Do Central Air Conditioner Rebates Encourage Adoption of Air Conditioning?

Shahana Samiullah, Southern California Edison
David Hungerford, California Energy Commission
Adrienne Kandel, California Energy Commission

ABSTRACT

Air conditioner rebate programs aim to replace low efficiency air conditioning purchases with high-efficiency purchases. When participants change from other forms of mechanical cooling (or no cooling at all) to central air conditioning, the hope is that they would have adopted central air conditioning anyway. The implicit assumption is that people prefer central air conditioning to other forms of cooling.

We analyze a 1990's efficient central air conditioning rebate program using econometric methods to distinguish between those participants who would have adopted central air conditioning in the absence of the program and those who adopted it due to the rebate program. We find that about 5% of participants adopted central air conditioning because of the program – increasing their energy use.

These results raise questions about program effects: Is this increase in central air conditioning purely a subsidy effect, or does the program reinforce the growing social norm that air conditioning is a necessity? Could it give "good citizens" permission to buy central air conditioning because the subsidized models are "efficient"?

Using information collected as part of an alternatives to compressor cooling project and additional literature on air conditioning use behavior, we develop some potential explanations for rebate program effects and suggest design considerations for future air conditioner efficiency programs.

Introduction and Background

In 1994, Southern California Edison (SCE) distributed 6202 rebates for efficient central air conditioners as part of the 1994 Efficient HVAC Equipment Rebate Program. At that time, SCE was serving about 3.56 million households. Like any other rebate program, the objective of this program was to move the consumers to high efficiency units when they are in the market to purchase a central air conditioning unit or motivate consumers to early retirement of their old inefficient unit by replacing it with a higher efficiency unit.

When analyzing program impacts one of the crucial questions asked is the effect of the rebate on participant behavior that can be translated into intended true effects of the program. In evaluation lingo this is called "net effects" - free of any non-program related effects.

This paper examines factors leading to the adoption of central air conditioning in two ways. First, we examine the available SCE program data using a statistical analysis to assess to what extent the program induced new adoption of central air conditioning and with what impacts. Second, we offer a social analysis of the observed results to improve our understanding of why people adopt different kinds of cooling technologies. In this section, we review some social aspects of cooling and their influence on central air conditioning adoption. In conclusion, we suggest a more comprehensive approach to the problem of growing energy use for cooling that could lead to fundamentally different program design.

Data Source

A large random sample from the 6202 efficient central air conditioner rebate participants in the program tracking system, were included in the general-purpose Residential Appliance Saturation Survey (RASS). 830 completed surveys by program participants and 4846 surveys from the general population households (rebate nonparticipants) surveys were used in the quantitative analyses. One of the survey questions asked respondents whether they had bought central air conditioning over the last year (since 1993), and if so, whether the air conditioning unit was an addition or replacement. This question forms the basis of our quantitative analysis.

Cooling Behavior and Rebate Program Targeting

The RASS survey asked a number of questions regarding cooling practices. It seems 40% of SCE households had central air conditioning as of the survey date, while 20% had window or wall air conditioners. 11% reported evaporative cooling. 9% reported an attic fan, while 8% reported a whole house fan. 56% had portable fans, and 44% reported ceiling fans.

The rebate program managers were aware of this variety of cooling methods. They marketed the program mostly through air conditioning contractors, and expected it to attract mostly households replacing older systems or remodeling their home. The program required that households use the rebate only to replace old systems rather than to newly adopt central air conditioning. According to the recollection of the one rebate program manager still at SCE, however, there was no enforcement of this requirement because the money was considered better spent on rebates than onsite inspections.

