**Title**

# Social Dimensions of Demand Response Technologies



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# Social Dimensions of Demand Response Technologies

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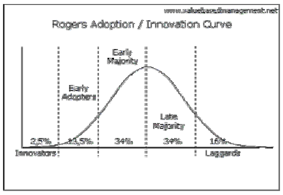
# Vision

The goal of the Demand Response Enabling Technologies Development group is to develop technology that will enable residential customers to reduce electrical consumption during periods of peak demand. Yet how people might use, accept, and adopt these technologies is not well understood. This analysis looks at the potential issues regarding customer implementation and suggests approaches towards the successful adoption of these technologies.

One such technology is the Demand Response Electrical Appliance Manager (DREAM) which receives price and reliability event signals from the electrical utility. DREAM responds to these signals to reduce electrical consumption with automatic measures (i.e., turn down thermostat or turn off pool pump) and guidance to the occupant (i.e., delay clothes drying).



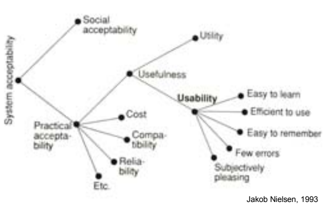

How do people adopt new technologies?

**"Technology will be adopted only if the perceived return outweighs the effort required to understand the new technology"**

-Michael Mozer, 2005

## Research Questions

Several social and behavioral challenges emerge with the residential customer implementation of demand response technology: perceived utility, usability, social and practical acceptance, and adoption of the technology. How can one evaluate each of these challenges? What are similar technologies to study that would shed light on demand response technologies, such as DREAM? How can we use the results of this study to improve potential adoption of demand response technologies?




# Methods

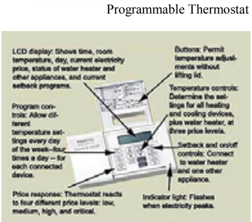
The DREAM control system and interface is analogous to a programmable communicating thermostat. To evaluate this device, a literature review was conducted to explore how current thermostats are used. In addition, a user interface was developed and tested.

The literature review included the broader topic of the social and behavioral aspects of energy use, which influences thermostat use. Conducting a literature review in this area encountered several problems. Research in the area of the human factor in energy use has declined since the mid-1980s (Lutzenhiser, 1993). In addition, the behavioral literature is spread over several disciplines, which makes it more difficult to access. A physical-technical-economic model of consumption that assumes rational behavior dominates energy use research and policy. While social-technical models have been postulated, which include humans as central actors in energy consumption, none are widely used. One model from David Wyon describes the design of successful control systems as user empowerment. His 3-I's model includes providing insight (how does the device work, what is the need for it?), information (feedback, how is the system working), and influence (allow the user control).

The process of designing and testing user interfaces, however, is well documented, thanks to the rapid increase in web development and software tools. Usability engineering requires several steps: a functional analysis of the user's desired tasks, developing personas and scenarios, competitive analysis, setting usability goals, design, evaluation, prototyping, iterative design, and feedback from field use (Nielsen 1993). A heuristic analysis is an evaluation of the interface by experts using Nielsen's 10 point system. These methods were used in evaluating a potential interface for DREAM.

Manual Thermostat

Programmable Thermostat




Programmable Communicating Thermostat

DREAM interface

# Findings

**Programmable thermostats are not well adopted and used.**

• Approximately half of the thermostats used in California households are programmable thermostats according to the 2003 Residence Appliance Saturation Survey (RASS). Looking at the air conditioning setback habits with manual vs. programmable thermostats shows that having a programmable thermostat does not affect setback behavior (CEC, 2004).

• A study by Carrier looked at the operating mode of installed programmable thermostats in households within the jurisdiction of four utilities, LIPA, ConEd, SCE, SDG&E. Of the 35,471 thermostats monitored overall, only 47% were in program mode in which the thermostat uses the schedule previously input by the occupant to control temperature setpoints. The rest were in Hold mode, which effectively turns the thermostat into a manual thermostat. The households within the two southern California utilities showed a higher percentage (65%) in program mode, although it is unclear why (Archacki, 2003).

• Kempton et al found that 75% of residents in a multi-family building did not use their thermostats but controlled cooling manually (Kempton, Feuermann, & McGarity, 1992).

• Several field studies of programmable thermostats indicate no energy savings compared to manual thermostats (see table below).

**Field Studies on Programmable Thermostats (PTs) and Energy Use**
David Shiller, Energy Star, EPA, 2006

| Organization | Investigators | Location & Year | Sample size | Conclusions |
|---|---|---|---|---|
| Southern California Edison | Paul Reeves<br>Jeff Hirsch<br>Carlos Haiad | CA 2004 | N/A | Energy savings depend on behavior and can be + or - |
| Energy Center of Wisconsin | Monica Nevius<br>Scott Pigg | WI 1999 | 299 homes | No significant savings. PT's don't change behavior. |
| Connecticut Natural Gas Corporation | David Cross<br>David Judd | CN 1996 | 100 homes | PT's cause no significant behavior change. |
| BPA / PNNL | Craig Conner | NW 2001 | 150 homes | No significant behavior change / savings. |
| Florida Solar Energy Center | Danny Parker | FL 2000 | 150 homes | No savings, some increases. |

**The reasons programmable thermostats are not used are not understood.**
Some reasons cited by researchers and manufacturers are:

*Too difficult to program*

Some thermostats come with 100+ page manuals!

*Lack of understanding of how they work*

Myth #1: a thermostat works like a valve (the lower the setpoint, the faster the air conditioner will work)

Myth #2: if I set my thermostat down during the day, it will take more energy to h eat the house when I get home than what I saved by turning it down

*Lack of need*

Personal control increases sense of comfort (the act of adjusting the thermostat helps people feel more comfortable (Hackett & McBride, 2001).

Not flexible enough to fit variable schedules

No energy savings

**The motivation to save energy is not wholly driven by financial incentives.**
Motivation to save energy is affected by: attitudes (altruism, egotism), role models, neighbors, media campaigns, lifestyles, incentives, whether program is initiated by by utility or non-profit, education, and feedback.

**Predicting success requires stochastic modeling**

• Residential energy end use is highly variable
  200-300% difference in energy between identical houses
• Comfort models for commercial sector (such as PMV) are not applicable for residences
  Temperature preferences highly variable
  Schedules, clothing levels, metabolic rate more flexible than office environment

## Suggestions

One of most important contributors to energy savings is the occupant's attitude. Suggestions for improving demand response technologies include the following:

• Allow the user to control
• Provide feedback
  feedback + advice is effective
  information should be humanized, not dull numbers
  providing energy consumption per appliance is effective
  compare energy consumption with neighbor
• Incentives should include:
  Social: imitative (role models) and obligation
  Environmental: fewer greenhouse emissions
  Financial: look at how much lost vs gained
• New devices require education and training

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