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Witness: Sarah J. Darby, Environmental Change Institute, University of Oxford

SOUTHERN CALIFORNIA GAS COMPANY

ADVANCED METERING INFRASTRUCTURE

REBUTTAL TESTIMONY

CHAPTER 5

ESTIMATED CONSERVATION IMPACT OF PROVIDING DAILY GAS INFORMATION TO CUSTOMERS

Prepared Rebuttal Testimony

of

Sarah J. Darby

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

May 7, 2009

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I. BACKGROUND

The purpose of this testimony is to respond to the intervenor testimony submitted on April 23, 2009 by the California Public Utilities Commissions' (CPUC or Commission) Division of Ratepayer Advocates (DRA), The Utility Reform Network (TURN), and the Utility Workers Union of America (UWUA) intervening parties to the Southern California Gas Company's (SoCalGas) Advanced Metering Infrastructure (AMI) proceeding, Application (A.) 08-09-023. Specifically, my testimony will address issues raised by the above intervening parties in relation to Chapter V (Estimated Conservation Impact of Providing Daily Gas Information to Customers) of my Errata to Prepared Direct Testimony filed on January 6, 2009.

II. INTRODUCTION

The aim of this testimony is to discuss the points raised by DRA, TURN and UWUA in relation to the potential conservation impact of improved feedback. I respond to each based on available evidence, acknowledging areas of uncertainty, and conclude that the estimates for participation and for conservation effect presented in my Errata to Prepared Direct Testimony are reasonable. SoCalGas' assumptions are also supported by research that has been published since the filing of my Errata to Prepared Direct Testimony.

III. SOCALGAS HAS PRESENTED STRONG SUPPORT FOR ITS PROPOSED CONSERVATION BENEFITS

First, all three interveners assert the uncertainty related to estimates of savings resulting directly from improved feedback. There is uncertainty in relation to estimates of how many people will use feedback and also in relation to the level of conservation that will result. Every trial and experiment to date produces different answers, and we can expect this to continue. Each trial involves different people in different buildings at different times, in varying climates and in different social, economic and political conditions. None of this should detract from the main lesson, which is that improved feedback on energy usage normally has a conservation impact. It does so by making energy usage more visible and understandable, and by demonstrating the effectiveness or otherwise of physical or behavioral changes.

The question then arises as to how much effort needs to be expended into improving feedback, who should make such an effort, and the level of technology required. If everyone simply checked their meters and bills more often, would that be adequate to kick-start major improvements in energy literacy? The evidence is that bills are too infrequent and not specific enough about end-uses to be much help, while meters are normally neither user-friendly nor easily accessible. A minority of motivated people can make substantial savings through changing their patterns of usage and investing in efficiency, using bills and meter readings to judge the effectiveness of these changes; but AMI does have the potential to offer higher quality, more frequent, and more accessible feedback across the whole population. DRA states that:

> "DRA agrees in concept with attributing a conservation benefit to gas AMI based on day-late or near real-time customer usage information feedback."[1]

The challenge is to optimize this benefit, using appropriate technology and customer information initiatives, in a cost-effective manner.

The regulatory issues posed by gas AMI in general and gas usage information feedback are of course somewhat different from those posed by electricity. Gas is a fuel, not an instantaneous process; it has fewer end-uses than electricity; it can be stored and there is far less need to control peak load than there is with electricity. The familiar 'demand response' arguments for electricity feedback do not apply to gas, but the 'invisibility' problem is the same and the need for conservation is the same. Most of the studies I reviewed up until 2006 are related to conservation, not demand response. These conservation studies were the source of the figures for the conservation impact that are given in Chapter V of my Errata to Prepared Direct Testimony. In recent years, the volume of peak-reduction trials using some form of feedback has

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[1] Division of Ratepayer Advocates, Report on The Application of Southern California Gas Company on Advanced Metering Infrastructure, A.08-09-023, Executive Summary, Section V, p. 4, lines 11-12

grown and it is clear that, even when the aim is for peak reductions, there is usually a conservation effect. Where the aim is for overall conservation, the conservation effect is typically higher.[2]

IV. CALIFORNIA REGULATORY SYSTEM IS RECEPTIVE TO CONSERVATION PROGRAMS

In the California regulatory system, where profits are decoupled from volume sales, the possibilities for substantial cuts in gas usage are greater than in most parts of the world. This decoupling allows utilities to implement conservation programs without having conflicting objectives.

This proceeding occurs at a time when energy policy is being examined with a new intensity in the USA and when the need for reducing the use of fossil fuel has never been greater. Whether for reasons of climate change mitigation, energy security of supply or household economy, the conservation figures being discussed in policy documents at local, state and federal level are far in excess of the estimates made by SoCalGas in its application. In order to achieve a 40% reduction in emissions from existing homes by 2020, as envisioned in the California Energy Efficiency Strategic Plan, a whole suite of initiatives will have to be employed and households will have to make many changes in equipment and practices. This is a new policy environment and a favorable background for any rollout of AMI and associated feedback programs. As noted by everyone in this debate, the context for feedback programs has an important part to play in their success.

V. FEEDBACK PROVIDED BY AMI PROPOSAL WILL ENABLE CUSTOMERS TO CONSERVE MORE EFFECTIVELY

Conservation gains from making energy use more visible and understandable, through the provision of clear feedback, are complementary to conservation gains from installation of energy

[2] King C and Delurey D (2005) Twins, siblings or cousins? Analyzing the conservation effects of demand response programs. Public Utilities fortnightly March 2005.

efficiency measures. They are also complementary to education or marketing initiatives. The estimated savings put forward by SoCalGas do not stem from physical efficiency measures but from changes in patterns of behavior that are stimulated, maintained and developed through better understanding of how home energy systems work. Feedback-related technology is essentially an enabling tool for the customer's use. It therefore complements efficiency and education or advice programs. The strong likelihood is that improved feedback will lead to greater effectiveness of other initiatives - but the SoCalGas savings estimates do not assume this. Instead, they simply assume that individuals who use improved feedback will start to conserve fuel through changes in behavior patterns. There may be a danger of double counting stimulus for conservation from energy efficiency or educational programs and from feedback opportunities at some stage in the future, given the complexities of energy-related behavior in real life and the working out of many influences on such behavior.[3] But the estimates given by SoCalGas for the likely conservation impact of improved feedback are based on additionality to all influences on behavior in operation when the improved feedback commences.

VI. INTERVENOR'S ALLEGATION THAT CUSTOMERS MUST CHOOSE BETWEEN CONSERVATION AND COMFORT IS UNSUPPORTED

I do not accept that offering customers a means of reducing their consumption leads to any loss of comfort. The whole point of improving feedback is to put customers in a position where they have more control over their usage and can decide how to use energy to their best advantage. I discuss options open to customers in more detail below.

While it is impossible to do more than estimate the likely conservation gains from a feedback program supported by AMI, I maintain that the estimates made in SoCalGas' application are reasonable and that the most recent research evidence (since the application) does nothing to alter that conclusion.

[3] TURN, Schilberg, pp. 11-13

VII. DRA'S CLAIM THAT SOCALGAS' CONSERVATION BENEFIT IS OVERESTIMATED IS UNSUPPORTED

While it is true that few of the data cited in my Errata to Direct Prepared Testimony and responses come from California, it is not the case that they are irrelevant to California. The conservation effects from improved feedback that are set out in my Errata to Prepared Direct Testimony were measured in Japan, the Netherlands, Ontario, Newfoundland, British Columbia, Arizona, California, the UK and Germany. In spite of differing climatic conditions, housing types and cultural practices, these studies observed effects that illustrate a common finding: that when a largely invisible process (gas or electricity use) is made more visible, people respond by learning how to use fuel more sparingly and effectively. I have not seen any evidence that Californians are radically different from other people in the way in which they respond to improved feedback.

In search of greatest relevance to this application, I selected the trials and studies that involved heating/cooling loads and, if possible, gas. A key message from the research literature is that making energy use more visible produces a conservation impact, and that geography and climate are only two of many variables that affect the actual impact.[4]

DRA challenges the higher conservation effect expected for dedicated energy displays, in comparison with internet-based feedback. The main reasons one would expect greater impact for this is the increased accessibility of a dedicated display, in time and in location. It is readily visible and households do not have to make a special effort to find the information they are seeking. Another reason why a dedicated display is likely to have more impact is that home energy-related decisions are made by all members of a household, not just one.[5] An in-home display is more likely to act as a common point of reference for all than a web-page.

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[4] Lutzenhiser L and Bender S (2008) The 'average American' unmasked: social structure and differences in household energy use and carbon emissions. Proceedings, American Council for an Energy-efficient Economy summer study, paper 7552.

[5] Lutzenhiser et al. *Behavioural Assumptions underlying California Residential Sector Energy Efficiency Programs.* CIEE, April 2009 (See Attachment V-1)

VIII. THE COMMISSION SHOULD IGNORE DRA'S PROPOSAL TO REDUCE SOCALGAS' ESTIMATE OF CONSERVATION BENEFITS ASSOCIATED WITH ITS AMI PROPOSAL

DRA has set its arguments in support of a reduced estimate for conservation benefits from AMI-based feedback in Chapter 7 of its testimony. DRA's 8% participation estimate for both web-based and IHD feedback (4% participation for each) is based on the figure for the most enthusiastic respondents to the SoCalGas survey carried out with 563 members of their Customer Insight Panel – those 38% who strongly agreed that if their daily gas usage and cost were made available, it would influence their usage. However, the 30% who "somewhat agreed" with this statement were clearly on the positive side of neutral, and it would not be unreasonable to include some of the 19% of "neutral" respondents as potential participants, though I did not do so here. Including the 68% who agreed with the proposition in my calculation led me to a figure of 15% of the SoCalGas customer base as initial participants, which I adjusted down to 13% purely out of caution. I do not think there is any justification for moving the participation figure downwards again, especially as both computer literacy and interest in energy are on the rise rather than declining.

There does not seem to be a valid reason behind crediting both web-based and display-based feedback with 4% savings. As explained in our response to DRA's question 1c of DRA data request SCG0809023-008,

> 'The [estimated] difference in conservation effect [between online and display-related feedback] is accounted for by two related factors. First, whether the device is clearly visible in the home and has the display of energy consumption as its primary function (so that the customer will look at it for that reason, and will not have to seek out energy information among many other functions). The second factor is the extent to which the customer has instant, or near-instant, access to the data – the 'directness' of the feedback.'

We could add a third factor; that an in-home display is more likely to be visible to all members of the household, whereas online data is typically only visible to the person consulting the Internet on a PC or other device. It therefore serves as a focus for conversation and a common point of reference. Early findings from the UK Demand Reduction trials are that a high proportion of households with an in-home display talk about it to others. As pointed out in the recent White Paper sponsored by CPUC, there is an implication in typical efficiency programs that, "household composition is basically irrelevant … management is a function of gathering information and making strategic choices, but not really a function of talking to people … roommates, family etc. are not primary audiences and conservation behavior – as opposed to efficiency investment – is not a featured target."[6]

For these reasons, it is realistic to expect a higher conservation impact from more direct, dedicated forms of display than from online feedback.

IX. RECENT TRIALS IN NORTH AMERICA SUPPORT SOCALGAS ESTIMATES OF EFFECT

Results are now in from the largest of all North American trials[7], with 30,000 participants (20% adoption rate in northern Ontario). There was an average 6.7% electricity saving per household – equivalent to 1.3% overall conservation in the population – although the displays had batteries that ran out after a few months and that were not replaced in a majority of cases. When surveyed, 76% of a sample of 996 (31% response rate) said that they had responded to their real-time electricity feedback by setting back their thermostats; 74% had been more careful about opening windows; 65% had cleaned their furnace filter and 43% had insulated their water heaters. Participants stated that they valued the kWh information more highly than the kW information (that is, the information most relevant to managing heating loads), and this was especially true of those who continued to use the device throughout the two years of the trial (29% of the total). This trial shows worthwhile responses to feedback and holds lessons for future programs. It broadly supports the estimates for conservation impact given by SoCalGas. It

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[6] P23, Lutzenhiser et al. *Behavioural Assumptions underlying California Residential Sector Energy Efficiency Programs.* CIEE, April 2009

[7] Hydro One: In-Home Real Time Display. Presentation by Giuliana Rossini to the 2nd Annual Conference on Home Energy Displays held in Orlando, Florida, April 1-2, 2009 (see Attachment V-2)

is worth reiterating, that SoCalGas has assumed a very slow rate of increase in participation for its figures –a growth rate per year of 1% of those already participating in the previous year.

The findings from a Massachusetts trial of real-time electricity displays in 3,500 homes, just released,[8] show an overall saving in one year of 1.9% over (weather-adjusted) baseline in the entire sample, which rises to 2.9% among those who used the displays. This was in spite of technical difficulties with the displays, and battery failures as in northern Ontario. The participation rate was very high – 76% of those who were offered a display - reflecting the fact that most customers did not have to pay anything for their device.

Closer to California, a smaller trial of five types of home energy displays in Nevada (93 participants) was conducted with a more qualitative approach. Two-thirds of participants in this trial saved energy, with the savers increasing their understanding over time and with high levels of satisfaction. Average savings per participant were 5.2% over baseline, weather-adjusted, over a period of 6 months.[9]

These very recent findings (not yet fully published and reviewed, but publicly presented and debated) indicate that SoCalGas' estimate of an overall conservation effect of just under 1% in the first year of AMI rollout and associated feedback provision is, if anything, over-cautious. The question of whether findings for an electricity conservation program (note: not a peak-reduction program) are applicable to a gas conservation program is addressed below.

X. AMI AND ENERGY EFFICIENCY PROGRAMS ARE NOT DIRECTLY COMPARABLE[10]

AMI is different in kind from an energy efficiency program. It is an infrastructure that can be used to promote energy conservation through improved feedback, but it also has other functions. Both can be valuable for energy conservation, and both can work together to that end,

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[8] Evaluation of the Massachusetts Power Cost Monitor Programme. Presentation by Antje Siems to the ACEEE Symposium on Market Transformation, March 30-31, 2009. http://www.aceee.org/conf/mt09/E3_Residential_Energy_Use_Feedback_Antje_Siems.pdf

[9] Home Energy Displays: highlights form the Nevada Product Trials.Presentation by Larry Holmes to the 2nd Annual Home Energy Displays Conference, Orlando, Florida, April 1-2, 2009 (see Attachment V-3)

[10]DRA Report, dated April 23, 2009, Executive Summary, 1-11.

but a direct comparison between the two is not realistic. As stated above, feedback can complement energy efficiency programs as well as promoting energy conservation through awareness and changes in energy-using practices.

XI. CONSERVATION DOES NOT EQUATE TO LOSS OF VALUE TO THE CONSUMER

There is not the slightest element of coercion in a feedback program and I cannot see how there is therefore any loss of value. Control is vested in the consumer, who only uses less gas if s/he wishes to do so. The examples of savings that emerge from feedback program, again and again, come from people who report switching off equipment that is not being used; ceasing to heat unused rooms, ceasing to heat water all day long when it is only required for an hour or so, and so forth. They are reducing waste and/or willingly changing their habits, not being coerced and not reporting any "loss of value." A good in-depth account of the impact of feedback displays on the lives of a small set of households is given by the Prospectory.[11] This illustrates a range of reactions, and also shows how new information can affect thinking, action and household dynamics. Some households respond positively to the new information, others less so, but there is no hint of loss of value, because the energy users themselves are in control of their usage.