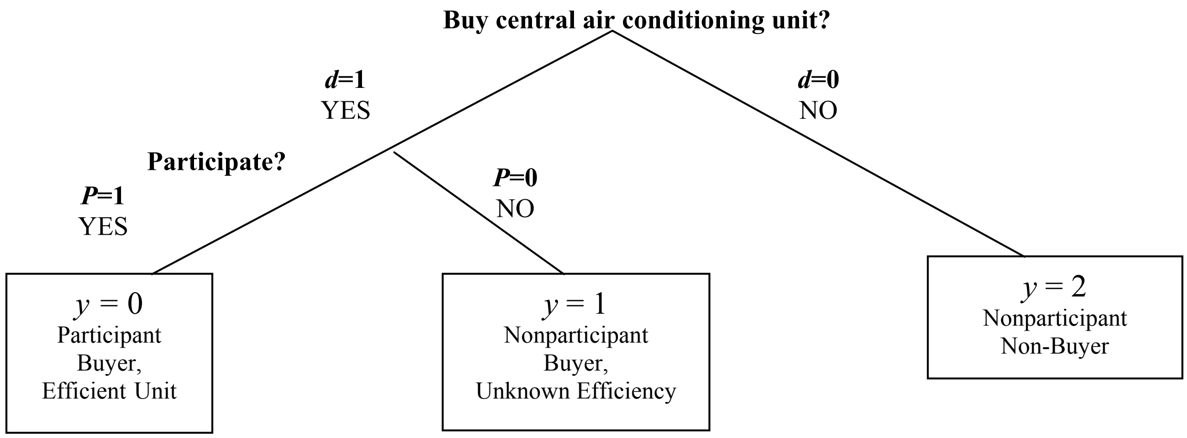
Quantitative Analysis and Results

To assess net effects, researchers often use non-participant behavior as a proxy for program participant behavior in the absence of the program, applying statistical methods to correct for observed differences between participants and nonparticipants, and mitigate the inaccuracies caused by unobserved differences. We applied one such method, a two-stage procedure called "instrumented decomposition." First, we use a nested logit regression to jointly estimate households' decisions to buy central air conditioning in 1993, and to participate or not in the rebate program. From this we estimate what proportion of new adopters of air conditioning only did so because of the program. Second, we use a linear regression to estimate the energy impacts of these decisions.

The first stage, then, is to model purchase decisions, thereby revealing factors that seem to influence the adoption of new air conditioning equipment. The household has three possible choices to make: purchase an air-conditioning unit by participating in the rebate program (choice 0), purchase an air conditioning unit without participating (choice 1), and do not purchase an air conditioning unit during the program period (choice 2). Since two of these discrete decisions (to purchase) are similar, we follow standard econometric practice and apply a nested logit model, which we estimate simultaneously rather than sequentially to minimize variance. Train et al (1994) established the use of such nested logit models in energy program evaluations, for estimating free ridership. To handle the choice-based sampling, we use the Manski-McFadden conditional maximum likelihood estimator.

The nested logit decision tree, which shows what choice combinations are possible but does not imply sequential decision-making, is shown in Figure 1.

Figure 1. The Basic Nested Logit Model: *y* is the Choice and the Branch Number



The observable dependent variables, or choices, are participation, P, and central air conditioning purchase d, and these choices are driven partly by the unobserved variable b, the natural tendency to buy or replace a central air conditioning unit during the program period without program incentive. After the regression is run, b is estimated by noting that b is the probability of purchase given no program participation, and applying Bayes' Law:

$$pr(b_i = 1) = \Pr(d_i = 1 \mid P_i = 0) = \frac{\Pr(d_i = 1 \; and \; P_i = 0)}{\Pr(P_i = 0)}$$

Thus $\hat{b}$ is the regression-predicted probability of branch (y=1), divided by the sum of the predicted probabilities of branches (y=1) and (y=2). $\hat{P}$, meanwhile, is the predicted probability that branch (y=0) is chosen.

The independent variables of the nested logit regression are shown in Table 1, along with their effects on the choices, according to the results of the nested logit estimation. In the following sections, we discuss the implications of this model for understanding who purchased central air conditioning, who participated in the rebate program, how many participants would have purchased in the absence of the program, and what effects the program had on new adoptions of central air conditioning.

