, and can be used as a reference for the following text.

An example scenario: Mary

About Mary: Mary, a 36 year old woman, is a successful novelist who works on a desktop computer in her home office. She is married and has two school-age children. They make a good living and money is not a problem. She writes during the daytime while her family is out of the house. In her free time, Mary takes her kids to Edsen Park and goes to fitness classes at a local gym.

Work environment: Mary’s office is located in a small spare bedroom on the second floor of their house. It is

Precontemplation	<ul style="list-style-type: none"> • “Plant the seed” to acknowledge problematic unsustainable behaviors • Address barriers to sustainable energy action by providing information of actions that make a difference
Contemplation	<ul style="list-style-type: none"> • “Tip the balance” in favor of change
Preparation	<ul style="list-style-type: none"> • Develop a <i>plan</i> that is acceptable, accessible and effective. These plans can relate to “one-shot actions” or “day-to-day” actions
Action	<ul style="list-style-type: none"> • Reinforce action • Develop intrinsic motivation
Maintenance	<ul style="list-style-type: none"> • Maintain behavior by developing intrinsic motivations of interest, curiosity, enjoyment and competence.

Table 2. Motivational goals at each stage of change

summertime. Due to the sunlight and heat from the computer, this room heats up quickly. Mary often finds her eyes hurt from long hours on the computer.

Motivational stage: Mary is a precontemplator. While she is somewhat aware of general environmental problems, she does not believe that her own personal energy use - and in particular, her computer usage - has much negative effect. In general, Mary does not believe she has the time or energy to make big energy changes.

Computer usage habits: Mary works from 9am to 3pm every weekday. She takes a 1 hour lunch break at noon. During break time and at the end of her workday, Mary leaves her computer and monitor on until she returns to work the next day. She rarely turns her computer off, as she believes keeping her programs open and available when she comes back saves her time and effort. Mary does not know or make use of her computer’s automatic power management features.

STAGE 1 – PRECONTEMPLATION

Goal #1: “Plant the seed” for individuals to acknowledge that their current energy behaviors are problematic.

Recommendation #1: Provide personalized feedback that acknowledges *both* the benefits and consequences of the individual’s *non-sustainable* energy behavior. Present this information in moderation, and in a neutral, non-biased way. Present these benefits and consequences in relation to what the individual values.

Rationale: Precontemplators are passively *reluctant*, rebelliously *resistant*, overwhelmed and *resigned*, or *rationalizing* [38]. To account for this, technologies must acknowledge both the pros and cons of the individual’s current non-sustainable energy behaviors before they can expect precontemplators to “decrease resistance” [38] and become open to considering the “not so good” things”. This is especially important in the context of motivating sustainable energy action since *non-sustainable* behaviors offer many benefits such as comfort, luxury, convenience, social status, and sometimes cost. These benefits appeal to values such as Rokeach’s “a comfortable life” and “social recognition”. In addition, it is important not to bombard the individual with too much information, as more intensity will often produce fewer results with this group [38]. Indeed, once the ‘seeds’ have been planted, precontemplators often need time to let them germinate [38].

Example, centered on Mary’s computer and monitor use

<p>Total energy used this week: 29.95 kwh, (CPU and monitor left on for 168 hours)</p> <p>Pros: Leaving your computer and monitor on makes your work readily available when you come in the next day, improving the flow and efficiency of work.</p> <p>Cons: 1) Cost = \$3.07 this week. (At this rate, cost for the month will be \$12.28. 2) Amount of CO₂ emissions = 74.88 kg this week. (At this rate, CO₂ emissions for the month = 287.52 kg).</p>

Recommendation #2: Refer to social norms regarding sustainable energy behaviors by aligning the use of descriptive and injunctive normative messages.

Rationale: *Social norms* are “the ‘rules’ or expectations for appropriate behavior in a particular social situation” [27]. The idea is motivate the individual to think: “if other people value it, maybe I should as well”. *Descriptive norms* are “perceptions of behaviors that are typically performed” (e.g. “85% of your neighborhood recycles”). These norms appeal to Maslow’s value of “love/belongingness”. *Injunctive norms* are “perceptions of behaviors that are typically approved or disapproved” (e.g. a thumbs-down sign with the text: “Protect the environment – don’t litter!”). These norms appeal to Rokeach’s value of being “obedient”. Normative messages that *align* normative and injunctive messages tend to have higher rates of success [10].