XII. SOCALGAS' CLAIMED CONSERVATION BENEFIT IS NOT OVERESTIMATED DUE TO DIFFERENCES BETWEEN GAS AND ELECTRICITY

There are three TURN arguments in relation to this point. The first two hinge on the fact that gas bills in general are smaller than electric bills, and that small reductions in consumption due to conservation are unlikely to motivate average customers to monitor their usage. This line

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[11] http://www.prospectory.co.uk/HTMLobj-701/TalybontTrial.pdf. See also Dobbyn J and Thomas G (2005) *Seeing the light: the impact of microgeneration on the way we use energy. Qualitative research findings.* Hub Research Consultants, London, on behalf of the Sustainable Consumption Roundtable Darby S (2003) *Making sense of energy advice.* Proceedings, European Council for an Energy-Efficient Economy Summer Study, St Raphael, 6.157. http://www.eceee.org/conference_proceedings/eceee/2003c/Panel_6/6157darby/

of argument, based on a view of consumers as rational-economic actors (increasingly disputed in research on energy and behavior, and indeed in the discipline of behavioral economics), was answered in the SoCalGas response to TURN (data request DR-01 A.08-09-023, response 4). Drawing on results from recent feedback pilots in Sweden and on recent research from the USA, I concluded that the evidence indicates that, "customers use feedback primarily because they appreciate the knowledge, understanding and sense of control that they gain from it… energy consumption in homes is influenced by a range of factors, which may or may not include economics … cost savings can and do follow use of feedback… but they are not always the main motivation for seeking it out or for continuing to use it."

The third point raised by TURN is that there are fewer discretionary uses for gas than for electricity, and therefore fewer ways in which a customer can conserve. While I agree that most customers are unlikely to make major changes in their cooking habits (or would be very unwilling to do so), I argue that the scale and importance of the 'big two' – water heating and space heating – is such that conservation changes of the order of 10% or more are entirely possible. They may involve changes in usage patterns, but they are likely to be changes that are simply made and that can be sustainable. Ms Schilberg gives one herself, by citing the 20% of customers who setback their thermostats in the evening. This either means that 80% of customers do not practice any setback, or that 30% go to bed with the thermostat set at 66 degrees or over. Even the latter sounds like a substantial savings potential, once customers become more aware of their night-time usage and reflect that a warm bed is all that is normally needed for overnight comfort.

XIII. GAS CONSERVATION DOES NOT NEED TO INVOLVE DISCOMFORT AND INCONVENIENCE

While I appreciate the information from TURN, there are specific points in their testimony on the subject of gas conservation and loss of comfort that fail to convince. These are:

- Shorter showers. Any household member who is enthusiastic about saving gas is likely to experience a shorter shower as a satisfactory use of resources, not as a loss of comfort. There is no compulsion to spend less time in the shower, and hence no loss of amenity.
- Water heater temperatures. In the UK, the recommended storage temperature is normally 60 °C but this is often exceeded. While the US consumer Product Safety Commission may recommend a setting of 120 degrees Fahrenheit to prevent scalds, I would be surprised if it, too, were not often exceeded. Proposing that some customers have scope to reduce the temperature in their tanks still seems reasonable.
- Line drying. As a regular line-dryer, I strongly dispute that it involves a, "considerable investment of time and effort." In my experience, hanging out the family washing involves a welcome breath of fresh air along with gentle bending and stretching exercise, lasting roughly ten minutes. In addition, line-drying is exactly the sort of thing that health policymakers are beginning to promote (along with use of stairs rather than elevators, etc), as part of an attempt to stave off epidemic obesity and diabetes. I doubt whether the diktats of Home Owners' Associations are immutable when it comes to line-drying. When a majority of experts at the Copenhagen conference in April no longer believe that it will be possible to restrict mean planetary warming to 2°C, [12] it seems to be time to question the wisdom of bans on line-drying. Replacing fossil energy by human energy can have many merits.[13]
- Heating systems. Central heating systems in the UK commonly have radiator thermostats, allowing unused or seldom-used rooms to be kept at cooler temperatures. There is of

[12] http://www.guardian.co.uk/environment/2009/apr/14/global-warming-target-2c

[13] Norgard JS (2005) Under-use of body energy and over-use of external energy. Proceedings, European Council for an Energy-efficient Economy, paper 1,269. http://www.eceee.org/conference_proceedings/eceee/2005c/Panel_1/1269norgard/

course no loss of comfort in ceasing to heat unused rooms, and so adapting forced-air systems to allow for this would be an uncontentious benefit for customers and environment.

- Temperature setback and PCTs. To the comment above on temperature setback at night-time, I add the likelihood that there is potential to setback temperatures, or switch off, during the day when the house is unoccupied, or during vacations. Again, this involves no loss of comfort. The research evidence on the effectiveness of PCTs is not encouraging at present: it looks as though it is unwise to expect much conservation from them at present.[14]

XIV. CONSERVATION BENEFITS DO NOT ONLY ACCRUE TO HIGH CONSUMERS

I have addressed most of the questions raised by Barbara Alexander (UWUA) in the rebuttals above, and SoCalGas Witness JC Martin is responding on the issue of how CPUC has dealt with estimated conservation impacts in proceedings involving SCE and PG&E. However, Ms Alexander raises an important point on page 8 of her testimony, "customers on low incomes may not be able to use feedback to lower their consumption without compromising comfort and health, with the elderly and very young at special risk." My own research on energy advice to low-income households showed how feedback boosted the effectiveness of advice.[15] The largest program I studied recorded 10% average (measured) energy savings from behavioral change among low-income households in a deprived area of central Scotland. These savings related to space and water heating as well as to electrical appliances. In this case, the feedback involved checking the meter over a period of some three months in consultation with the adviser, and

[14] E.g. Moezzi and Bartiaux (2007) *Liberating energy analysis.* Proceedings, European Council for an Energy-efficient Economy, paper 1,337. http://www.eceee.org/conference_proceedings/eceee/2007/Panel_1/1.337/

[15] Boardman B and Darby S (2000) *Effective Advice: energy efficiency and the disadvantaged.* A report for the Electricity Association Fuel Poverty Task Force. Environmental Change Institute, University of Oxford. http://www.eci.ox.ac.uk/research/energy/downloads/effecticeadvice-rpt.pdf Darby S (2003) *Making sense of energy advice.* Proceedings, European Council for an Energy-Efficient Economy Summer Study, St Raphael, 6.157.. http://www.eceee.org/conference_proceedings/eceee/2003c/Panel_6/6157darby/

using the readings to establish whether the households were on track to reach the budgets they had set themselves.

The relevant point here is that the households involved were able to make immediate savings on heating and water heating without compromising comfort, and as a prelude to accessing grants to invest in insulation and reduce their fuel bills further. Use of feedback formed a part of the process and was useful to them. Low-income households can and do make savings that are significant to them.

The northern Ontario trial, referred to above, found that the highest savings were made by customers in the 10,500 – 15,000 kWh / year consumption bracket (8.6%). But those using 6,000-10,500 and less than 6,000 kWh a year saved 7% and 7.6% respectively; lowest savings were made by the highest consumers (only 2.8%). This supports the evidence from the UK advice programs, that relatively low consumers may still have options for voluntary savings, without loss of comfort. It would therefore be a mistake to offer improved feedback only to the high consumers, however great their potential for savings may be.

XV. CONCLUSION

The estimates for participation and for conservation effect presented in my Errata to Prepared Direct Testimony and reaffirmed in this Rebuttal Testimony are reasonable.

This concludes my rebuttal testimony.

ATTACHMENT V-1

Behavioral Assumptions Underlying California Residential Sector Energy Efficiency Programs

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DISCLAIMER

Abstract

This white paper explores the ways in which residential consumers are addressed by California utility-managed energy efficiency programs, and offers suggestions for improvements that might better support the state's ambitious greenhouse gas reduction goals. The report reviews the assumptions that underlie the state's residential energy efficiency policies and programs. A key set of assumptions can be found in a *physical-technical-economic model* (PTEM) that has oriented energy efficiency program design for several decades. The authors examine a suite of programs currently in operation and identify four somewhat different approaches being taken to influence consumer behavior and choice. They are variants of the PTEM, but also diverge by adding somewhat more realistic elements.

The report also considers a series of social science reviews of energy efficiency programs and paradigms. All of the reviews are critical of conventional assumptions about consumer behavior and choice, stressing complexity in the determination of residential-sector energy demands and conservation/efficiency responses. A series of alternative perspectives on behavior are also reviewed, including work in the areas of behavioral economics, economic anthropology, sociological theories of lifestyle, consumer segmentation approaches, and emerging themes in social science theory and energy efficiency policy development in Europe that focus on macro-systems, markets, and supply chains.

The white paper concludes with discussions of evolving program approaches, program practice and craft knowledge, reframing policy conversations, and research needed to support more effective and widespread energy efficiency improvements in the residential sector. A program-focused and experimental approach is recommended, in which new theory would be tested in modified program designs and evaluation strategies.

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Executive Summary

This white paper examines the behavioral assumptions that underlie California's residential-sector energy efficiency programs and recommends improvements that will help to advance the state's ambitious greenhouse gas reduction goals. The report is divided into six major sections. The first section provides an introduction to the problem and an overview of the research design. The second considers theoretical basics and research questions, and provides details related to the data and methods used in the research. The third focuses on the energy efficiency programs themselves and identifies several types of behavioral approaches in use. The fourth reviews social science critiques of the behavioral assumptions of energy efficiency programs. The fifth discusses several new approaches that might help to provide program design with a basis in a more realistic view of residential demand. The final section offers conclusions and recommendations.

Introduction and Overview

In the opening section of the report, we introduce the topic and provide some background and context. We also consider the potential value of the research reported here, briefly outline the methodology used, and present the overall organization of the white paper.

Over three decades, a series of energy efficiency interventions has helped to slow the rate of growth of residential demand through modest incremental improvements in buildings and technologies that have had large overall impacts. However, in the current policy environment, with growing concern about climate change and ambitious state targets for reducing greenhouse gas emissions, large *net reductions* in energy consumption will be required. This will necessitate a better understanding of consumer behavior and technology choice in order to fully deploy both private- and public-sector resources in this effort.

A key purpose of this white paper is to consider the energy efficiency program landscape, including assumptions currently made about energy use behavior and consumer choice, in order to assess the likelihood that "we can get there from here." In other words, do the concepts, approaches, paradigms, and models that have guided residential energy efficiency policies and programs over the past thirty years provide an adequate foundation to support the kinds of dramatic improvements in energy efficiency that will be required in the next thirty years (and beyond)?

Research Design

The research design drew upon several sources of data. These included an examination of California residential energy efficiency program documents filed by the investor-owned utilities (IOUs) with the California Public Utilities Commission (CPUC), as well as official CPUC policy documents. IOU and public utility program planners and managers were interviewed about program design, assumptions, implementation, and evaluation. The interviews provided information on both *program context* and *real-world operation* realities that are often not captured in documents. The research team also conducted an extensive review of the social science literature, as well as publications in the "gray literature," consisting of conference proceedings and program reports.

In order to provide a breadth of perspectives and an improved basis for discussions going forward, the white paper also includes a review of energy efficiency paradigms and programs in the United Kingdom (UK), with some mention of developments elsewhere in the European Union (EU). Some potentially important differences between the U.S. and Europe in terms of behavioral assumptions and program design may have important implications for future U.S. energy efficiency policy development and program planning.

Theoretical Basics, Research Questions, and Methodology

What are *assumptions* and why should anyone care about them? Assumptions bring with them conceptual frameworks (*frames*) or *perspectives – angles of observation*, *lenses*, and *points-of-view*. Even in the natural sciences, the existence of *paradigms* (or *meta-theories* made up of sets of assumptions about natural systems) guide what Kuhn (1970) called *normal science*.

In energy efficiency thinking, a set of fairly well established, shared assumptions has guided debates, policies, and programs over the past three decades. It is something short of a *paradigm* (which is usually considered to be rooted in a set of accepted formal theories). But as an orienting *frame* (or framework of ideas and assumptions), it has been quite durable and, in many quarters, unquestioned. This policy frame developed with the advent of the idea that energy efficiency could be a preferred *source of new supply* – an idea that has influenced electricity-related regulatory policy for thirty years. A variety of policies and a large energy efficiency industry have grown up around the concept of energy efficiency as a source to be considered in resource procurement decisions. All function in legalized regulatory contexts, where technical issues dominate, solutions are highly engineered, and economic analysis strongly influences thinking about alternatives, policy choices, and program delivery.

In terms of the "nuts-and-bolts" of the policy frame, a *physical-technical-economic model* (PTEM) has characterized consumer behavior and choice as instrumental, purposeful, rational, and secondary to the devices, machines, and appliances that are seen as the actual *users* of energy. The role of energy efficiency programs is to insert efficiency *measures* (usually substitute devices) into this PTEM context, providing equivalent "energy services" at reduced levels of energy demand. The approach is encoded in regulatory requirements, official policy manuals, and evaluation protocols. It orients regulatory actions and standards for approval of IOU investments in energy efficiency as a *least cost* source of supply. This is important because, as we discovered, both an extensive literature and IOU staff accounts are critical of the fundamental assumptions and elaborated elements of the policy frame. But it persists as a less-than-complete view of energy demand realities because of very real regulatory imperatives.

Energy Efficiency Programs Examined in the Research

Data on current California residential programs were obtained from official program documents. The analysis focused on the four large California IOUs: Southern California Edison (SCE), Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Gas (SCG). By carefully examining the Program Implementation Plans (PIPs), logic models, and related documents for each program, the research team was able to identify theoretical assumptions that appear to underlie the program design and strategies. In addition, we also looked for barriers (often explicit, but sometimes implied) that the program sought to overcome through the strategies and activities identified. Appendix A presents a complete listing of programs, with brief descriptions and primary consumer behavior/choice issues addressed by each program.

The California IOU residential energy efficiency program portfolio can be broadly understood as containing a range of activities and tactics expected to affect the environment within which a residential consumer makes decisions about how to use energy. In some cases, changes in the energy use of products or buildings are invisible to the customer (for example, when codes and standards are changed or retailers are convinced to stock a product that would otherwise be unavailable). In other cases, the information and inducement activities are quite visible (for example, when rebates are offered for a specific appliance or direct mail efforts inform customers of energy efficiency options).

Most programs contain an informational or training component, but the actual message delivered in these typically reflects an overwhelming application of a *proto-economic rational actor theory* related to the PTEM. Consistent with this theory, programs try to overcome barriers resulting from market imperfections by improving information, altering standard practice, providing exposure and rebates, and generally making customers aware of the (typically economic) benefits associated with making the “correct” choice.

In this approach, the two most important *levers* for overcoming barriers are: (1) information that can affect decision-making by improving receptivity on the part of customers to types of information (about energy efficiency, new technologies, reliability, and/or cost); and (2) rebates and price reductions that affect decision-making by changing the economic calculus associated with a given decision and, more generally, signaling the utility preference. Setting rebate levels, however, is not necessarily based on an economic formula. In some cases, the rebate is available simply to entice a participant to choose one product over another.

Although the California IOU residential energy efficiency program offerings are rooted in the PTEM policy framework, they have branched out to affect behavior in a variety of ways not strictly contained in that framework. From our interviews with utility staff and evaluators, we learned that program documents are not simple statements of fact or projections of planned outcomes. They are also proposals that *sell* goals, aspirations, and activities in an acceptable language. They are, at best, imperfect representations of what programs are intended to do, let alone reflections of what they actually do.

However, we do believe that the PIPs and other documents communicate at least core assumptions and program framings of consumer behavior and choice. In addition, program learning and field experience (*craft knowledge*) are important program assets that cannot be documented in PIPs. It is important to note that craft knowledge is an uncertain substitute for formal knowledge gained through systematic research; and craft knowledge is transitory, often leaving the organization when its steward leaves. Finally, we note a striking tension between program innovation (including multi-faceted and adaptive engagement with residential customers) and device-centric program accounting languages, measurement, and attribution regulations.

