



Usability of residential thermostats: Preliminary investigations

Alan Meier^{a,*}, Cecilia Aragon^a, Therese Peffer^b, Daniel Perry^b, Marco Pritoni^c

^a Lawrence Berkeley National Laboratory, Berkeley, California, USA

^b University of California, Berkeley, California, USA

^c University of California, Davis, California, USA

ARTICLE INFO

Article history:

Received 30 November 2010

Received in revised form

21 March 2011

Accepted 22 March 2011

Keywords:

Programmable thermostat

User interface

Amazon mechanical Turk

Usability test procedure

Energy star

Energy conservation

ABSTRACT

Residential thermostats control 9% of the total energy use in the United States and similar amounts in most developed countries; however, the details of how people use them have been largely ignored. Five parallel investigations related to the usability of residential thermostats were undertaken. No single investigation was representative of the whole population, but each gave insights into different groups or usage patterns.

Personal interviews revealed widespread misunderstanding of thermostat operation. The on-line surveys found that most thermostats were selected by previous residents, landlords, or other agents. The majority of occupants operated thermostats manually, rather than relying on their programmable features and almost 90% of respondents reported that they rarely or never adjusted the thermostat to set a weekend or weekday program. Photographs of thermostats were collected in one on-line survey, which revealed that about 20% of the thermostats displayed the wrong time and that about 50% of the respondents set their programmable thermostats on “long term hold” (or its equivalent). Low-income families were visited and their thermostats photographed. Even though 85% of the respondents declared that they use programming features to automatically raise or lower the temperature, the photos indicated that 45% were in hold. Laboratory tests were undertaken to measure usability of thermostats. A measurement protocol was developed and a metric was created that could quantitatively distinguish usability among five thermostats. This metric could be used to establish minimum levels of usability in programmable thermostats and other energy-using devices with complex controls.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction

Residential thermostats have been a key element in controlling heating and cooling systems for over sixty years. During this period, consumer expectations regarding the quality of the indoor thermal environment have increased. People expect thermostats, by controlling the heating and cooling systems, to carefully regulate temperatures, respond rapidly to changes in preferences or outside conditions, all with only infrequent input by the occupants. Modern, programmable, thermostats are typically marketed as “energy-saving” and consumers typically justify their purchase with this goal in mind.

Residential thermostats have been relatively ignored as a focus of research. This may be surprising given that they control 9% of the total energy use in the United States [1] and similar amounts in most developed countries. With such a large amount of energy in play, it is essential to understand the thermostat’s technology and

the way the occupants interact with them. Furthermore, thermostats themselves are undergoing a dramatic change in capabilities. Today’s thermostats generally control only temperature; however, in the near future they may control ventilation and humidity, and take into consideration occupancy and the price of the energy. Finally, thermostats are being connected to the Internet and expanded networks inside homes, suggesting that controls are likely to become much more complex.

In 1995, the Energy Star Program established technical specifications for “energy-saving” programmable thermostats. Many building codes and government programs require installation of programmable thermostats because of their assumed energy savings. Nevertheless, there have been few careful studies of the energy savings attributable to these thermostats. Several recent field studies have found no significant savings in households equipped with programmable thermostats compared to households with manual thermostats [2–5]. Two other studies found that homes relying on programmable thermostats actually consumed more energy than those where the occupants set the thermostats manually [6], especially in homes equipped with heat pumps [7]. Anecdotal evidence suggested that the thermostats were overly complex and

* Corresponding author. Energy Analysis Department, Lawrence Berkeley National Laboratory, MS90R2000, Berkeley, CA 94720, USA. Tel.: +1 510 486 4740.
E-mail address: akmeier@lbl.gov (A. Meier).