Purchase Decision

Table 1 shows the "top" branch nested logit results: the decision to purchase central air conditioning during the program period, or not (note that a positive coefficient means a decreased probability of purchase). We see that desert residents were the most likely to buy central air conditioning during or near the program year (compared to the included SCE planning zones of Central Valley, Coastal, and Inland). Owners of middle-aged homes were the most likely, as one would expect since newer homes tend to be built with central air conditioning while the oldest homes may not easily retrofit. Also, older homes tend to house lower income people in SCE territory. Homeowners were more likely to get central air conditioning than renters. So were people who had needed to do maintenance or repairs on their heating or cooling system, and people who use their thermostat to control home temperature or who cool their home as needed. (The alternative was rarely cooling the home.) Higher income households had more central air conditioning systems, as did retired people. Finally, people who added square footage to their home or replaced the heating system were more likely to get central air conditioning, perhaps as part of a general home upgrade.

Participation Decision, Given Purchase

We compare purchasers who participated with those who did not in the "bottom" branch nested logit results of the participation decision shown in Table 1. High electricity users were more likely to participate, given the purchase of central air conditioning. People in older homes were more likely. People in desert homes were less likely. Owners participated considerably more than renters. People who did not identify themselves as nonwhite participated more, as did people whose home language was English. People who report setting their space cooling thermostat by time of day were also more likely to participate; perhaps this reflects a level of sophistication or familiarity with SCE programs and suggestions. Also related to sophistication, people able to answer the square footage question on the survey were more likely to participate. People in new homes (built after 1990) were far less likely to be participants than others, given purchase. If we speculate that newer homes are less likely to undergo major remodeling and that newer equipment is both more efficient and less likely to be in need of repair or replacement, this observation supports an interpretation that program participation is much more likely to occur when the units are being replaced anyway. Also, people reporting their purchase as an upgrade from no central air conditioning (Had No CAC) were 37% less likely to participate than those who reported their purchase as a replacement (Had CAC).

Table 1. Nested Logit Regression Results

Variable	Coefficient	Standard Error	t	Probability of No Relation
Top Branch Predicting Probability of No Purchase				
Top Branch Intercept	7.7049	0.5964	12.9191	0.0000
Pre-program Electricity Use	-0.1036	0.3176	-0.3262	0.7443
Coastal Planning Zone	0.2681	0.1811	1.4804	0.1388
Central Valley Planning Zone	0.7369	0.2525	2.9181	0.0035
Inland Planning Zone	0.4099	0.2009	2.0407	0.0413
Single Family Home	-0.2184	0.1958	-1.1152	0.2648
Age of Home	-4.0786	0.7173	-5.6864	0.0000
Age of Home Squared	4.2247	0.6092	6.9345	0.0000
Homeowner	-0.7217	0.2636	-2.7375	0.0062
Uses Thermostat	-0.9478	0.0832	-11.3975	0.0000
Cools As Needed	-1.3870	0.1484	-9.3460	0.0000
Recent HVAC Maintenance	-0.3216	0.1083	-2.9699	0.0030
Δ Cooling Degree Days (base 70)	0.4489	0.1587	2.8282	0.0047
Δ Heating Degree Days (base 60)	1.3188	0.3063	4.3053	0.0000
Income	-0.5524	0.1085	-5.0900	0.0000
Replaced Heating System	-3.9779	0.3895	-10.2139	0.0000
Retired	-0.3439	0.1105	-3.1128	0.0019
Added Square Feet	-2.4659	0.4915	-5.0168	0.0000
Bottom Branch Predicting Probability of Nonparticipation Given Purchase				
Bottom Branch Intercept	4.7678	0.6899	6.9114	0.0000
Pre-program Electricity Use	-1.3052	0.5488	-2.3785	0.0174
Coastal Planning Zone	0.5557	0.2742	2.0269	0.0427
Central Valley Planning Zone	0.8792	0.3268	2.6905	0.0071
Inland Planning Zone	0.3170	0.3083	1.0283	0.3038
Single Family Home	0.3063	0.2915	1.0508	0.2933
Age of Home	-0.7048	0.4001	-1.7617	0.0781
Homeowner (not renter)	-2.0186	0.4550	-4.4369	0.0000
Sets Thermostat Timer	-0.5147	0.1879	-2.7389	0.0062
New Home	7.0316	2.6232	2.6805	0.0074
Education Level	-0.0953	0.0833	-1.1439	0.2527
No Answer on Education	-0.5400	0.1783	-3.0294	0.0025
Not Self-identified Nonwhite	-0.5446	0.2059	-2.6449	0.0082
Square Feet	-0.1800	0.1329	-1.3545	0.1756
No Answer on Square Feet	0.8708	0.4381	1.9875	0.0469
English Speaker at Home	-0.8358	0.3304	-2.5295	0.0114
Had CAC before program	1.3279	0.3016	4.4030	0.0000
Had No CAC before program	3.5560	0.3345	10.6298	0.0000
Inclusive Value Relating the Branches				
Inclusive Value	0.2012	0.0340	5.9202	0.0000