Critiques: Assessing Strengths and Weaknesses of Assumptions

Social science reviews of research on energy efficiency are all highly critical of the PTEM policy frame, whether explicitly identified by that term or not. Critics disagree with nearly every element of the PTEM, including its focus on devices, purposive behavior, costs, calculation, rationality, information, program accountability, energy services, and averages. Despite being rooted in strong paradigms from engineering and economics, the model fares poorly when considered in the light of empirical data on actual energy-use behaviors, efficiency choices, and levels of energy demand. As an efficient way to examine this literature, we consider several frequently cited review articles that have examined a range of key research and debates in the field.

Lutzenhiser (1993) points to the extreme variability in real-world energy use. He reviews research that shows those differences to be associated with consumer demographics, cultural backgrounds, and local social influences. He notes that, because energy is invisible, persons are ordinarily not conscious that they are using it. The vast majority of all behavior is governed by unconscious (but not necessarily in any sense “irrational” or incompetent) habitual action and habit-based routines. Also, energy use is rarely *individual*. Rather, it is collective – performed in and by groups living together; and even when the consumer is a single person, their behavior is social in the sense of being oriented to socially-sanctioned goals and often under the indirect scrutiny of social others. Finally, routine action is *cultural* – i.e., behaviors, appliances, devices, personal possessions, houses, and so on, have meaning to persons and groups. They manage, care for, use, and abuse them in cultural ways. In essence, culture is “doing the right thing.”

Wilhite et al. (2001) build upon these understandings by arguing that policies intended to reduce energy use can be improved if consumers’ energy requirements are viewed from the social actor’s perspective. The authors urge a focus on *energy services* rather than devices – language that has some congruence with the PTEM. However, they stress the fact that the “service” a consumer is aiming for is not given in nature, but is a socially defined and maintained business. While recognizing that individual choice affects energy consumption, they point out that these choices are strongly shaped and conditioned by the *upstream systems* that affect individuals and social groups.

They acknowledge the efforts by market transformation advocates to influence choices made for consumers by actors in the technology supply chain. However, they also note that market transformation initiatives tend to focus narrowly on technology adoption, while overlooking the processes of *social shaping of the devices themselves*, as well as the shaping of wants, needs, standards of comfort and convenience that in turn shape the levels of energy services expected and required by residential consumers. They term this process the *social and technical construction of needs* (Wilhite et al. 2001, 117).

Stern (2008) reviews the social psychological literature on how consumer choices are affected by various intervention approaches, and argues that energy use and efficiency choice in the household are complexly determined by a combination of social, contextual, and psychological factors. The pattern of influences – which factors matter most – can vary greatly across behaviors and places, with the strongest influences often being contextual. He reinforces earlier findings that efficiency choice is infrequent and is rarely carefully considered. Stern also notes that the effects of psychological variables are often indirect and may matter only in limited situations.

Stern concludes that the more a behavior is shaped by technology, infrastructure, regulation, financial cost, convenience, and other contextual factors, the weaker the effect of psychological variables. Also, he sees an interdisciplinary approach to understanding and influencing environmentally significant behavior as the most productive. This is an approach that seeks to understand the full range of causes of behavior and their interactions, and to base interventions on that understanding.

Considering interdisciplinarity, Wilson and Dowlatabadi (2007) observe that although disciplinary domains and alternative models all point to complexity, there is no clear way forward without further research and efforts to integrate models that focus on different levels of analysis and emphasize different sets of variables. Keirstead (2006) examines the fates of several efforts to integrate theories and sets of causal factors in household energy analysis. Rather than finding progress along these lines, he observes greater emphasis on disciplinary approaches in recently published studies. He is particularly concerned about the state of knowledge in the UK, but draws upon a global literature to assess the status of integrated models.

Finally, our own review of recent developments in the UK and the rest of the EU provides some support to Keirstead's view, but also suggests some developments that merit attention in the U.S. Europe has had its own version of the PTEM, as well as concerns about the failures to increase the penetration of more efficiency technologies – an *efficiency gap* that has often been credited to an *information deficit*. However, information campaigns focused on increasing the uptake of better equipment have not been dramatically successful.

In European policy circles, there seems to be a more widespread discussion of sustainable consumption and consumer lifestyles than in the U.S. There also seems to be a growing recognition in the EU of a limited understanding of how consumption patterns are determined. New EU government initiatives to promote *pro-environmental behaviors* are being accompanied by research to determine just how behavior-change potentials vary across lifestyle groups, and how appeals, offers, and interventions might be targeted.

At the same time, recent research on the effectiveness of energy information raises questions about how well even customized information might work (Bartiaux 2008), shifting attention to socio-technical networks and socio-cultural conventions. This movement mirrors U.S. findings regarding the complexity of household consumption behavior and echoes Stern's observations about the relationship of information to a host of other factors related to choice under constraint. However, it seems that efforts to construct policies and programs that focus on larger systems in a market-transformative mode remain as limited in their development in the EU as in the U.S.

Alternative Models and Innovations

In this section, we evaluate five alternative developments that might hold promise for expanding the conventional energy efficiency policy frame in ways that may take consumer behavior and technology choice more realistically into account. They include insights into consumer behavior and choice from: behavioral economics; cultural and economic anthropology; sociological studies of status and lifestyle; consumer segmentation approaches; and new themes focused on broader systems being proposed by social scientists and energy analysts in the UK and the EU.

We found that *behavioral economics* seeks to provide *neo-classical economics* with more realistic psychological foundations. Some useful insights from behavioral economics that might contribute to improving the PTEM involve: areas of consumer perception, judgment, and choice that involve risk assessment; loss-aversion in a cost/benefit calculation; commonly-observed patterns of judgment while assessing choices; reference values in choice; the role of emotions; and normative understandings of fairness.

However, a view of economic choice from the perspective of *cultural and economic anthropology* presents a starkly different picture. In this view, energy makes possible the consumption of cultural goods that arrive in homes bearing social biographies that are shaped by commercial interests and public policies, the bulk of which encourages consumption. What's more, the consumption of some important cultural goods that are also heavily energy-consuming items (such as houses, appliances and cars) is connected with the visible display of success (i.e., social performance). These forms of consumption are also reinforced by a range of social pressures, both formal and informal. Furthermore, in terms of energy efficiency behaviors and choices, anthropologists point to gender imbalances within the household in the distribution of energy efficiency costs and benefits.

In *sociological* accounts of lifestyle, an emphasis is placed on social classes, social status hierarchies, and other ways that consumers' lives are organized. Sociologists argue that it is not just whim or arbitrary "group think" that produces and enforces cultural patterns. Instead, real social work is being performed by status displays of houses, cars, appliances, clothes, and the rest. Important distinctions are being made, and relative power and influence are being exercised. In this view, variability in energy use follows lifestyle status differences. We also link this research to a less social-structural lifestyle tradition in energy analysis that has argued for examination of lifestyle in order to understand consumer differences that are salient to policymaking and program targeting. And we note that when we use the notion of lifestyle in this way, we may be able to see where particular social groups are inadvertently overlooked in current energy efficiency offerings.

We also examined the use of *consumer segmentation* in energy efficiency program marketing and identified some inherent problems that have to do with connections to underlying theory, including incorrect theory (e.g., individualistic/psychographic) and absence of theory. We also discussed problems related to data and models: with specifying consumer types with any confidence; and with alignment of segments with policy instruments. However, we conclude that segmentation is widely practiced in energy efficiency program marketing, where it represents an important acknowledgment of variability in customer populations (and a commitment to take diversity into account), and can provide a basis for program innovation and new conversations about policy and programs.

Finally, in terms of cutting-edge thinking in Europe, we found questions about the adequacy of the energy efficiency paradigm to address significant carbon reduction goals, particularly in the face of rising energy demands at the same time that efficiency programs have been producing gains. Notions of *average*, *normal*, and *baseline* levels of consumption are being replaced by an appreciation of variability and difference. The desire for sustainable lifestyles is coming to be seen less as a matter of influencing *individual choice* than of confronting the force of expanding societal aspirations and expectations.

In this regard, EU authors point out that the diffusion of the new, more efficient technologies to replace outdated appliances in households needs to be carefully balanced with an understanding of how these technologies can also create new consumer expectations and standards. Technologies and supporting institutions/policies can be seen as "lock-in" influences.

New models of change include Spaargaren and van Vliet's (2000) *social practices framework* that conceptualizes simultaneous changes in both lifestyles and in *systems of provision* that support energy practices. In this view, *lifestyles* are linked to norms, routines, and habits; patterns of energy use are related to patterns of social routines. This is equivalent to the meaning of cultural patterns in anthropology. But this definition of *normalcy* locates inertial forces in larger social and technical systems, as well as households and neighborhoods.

This has implications for energy efficiency policy and intervention. Rather than suppose that lifestyles can be changed by the force of political, moral, and environmental commitment, or by persuasion, a *practices approach* understands changing conventions of everyday life to be the result of collective, contingent, and emergent processes of socio-technical co-evolution (Shove 2005). Careful attention is required as to how technologies, devices, and appliances regularize and concretize routines, carry meanings, and force behavior to adjust. And the fact that they are not acquired and used solely as a result of individual preferences and choices, forces attention to regulation in production, manufacturing, retailing, and distribution, along with consumer choice.

And this, in turn, requires a better understanding of how consumers have become parts of large technical systems (such as energy infrastructures) that are now so integral to everyday life. The focus turns to *commodity chains*, through which goods and services are produced, delivered, accessed, used, and disposed of. This is the *upstream* world of market transformation interventions. But the European variant has as its aim a much broader agenda.

Going beyond simply understanding supply-chain actors' motivations and needs in order to influence them to acquire approved products (such as CFLs), the *systems of provision* perspective suggests that interventions should also take place at the point of design, product mix determination, etc. The objective would be to more fully understand the *how* and *why* of technology decision-making, and the exercise of control in the supply chain in order to pro-actively influence the actual shaping of technologies before they come to market.

This is not something that can be effectively done by social scientists or technology-oriented officials any better than the current market arrangements that too often simply deliver technologies by the container load, accompanied by cultural encouragements intended to stoke consumer demand for goods that we now realize have significant energy and environmental consequences. What is needed is continuing critical conversation about technology that more fully incorporates the long-term interests of consumers, ecosystems, and governments, in addition to those of investors, managers, production workers, and supply-chain intermediaries.

Conclusions and Recommendations: Implications for Policy, Research, and Experiments

In this final section, we step back and try to take a larger and longer view. We have learned that energy use and efficiency choice are complexly molded by a variety of influences. We can also see that the overly-narrow PTEM policy frame serves some important policy goals related to accountability and prudence. In the light of those facts, we consider some alternatives, drawing upon: (1) the *forward-looking* views of energy efficiency program managers; (2) California's new bold policy initiatives; (3) proposals for *new imagery* in energy efficiency policy, grounded in improved understandings of consumer behavior and choice; and (4) key statements of uncertainties and research needs from the California Air Resources Board (ARB) and the National Academies' National Research Council (NRC). We conclude the white paper with considerations for energy efficiency program innovations that link implementation and formal learning, either through an *experimental design* or *market transformation pilot* approach.

There is evidence of increased attention in programs to information supplied to consumers via multiple channels (and some evidence of targeting messages to subgroups of consumers, or *segments*), as well as market transformation interventions *upstream* and at the point of purchase of energy efficiency products (primarily light bulbs, but also HVAC systems). Interviews with utility staff show that they generally view new forms of customer communication and supply-chain intervention as important innovations that warrant continued development. However, they repeatedly cite regulatory requirements as obstacles, particularly *attribution* problems for non-device-centered expenditures, or "expenditures that cannot be directly traced to an end-user and a meter."

Social scientists and energy analysts in both the U.S. and Europe, as well as utility program staff and the regulators who have approved the current program plans, are in agreement that larger systems within which consumer choices are made need to be an important focus of attention. The California Public Utilities Commission recently took this position forcefully in the *California Long-Term Energy Efficiency Strategic Plan: Achieving Maximum Energy Savings in California* *for 2009 and Beyond* (CPUC 2008a). The plan includes calls for: rapid and large-scale improvements in new residential buildings; residential *whole-house* retrofits; reducing appliance *plug loads*; and transforming residential lighting. The strategies identified by the CPUC include interventions at all levels of the supply chain, from technology manufacturers to residential consumers. The CPUC's goals and the state's ambitious statewide carbon emissions reduction targets in Assembly Bill 32 (ARB 2008a) require serious consideration of consumer behavior and choice in real-world contexts.

New Imagery and Co-Provision

Kunkle et al. (2004) proposed that some important lessons for energy efficiency policy could be learned from the consumer response to the 2001 California energy crisis. That response included significant voluntary conservation and concern about long-term energy and environmental problems in the state (Lutzenhiser et al. 2004). The title of the Kunkle et al. paper suggested that *new imagery* was called for in energy efficiency policy framing. We also argue that this imagery is much like that proposed in the language of *co-provision* in the UK and EU.

Kunkle et al. concluded that several residential-sector energy efficiency policy lessons could be learned from the experience – all supporting a new understanding or *policy re-framing* of people and technologies. These lessons are: replacing a focus on *measures* with a focus on *behavior*; seeing conservation behavior as endemic, unevenly distributed in the population, and evolving; and understanding that the *capacities* of households to take pro-environmental actions *can be enhanced* by external influences, if the levels of interest (*concern*) and conditions (Stern's *context*) are supportive.

In a *co-provision* view, the energy user is similarly an active agent – a social and cultural agent – in the management of his or her own domestic scene. His/her action needn't be economically oriented or rational and intentional (and probably rarely is), and it is constrained and shaped by a variety of actors and institutions outside of the control of the energy user. But the end-user, nonetheless, is much more than a *recipient* of energy services and interventions. Effective energy efficiency policies in this world are likely to involve *support* and *coordination*, instead of (or along with) the more traditional *inducement* and *information delivery*. One of the utilities we interviewed is pioneering just such a "compact with the customer."

Uncertainties and Research Needed to Support Policy Evolution

We believe that new perspectives can lead to better grounded and more effective energy efficiency policies and programs. However, we stress the importance of basing programs and plans on well-supported assumptions. When evidence is lacking on *which* assumptions are valid, or *where* they are valid, we need to determine the answers empirically. In short, programs to change behavior should be grounded in behavioral science, as well as in technology and economics.

We considered some critical *areas needing behavioral research* identified by the National Academies' National Research Council and by the California Air Resources Board. We have woven their overlapping and complementary research priorities together in three *themes*. These are: (1) *Research on the Fundamentals of Consumption and Choice*; (2) *Research to Improve Communications and Influence*; and (3) *Research to Support Joint Private/Public Action.* Each area includes sub-topics that call attention to uncertainties at various locations in the market system and in various program approaches.

Experimental Design

While a good deal may need to be learned before we can mount truly large-scale, multi-dimensional energy efficiency interventions, we do not have the luxury of time to pursue a long-term research agenda first. We believe that research can proceed in parallel with energy efficiency interventions and program innovation, and, in fact, can be built into the energy efficiency policy and program process in at least two ways.

The first is *experimental design*, in which insights and hypotheses from the social science literature, program evaluation, and program implementer knowledge are combined in program innovations that can be tested under at least semi-controlled circumstances. Program experiments can be designed to optimize the impacts of conventional treatments (such as prices, rebates, and information), fine-tuning them along lines suggested in the psychological and behavioral economics literatures. For example, applying a psychological frame (such as Stern's multi-level *choice-in-context approach*) would suggest a focus on decision-making and information processing, but with attention to social influences and a variety of context factors. Experiments could attempt to affect certain factors, while controlling for others. The model would predict that different sets of factors are likely to be important for different technologies, behaviors, or outcomes.