Example: While Mary’s current computer usage habits are not energy-efficient, a thumbs-up sign with the following text may increase the value she places on sustainable computer management:

In our last monthly survey, your neighborhood saved 471 kwh (or) \$ 48.23 (or) 1177.5 kg in carbon dioxide emissions due to the use of efficient computer power management

Goal #2: Address barriers to sustainable energy behaviors, such as “not feeling competent” [14] and “not believing it will yield a desired outcome” [45].

Recommendation: Provide personalized feedback of a variety of small energy actions that, if performed, would have positive impacts on the environment.

Rationale: By providing many choices of energy actions that can make a positive impact, we appeal to Rokeach’s value of being “capable” and address the barrier of “not feeling competent” [14]. In addition, presenting a variety of *choices* appeals to the Rokeach value of “freedom”, and increases one’s sense of personal control [43] and intrinsic motivation [30]. By providing projections of the positive impacts of potential energy actions, we address the barrier of “not believing it will yield a desired outcome” [45].

Example: Feedback technologies could provide one energy tip per day (to provide information in moderation), presenting a variety of choices of small energy actions that could make a difference.

Energy tip of the day! – Energy-efficient monitor usage
Your monitor currently uses approximately 88.0 watts when on (only 3 watts less than your CPU). Turn down the brightness and increase the contrast instead. At a brightness setting of 15 and contrast of 100, your monitor would only use 59.4 watts. If your monitor was left on continuously for 1 week, you would save 6.2 kwh (or) 15.4 kg in CO₂ emissions, equivalent to planting one full-grown maple tree in Edsen Park.

STAGE 2 - CONTEMPLATION

Goal #1: “Tip the balance” in favor of change [38]

Recommendation #1: Provide personalized feedback on the *pros* of *sustainable* energy behavior, and the *cons* of *non-sustainable* energy behavior. The pros should emphasize an improvement to the individual’s quality of life (in relation to what they value). The cons should be presented in terms of loss (in relation to what they value) rather than gain.

Rationale: Contemplation is the stage in which evaluations of the pros and cons of the behavior are more or less equal [38]. The goal in this stage is to reduce these feelings of ambivalence by providing a more one-sided perspective. The individual should perceive the ‘pros’ of sustainable behavior as enhancing their quality of life. This is especially important as people *resist* making changes that they perceive as *reducing* their quality of life, in particular motivations that stress self-sacrifice for the welfare of the common good [31]. The ‘cons’ should focus on the *costs* of *non-sustainable* behaviors, from a perspective of *loss* rather than gain [50]. This maximizes the impact of information as people are more willing to take actions to avoid or minimize a loss, than do the same action for gain [50]. Finally, the focus on values is important, as it emphasizes *personally relevant* information or feedback, which can be extremely persuasive at this stage [38].

Example:

CPU usage this year: 734.4 kwh (CPU on for 8765.8 hours)
LOSS through inefficient usage:
42% Inefficiency = 308.4 kwh (out of 734.4 kwh)
\$31.58 – enough to pay for one month of kickboxing classes
771 kg CO₂ – requires 70 full-grown maple trees to absorb it within a year
To improve your efficiency, you can: Turn off your CPU when you are finished for the workday. In the summertime, this will reduce the temperature in your office by approximately 3.6 degrees.

Recommendation #2: Encourage energy action by informing people of the discrepancy between their positive energy attitude and their corresponding behavior.

Rationale: *Cognitive dissonance* can be used to promote enduring changes in attitude and behavior [47]. It is “an uncomfortable state” that occurs when a person holds an attitude and a behavior that are “psychologically inconsistent” [18]. When this happens, people try to reduce this uncomfortable feeling, either by changing their attitude or their behavior [18]. This theory appeals to Rokeach’s values of ‘inner harmony’ and being ‘honest’. As contemplators hold pro-environmental attitudes but do not behave according to those attitudes, feedback technologies can invoke cognitive dissonance by reminding people of a specific pro-environmental attitude they hold, informing them of the *discrepancy* between their attitude and the corresponding behavior, and encouraging a change towards more sustainable behavior [46].

Example:

Last week, your computer was on when you weren't present 69% of the time. We know how much you care about sustainable energy usage! Next week, how about putting turn off your computer more often when you know you'll be away from it for awhile? You'll be glad that you did!