Sample size = 5001. Simultaneously estimated nested logit regression, using the consistent Manski-McFadden conditional maximum likelihood estimator to handle the choice-based, stratified sample. Variables are rescaled.

Natural Buyership

We define participant "natural buyers" as participants who would have purchased a central air conditioning system during the program period even without a rebate, including replacers of older systems. This purchase can be a replacement or a new adoption of central air conditioning. Participant natural buyership is estimated as:

$$\text{participant natural buyership} = \frac{\sum_i P_i \hat{b}_i}{\sum_i P_i}$$

The model predicts that 9.7% of participants (about 600 households) are natural buyers, with a standard error of 1.1%. (Free riders, a subset of participant natural buyers who would have bought an *efficient* system without rebate, must number less than that 9.7%.) This number is small because there was little natural market for air conditioners in 1993-4 in greater Los Angeles, according to RASS survey results. Only 2.4% of nonparticipants sampled – representing just over 85,000 households - reported adding or replacing central air conditioning during that period.

One might ask whether the nonparticipant central air conditioning sales were naturally low in that recession period, or whether the rebate program become so widespread that it "hogged" all the air conditioner purchases, turning nonparticipant buyers into participants. The former is the case; there were only 6202 program participants, while over 85,000 nonparticipants bought central air conditioning. If the program did not exist and all participants had been nonparticipant buyers, the nonparticipant central air conditioning purchase rate would only have been 2.6%.

Does the Program Increase Air Conditioner Ownership?

A RASS survey question asked whether purchasers of new central air conditioning were replacing an old unit, or whether they had added central air conditioning to their home. 78% of rebate recipients said replacing, 5% adding, 17% didn't answer. Thus, about 78 to 95% of purchases were replacements; the balance were new adoptions. If answers to the addition/replacement question are missing completely at random (meaning people who answered the question are just like people who didn't), then the survey indicates that 94% of central air conditioning purchases were replacements and 6% were new adoptions. [$78\% \div (78\% + 5\%) = 94\%$.] This represents around 372 of the 6202 program participants. Table 2 summarizes this result, and provides parallel information for program nonparticipants purchasing central air conditioning during the program period. The table is based on responses from 830 participants and 169 nonparticipant purchasers of central air conditioning. Numbers are in percentage form because the sample is stratified, so sample counts would be misleading. Nonresponse to the replacement/adoption was probably high because the question was placed to the side of a question on the age of the previous system, and probably inherited many of that question's nonrespondents.