There are a number of challenges to be faced in designing and mounting program experiments, however. First, treatments need to be carefully considered and, to the extent possible, be based upon credible theory. This involves real up-front time and planning costs to assure systematic design and rigorous execution. Second, the selection of the targeted energy-use behavior, technology, and/or context is an important consideration. With limited resources and, more importantly, limited time and attention capacity to mount multiple simultaneous experimental interventions, care will be required in selecting targeted behaviors, technologies, contexts, etc. Third, in every case, the experiment must either be carefully controlled in terms of treatment delivery (i.e., controlling other influences and confounding factors), or with careful measurement of all of these. The less control, the greater the need for measurement of other factors, and the larger the needed sample in order to detect and estimate treatment effects with any degree of confidence.

Adaptive Management and Theory-Based Market Transformation Pilots

A somewhat related approach also builds off of current programs and proposed ideas for new programs. It stresses innovation, experimentation (in a somewhat looser sense than in experimental design, as discussed above), and integrated research in support of program evolution. It uses a *pilot* logic (but in a more rigorous form than many earlier pilot energy efficiency programs that were essentially implementation of a novel program approach in a small population) with fairly conventional energy-impact evaluation, and possibly some process evaluation to document issues in implementation. The pilot program logic that we would advocate first acknowledges the complexity and multi-dimensionality of the systems in which energy use behavior and energy conservation behavior takes place. It explicitly sees change as challenging, the knowledge-base as limited, and outcomes as multi-causal and uncertain. However, it is explicitly *experimental* in focus and relies heavily upon both an evolved form of current program evaluation practice and a supportive set of basic research activities.

The approach we have in mind relies upon *near real-time* assessment and feedback to program implementers, ongoing and linked system-focused studies, and improved information and decision support for program designers and policymakers. It allows programs to *fail* and still produce useful knowledge. It quickly identifies *successes* and allows for the dissemination of that information and fairly rapid integration into other programs; and it promotes innovation and experimentation at all levels of program delivery.

The roots of this approach can be found in two quite different sources: *adaptive management* in federal and state natural resource policy and programs, and the *theory-based approach to market transformation* from pre-crisis market transformation thinking in California. Adaptive management (AM) is a well-established approach to dealing with uncertainty, interventions, and complex ecological systems. It has been applied in a wide range of natural resource management situations, from forest ecosystems to fisheries, watersheds, and regional biosocial systems.

In the late 1990s, as market transformation initiatives proliferated with the restructuring of electric utility regulation, a line of thought similar to adaptive management developed in the market transformation context. As utilities, regulators, and environmental organizations paid more attention to market systems and potentials for interventions *upstream* from points of technology choice and end-use, the need for better knowledge of market systems became apparent. Linking to the tradition of *theory-based evaluation* (e.g., Weiss 1997), Blumstein, Goldstone, and Lutzenhiser proposed a *theory-based approach to market transformation* that shares a number of characteristics with adaptive management (Blumstein et al. 2000).

The goal of this approach was strategic interventions in market systems that would build upon existing formal knowledge and craft knowledge, promoting innovation, but with real-time monitoring and evaluation feedback, program improvement, and growth of knowledge. However, Blumstein et al. also anticipated that the work in which we wish to intervene may well be different than we imagined; also, that it is in flux and may change in important ways while the intervention is in the field. Programs may turn out to need adjustment, or to be failures and will need to be terminated.

However, a considerable amount of knowledge can be gained from "failures" – they are hardly a waste of resources and something for program implementers to deny and conceal. Rather, they may be gold mines of information about markets and actors. Blumstein et al. also saw an important need for market-focused research in parallel with and linked to real-time evaluation. Knowledge gaps exist before we enter a market and they need to be addressed *while interventions are in the field*. Gaps will also be identified in the course of program implementation, adaptation, and modification, and will require new studies to inform subsequent policy development and program planning.

As in the case of experimental design, the pilot approach requires us to carefully ask fundamental questions and inventory our knowledge in the social sciences, energy efficiency program evaluation, existing market studies, and through excavation of craft knowledge. We will also undoubtedly need to undertake new research and carefully select target behaviors, technologies, systems, and locales.

The design processes for pilot interventions should probably be more open and collaborative than traditional utility-based energy efficiency program planning. The logic of *new imagery* regarding consumer roles and *co-provision* of environmental benefits would seem to argue strongly for an open, collaborative, and dynamic energy efficiency planning and implementation process. Actual implementation of pilots with real theoretical bases and near real-time evaluation and feedback is not necessarily easy. The *logic models* and *program theories* that are produced for various energy efficiency programs, where they exist, are often sketchy, simplistic, and, in many cases, intended for regulatory compliance, rather than program implementation and management. Also, new forms of evaluation or new sorts of evaluator-implementer-regulator relationships will need to be explored in order for near real-time monitoring and feedback to provide actionable information for program adjustment, or even possible pilot program redesign-in-process.

Finally, the relationship between research, implementation, evaluation, and policy development will need to be examined and redefined. Currently, research is conducted apart from programs, either by academic researchers or by consultants that are directed toward particular problems by policy agencies. Research results – particularly those found only in the scientific literature – are probably rarely used to inform program design or policy development. The basic studies proposed by both the NAS and the California ARB should not be assumed to necessarily have a direct or immediate impact on energy efficiency programs or policies in a world in which research is separated from practice.

1. Introduction and Overview

In this section, we introduce the topic of the paper and provide some background and context. We also consider the potential value of the research reported here, briefly outline the methodology used, and present the overall organization of the white paper and its major elements.

1.1 Purpose of the Research: Understanding Energy Efficiency Program Perspectives on Energy Consumers

The aim of this white paper is to explore the ways in which residential consumers are addressed by California utility-managed energy efficiency programs, with the intention of offering suggestions for improvements that might better support the state's ambitious greenhouse gas mitigation goals. These programs have a nearly three-decade history, during which a series of evaluations has estimated that a significant amount of electricity and natural gas savings has been acquired as a result of their interventions in the residential sector. These interventions have helped to slow the rate of growth of residential demand, with savings coming from a series of relatively modest incremental improvements in buildings and technologies over the years that have resulted in large cumulative impacts on overall energy demand. When California's per capita consumption is compared to that of other states, the strikingly lower rates in California can be traced, to a significant degree, to more aggressive energy efficiency policies and programs (e.g., Kandel et al. 2008).

However, in the current policy environment, goals are being developed at the state and regional levels to achieve large *net reductions* in energy use and emissions, rather than simply aiming to slow growth (ARB 2008a; CPUC 2008a). Since this will require effective new policies, resulting in a range of new energy-use practices and patterns, the questions of *behavior* and *behavior change* come to the fore. Governments, utilities, market actors, and consumers will all need to make decisions about technologies and energy service requirements. New standards, codes, understandings, and values will all likely be involved. New hardware systems (e.g., zero-energy buildings, highly efficient appliances, significantly more efficient cities and industries) will be required. Reconsidering needs and wants, along with patterns of work and play, are on the table.

A key purpose of this white paper is to consider the energy efficiency program landscape, including assumptions currently made about energy-use behavior and consumer choice, in order to assess the likelihood that "we can get there from here." In other words, do the concepts, approaches, paradigms, and models that have guided residential energy efficiency policies and programs over the past thirty years provide an adequate foundation to support the kinds of dramatic improvements in energy efficiency that will be required in the next thirty years (and beyond)?

1.2 Design Logics / Program Understanding

Programs are not implemented haphazardly, particularly in a highly regulated and legislated environment. Energy efficiency programs in the residential sector have been subject to oversight and evaluation, particularly to the degree that either ratepayer or taxpayer funds have been involved. The logics of programs have been articulated and subjected to review and critique. Program logic should inform program design and implementation, which, in turn, should provide a basis in "real-world" learning that can modify the program logics. Blumstein et al. (2000) discuss this process of iterative improvement in efficiency programs – at least as an ideal for program development. Vine (2008) also discusses how program implementers can learn from program evaluators.

Underlying program logics are assumptions about the nature of the world. These include: what energy is, how it is used, and who uses it; how changes take place in usage patterns; and how programs can intervene in order to stimulate and direct change. In the residential sector, these include understandings about: the effects of weather on the thermal performance of buildings; the efficiencies of different designs for energy-using devices (from lights to air conditioners, cable boxes to dishwashers); and the *behaviors of consumers*, including *how they make choices* on purchasing energy-using devices, as well as *how they use those devices.* The effects of weather, buildings, and equipment are described and predicted by theory in meteorology, physics, and engineering. The effects of behavior should be informed by theory and research in sociology, psychology, economics, and anthropology – the social sciences.

The physical and technological factors are fairly well understood.[1] In principle, at least, the better our understanding of people and behavior, the better the efficiency program logics, the more effective the programs, and the larger the energy savings. It turns out that behavioral knowledge is much more limited and provisional than physical theory, and that residential-sector energy efficiency programs may not benefit very much from the behavioral knowledge that does exist.[2]

1.3 Significance and Applications

It would seem reasonable to assume that program logics built upon limited (often claimed erroneous) assumptions about consumer behavior cannot support optimally effective programs. In fact, a strong case can be made for that conclusion. However, if the goals and aspirations of the program are modest, and if the behavioral assumptions are either *close enough* to reality or *adequate in practice* (i.e., in the pragmatic actions of program implementers), then programs can

[1] It should be noted that these understandings are most complete when buildings, systems, and appliances do not interact with actual human users, who tend to mess up the most thoughtful and thorough physical depictions.

[2] This is also true of other sectors. For example, see Biggart and Lutzenhiser (2007) for a discussion of applications of theory in economic sociology to the problem of chronic and seemingly "irrational" under-investment in energy efficiency in the commercial and institutional sectors.

be effective, even if based on limited understandings or ad hoc ideas. This has largely been the case in what is now often called the *energy efficiency industry*. Both "close enough" and "in practice" have been enough to "pick the low-hanging fruit," for which program managers tell us there remains a fair amount to forage.

When that fruit is picked, however, and much more ambitious energy-saving targets are pursued, a stronger case can be made for program logics and program designs that are based on more systematic knowledge and that incorporate iterative learning and improvement of assumptions in more formal ways.[3] It is hoped that this white paper will provide some basic information that can contribute to improved understanding and more effective program designs going forward.

1.4 Research Design

This white paper is the result of a research process in which we sought to discover the behavioral assumptions that underlie residential energy efficiency programs in a systematic way. We conducted an extensive review of the social science literature, as well as publications in the "gray literature" that consists of conference proceedings and program reports.

The project was not funded at a level to allow an in-depth review of all evaluation research, market assessment, and so forth, contained in public databases (such as the archives maintained by the California Measurement Advisory Council [CALMAC 2008]). We were able to access scientific databases to conduct a thorough review of residential-sector research reported in key energy journals. We were also able to carefully review conference papers back to 1998 in some key energy efficiency conference proceedings, including those of the American Council for an Energy-Efficient Economy (ACEEE), the European Council for an Energy Efficient Economy (ECEEE), and the International Energy Program Evaluation Conference (IEPEC).

We also drew upon several key critical reviews of behavioral assumptions and models that have been conducted in related areas – e.g., focused on the social science of energy use, social science and climate-change mitigation, consumer environmental decision-making, household demand theory and models, and home energy efficiency consumer choice. Key findings from those reviews are reported below.

We reviewed the residential energy efficiency program planning documents filed by the regulated California utilities with the California Public Utilities Commission (CPUC) and, in particular, we carefully reviewed and assessed each for evidence of behavioral assumptions. We examined the Program Implementation Plans (PIPs) developed by the utilities, as well as periodic program performance reports, and program logic models (where available). Evaluation

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[3] Program evaluations are currently required that are intended to provide, among other things, findings about program logics and implementation that can be used to iteratively improve programs. This may provide a foundation for improvement. But a commonly voiced complaint of evaluators is that the lags between program start-up, evaluation data-gathering, reporting, and subsequent program design/redesign are such that formal findings are rarely available in the right time or place to inform program development (Vine 2008).

reports for the current program cycle in California (2006-08) were not yet available for review.[4] We also examined the consumer information provided on utility websites to assess the form and content of messages, program offerings highlighted on the web, and program offerings presented to utility customers.

Documentary sources were complemented with a series of interviews with utility program managers, evaluators, and knowledgeable observers who have been involved in residential-sector energy efficiency program development and delivery for a number of years. These interviews provided information on both *program context* and *real-world operations* realities that are not necessarily captured in documents.

Data from all of these sources were combined and organized, and are presented in this white paper as a primer on residential-sector programs, assumptions, critiques, and knowledgebase, and the implications for policy going forward. The overview presented is intended to be objective and grounded in data and peer-reviewed scientific assessments. Many of the outside observers have been critical of behavioral knowledge and assumptions in the efficiency industry in the past. These are reported dispassionately, but with admitted sympathy. The fact that the efficiency program world is evolving in terms of behavioral understandings is also noted, along with promising developments on a number of fronts. But the bulk of the report is intended to report findings that can be useful, and that may actually be used by policymakers and program operators.

In order to provide a breadth of perspective and an improved basis for discussions going forward, this white paper also includes a review of energy efficiency paradigms and programs in the United Kingdom (UK), with some mention of developments elsewhere in the European Union (EU). This review is not intended to be definitive, but we include it because, while the UK and EU face similar policy and program problems in the residential sector (and have traditionally approached them in ways that are not radically different from those in the United States and California), there are some differences that may have important implications for those of us in the U.S. In some areas related to thinking about consumers, behavior, and energy systems, European approaches are different in focus and scale.

The conclusions that we reach in this white paper – including research needs and thoughts about implications for future efficiency policies and climate change discussions – are our own. We believe that they are well grounded in both the study's findings and in a body of work by many others in this field, but they are not presented as unequivocal or definitive. They are intended to contribute to conversations that will require the active participation of a much wider community of persons and groups involved in the use and conservation of energy, both in California and, as goes California, elsewhere as well.

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[4] An exception was the San Diego Gas and Electric (SDG&E) Company's evaluations. These were surveyed for general information, but are not reviewed here.

1.5 Organization of the Report

The white paper is organized into six major sections. Following this introductory section, the second discusses some theoretical basics and empirical questions to be addressed by the research. It includes discussions of the broad theoretical context from the social sciences, and contrasts this with traditional energy efficiency paradigms appropriated from engineering and engineering economics. This section also presents the key research questions for the white paper study process, discusses the data used, and considers relevant methodological issues.

The third section examines the California program landscape and summarizes significant behavioral assumptions of programs and program designs. The changing nature of assumptions (and related program approaches) is considered, along with core perspectives that seem to be enduring features of efficiency policy since at least the 1980s.

The fourth section reviews *relevant literatures* and *past critiques* of policy and program behavioral assumptions. Some of the critical reviews are from the early 1980s, while others are as recent as 2008. They share some key insights, although they also evidence changes in theory, as well as practice. Contributions from some specific sub-literatures in social psychology, economic anthropology, and behavioral economics are considered. Also, the results of searches of both the contemporary published scientific literatures and the gray literature on household energy use, efficiency choice, and conservation behavior are presented. A good deal of innovative and sophisticated recent research on residential consumers and consumption has been done by European researchers and theorists, and some key strands of that work are presented.

The fifth section considers *alternatives* to conventional energy efficiency industry approaches that might provide improved foundations for residential-sector programs. It includes discussions of behavioral economics, the *lifestyle* approach to energy use, forms of *consumer segmentation* that are in use in some residential programs, and advanced approaches being considered in Europe that focus on social systems, culture, and actor-networks.

The final section offers conclusions and recommendations for research and further policy discussions. It also includes research recommendations from a recent National Academy of Sciences study of environmental choice in the consumer sector that are particularly relevant to the goals of the white paper. The discussions in this section stress the importance of innovation, experimentation, collaboration, and multifaceted intervention in policy and program development. Again, it is intended to open a space for conversation, not as a final word on what comes next.