Recommendation #3: Provide encouragement for small energy actions (whether or not the individual's original intention was sustainable energy usage) to encourage bigger energy actions in the future.

Rationale: This recommendation makes use of cognitive dissonance through "Foot-in-the-Door" processes [50]. The idea is that if people can be encouraged to perform a small energy action of their own accord, they can be encouraged to perform larger energy actions in the future [46]. This occurs due to cognitive dissonance, where once someone takes part in an external behavior, they will change their attitudes in order to *internally* justify or rationalize their actions [18].

Example: On Thursday, Mary was working on her child's upcoming surprise birthday party invitations when her children arrived home. Mary turned off her monitor to keep the invitation a secret in case they glanced over. While her original intention was not energy savings, the following message could be provided the next day:

Thanks for turning off your monitor! In doing so, you have saved 0.79 kwh (or) \$0.08 (or) 1.98 kg in CO₂ last night. To take further energy-efficient actions, consider putting your computer to sleep at the end of each workday. This keeps your programs open when you come in the next day, and provides an opportunity to get a cup of coffee before the workday.

Recommendation #4: Link the feedback technology to a sustainable energy usage online community website, where the individual can browse and read information (at their own accord) on the experiences of sustainable energy users in the community.

Rationale: While contemplators are open to information, they are not yet ready to make a commitment [38]. This recommendation allows the individual to read about the experiences of individuals who value the importance of sustainable energy usage, which appeals to social norms regarding energy usage, and does not push any type of commitment.

Example:

Visit the [Sustainable Lifestyles Community Website](#) - Read about the experiences of real people who have made small energy changes that have made big impacts.

STAGE 3 – PREPARATION

Goal #1: Support individuals in developing a *plan* that is acceptable, accessible and effective [38]. These plans can relate to "one-off actions" (e.g. purchasing an energy-efficient fridge) or "day-to-day" actions (e.g. taking shorter showers) [46].

Recommendation #1: Support individuals to self-set specific and quantitative goals (preferably at medium to

high levels of difficulty), and provide support to help them develop multiple methods in which to achieve these goals.

Rationale: A *goal* is defined as "an internal representation of a desired outcome" [3]. At this stage, individuals may have abstract goals but do not necessarily know the best way to achieve them. In this section, we discuss three factors that influence the success of goal achievement – these include goal-setting, goal commitment and implementation intentions.

Specific, difficult and *self-set* goals lead to higher performance and commitment than do-best, easy or assigned goals [49]. Specific goals make clear when the goal has been achieved [49]. Difficult goals provide a greater sense of achievement, though there is a lower probability of success [49]. Achieving difficult goals may appeal to Rokeach's value of being "capable", and Maslow's value of "esteem". Goal difficulty can start at the easy level, as success builds on success, and with each small change the individual builds self-efficacy about making bigger changes [38]. *Implementation intentions* are the "plans that specify the when, where and how to lead to goal attainment" [24]. Implementation intentions may appeal to the Rokeach values of being "logical", or "imaginative". Goal intentions that are furnished with implementation intentions are more easily attained than mere goal intentions [25]. Flexibility in goal attainment is good, providing the option to switch to other routes [24].

Example: Based on the Mary's usage patterns, the feedback technology can provide options of easy, medium and difficult goals, their results, as well as several methods that Mary can use achieve these goals.

I would like to set a medium difficulty level goal to reduce my CPU and monitor usage. Goal period: Begins Nov. 1, 2010, ends: Dec 1, 2010. My current monthly usage: 119.8 kwh. My goal for next month: 95.8 kwh.

To achieve this goal, I can do the following: 1) turn my monitor and CPU off at the end of every workday, 2) make use of automatic computer management settings to hibernate my CPU after no activity for 3 hours, or 3) Turn off my monitor if taking a break longer than 15 minutes.

Recommendation # 2: Encourage individuals to apply their personal knowledge or expertise in reaching their goal.

Rationale: In addition to computer supported implementation intentions, feedback technologies can also encourage individuals "to apply their personal knowledge or expertise to a situation" – this is called *adaptive muddling* [31]. When this happens, people perceive a role for themselves, and may feel an obligation or responsibility to help the change succeed [20]. This has two benefits. First, it may increase the individual's level of goal commitment, targeting the Rokeach values of being "responsible", "helpful" or having "wisdom". Second, adaptive muddling may encourage self-reflection of one's energy behaviors, which in turn may motivate the *intrinsic* satisfactions of curiosity or interest.