Table 2. Which Purchasers Already Had Central Air Conditioning

	Percent of Participants	Percent of Nonparticipants
Had CAC before purchase	78%	38%
Had No CAC before purchase	5%	32%
Replacement/adoption question unanswered	17%	39%

To estimate what proportion of the rebate recipients' new adoptions of central air conditioning were caused by the rebate program, we estimated each new adopter's natural buyership probability, $\hat{b}$, and summed them. The result: 85% of the 372 new adoptions are estimated to be due to the rebate program, if answers to the adoption/replacement question are assumed missing completely at random. If we assume every household that did not specify adoption or replacement was in fact replacing an old central air conditioning system, we still get 85%. If they're all new adopters we get 90%. When we tested model sensitivity to independent variable choice by dropping one half the independent variables from estimation, the range became 90-92%. Dropping the other half instead, it was 85-90%. In short, there is a very robust finding that around 85 to 90% of rebate program participants who newly adopted air conditioning did so because of the program. These participants received a subsidy intended to cut space cooling electricity use, and instead they increased it.

The remaining 15% or so of new adopters were buying central air conditioning anyway and one can hope that the rebate program steered their choice of systems toward an efficient model. In all, households adopting new air conditioning for the first time increased energy use about 475 kWh per year per household, according to results of the energy savings regression that forms the second stage of the instrumented decomposition method (details in Kandel, 1999). Still, savings on air conditioning replacers outweighed energy use increases on new adopters, so that on average, the program saved 330 kWh per program participant household, after subtracting off free riders' savings, according to regression results.

Potential Explanations for Adding Central Air Conditioning

The results presented above show that at least some participants may have added central air conditioning to their homes, increasing their potential energy consumption, as a result of the program incentive. To further understand the implications of such a finding, and to inform policy and future program design, this section discusses some of the potential explanations for the growing demand for central air conditioning, particularly in mild climates. This discussion is primarily derived from interviews conducted and literature reviewed as part of one author's participation in an Alternatives to Compressor Cooling Project funded by the California Institute for Energy Efficiency (Hall, Hungerford & Hackett 1994; Lutzenhiser et al 1994).

Increasing use and installation of central air conditioning in mild climates, such as the non-desert areas of Southern California, has large implications for energy demand, especially during peak periods. One typical explanation suggests that this trend is simply a function of "need." However, taking that interpretation as self-evident relies on certain assumptions about the need for "thermal comfort."

A plain(er) language interpretation of current thermal comfort science literature is that people's bodies are "comfortable" at particular, unvarying temperatures and that these individually ideal temperatures are distributed normally in the population. In a sense, this line of research treats human bodies as instruments that register temperature, much like a thermometer, and signal adjustment mechanisms that operate to return the body to that temperature "setpoint," much like a thermostat. The comfortable temperature is that temperature at which vasodilation, vasoconstriction, perspiration and shivering—as well as seeking shelter, making fire, and turning on the air conditioner—do not happen. The physical as well as the social dimensions of "thermal comfort" drive people to seek a constant temperature at which they are comfortable. Any thermal sensation would be, by definition, uncomfortable. Therefore, the goal of cooling (and heating) systems is to achieve the constant temperature, or "set-point," to achieve a *lack of* discomfort. For groups of people, whose individual “set-points” vary, thermal comfort scientists develop sampling distributions of those experimentally-derived temperatures (Fanger 1972). The result is a “set-point” that building engineers can use to minimize the number of complaints they receive. By this definition, any natural climate is uncomfortable most of the time because it does not meet the condition of constant temperature, so buildings in every climate, no matter how mild, require thermal comfort systems.

This mechanical, instrumental definition of comfort has value for its intended purpose, to provide guidance to building engineers operating sealed buildings. Yet this definition, over time, appears to have jumped the divide between work and home, and changing expectations of what constitutes a proper “new” home for central heating and air conditioning systems have made non-centrally air conditioned new homes a rarity in California, at least. However, the methods inherently assume the thermal neutrality definition of comfort. Virtually all of the research that has been conducted on thermal comfort and thermal preferences, as well as research on the physiology of temperature stabilization and human response to thermal stimuli, has focused on "finding" the thermal "set-point" or identifying the mechanisms which achieve it (see Parsons 1993; Hensel 1981; McIntyre 1980 for reviews of this literature). Other, more recent studies have recognized the inadequacy of this explanation and have offered expansions on its basic premises to include adaptation and acclimatization to help explain differences in comfort preferences between groups and over time (see, for instance, de Dear, 1998 and Humphries, 1994). The fundamental goal and design of this research, however, is to find each individual’s “set-point” rather than to determine whether or not those individuals prefer a constant temperature, or have different expectations (from a constant temperature) for the thermal environment under different social conditions.