2. Theoretical Basics, Research Questions, and Methodology

In this section, we provide some background on linkages between programs and theories. We also talk specifically about some key energy efficiency theoretical perspectives (e.g., the *physical-technical-economic model* [PTEM] approach) and long-standing criticisms of these approaches, but at a fairly high level of abstraction (detailed critiques are presented in Section 4). Finally, we describe our specific research questions and outline our research design, including data sources (their strengths and limitations) and analytic approaches.

2.1 What are "Assumptions" and Why Should Anyone Care About Them?

On the most mundane level, life is all about *assumptions*. Webster (Webster 2008) defines *assume* as:

> "5: to take as granted or true"

And *assumption* as:

> "5 a: an assuming that something is true; b: a fact or statement (as a proposition, axiom, postulate, or notion) taken for granted"

Leaving aside some of the circularity of these definitions, what the term seems ordinarily to refer to are "taken-for-granteds" about the world: *The sun will come up. Leaves drop in the fall. Cold houses can be unbearable. Tea is best served hot. Children should be seen and not heard. Fat should be avoided. Strangers are up to no good.* And so on … All of these are commonly held notions. Some are likely nearly universal (the sun rises and leaves fall). Some are debatable and others are (or should be) contentious. The point here is that assumptions about the world are indispensable for getting through everyday life. There is simply too much going on for us to "think our way through" every situation or choice. So we rely on personal experience and the *common wisdom* (or *common sense*) of others from our times and tribes to equip us with unconscious habits of action (routines, practices) and habits of thought (assumptions, beliefs) that make life possible, and, in those rare instances where actual choices are involved, make choices for survival, satisfaction, pleasure, and sacrifice possible.

Is this too philosophical for a white paper on energy use? Not really. We are interested in the assumptions that underlie our policies and programs focused on people. And it turns out that our formal policy discussions and rational programs are full of assumptions. Some are probably as reasonable as expecting the sun to rise. Others could probably use some work. A few seem to be highly debatable and, if they are wrong, they could pose serious problems for efforts to construct more effective interventions that allow us to move more rapidly to reduce the amounts of carbon being put into the atmosphere.

Assumptions are ordinarily not free-floating. They come with conceptual frameworks (in recent scholarship popularly termed *frames*) or *perspectives – angles of observation*, *lenses*, *points-of-view*. Assumptions usually come in sets that refer to one another in order to make sense. The parable of the blind scholars and the elephant illustrates this nicely. Each "sees" a different beast based upon his/her limited information and expectations. Inferences lead to others and additional information is processed in such a way as to support and elaborate the first assumption – rarely to question it. The canons of science aim to stretch these frames by allowing in contradictory evidence and interpretation – and sponsoring lively debates about each. But even in the natural sciences, the existence of *paradigms* (or *meta-theories* made up of sets of assumptions about natural systems) guides what Kuhn (1970) called *normal science*. Paradigms link assumptions and interpretations in which we have considerable investment and ownership, even when there is a growing weight of contradictory evidence. Kuhn points out that the latter is often ignored until a new paradigm emerges that can explain both old facts and new observations.

In energy efficiency thinking, a set of fairly well established shared assumptions has guided debates, policies, and programs over the past three decades. It is something short of a *paradigm* (which is usually considered to be rooted in a set of accepted formal theories); but, as an orienting *frame* (or framework of ideas and assumptions), it has been quite durable and, in many quarters, unquestioned. The framework provides a vocabulary for analysis and discussion. It provides channels for organizational activity and legitimation of energy efficiency as a worthy and achievable social and technical goal. In organizational theory, it would be said to represent a set of *institutionalized understandings* that can be taken as givens, so that organizations (in this case, regulatory agencies, environmental advocates, forecasting and planning bodies, utilities, technology firms, consultancies, and a host of other actors and agents in the efficiency industry) can construct themselves in reference to this frame, associating their goals and activities with its presumed virtues.[5]

Frames are useful. They tell us what to look for and how to see it. Without them, it's all forest or all trees – in either case, a torrent of information that is only useful if we can organize it and make sense of it. Knowing particular ways to "look" at a building and its heating system as the temperature drops allows us to understand what its heating requirements are and how much energy will be required to meet them. A perspective on the problem that features prominently in heating systems and fuel costs allows us to think about how spending on a new furnace might translate into future money savings from lower natural gas bills. But both of these frames – the *physical/technical* and the *proto-economic* – can also produce blind spots (Stern 1986). Simply because they seem to so clearly illuminate the world (in this case, a world of devices, weather, costs, prices), other parts seem to disappear. At least, they fade sharply from the analyst's view and fall into the realm of the random, noisy, messy, disorganized parts of the world.

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[5] Classic statements of institutional perspectives on organizations – the developers and implementers of policies – can be found in Scott (1992) and Powell and DiMaggio (1991).

2.2 Traditional Range of Assumptions in Energy Efficiency Policy and Implementation

We first consider the policy context of energy efficiency program assumptions and frameworks as they have evolved in California since the early 1970s. This context goes a long way in explaining the frames that have been selected and elaborated there (and, with California's lead, elsewhere as well). We then discuss specific elements of the frame and its embedded assumptions about humans, behavior, and choice – in this case, residential consumers.

2.2.1 The California Energy Efficiency Policy Context

For the first time in American history, serious concerns about energy supplies and the social and economic impacts of shortages appeared, following the oil embargo and energy crisis of 1973. The crisis was national (international, actually), but its effects were fleeting in much of the country. California and the Pacific Northwest were somewhat different. Because of environmental concerns and rapidly escalating costs for nuclear power plants, attention in both regions turned to the *demand-side* and prospects for reducing the use of energy, rather than simply supplying more of it to keep up with growing populations and economies.[6]

In California, the Warren-Alquist Act in 1974 created a state agency charged with assessing and forecasting rates of growth in the demand for electricity and natural gas, in order to provide a standard against which to judge whether power plant proposals should receive state siting approval. The new California Energy Commission (CEC) was made responsible for independent forecasting and planning for the energy system.

In both California and the Northwest, a policy assumption was made that *energy efficiency* was the preferred *source of new supply* and should be pursued as a least-cost alternative to the building of new generating facilities of any type. This idea of using improvements in efficiency to free up energy for sales to new users and uses has been an accepted feature of electricity-related regulatory policy for the last thirty years.

As a result, a wide array of programs and energy-savings evaluation activities has been implemented across the West Coast of the U.S. (and in adjacent British Columbia in Canada). Numerous institutions have come into existence to plan, deliver, assess, research, and support energy efficiency activities. They include state energy agencies, national research laboratories, state research and development (R&D) programs, utility-sponsored energy efficiency support and acquisition programs, university research centers, and public/private consortia and coordinating organizations. This *energy efficiency industry* also includes a large number of private engineering, consulting, analysis, and energy efficiency program delivery firms working in the region and employing a significant number of energy efficiency specialists, from engineers and policy experts to marketing, program management, rating, auditing, and modeling practitioners.

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[6] Historical material in this section draws on Lutzenhiser (2009).

The range of policy approaches has been similarly broad, with a varied set of instruments deployed to reach different sorts of targets. Still, all function in legalized regulatory contexts where technical issues dominate, solutions are highly engineered, and economic analysis strongly influences thinking about alternatives, policy choices, and program delivery.

The instruments and activities include the following:

- **Laws, regulations, building codes, and appliance standards**
- **Modeling, forecasting, and planning processes**
- **Public information** – ranging from formal hearings to consumer websites and energy efficiency information delivered with monthly utility bills
- **Technology research, development, and demonstration (RD&D)** – e.g., related to buildings, devices, control systems
- **Technical assistance, information, and education** – from lighting and systems design assistance to providing data on comparative efficiencies of equipment, calculators for costs and paybacks, technical training courses, and programs in schools, etc.
- **Payments, incentives, rebates, grants, and tax credits** – direct infusion of money from government and ratepayer sources to encourage, induce, and/or subsidize energy efficiency hardware installation, even sometimes to encourage behavioral conservation[7]
- **Free hardware, installation, and maintenance** – particularly in the case of low-income energy users, but sometimes in the form of free light bulb distribution to the public or free home energy audits and tune-ups
- **Rates, taxes, and fees** – the "stick" to go with, or instead of, the "carrots" (e.g., higher prices for larger volumes of energy use or for consumption during high demand time periods)

All of these *demand side management* (DSM) activities are theorized to provide energy savings, as well as *non-energy benefits* (such as improvements in the quality of life and/or environmental conditions). However, the primary policy justification for these activities and expenditures is the logic of *avoided cost*. DSM delivers energy to the system at costs that have, in most time periods, been lower (often *much lower*) than the costs of new generation in the forms of coal, natural gas, petroleum, or nuclear power plants; Amory Lovins refers to these energy savings as *Negawatts* (Lovins 1989). This supply is created out of savings from many sources, so the cost of an individual Negawatt is variable. Some are inexpensive and pay for themselves in a very short time with costs recouped by savings on energy bills; others produce smaller efficiencies at higher

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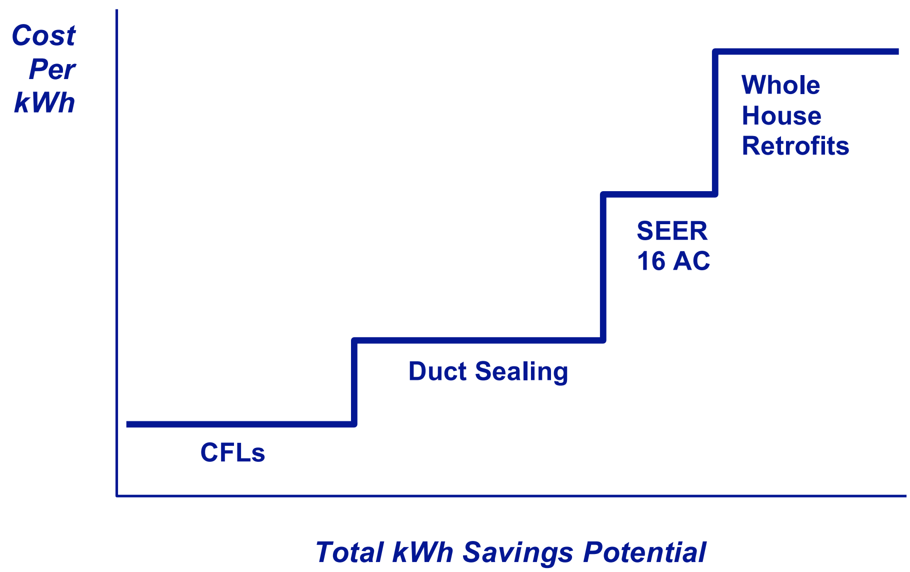
[7] During the California 2001 electricity crisis, the *20/20* program reduced power bills by 20% when households saved at least 20% compared to the previous year (Lutzenhiser et al. 2003).

costs. All can be ranked by cost and savings in an energy efficiency *supply curve* (Meier et al. 1982) that can be used to compare technologies and prioritize programs, expenditures, and investments (e.g., Figure 1).

Figure 1: Illustrative Energy Efficiency Supply Curve



Energy efficiency has enjoyed a privileged position in electricity resource acquisition policy, as the "top of the loading order" in California utility regulation (CEC et al. 2003). As alluded to earlier, the cheapest points on the supply curve are sometimes called the *low-hanging fruit*, and some of this fruit has indeed been picked over the past thirty years. But substantial energy savings remain, for several reasons. First, the goal of energy efficiency policy has been to *slow* system expansion and, in most time periods, fairly modest efficiency gains were all that were needed (and all that were funded) to avoid construction of new power plants. Modest support leads to modest results. Second, there is an *efficiency gap* between what's imaginably cost-effective (*economic*) for rational firms and individual consumers to pursue, and how they actually behave.[8] Efficiency assumptions and models don't seem to reflect real-world choices, and these real consumer choices yield less savings than what models predict. Finally, unexpected periodic declines in fuel costs (particularly natural gas) and new electricity generation technologies (e.g., gas combustion turbines) contributed in the 1990s to declining commitments to efficiency that have only been rekindled since the electricity supply crisis of 2000-2001.[9] In summary, while interest in energy efficiency has been a lasting object of policy concern, energy savings results have yet to approach energy savings potentials.

[8] The *energy efficiency gap* formulation has been around for decades and its origins are unclear. A fairly thorough explication can be found in Brown (2001).

[9] See Borenstein (2002) and Lutzenhiser et al. (2003) for the background on the crisis and its longer-term influences.

2.2.2 The "Nuts and Bolts" of the Policy Frame

The regulated utility context provides the primary framework for promoting energy efficiency programs and strongly influences their forms and contents. The policy frame includes both explicit and implicit assumptions about consumers and consumer roles in energy use and energy efficiency. Programs are proposed by regulated utilities, and the regulatory body (the CPUC, the sponsor of this white paper study) conducts formal hearings, assesses findings of fact, and rules on the program proposals, either accepting or denying them, and issuing guidelines for their planning and operations. Since regulated monopoly utilities are permitted specific rates of return on their investments, from the inception of energy efficiency policies and programs in the 1970s, regulators have been concerned about costs, benefits, and the prudent use of ratepayer dollars to secure energy savings. As a result, a fairly high level of accounting is required on the part of program operators and a high degree of accountancy characterizes program regulations.

This means that within the current framework, monetized costs and benefits – particularly to ratepayers – are of primary importance. Energy usage measurements are crucial and strict guidelines have been developed for the estimation of energy savings in official *evaluation, measurement and verification* (EM&V) protocols (CPUC 2006). Proof of the *cost-effectiveness* (of energy efficiency program spending) is required; and a key notion in this regard is that energy efficiency improvements are *investments* that yield a *return* in energy savings and, particularly, in dollar savings from energy use foregone.

The language of the California *Energy Efficiency Policy Manual* issued by the CPUC makes the case succinctly (CPUC 2008b, A-6):

> "This Commission relies on the Total Resource Cost Test (TRC) as the primary indicator of energy efficiency program cost effectiveness, consistent with our view that ratepayer-funded energy efficiency should focus on programs that serve as resource alternatives to supply-side options. The TRC test measures the net resource benefits from the perspective of all ratepayers by combining the net benefits of the program to participants and non-participants. The benefits are the avoided costs of the supply-side resources avoided or deferred. The TRC costs encompass the cost of the measures/equipment installed and the costs incurred by the program administrator. The TRC should be calculated utilizing a discount rate that reflects the utilities' weighted average cost of capital, as adopted by the Commission."

The TRC is primarily concerned with average costs spread across a collection of program participants – an aggregation of individual consumers whose benefits can be identified and whose costs can be estimated. Investments in energy efficiency are either made by the participant directly or are supported in some way through the use of energy efficiency program funds. In either case, money changes hands, energy flows are affected, and accounts are balanced. However, the CPUC acknowledges some difficulties in understanding consumer behavior. In the CPUC's *California Standard Practice Manual* (CPUC 2002), developed to govern energy efficiency program design, the challenge is described as follows in a discussion of the strengths and weaknesses of the *participant test* of program benefits. First, the economic logic is presented (CPUC 2002, 8):

> "The benefits of participation in a demand-side program include the reduction in the customer's utility bill(s), any incentive paid by the utility or other third parties, and any federal, state, or local tax credit received…

> The costs … are all out-of-pocket expenses incurred as a result of participating in a program, plus any increases in the customer's utility bill(s)… [including] the cost of any equipment or materials purchased, … sales tax and installation; any ongoing operation and maintenance costs; any removal costs (less salvage value); and the value of the customer's time in arranging for the installation of the measure, if significant."