Example: In addition to providing automatically generated implementation intentions (as in the previous example), feedback technologies can also ask questions such as:

What are some other ways you can achieve this goal? Use your creative thinking to use your computer more efficiently!

Recommendation #3: Within the sustainable energy usage online community, provide individuals in the preparation stage with the option to be connected to energy “mentors” - individuals who are in the action or maintenance stages of sustainable energy behavior change.

Rationale: This recommendation makes use of *social diffusion* - the observation that people are more likely to follow the modeled behavior or example of others (who they have direct experience with) that have successfully adopted energy actions [50]. In addition, being connected to an energy mentor implies a level of commitment, which may be acceptable for individuals in the preparation stage who are ready to act in the near future.

Example: Feedback technologies could provide Mary with brief descriptions and profiles of energy mentors, and highlight those who have similar interests as the individual in preparation. In addition, feedback technologies could provide text chat, photo exchange or other ways in which they communicate and share their experiences.

STAGE 4 – ACTION

Goal #1: Reinforce action

Recommendation: Provide positive performance feedback in relation to the progress made towards energy goals set in the preparation stage.

Rationale: Positive performance feedback tends to increase intrinsic motivation, whereas negative performance feedback tends to decrease intrinsic motivation [13]. Providing positive feedback on goal progress may lead to experiencing the intrinsic emotion of competence, and the Rokeach value of being “capable”.

Example: Feedback technologies could visualize a history of progress, with positive reinforcing messages such as

You have made great progress towards your goal today. Keep using energy efficiently, and you'll reach your goal five days from now!

Goal #2: Develop intrinsic motivations for sustainable energy behavior.

Recommendation: Allow interactive exploration, customization and annotation within the feedback interface.

Rationale: Allowing for interactive exploration may invoke self-reflection of one’s energy behaviors, and in turn, the inherent satisfactions of curiosity and interest. This is important as “constructive behavior change arises when the person connects it something of intrinsic value” [38].

Example: Interactive exploration of the interface could easily allow Mary to explore with “what if” questions of energy usage, for instance by manipulating existing

information to see the positive or negative effects. Providing customization and annotation allows the interface to be more personalized to the individual, which is a more effective motivator than general and non-personalized information [50].

STAGE 5 – MAINTENANCE

Goal #1: Provide support for energy actions to become energy habits

Recommendation: Based on the situation and activity, present *prompts* at opportune times to remind individuals to take specific energy actions. As the habit becomes well-instantiated, these prompts can gradually disappear.

Rationale: *Habits* are “associations between goals and actions that allow the instigation of *automatic* behavior on the activation of these goals by the environment” [1]. In other words, when a behavior has been performed many times in the past, future behavior becomes increasingly under control of an automaticized process [19]. We argue that the instantiation of habits may be especially important in this stage, as it may help with reducing the occurrences of relapse and recycling.

Example: Feedback technologies can make use of sensing technology, work rhythms and sound to provide prompts based on Mary’s usage patterns. For example, before Mary leaves for her lunch break, a prompt could be:

Leaving for lunch? Don't forget to turn off your monitor and put your computer to sleep!

Goal #3: Maintain behavior by further developing intrinsic motivations.

Recommendation #1: Provide the choice for individuals in the maintenance stage to become “energy mentors” to individuals in the preparation stage.

Rationale: This recommendation makes use of cognitive dissonance - “individuals who have attempted to persuade someone else will internally rationalize their behavior, and therefore are particularly prone to increase their commitment” [50]. In addition, it adds a dynamic component to the feedback interface, and may inspire new and unpredictable ways in which an individual’s motivation may be sustained. This method targets the Rokeach values of “social recognition” and “wisdom”, and through these, may increase the intrinsic satisfaction of enjoyment.

Example: Feedback technologies can ask whether Mary would like to act as an energy mentor to someone who is looking for advice on sustainable computer energy usage. Mary could be asked to write a brief description about herself, her interests and experiences with computer energy usage, and will be contacted when someone has chosen her for a mentor.