These problems are exacerbated by the increasing proportion of houses equipped with central air conditioning in California "transition climate zones”—which have climates that may reach higher temperatures during the day, but cool off sufficiently at night that thermal mass can be used to dampen daytime cooling needs (Huang 1993). In such areas, "demand" for compressor cooling is questionable even by conventional criteria. Not only do rebates encourage air conditioning there, they essentially encourage a particular type of cooling technology and may even dissuade people from considering less-conventional cooling alternatives like thermal storage and evaporative cooling. The hegemony of compressor-driven air conditioning is thus enforced, even in dry or moderate climates where different cooling technologies may be more effective and more efficient.[1]

The encroachment of compressor-based central air conditioning into such areas, then, presents problems for the effort to promote and advance non-compressor-based cooling technologies (e.g., nighttime ventilation, thermal mass). One plausible explanation of this

[1] SCE did offer evaporative cooling rebates at the same time they offered central air conditioning rebates, but the evaporative cooling rebates were supposed to be for people who already had central air conditioning, so they would use it less frequently. They were, in fact, effective in this regard, reducing recipients’ average energy use by about 1000 kWh/year (Kandel, 1999). Only 1624 households participated in this program, available to SCE’s 1.8 million non-coastal customers.

movement is that the presence of central air conditioning is no longer climate driven, but that it has become standard feature of a normal house. As a result of such "standardization," central air conditioning is routinely installed and operated in climates where it may not be necessary, and may indeed be inappropriate. This presents larger problems for conservation efforts. Not only is central air conditioning use "normalized" so that more people are using the technology, but as its presence becomes common, people begin to expect, and even demand, that their stores, offices, and homes feel air conditioned, not because they are necessarily uncomfortable without it, but simply because to be without it is to be, literally, sub-standard. We argue here that the standardization of central air conditioning has had the effect of "normalizing" a particular conception of comfort and a specific type of cooling-related experience. What is at issue is not so much a question of whether new technologies can provide sufficient comfort, but rather a question of how comfort is defined and how the experience of being cool is understood (for a thoughtful discussion of this issue, see Kempton &. Lutzenhiser 1992)

Air conditioning has become much more than a simple cooling tool. It has become so much a part of the building in all but the mildest climates that a new house without air conditioning "cannot be marketed," according to the builders, developers, and real estate people interviewed for the Alternatives to Compressor Cooling study (Hall Hungerford & Hackett 1994). The common explanation for this is that people would not buy a house without air conditioning because they believe they would be uncomfortable during hot weather.

There is some evidence that the new technology of central air conditioning was not widely and immediately accepted as the greatest thing since sliced bread. In fact, the general public was somewhat skeptical of the benefits of an expensive technology that added as much as 10-20% to the cost of a typical tract house. In fact, marketing of air conditioning technology during that time focused the technology's modernity and dispelling the perception that it was frivolous and pretentious (for a social history of air conditioning, see Cooper 1985). At the very least, this suggests that there has been something of a shift in people's perception of the "need" for air conditioning technology in general and central air conditioning in particular over the forty-plus years since it became widely available. In other words, what people expect may have changed, explaining why houses in mild climates that were originally built without, and presumably did not need, central air conditioning are now being retrofitted to the new technology

Conclusions

In the context of shifting expectations and the questionable premises underlying thermal comfort science, it seems reasonable to suggest that the availability of incentives for installing central air conditioning may, in this case, have encouraged additional air conditioning use in some cases. Further, such incentives may be helping solidify the perception that compressor-driven central air conditioning is normal, standard, and environmentally benign, as long as it's efficient.