Limitations in knowledge render the focus on consumer costs and benefits problematic and, therefore, of low priority relative to other cost-effectiveness tests that focus on system benefits, TRCs, and program implementation costs (CPUC 2002, 9-10"):

> "None of the Participant Test results (discounted payback, net present value, or benefit-cost ratio) accurately capture the complexities and diversity of customer decision-making processes for demand-side management investments. Until or unless more is known about customer attitudes and behavior, interpretations of Participant Test results continue to require considerable judgment. Participant Test results play only a supportive role in any assessment of conservation and load management programs as alternatives to supply projects."

The CPUC guidelines evidence an implicit assumption that consumers are essentially *economic actors* who are intrinsically interested in costs and returns, are information seeking, calculative, rational, and conscious of the purposes of their energy use. The *Policy Manual* defines "end-use" as (CPUC 2008b, A-8):

> "The purpose for which energy is used (e.g., heating, cooling, lighting)."

Energy is *used* in purposive ways. And energy is *saved* through (CPUC 2008b, A-8):

> "Activities or programs that stimulate customers to reduce customer energy use by making investments in more efficient equipment or controls that reduce energy use while maintaining a comparable level of service as perceived by the customer."

This statement captures in one sentence some of the most important elements of the policy frame's understanding of consumers. Energy savings result from *investments* in *equipment* that maintain the "energy services" that meet persons' *purposes.* The focus is squarely upon devices, rationalistic and attentive behavior, and economic exchange, while maintaining ratepayer satisfaction. In sum, the role of programs is to insert energy efficiency "measures" (devices) into this consumer context, providing equivalent services at reduced energy levels. The insertion program ought properly to be relevant to service requirements and to the economics of the measure. There is no mention of whether the customer's needs are being met; they are assumed to have been met.

2.2.3 The PTEM

The *physical-technical-economic model* (PTEM) of energy use has been criticized widely and some of those criticisms – and alternatives – are discussed in the following sections. Years of program experience have probably led to fairly widespread skepticism of the model as an accurate depiction of conventional behavior and the point of this paper is not to recite endlessly the weakness of the formulation. We are interested in alternatives and improved understandings that allow more effective policies and programs as we face a climate crisis. However, it is very important to recognize that the PTEM approach is not simply "old thinking," but represents a foundational formulation that has been, and continues to be, deeply rooted in: (1) formal paradigms and models; and (2) regulatory policy and practice. As such, it is not something that can change without considerable resistance.

The PTEM represents a marriage of strong paradigms. At its core is an *engineering view* of the world and its energy efficiency potentials. This is a world populated by buildings and devices that are connected to electricity grids and natural gas pipelines. It is most clearly depicted in *demand forecasting models* of the type managed by the CEC. This *bottom-up* model consists of populations of millions of appliances that have average usage characteristics that can change in aggregate over time. Its "saturations" of equipment can vary. It also contains "building stocks" that consist of dwellings of various sizes, types, and vintages. It considers the effects of weather on buildings and HVAC systems, as well as population growth effects on stocks and saturations. It produces aggregate projections and it has no people, per se, except as are found in assumed average appliance usage rates and temperature settings, and in technology adoption (saturation) rates. It is a world of machines and objects envisioned from afar, in which the technological outcomes of aggregate choices are as close as we can come to actual households and behaviors.

In this world of devices (first critics, and now many energy efficiency industry actors, say *widgets*), the consumer must be a self-conscious device-user. On top of that, she or he must also be an economic actor – a notion imported into energy efficiency policy and supply substitution accountancy as a simplified version of utility theory from neoclassical economics. If not (as in the problematic *participant test*), then system-level rationalities are applied on his/her behalf. Also – and this is a key point – the common use of *averages* (such as average appliance holdings, average-sized houses, average appliance energy use rates, etc.) also tends to assert *average consumers* conducting themselves in unexceptionally *normal* ways.

In reality, and particularly as a result of criticisms over the years and real-world efficiency program experience, this view is hardly universally held. But it is more than a straw man. To an important degree – and time will tell how important – the consumer is *necessarily* seen as secondary to devices, as a rational user/manager purposively obtaining *services,* and as someone interested in energy efficiency costs and benefits. This is a paradigmatic imperative of the engineered system interests, the power of proto-economic beliefs in rationality (because the alternative is unimaginable), and the requirements that utility regulators treat energy efficiency programs as accountancy problems. In practical terms, this means that residential energy efficiency policy discourse and supporting analysis must be conducted in a highly coded vocabulary that includes specific terms and concepts to be applied to energy consumers. Without mapping the discourse here, it is useful to simply single out some of the key terms from the policy documents, including: *participants*, *energy services*, *end-uses*, *costs*, *returns on investment*, *discount rates*, and *bill reductions*.

Alternatively, the social science literature and reviewers of energy efficiency policies and programs (discussed below) point to the importance of social context, and particularly *market transformation* approaches to energy efficiency that focus attention *upstream* from consumers in technology markets. This interest is also evidenced both in current utility programs (discussed in the following section), as well as in recent CPUC strategic plans (e.g., CPUC 2008a).

For some time, there have been market-related considerations in energy efficiency policy discussions and program evaluations around the idea of "market barriers" to efficiency choice. While that notion is in many ways problematic (Shove 1998), it has been elaborated significantly over the past decade and used in a variety of ways in energy efficiency program evaluation (Hall et al. 2005). However, discussion of *barriers* or *market transformation* is nonexistent in the *Practices Manual* and mentioned only in passing in regards to *emerging technology* program investments in the *Policy Manual*. The keystone principle statements for energy efficiency programs seem to be firmly rooted in the PTEM – as we have noted, for some very good institutional reasons.

2.3 Empirical Questions and Methodology

We began our assessment of residential-sector energy efficiency program behavioral assumptions with a significant amount of background information based on past experience research. However, we also approached the problem as a set of research questions for which we did not pretend to have ready answers. As a result, consideration was given to uncertainties and unknowns, as well as to testing understandings that the authors and others have developed over the past several decades as observers and participants in energy policy and programs.

Our questions included:

- *What are the assumptions about consumer behavior that underlie energy efficiency programs?*
- *What exactly are these "programs"?*
- *Can we identify explicit, articulated assumptions?*
- *Can we uncover implicit/embedded assumptions?*
- *If so, why are they not explicit?*
- *Are the long-standing criticisms of limited conceptions and simplistic models still warranted?*

The first question was addressed to some degree earlier in this section through the examination of foundational assumptions that come with the regulated utility policy frame. However, we were interested as well in the deviation from that frame on a case-by-case basis, as well as any possible systematic *evolution* of that frame – e.g., in addressing *barriers* and undertaking *market transformation* interventions. Also, we were interested in any evidence of attempts to communicate with consumers and influence them on bases other than PTEM criteria. For example, the *Policy Manual* identifies both *information and education* and *marketing and outreach* activities as energy efficiency program approaches (CPUC 2008b, A-10, 11). Both of these are described as oriented toward communicating *energy efficiency opportunities* and *investment* potentials, but they suggest a space in the policy framework for perspectives on consumers that reach outside of the PTEM.

2.3.1 Program Data Sources

To address all of the questions on the above list, starting with, *What are the "programs"?*, we first conducted a systematic examination of California residential energy efficiency program activities reported to the CPUC by the regulated utilities. We collected official program filings by the utilities and paid particular attention to explicit program plans and logic statements found in the Program Implementation Plans (PIPs). We sampled monthly progress reports for current programs. We examined the program *logic models* submitted by some programs – statements of *program theory* that lay out what the program is supposed to accomplish, by what means, and why those means are expected to lead to success. We also briefly reviewed utility filings for the upcoming 2009-11 program cycle (sufficiently to identify any important differences).

In considering how the residential programs were communicating with consumers and what messages they were delivering, we also examined the websites for the major regulated utilities, as well as those of the largest non-regulated publicly-owned utilities. We recorded observations about website architecture, ease of use, prominent messages, the nature of the appeals (e.g., to cost savings, environment, etc.), and services (energy audits, programs, rebates, etc.).

We considered assessing print and electronic media advertising and bill inserts. But after discussing the situation with experienced evaluators currently working in California and key utility informants, we concluded that this would not add significant value, and it would likely be costly in terms of the scarce funds and time available.

We also conducted a series of telephone interviews with experienced utility energy efficiency policy and program staff to better appreciate the program goals and designs, as well as to better understand the energy efficiency program world from the points-of-view of utility program managers. We did not attempt to be exhaustive in our sampling, since we learned early on that the programs consist of a diffuse set of actors and activities spread across end-use technologies, customer sectors, and geographies. We also found that they are organizationally complex, often operated through a combination of: (1) direct utility service delivery; (2) prime contractors; (3) subcontractors (and sub-subcontractors); (4) third-party implementers; and (5) local government partners. The levels of program experience and breadth of responsibility also vary widely across programs and actors. A thorough examination of the programs and their assumptions was outside of the scope of this paper.

It is also important to note what we *did not attempt to do* with this project, and particularly its data-gathering activities. We did not attempt to assess the reasonableness of various program designs. Nor did we attempt to gauge program success or failure. We did not try to measure impacts or outcomes. We did not consider whether the program as implemented was the one that had been planned. And we didn't touch on the quality of the information provided. All of these are legitimate *evaluation activities* and they are, in fact, currently being performed by professional program evaluators. Those evaluations are multi-year undertakings and are funded at levels higher than our white paper study.

We also *did not* attempt to perform a meta-evaluation that might tease insights out of a number of already completed evaluations. There are several reasons for this as well. First, while there are a large number of evaluations archived on the CALMAC website, there are only a few that concern the current (2006-08) California program cycle, and these are from a single small utility territory. Second, another white paper in the series is focused on lessons learned regarding consumer behavior and choice from *process evaluations* and the undocumented knowledge of *process evaluators*. Third, while a meta-evaluation of utility program evaluation documents might be interesting, it is not clear that it would yield any unique insights for what is intended to be a fairly *high-level* analysis.[10]

2.3.2 Reviews of the Literature

In addition to collecting program data, we identified some key reviews of the literature on residential energy efficiency policies and programs, consumer choice, and environmental decision-making. As noted above, many (inside and outside) observers have been critical of behavioral knowledge and assumptions in the *efficiency industry* in the past – where there has been skepticism about the value of behavioral research and the benefits of behavior change. Some of those critiques are fairly recent and echo earlier calls for improvement. We would have expected that criticisms and calls for broader perspectives over the past fifteen years or so might have influenced program practice, as well as residential-sector energy efficiency thinking and research. We also might imagine that improved models, or at least debates, would have taken place in the scientific, policy, and programmatic literatures.

We also searched the energy analysis and social science literature published since 1998 concerning residential energy use, consumer behavior, and household energy efficiency technology choice. To this, we added papers published on those topics in the conference proceedings of the three leading energy efficiency policy and program organizations – ACEEE, ECEEE, and IEPEC. Reviewing all of this work, we found surprisingly few new developments in the literature over the past decade. We do report some of the focal topics of that work, which lends support to our conclusions about some movement toward greater realism in conceptualizing consumer roles in energy analysis and efficiency program thinking.

Finally, because our goal is to provide access to the most current ideas about energy and behavior, we also examined debates, developments, and emerging themes in residential energy efficiency research and policy in the EU, and particularly in the UK. As noted earlier, some important differences between the European approach and that in the United States and California may have implications for U.S. energy efficiency policies and programs going forward (and vice versa).

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[10] "High-level" in the sense of distance from the phenomena of interest – i.e., the "thirty-thousand foot view," although in this white paper we would prefer to believe that it's more of a "five-thousand foot view."

3. Energy Efficiency Programs Examined in the Research

In this section, we first outline our methodology and sources of data on the California residential-sector energy efficiency program landscape. We then provide a summary review of the programs and suggest a four-element typology of program theories and delivery approaches. We examine customer communications form and content in a very high-level way, looking primarily for evidence that might contradict our findings from analyzing program data. Finally, we offer some conclusions about energy efficiency program logics, designs, overall strengths, and limitations.

3.1 Methodology and Approach

Data for this research were obtained from official program documents, which were summarized on a variety of dimensions for each program. The analysis focused on the four large California investor-owned utilities (IOUs): Southern California Edison (SCE), Pacific Gas and Electric (PG&E), San Diego Gas and Electric (SDG&E), and Southern California Gas (SCG). The research team reviewed information in the FY 2006-08 Program Implementation Plans (PIPs) filed with the CPUC. Reviewing efforts designed to operate (either directly or indirectly) in the residential sector resulted in a list of 85 programs. Descriptions for each were developed that included information on:

- Market Sector and Status (statewide or local, and existing or new)
- Program Titles
- Program Descriptions
- Target Populations
- Anticipated Outcomes
- Strategies

Using this information and other details from the PIP for each program, the research team focused on identifying overarching theoretical assumptions that appeared to underlie the program design and strategies. In addition to identifying the theoretical underpinnings that appear to drive the program theory and logic, we also looked for barriers (often explicit, but sometimes implied) that the program sought to overcome through the strategies and activities identified. Appendix A presents a complete listing of programs with brief descriptions, and the primary consumer behavior and choice issues addressed by each program.

3.2 Program Review Summary

All of the programs reviewed seek to influence the environment within which energy is used in the residential sector. The specific activities and tactics that comprise the overarching residential portfolio reflect a multi-pronged approach to addressing energy use and increasing energy efficiency among residential customers. The program activities and tactics include upstream incentives provided to manufacturers and retailers, installing new refrigerators and lighting for free, or convincing builders to change the way that new single-family homes are constructed. While it is true that all programs, in one way or another, seek to increase the likelihood of selection and installation of efficient measures, different programs do this by focusing on different parts of the residential market, using a variety of different tactics.

3.2.1 Typology of Activity

In Table 1, we categorize program activities in the 2006-08 program portfolio of the California IOUs into four types, based on their focus and degree of direct contact with customers. While some programs may fall into more than one category, we attempted to identify a primary focus of activities and, in most cases, this was quite successful.[11]

Table 1: Programs by Focus of Activity

1. DIRECT INSTALL	2. DIRECT INTERACTION, CONTACT OR INFLUENCE	3. MARKET ACTOR FOCUS	4. INDIRECT CONTACT OR INFLUENCE
These programs affect residential consumers by removing inefficient measures and replacing them (at no cost) with more efficient versions. Examples include low- and limited-income refrigerator and lighting programs.	These programs seek to directly influence the decision-making of residential customers. In these programs, the consumer has a choice, and the utility is attempting to affect that choice. Examples include appliance rebate programs and weatherization efforts.	These programs affect residential consumers by changing the standard practice of market actors that serve the residential sector (manufacturers, contractors, developers, and multifamily property managers). Examples include residential new construction, training for codes and standards, and upstream lighting and HVAC programs.	These programs seek to influence the behavior and decision-making process of residential consumers through messages or activities that raise awareness or increase knowledge. Examples include mass-marketing and school-based programs.

As a first-cut differentiation, this is obviously a simplified description of the residential program landscape in California. Some programs do not fit neatly into any category (for example, multifamily rebate programs, where the owner is most similar to a commercial customer) and a few others fall into two or more categories (for example, upstream lighting efforts, where significant effort has occurred in changing the behavior of manufacturers and the stocking practices of retailers, but point-of-sale materials and altered price-points for rebated products seek to affect the choice of residential consumers). Nevertheless, the basic typology allows us to

[11] ENERGY STAR® Homes, for example, may include marketing activities to inform potential purchasers of the ENERGY STAR® option, but the program activities are overwhelmingly focused on changing the behavior of the contractors, developers, and suppliers involved in the production of new homes.

discuss the behavioral assumptions embedded in the logic of different strategies without discussing each program in depth.