Recommendation #2: Provide a way for individuals to take part in journal-keeping of their daily energy experiences,

and use this to encourage further thought in regards to more advanced energy actions they can take part in.

Rationale: Journal-keeping is a form of expressive practice and promotes reflection on one's experience [8]. Reflection upon one's energy behaviors and progress over time may invoke the intrinsic satisfactions of interest and enjoyment. Viewing one's progress over time may invoke the intrinsic emotion of competence and lead to higher perceptions of self-efficacy. This is important as "in order for individuals to experience long-term success, they require adequate *self-efficacy* and *intrinsic* attributions of the behavior" [38].

The importance of self-efficacy and intrinsic motivation is supported by the work of Woodruff et. al., which studied the motivations and values of "extremely green individuals" who have made "significant accommodations to their homes and lifestyles in order to be more environmentally responsible" [48]. Participants in the study had "*strong self-reliant tendencies*", where through the process of "pursing their environmental goals", "creatively solving problems" and "modest mental challenges", they derived satisfaction from the "cleverness and resourcefulness" of their solutions and gained a strong sense of "empowerment and confidence" [48]. From these findings, we observe that these participants were able to maintain their behavior due to intrinsic satisfactions of their energy actions, such as interest and curiosity, which eventually led to enjoyment and competence. These seem to reflect the Rokeach values of being "intellectual", "imaginative" and "capable". Finally, perhaps the goal of technologies at this stage is to consider that while it may not always be possible for every decision to be "maximally green", it is possible to be "just a little more conscious and aware" [48].

Example: Feedback interfaces could allow many flexible ways in which Mary could annotate or journal-keep within the interface. Examples include allowing Mary to take snapshots of the visualization, where she could circle or highlight areas of interest to her and write her thoughts in regards to the visualization. If desired, feedback interfaces could also automatically record the energy usage summaries of each day or week in the journal.

DISCUSSION

Several challenges arise in the practical application of our framework to the design of energy feedback technologies. As it is based on TTM's model of behavior change, we encounter the same critiques as those of the TTM.

First, the TTM assumes that behavior change occurs in discrete states and that individuals can only be in one stage at a time [33]. However, studies have shown that "rather than simply being in one stage or another, clients show patterns of differential involvement in each of the stages" [37]. If this is the case, "the concept of stages loses its meaning" [33]. For example, in our scenario, Mary could be in the maintenance stage of sustainable computer usage, as well as in the contemplation stage of starting a compost. While we recognize the value of this critique, we make use

of the stages of change (and the TTM) for its heuristic value, recognizing it is a simplified model of "*ideal change*" [33], rather than how energy behavioral processes necessarily occur in real life. We hope the value of our framework lies in its contribution of a new and potentially useful way of thinking about motivating sustainable energy behaviors, while also inspiring new ideas and approaches to this problem.

Second, the TTM is a general model of behavior change [33] with applications in a wide variety of addictive and health-risk behaviors [38]. To our knowledge, no other work has applied TTM to energy behaviors. While we believe we have shown that TTM provides a useful starting point, further exploration is needed as to whether the TTM is a suitable model to apply to this problem.

Third, we argued that the *success* of feedback technologies (that make use of the framework) lies in its effectiveness in motivating a move towards the *next stage* of change. Based on this, feedback technologies must necessarily be able to correctly assess the stage of change the individual is in, as well as evaluate whether a move to the next stage has occurred. This puts forth some difficult challenges in terms of validity of stage assessment and staging algorithms. This clearly needs further exploration and study.

Finally, from a technological perspective, there is the question regarding the life cycle and end goal of feedback technologies. Two approaches are mentioned in the work of Pierce et. al: Should technologies "evolve over time" to keep pace with user's "deepening commitment and understanding", or should they "act as a type of training device that is no longer needed after certain behavioral or intellectual changes have been made"? [40]. If technologies are adaptive, we argue that a dynamic component should be present (e.g., the use of social networks), as feedback technologies cannot be expected to keep up with complex human motivations. If technologies act as training devices, HCI designers should also consider sustainable interaction design principles as mentioned in [7].

CONCLUSION AND FUTURE WORK

We have made three contributions. The first is a framing of motivational psychology literature as key notions important to designers of technology that aims to motivate sustainable energy behavior change. The second is a critique of selected feedback technologies from a motivational perspective. The third is a motivational psychology framework that addresses individual motivations at different stages of behavior change.