Our statistical results suggest that about 5% of SCE's efficient air conditioning rebate recipients adopted central air conditioning only because of the program, and would be making other cooling choices without it. (About 1% adopted central air conditioning but would have otherwise, and the other 94% were replacing older systems.) This is for a program nominally aimed at air conditioning replacers and marketed largely through air conditioning contractors; one could expect higher program-induced adoptions without such precautions.

These numbers suggest a first-choice policy of offering comfort services to homes, with individuals' needs, tastes, and comfort definitions taken into consideration as program implementers propose cooling and/or building envelope solutions, and subsidize them as a function of the energy they'll save. As a second choice, future rebate programs should include a variety of cooling and envelope technologies, as they did last summer in California, and air conditioning rebates in particular should clearly require the recipient be replacing a pre-existing system. Even then, we can expect some new air conditioning adoption, as we saw in the SCE program.

References

ASHRAE. *Thermal Environmental Conditions for Human Occupancy.* Atlanta: ANSI/ASHRAE standard, 1989.

Blumstein, C. 1992. “It's O.K. to want to be cool.” *Energy and Buildings. 19:3-4*. 259.

Cooper, G.A. 1987. "Manufactured Weather": A History of Air Conditioning in the United States, 1902-1955. Ph.D. Dissertation, University of California, Santa Barbara.

Fanger, P.O. 1972. *Thermal Comfort: Analysis and Applications in Environmental Engineering.* New York: McGraw-Hill, 1972.

Hall, D., D. Hungerford, B. Hackett. 1994 Barriers to Non-Compressor Cooling: Air Conditioners in Social Context. ACEEE. *Proceedings of the ACEEE 1994 Summer Study on Energy Efficiency in Buildings.* Volume 1, pp. 59-63.

Huang, J. 1993. “Analysis of Climatic Conditions and Preliminary Assessment of Alternative cooling Strategies for Houses in California Transition Climate zones” *Draft report submitted to California Institute for Energy Efficiency, March 9, 1993.*

Kandel, A.V. 1999. *Instrumented Decomposition: A New Method to Estimate the Net Energy Savings Caused by Efficient Appliance Rebate Programs.* Dissertation, U.C. Davis agricultural and resource economics department.

Kempton, W., Feuermann, D., McGarity, A.E. "I always turn it on super": user decisions about when and how to operate room air conditioners. *Energy and Buildings 19-3-4*. 177-192.

Kempton, W. and Lutzenhiser, L. eds. 1992. Energy and Buildings. Special Issue devoted to Air-Conditioning: The Interplay of Technology, Culture and Comfort. 19:3-4.

Kerslake, D. McK. 1972. *The Stress of Hot Environments.* Vol. 29 of *Monographs of the Physiological Society.* Cambridge: University Press.

Lutzenhiser, L. 1992. A question of control: alternative patterns of room air-conditioner use. *Energy and Buildings 19:3-4*. pp. 193-200.

Lutzenhiser, L. Bruce Hackett, David Hall, David Hungerford. 1994. *Alternative Cooling Technologies s for California: Social Barriers, Opportunities and Design Issues.* Universitywide Energy Research Group, University of California. Report UER-289.

Manski, C.F., and D. McFadden. 1981. "Alternative Estimators and Sample Designs for Discrete Choice Analysis," in Manski., Charles F. and Daniel McFadden, editors, *Structural Analysis of Discrete Data with Econometric Applications,* Cambridge, MA: MIT Press.

Parsons, K.C. 1993. Human Thermal Environments. London: Taylor & Francis.

Train, K., S. Buller, B. Mast, K. Parikh, and E. Paquette (1994), "Estimation of Net Savings for Rebate Programs: A Three-Option Nested Logit Approach," *Proceedings of the ACEEE 1994 Summer Study on Energy Efficiency in Buildings*, Asilomar, 7.239-7l249