For the analysis reported in Table 2, we assigned each program to a primary category. When program activities indicated a program might fit in more than one category, we assigned a *primary focus*. In some cases, the activities seemed equally balanced between two types – for example, the *Energy Watch Partnerships* implemented in PG&E's territory seemed to equally prioritize education/assessment and direct installation – in these cases, we assigned the program to a secondary category that was also a good fit.

Table 2: Distribution of Primary Program Activities

PROGRAM FOCUS	NUMBER OF PROGRAMS	SECONDARY CATEGORY
1. Direct Install	7	14
2. Direct Interaction	8	0
3. Market Actor Focus	20	6
4. Indirect Influence	43	0
Unclear / Uncategorized	*7*	*0*
Total	**85**	**20**

Our review suggests that the most common primary program approach involves efforts to influence the behavior and decision-making process of residential consumers through indirect influence – i.e., activities that raise awareness and/or increase exposure and knowledge about a product. This is likely due to the proliferation of programs focused on education and information in targeted areas or groups (for example, school programs, kiosks, local partnerships), as well as the efforts of *Flex Your Power*SM. Programs implemented by third-party contractors, in particular, are frequently focused on a specific constituency. Budget allocations and savings expected were not part of our review, so the high number of indirect influence programs should not be considered an indication of funding allocations or expected energy savings. Some of the largest program budgets are assigned to a few direct interaction programs, such as the Residential Energy Efficiency Incentive Program or PG&E's Mass Markets Program (which incorporates multiple program approaches and includes both residential and nonresidential customers).

Information efforts include mass marketing, websites, community-based marketing, product information, technical training for residential trade allies, education of schoolchildren and homeowners, and other awareness-improvement efforts. The aims of information programs and elements can range from providing technical information about devices and their performance, to broad energy *literacy* efforts and *social marketing* intended to stimulate targeted behavior change and affect technology choices.

3.3 Theories of Customer Behavior

Our review found that the most common theoretical underpinnings of the programs in the utilities' respective portfolios come from the PTEM and what we might call a *proto-economic* view. The program structure, measures, and strategies overwhelmingly reflect a framework rooted in economic assumptions – i.e., viewing the consumer as a rational actor who makes irrational decisions about investments related to energy use because of market imperfections and the resulting *barriers* (associated with imperfect information, performance uncertainties, split incentives, product or service unavailability, hassle or transaction costs, access to financing, or organizational practices).[12]

This framework leads to the following themes that we found repeatedly reflected in program assumptions as they map onto the four program approaches identified above.

➡ ***Focus 1:* Utility Action + Equity Concerns + No Expectations of Behavior Change = Direct Installation of Measures Required**

In the case of direct-install programs, the primary focus of the program is on exposure and equity. In these cases, it appears that the utility believes no effective conservation behaviors or choices of efficiency measures can be reasonably expected and, therefore, has chosen to provide measures at no cost to the customer. No purchasing decisions are required; the only behavior expected is acceptance. The recipient must accept the measure in order to benefit from the improved energy efficiency. Limited-income refrigerator replacement programs and mobile home tune-ups are examples of this approach.

➡ ***Focus 2:* Rational Actor + Direct Contact (information, rebates) = Improved Energy Efficiency Decision-Making**

In this model, the rational actor (targeted customer or participant) is open to making the "correct" or rational decision after the barriers associated with the decision have been reduced or eliminated. Market imperfections are addressed using *levers* to overcome the barriers that result from these imperfections. The mix of activities and tactics in the reviewed programs indicates that the biggest, or most used, levers are information and rebates/incentives. Almost every program contains one or both of these, communicating a view of residential consumers as rational and calculating – open to information about their purchasing choices and able to understand and process economic calculations and the benefits of rebates. New appliance programs often reflect this formula: significant cooperative advertising on the part of retailers and point-of-sale information reaches those in the market for new appliances, while the rebate is offered as a final inducement to the desired behavior – the purchase of a highly-efficient household appliance.

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[12] See Eto, Prahl, and Schlegel (1996) for a thorough discussion of *market barriers*.

➡ ***Focus 3:* Rational Actor + Improved Market Information/Inducements = "Correct" Behavior**

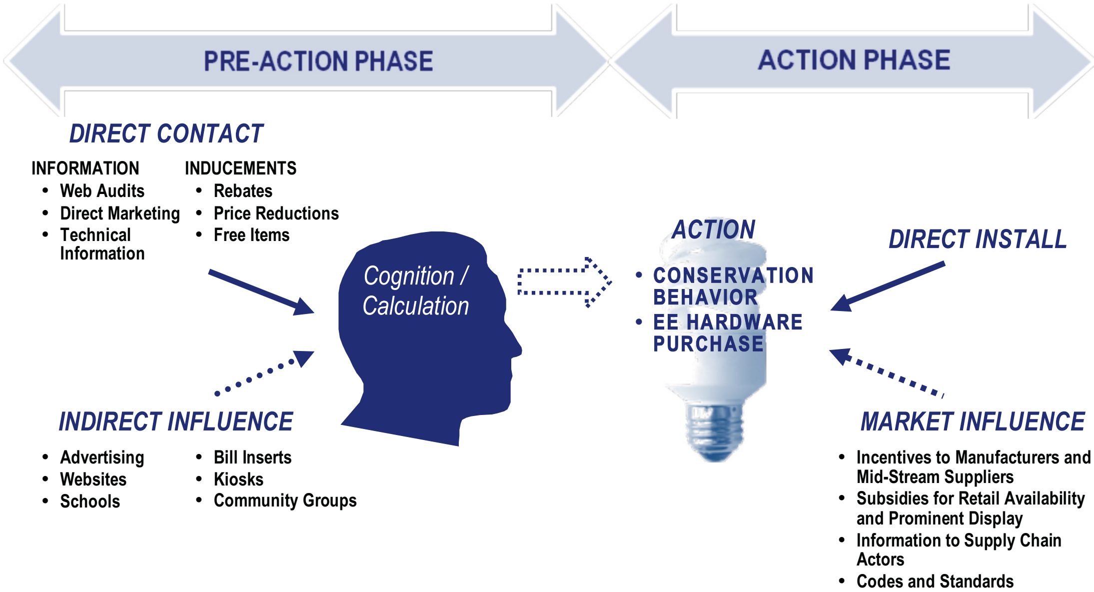
Another common theoretical assumption in program design seems to be that utility programs influence the market by testing and disseminating credible information. Programs with this orientation tend to focus primarily on verifying engineering expectations and communicating them to rational trade allies (new home builders, HVAC installers), who are then expected to use the information to sell a "superior" product (an ENERGY STAR® new home or a high-efficiency furnace) to future customers. These programs are often focused on overcoming barriers embedded in standard practice. For example, PG&E's pool-pump demonstration project was designed to travel throughout the utility territory and expose pool-pump vendors and repair staff to a new (more efficient) strategy for cleaning pools. Related programs work directly with *upstream* manufacturers, *midstream* distributors and wholesalers, and *downstream* retailers to demonstrate the profitability of energy-efficient products, and to use financial inducements (subsidies, cost-sharing, coop advertising, etc.) where argument and demonstration are not enough.

➡ ***Focus 4:* Rational Actor + Education and Media-Delivered Information = Permanent Change in Attitudes and Behavior**

While this program formula is similar to Focus 3, it reflects the different tenor and timeframe expected in education and mass-exposure communications programs. Rather than training market allies, these programs seek to alter the worldview of schoolchildren, local community members, and the general public. These programs assume that efforts to broadly communicate messages about the environmental effects of energy consumption will permanently create receptiveness to information about energy efficiency among those touched. This type of program can include the community organizing aspect of some local partnerships and the efforts to reach schoolchildren. These programs argue for an optimistic view of the power of education: that, done right, these efforts may fundamentally change the way people think about energy, although continuous reinforcement by mass-media messages may be needed as well.

It is helpful to consider the array of programs graphically to appreciate the range of approaches and how they logically target different phases of the efficiency choice and/or conservation action process. As noted, much of the influence is indirect. Some is intended to influence individuals cognitively and in terms of calculation. Much is focus at the *pre-choice* stage, although both direct-install and market-actor approaches are designed to intervene at the *action* stage – in each case, taking much of the business of choice out of the hands (and heads) of consumers. Figure 2 presents such a graphic.

Figure 2: California Residential Energy Efficiency Program Logics and Strategies



3.4 Form and Content of Direct Approaches to Consumers

In an effort to better understand the contents of both direct communications and indirect behavior influence (*Focus 1* and *2*, above), we also examined primary consumer information delivery channels for the IOU's residential energy efficiency programs. These included bill inserts and websites. We did not look closely at the *Flex Your Power*^SM (FYP) statewide marketing program, since it is currently the object of a large-scale CPUC evaluation. We cannot hope to duplicate that effort, nor are we in a position to contribute materially to it. We do note that the themes identified on the utility websites are very similar to those featured on the FYP site, although the latter has a distinct global-warming focus.

Websites were examined for all of the California IOUs, as well as those of several of the large municipal utilities. While we found considerable variation in structure and style, the contents of messages and communication channels between the utility and customer were quite similar. As noted, evaluations are underway in California of both utility and statewide information and marketing programs. Although it is not our goal to offer a detailed evaluation or critique of utility marketing, we wanted to see if the utility marketing messaging was different in any important ways from the portrayals in official program documents. The interest here was to discover any significant innovations or "broadening of the frame" in communications.

Along with websites, we examined bill inserts used by several of the utilities. These monthly newsletters are supplied to customers along with their monthly bills and, therefore, are an information channel through which the largest number of households might be reached. Energy conservation tips and energy efficiency program marketing were clearly present in these newsletters, and varied seasonally with relevance (e.g., air conditioning in the summer, heating in the winter, etc.). It was apparent, however, that this channel is mostly concerned with information about billing arrangements, rate notices, safety, company environmental policies, and various "newsy" items about holidays and so forth. Energy efficiency message contents did not vary significantly from that of the websites (which were referenced in the bill inserts).

We did not examine marketing materials for specific programs. Our own experience, along with advice from evaluators and utility program staffs, suggested that this would be a lengthy task, with uneven coverage that was likely to add no important information to the mix. Limitations of resources and the fact that major evaluations are doing this work already led us to conclude that the website focus would be adequate for our purposes. We did not focus on the accuracy or quality of the information provided on the websites, which can be of concern when technical information is adapted to meet marketing criteria.

All websites featured energy efficiency programs prominently on their homepages. Sites were strikingly uniform in their language, program offerings, and organization. In general, not much is said explicitly about *people*. It is assumed often and everywhere that people want to save money on their bills and that this desire is strong enough to motivate changes in behavior, provided the utility can help get the customer over a particular disruptive circumstance. This circumstance is typically *informational* ("tips" on conservation and efficiency, and home energy audits are offered to help customers identify opportunities for savings) or *monetary* (rebates are offered that will help customers "save even more").

Websites and newsletters invoke an interesting interplay between three primary motivators – *personal savings*, *the environment*, and *the community*. The formulation *save energy, money, and the environment* is repeated on multiple occasions across the sites; but often, particularly when discussing rebate programs, the environmental aspect is not included and the focus is almost exclusively monetary. "Community" is invoked in pitches for peak-hour reduction programs and tips (the language switches from *you* or third-person to *our* and *we*), but generally not for retrofits.

The intended audience seems to be, at least implicitly, a generalized *head-of-household* who possesses knowledge of current energy use in the home and of present appliances, who receives the bills, and who has the authority to make decisions. However, terms such as *family*, *roommates*, or *household* are rarely, if ever, used, giving the impression that household composition is basically irrelevant. An example is an invitation on one site to click on *Manage My Energy Use*, which leads to a standard array of information tools, tips, and opportunities for rebates for the single-family homeowner. The implication is that energy use in the home is *manageable* – controllable from some central position – and management is a function of gathering information and making strategic choices, but not really a function of talking to people. Non-owners, roommates, families, etc. are not primary audiences and conservation *behavior* – as opposed to *efficiency investment* – is not a featured target (although certainly mentioned in various energy-saving tips).

In sum, the direct and indirect marketing materials tended to echo the PTEM and proto-economic views found in program documents. There is an emphasis on self-interest, money, costs, control, and information deficits. Consumers are provided information and links to programs. The frame is broadened somewhat, however, as comfort and convenience are also worked into some messages; and there is clear mention of environmental benefits and some mention of community benefits from a more efficient and reliable energy system.

3.5 Conclusions About Programs

The primary task of this program portfolio review was to identify the behavioral change assumptions embedded in the activities and strategies of the programs. In principle, the activities, strategies, and desired program outcomes articulated in program documents would be expected to loosely reveal the program theory or logic. We use the word *loosely* here because this project lacked the resources to develop a logic model for each program based upon the PIP, and without doing so, we are relying upon the research team's experience with programs and reports to summarize the logic apparent in brief program descriptions. We were able to some degree to "ground truth" our reading, through interviews with program managers and evaluators. These were extremely helpful.

The California IOU residential energy efficiency program portfolio can be broadly understood as containing a variety of activities and tactics expected to affect the environment within which a residential consumer makes decisions about how to use energy. In some cases, changes in the energy use of products or buildings are invisible to the customer (for example, when codes and standards are changed or retailers are convinced to stock a product that would otherwise be unavailable). In other cases, the information and inducement activities are quite visible (for example, when rebates are offered for a specific appliance or direct-mail efforts inform customers of energy efficiency options).

Most programs contain an informational or training component, but the actual message delivered in these typically reflects an overwhelming application of a *proto-economic rational actor theory* (*sketch* or *stereotype*, rather than *theory,* might be more accurate). Consistent with this theory, programs try to overcome barriers resulting from market imperfections by improving information, altering standard practice, providing exposure and rebates, and generally making customers aware of the (typically economic) benefits associated with making the "correct" choice.

In this approach, the two most important *levers* for overcoming barriers are: (1) information that can affect decision-making by improving receptivity on the part of customers to types of information (about energy efficiency, new technologies, reliability, and/or cost); and (2) rebates and price reductions that affect decision-making by changing the economic calculus associated with a given decision and, more generally, signaling the utility preference. Setting rebate levels, however, is not necessarily based on an economic formula. In some cases, the rebate is available simply to entice a participant to choose one product over another.

3.6 Interview Insights

As noted, we conducted a series of interviews with energy efficiency program planners, evaluators, and utility marketing staffs. These interviews reinforced our understanding that, in addition to the traditional formally-approved PTEM approach, there is increased attention to information supplied to consumers via multiple channels, along with some evidence of targeting messages to subgroups of consumers or *segments*. There is also a significant commitment to market transformation interventions *upstream* and *midstream* in the markets, as well as at the point-of-sale of energy efficiency products (primarily light bulbs, but also some appliances). Those interviewed stressed that programs were (and would continue to be) as multifaceted as possible, reaching consumers and markets via a variety of channels, with different sorts of information and influence that – ideally, anyway – work in complementary ways to influence behavior and choice and to "bring customers along."

We have no evidence from our data sources that would support or question the comprehensiveness claim. As a goal, it probably makes sense. How well it can be realized in the program environment is probably reasonably easy to question. The interviews did show that key program staff generally view new and innovative forms of customer communication and supply-chain intervention as important and warranting continued development. However, regulatory requirements are repeatedly cited as obstacles, with serious *attribution* problems for non-device-centered expenditures – or expenditures that cannot be directly traced to an end-user and a meter. Expectations for immediate delivery of savings and short funding cycles were also mentioned as important features of the regulatory environment. There is certainly a tension between expansive and comprehensive program delivery aims and the requirements to focus and target programs, and to measure isolated impacts.

Staff also reported that programs are based on past practices, organizational learning, and the experience of individual program managers and implementers. However, learning and experience are uneven and cannot be taken for granted with staff turnover and a potential influx of inexperienced personnel in the case of any significant future program expansion. Also, programs are not, strictly speaking, *theory-based*, despite expectations of *program theories* and *logic models* by regulatory and evaluation best practice standards. Where these exist, they have often been constructed by evaluators after the fact.