Future work includes the development and implementation of feedback visualizations based on this framework, followed by an in-depth, longitudinal study of whether these visualizations actually motivated sustainable energy behavior change. We also need to further develop the framework to consider social, cultural, contextual, and

situational factors (such as disposable income) and how these might affect energy behaviors.

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REFERENCES

1. Aarts, H., Dijksterhuis, A. (2000). Habits as knowledge structures: automaticity in goal-directed behavior. *APA*, 78(1), 53-63.
2. Arkes, H. R. (1978). Competence and the maintenance of behavior. *Motivation and Emotion*, 2, 201-211.
3. Austin, J.T., Vancouver, J.B. (1996). Goal constructs in psychology: structure, process and content. *Psych. Bulletin*, 120(3), 338-375.
4. Becker, L.J. (1978). Joint effect of feedback and goal-setting on performance: A field study of residential energy conservation. *J. of Applied Psc.*, 63, 428-433.
5. Beebe, S.A., Beebe, S.J., Redmond, M.V. (1999). *Interpersonal Communication: Relating to Others* (2nd ed), Allyn & Bacon, Boston MA.
6. Bem, D.J. (1967). Self-perception: an alternative interpretation of cognitive dissonance phenomena. *Psc. Review*, 74(3), 183-200.
7. Blevis, E. (2007). Sustainable Interaction Design: invention and disposal, renewal and reuse. *Proc. ACM CHI'07*, 503-512.
8. Boud, D. (2001). Using journal writing to enhance reflective practice. In English, L.M. and Gillen, M.A (Eds). *New Directions in Adult and Continuing Education No.90*. San Francisco: Jossey-Bass, 9-18.
9. Cameron, L.D., Brown, P.M. (1998). Social value orientation and decisions to take proenvironmental action. *J. of Applied Social Psc.*, 28(8), 675-697.
10. Cialdini, R.B. (2003). Crafting normative messages to protect the environment. *Current Directions in Psc. Science*, 12, 105-109.
11. De Young, R. (1993). Changing behavior and making it stick: the conceptualization and management of conservation behavior. *Environment and Behavior*, 25(3), 485-505.
12. De Young, R., Kaplan, S. (1988). On averting the tragedy of the commons. *Environmental Mgmt*, 12, 273-283.
13. Deci, E.L. (1971). Effects of externally mediated rewards on intrinsic motivation. *J. of Pers. and Social Psc.* 18, 105-115.
14. Deci, E.L. (1975). *Intrinsic motivation*. Plenum, New York.
15. Deci, E. L., Ryan, R.M. (1985). *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press.
16. Deci, E.L., Betley, G., Kahle, J., Abrams, L., Porac, J. (1981). When trying to win: competition and intrinsic motivation. *Personality and Social Psc. Bulletin*, 7(1).
17. Deci, E.L., Ryan, R.M. (2000). Intrinsic and extrinsic motivations: classic definitions and new directions. *Cont. Ed. Psc.*, 25, 54-67.
18. Festinger, L. (1957). *A theory of cognitive dissonance*. Stanford: Stanford University Press.
19. Fishbein, M., Ajzen, I. (1975). *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*. Reading: MA: Addison-Wesley.
20. Folz, D.H. (1991). Recycling program design, management, and participation: A national survey of municipal experience. *Public Admin. Review*, 51(3), 222-231.
21. Fritzsche, D. J. (1995). Personal values: potential keys to ethical decision making. *J. of Bus. Ethics*, 14(11), 909-922.
22. Froehlich, J., Consolvo, S., Dillahunt, T., Harrison, B., Klasnja, P., Mankoff, J., Landay, J. (2009). Ubigreen: investigating a mobile tool for tracking and supporting green transportation habits. *Proc. ACM CHI'09*, 1043-1052.
23. Geller, E.S., Winett, R.A., Everett, P.B. (1982). *Preserving the Environment: New Strategies for Behavior Change*. Pergamon Press Inc.
24. Gollwitzer, P.M. (1999). Implementation intentions: strong effects of simple plans. *American Psychologist*, 54, 493-503.
25. Gollwitzer, P.M., Brandstatter, V. (1997). Implementation intentions and effective goal pursuit. *J. of Personality and Social Psc.*, 73, 186-199.
26. Gustafsson, A., Gyllensward, M. (2005). The power-aware cord: energy awareness through ambient information display. *Proc. ACM CHI'05*, 1423-1426.
27. Hockenbury, D.H., Hockenbury, S.E. (2003). *Psychology* (3rd ed.). New York: Worth Publishers.
28. Holmes, T. G. (2007). Eco-visualization: combining art and technology to reduce energy consumption. *Proc. of C&C'07. ACM Press*, 153-162.
29. Huitt, W. (2001). *Motivation to Learn: An Overview*. In *Ed. Psc. Interactive*, Valdosta, GA: Valdosta State Uni. Retrieved Jan 5, 09: <http://chiron.valdosta.edu/whuitt/col/motivation/motivate.html>
30. Iyengar, S.S., Lepper, M.R. (1999). Rethinking the value of choice: a cultural perspective on intrinsic motivation. *J. of Personality and Social Psc.*, 76(3), 349-366.
31. Kaplan, S. (1990). Being needed, adaptive muddling and human-environment relationships. In R.I. Selby, K.H. Anthony, J. Choi, and B. Orland (Eds), *Coming of age*, p19-25. Oklahoma City, OK: Environmental Design Research Association.
32. Kollmuss, A., Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research*, 8(3), 239-260.
33. Littell J.H., Girvin, H. (2002). Stages of change: a critique. *Behavior Modification*, 26(2), 223-273.
34. Locke, E.A., Latham, G.P., Erez, M. (1988). The determinants of goal commitment, *In the Academy of Mgmt Review*, 13(1), 23-39.
35. Maslow, A. (1943). A theory of human motivation. *Psc. Review*, 50, 370-396.
36. McCalley, L. T., Midden, C. J. H. (2002). Energy conservation through product-integrated feedback: the roles of goal-setting and social orientation. *J. Economic Psc.*, 23, 589-603.
37. McConaughy, E.A., Prochaska, J.O., Velicer, W.F. (1983). Stages of change in psychotherapy: measurement and sample profiles. *Psychotherapy: Theory, Research and Practice*, 20, 368-375.
38. Miller, W.R., Rollnick, S. (2002). *Motivational Interviewing: Preparing People for Change* (2nd Ed). New York: Guilford Press.

39. Petty, R.E., Cacioppo, J.T., Strathman, A.J. (1994). To think or not to think: exploring two routes to persuasion. *Persuasion: Pysc. Insights and Perspectives*, T.C. Brock and M.C. Green (Eds), p.81-116, Thousand Oaks, CA, US: Sage Pub. Inc.
40. Pierce, J., Odom, W., Blevis, E. (2008). Energy aware dwelling: a critical survey of interaction design for eco-visualizations. *Proc. Of OZCHI'08*, 287, 1-8.
41. Reeve, J. (1989). The interest-enjoyment distinction in intrinsic motivation. *Motivation and Emotion*, 13, 83-104.
42. Rokeach, M. (1973). *The Nature of Human Values*. New York: Free Press.
43. Rotter, J.B. (1966). Generalized expectancies for internal versus external control of reinforcement. *Pysc. Monograph: General and Applied*, 80, 1-28.
44. Ryan, R.M. (1995). Psychological needs and the facilitation of integrative processes. *J. of Personality*, 63, 397-427.
45. Seligman, M. (1975). *Helplessness: On depression, development and death*. W.H. Freeman, San Francisco.
46. Shipworth, M. (2002) *Motivating Home Energy Action: A Handbook of What Works*. Australian Greenhouse Office. Retrieved May 21, 2008: <http://www.environment.gov.au/settlements/local/publications/publications/motivating.pdf>
47. Thibodeau, R., Aronson, E. (1992). Taking a closer look: reasserting the role of the self-concept in dissonance theory. *Personality and Social Pysc. Bulletin*, 18, 591-602.
48. Woodruff, A., Hasbrouck, J., Augustin, S. (2008). A bright green perspective on sustainable choices. *Proc. ACM CHI'08*, 313-322.
49. Wright, P.M., Kacmar, K.M. (1994). Goal specificity as a determinant of goal commitment and goal change. *Organizational Behavior and Human Decision Processes*, 59, 242-260.
50. Yates, S. M., Aronson, E. (1983). A social psychological perspective on energy conservation in residential buildings. *APA*, 435-444.