The actual use of evaluation results as feedback into program design is the topic of another white paper (also see Vine 2008). We note, however, that the feedback from evaluation to program design and implementation has been ad hoc or nonexistent in an environment of rapid program expansion, development, and deployment. And while there are large numbers of programs underway, the low-hanging fruit still consists largely of lighting upgrades. In terms of replacing other devices, there are virtually no appliance programs or significant building shell retrofit programs – although there are some upstream activities related to new construction design, existing building performance, and, particularly, HVAC (see Appendix A).

3.7 Summing Up

In summary, the California IOU residential energy efficiency program offerings are rooted in the PTEM policy framework, but have branched out to affect behavior in a variety of ways not strictly contained in that framework. While the underlying program theories still seem to be largely proto-economic and not overly sophisticated in terms of information content, delivery, etc., it is important to recall that we are reading these "theories" out of formal program documents. From our interviews with utility staff and evaluators, we have learned that the documents are not simple statements of fact or confident projections, they reflect proposals that must "sell" goals and aspirations – representations of activities in acceptable language – and so forth. They are, at best, imperfect representations of what programs are intended to do, let alone what they actually do.

The purpose of process evaluation is to see how actual events unfolded and how well program plans and goals held up in reality. Those evaluations are underway for the California programs and their results will be reported at some point in the coming year. It is fair to note, however, that the programs are likely to be broader than represented in the program documents. Real-world assumptions may not be as stark and simple as implied in plans, and the actual knowledge and practices of program implementers may be richer (possibly much richer) than the record would suggest.

Even so, four points should be made. First, the record really is that – a formal statement of program goals and logics. It should somehow reflect actual goals and logics, even when they are admittedly in flux and subject to iterative improvement through program learning. This is actually also a regulatory expectation and legal requirement. It is not a stretch, then, to imagine that the PIPs and other documents do in fact represent at least core assumptions and program framings of consumer behavior and choice.

Second, program learning and field experience are important. They represent the basis of our actual working knowledge. They can be broad, deep, and subtle. However, they are not a substitute for formal knowledge gained through systematic research reported in peer-reviewed scientific and policy outlets, or for careful evaluation (also publicly reported). So-called *craft knowledge* is always key to making actual human activities possible and successful. But in the case of energy efficiency programs, as in other spheres of organized human activity – and particularly formally organized collective policy activity – experiential knowledge and formal knowledge should complement and learn from one another.[13]

The third observation is closely related to the second. Craft knowledge is transitory and often leaves the organization when its steward leaves. The rapid ramping up of energy efficiency activities, the delivery of programs through multiple layers of contractors, subcontractors, partners, and third-party vendors – with the most experienced parts of the workforces aging and starting to retire, and the least experienced entering with little or no training in energy efficiency programs, let alone consumer behavior and choice – is a recipe for the *loss of craft knowledge*. What we may have now that is not clearly reflected in energy efficiency program plans and logics that make them, on-the-ground, better or more realistic than they appear on paper, is

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[13] An important mechanism for this is the feedback of evaluation results into program planning to allow institutional learning and iterative improvement. We cannot go into this here, but experienced evaluators and meta-evaluators commonly lament the lack of feedback and the resulting negative consequences for program design and delivery (Vine 2008). Also, it has been observed that craft knowledge may differ significantly from formal knowledge, but this is often unacknowledged because it occurs under conditions of formal constraint (Moezzi & Bartiaux 2007).

clearly not something that we can take for granted as a part of the energy efficiency policy and program landscape in the future.

Finally, the tension between program innovation – including multi-faceted and adaptive engagement with residential customers – and device-centric program accounting languages, measurement, and attribution regulation is striking. The fundamental logics of the former (e.g., focused on consumer engagement and segmented tastes) seem polar opposites of the latter, where financial considerations and homogeneous energy uses are generally assumed. We will not attempt to resolve that tension. However, the reviews of findings from the social sciences that follow will stress the complexity and multi-dimensionality of household energy use, conservation behavior, and efficiency choice. This will either serve to increase the tension or push the conversation up a level to consider larger policy goals and system interventions on a broader scale.

4. Critiques: Assessing Strengths and Weaknesses of Assumptions

So what's wrong with the PTEM framework, rooted as it is in policy requirements and elaborated (and improved upon) in a range of California energy efficiency program offerings? Energy conservation policy across the U.S. has been dominated by this perspective. It has foundations in well-established, neoclassical economics and draws directly on technological theories of efficiency. This policy frame informs ratemaking, energy efficiency potential studies, load forecasting, and impact assessment. Why isn't it good enough for consumer-directed programs?

There have been a number of critiques of this approach from different parts of the applied policy research world. Anthropologists, sociologists, social psychologists, and economists have all weighed in on the topic – as have energy analysts and evaluators. The criticisms are not identical and, in fact, the critics also sometimes have problems with the arguments and prescriptions of other critics.

The point of this paper is not to resolve those differences. However, we do wish to offer an overview of what numerous critics have had to say. An efficient way to do this is to consider some frequently cited review articles that summarize a range of key research and debates in the field. In this section, we consider review articles by Lutzenhiser (1993), Wilhite et al. (2001), Stern (2008), Wilson & Dowlatabadi (2007), and Keirstead (2006).

Some of the first critics of the PTEM were California researchers, including Bruce Hackett (UCD), Rick Diamond and Ed Vine (LBNL), and Hal Wilhite and Rick Wilk (UCSC), with considerable support for their views from energy efficiency policy thinkers working within the confines of the dominant paradigm.[14] In a nutshell, their key criticisms were that the conventional model makes unwarranted claims about human behavior and, at the same time, ignores the socio-cultural dimensions of energy use. They disputed the notion that energy users are independent, economically-rational individuals whose consumption patterns can be explained and predicted using neoclassical economic theory. They also questioned policy assumptions that conservation action and efficiency technology choices are guided by rational maximizing behavior and are necessarily responsive to financial incentives.

4.1 Household Energy Use is Social

In the review article "Social and Behavioral Aspects of Energy Use," Lutzenhiser (1993) first proposed the *physical-technical-economic model* (PTEM) label for the conventional policy

[14] This can be a long list, but it clearly should include Carl Blumstein, Sy Goldstone, Sylvia Bender, Lee Schipper, and Alan Sanstadt. It should also include a next generation of analysts, including David Hungerford, Katy Janda, and Christopher Payne.

frame. He contrasted the PTEM's world of energy flows, building characteristics, device efficiencies, and costs with a number of empirical studies of actual energy use. Where PTEM either asserts homogeneity of consumers or assumes it by default (e.g., in typical energy uses and average usage rates), consumption patterns have instead been shown to be highly variable across households, even among those living in physically identical dwellings (e.g., Socolow 1978; Diamond 1984).

Numerous studies have shown that there is considerable variability in energy use, depending upon the socio-cultural attributes and behaviors of the inhabitants. The review traces the variability to a range of social and psychological factors, including household demographics (e.g., age, ethnicity, income, family size), cultural backgrounds, and local social influences. Because energy is invisible, persons are ordinarily not conscious that they are using energy. This is not because they are stupid or distracted, but because energy systems are carefully hidden from view and habits are powerful elements of everyday life (and energy use). The vast majority of all energy behavior is governed by unconscious (but not necessarily in any sense "irrational" or incompetent) habitual action and habit-based routines. If this is true, then energy actions cannot be, in any continuous and conscious sense, "purposeful."

In addition, energy use is rarely *individual*, but collective – performed in and by groups living together; and even when the consumer is a single person, their behavior is social in the sense of being oriented to socially-sanctioned goals and often under the indirect scrutiny of social others. Routine action is *cultural* – i.e., behaviors, appliances, devices, personal possessions, houses, and so on, have meaning to persons and groups. They manage, care for, use, and abuse them in cultural ways. In essence, culture is "doing the right thing."

And economic anthropologists, in particular, have emphasized the shortcomings of neoclassical economic explanations of various forms of behavior involving production, consumption, markets, and exchange across cultures, including advanced industrial societies (Wilk 1996). They claim that cultural norms and societal influences shape and constrain the ways that people act in order to fulfill a wide array of needs or goals in any given situation, place, or time. In other words, *economic behavior* is performed in a variety of ways, with rationalistic forms posited by the PTEM being one of a number of varieties, and likely a very rare one. Anthropologists who have investigated energy efficiency choices in households point to the importance of social status and the *visibility* of technologies, rather than their effectiveness or returns on investment (Wilk & Wilhite 1985). Also, Kempton's work on *folk models* of energy use and his studies of real-world efficiency calculation show that even the most intentionally rational efforts are likely to reach incorrect conclusions (Kempton & Montgomery 1982).

Lutzenhiser's reviews of the psychological literatures on information, attitudes, and behavior change also suggest that energy efficiency and conservation messages have to be intelligible to the consumer (i.e., make sense from his or her point-of-view and understanding), be concrete, vivid and impactful, personalized, action-oriented, and offering advice about choice and behavior that is perceived to be fair, just, and equitable. At the same time, everyone doesn't receive the message, they don't "get" the same message, and they process the information in different ways. Also, the messenger is important in terms of perceived legitimacy, credibility, and trustworthiness of the information.

In studying program effects, the literature suggested that choice applies only in limited situations (most often a major purchase). When choices occur, non-economic considerations tend to dominate. Also, choices are often not carefully considered, and even when they are, awareness of costs, benefits, paybacks, rebates, tax credits, etc. is very limited. And, as Kempton's work shows, there is a variety of ways to be rational that don't produce energy-efficient results.

Lutzenhiser also reviews a range of work operating at levels of organization beyond the individual and household, including neighborhoods, social networks, communities, and firms. Processes operating at all of these levels collectively shape consumption and conservation behavior within a social context. While not explored in Lutzenhiser's review, if the diverse effects of psychological, cultural, and social factors, along with the physical and technical aspects of energy use, operate to simultaneously affect energy consumption, then improvement of the PTEM model would require a dramatic shift in thinking about complexity.

4.2 Energy Demand is Macro-Socially Determined

In the article "The Legacy of Twenty Years of Energy Demand Management: We Know More about Individual Behavior but Next to Nothing about Demand," Wilhite et al. (2001) argue that policy understandings of energy use can be improved if humans are seen as active energy users within various energy flows. This requires, in turn, that energy requirements be viewed from an energy-user perspective.

In this view, energy users are seen as actors that initiate energy consumption through various physical devices for the purposes of obtaining services. Note the congruence of the *energy service* language from the PTEM. A radical departure is not proposed, but an amendment that follows from a deeper understanding of what an *energy service* is and where it comes from. To the authors, the service is not given in nature, but a socially defined and maintained physical outcome.

In a residence, the most frequent energy services that come to mind are space heating, cooling, lighting, and energy used for cooking, cleaning, entertainment, and other activities. Moreover, these services are influenced by the perceptions of comfort and convenience – such as heating the house at 66°, or 70°, or 73° Fahrenheit for comfort, or using a washing machine to wash clothes for convenience. Hence, the *level of service* demanded will result in an energy profile that will be higher or lower, depending on the household *needs* as determined by the energy user(s). In terms of affecting global environmental change impacts from energy-use behavior, it is important to note that these *needs* are highly variable – e.g., possibly ranging from a frugal or *deeply green* lifestyle to one that accumulates devices and services to allow nearly 24-hour work and play (e.g., as seen in Knowlton's [1999] anthropological study of life in the Silicon Valley). Vastly different levels of service and environmental footprints are the result.

These divergent patterns are not simply the result of individual preference or idiosyncratic choice. While Wilhite et al. (2001) acknowledge that individual choice affects energy consumption, they claim that these choices are strongly shaped and conditioned by the *upstream systems* that affect individuals and social groups. They acknowledge the efforts by market transformation advocates to influence choices made for consumers by actors in the technology supply chain. But they also note that market transformation initiatives tend to focus narrowly on technology adoption, while overlooking the processes of social shaping of the devices themselves, as well as the shaping of wants, needs, standards of comfort and convenience, and the levels of energy services expected and required by residential consumers. They term the latter the *social and technical construction of needs* (p. 117), which is, in turn, reinforced by infrastructure, devices in use, cultural codes, routines, cost structures, and habits. To Lutzenhiser's observations about consumption and conservation being organized on multiple levels, the authors add details of the *upstream* workings and their intimate involvement in the very *downstream* structuring of needs, wants, and energy service requirements.

4.3 Environmentally-Significant Behavior is Complexly Determined by a Multiplicity of Factors

In the chapter *Environmentally Significant Behavior in the Home*, Stern (2008) reviews the social psychological literature on environmentally significant behaviors in the residential sector. He finds ample evidence of individual and small group factors that influence behavior and choice. However, he also concludes that a variety of social, demographic, and other *contextual* factors are also important, as are the physical, technical, and environmental realities.

Stern's review of the literature suggests that information on how to save energy delivered through media channels has little effect on energy consumption, although tailored information, such as an energy audit, can have larger effects on behavior. In addition, specific interventions (e.g., directed to a particular household) appear to be more successful than the general ones. Stern concludes that environmentally significant behaviors, such as energy use and efficiency choice in the household, are complexly determined by a combination of social, contextual, and psychological factors. This means that effective interventions that change behavior need to address significant barriers that span causal domains and economic, psychological, and sociological models. He presents a typology of key determinants, as shown in Table 3.

Table 3: Factors Influencing Behavior and Choice – Adapted from Stern (2008)

FACTORS INFLUENCING BEHAVIOR AND CHOICE
Contextual Factors (constraint and facilitation)
• Available technology
• Embodied environmental impact (e.g., energy efficiency of buildings, vehicles; materials in consumer products)
• Legal and regulatory requirements
• Material costs and rewards (payoffs)
• Convenience (e.g., of public transit, recycling)
• Social norms and expectations
Continued

FACTORS INFLUENCING BEHAVIOR AND CHOICE
Personal Capabilities
• Financial resources
• Literacy
• Social status
• Behavior-specific knowledge and skills
Habit and Routine Attitudinal Factors
• Personal values
• General environmentalist predisposition (abstract norms)
• Behavior-specific (concrete) norms and beliefs
• Non-environmental attitudes (e.g., about product attributes)
• Perceived costs and benefits of action

Key conclusions by Stern (2008, 373-378), and their implications for the design of programs and policies focused on behavior change by residential consumers, include:

1. The influences on environmentally significant behavior are more varied than reflected in most psychological or economic research.

2. The pattern of influences – which factors matter most – can vary greatly across behaviors and places. One should not expect that the influences found to be strongest in one study generalize across behaviors.

3. The strongest influences on behavior are often contextual. These are generally the factors listed at the top of Table 3 that are emphasized by engineers, economists, sociologists, political scientists, and policymakers. Psychologists rarely examine more than a few of these strong contextual influences on behavior, and have instead focused their attention on personal and interpersonal variables toward the bottom of the table.

4. The more a behavior is shaped by technology, infrastructure, regulation, financial cost, convenience, and other contextual factors, the weaker the effect of personal variables (Black et al. 1985; Guagnano et al. 1995). Effective laws and regulations, strong financial incentives or penalties, irresistible technology, powerful social norms, and the like can leave little room for personal factors to affect behavior.

5. Although behavioral models typically presume that behavior is chosen, choice models apply only in limited situations. The implication is that the favored variables of psychologists and economists are important mainly at the restricted places and times when choice models apply.

6. Choices, when they are made, are not often carefully considered.

7. The effects of many psychological causal variables on specific behaviors are highly indirect. However, some of these variables can potentially influence a wide variety of behaviors. Social-psychological research is helping to reveal the workings of the personal factors influencing environmentally significant individual behavior, though strong debates continue in the field about which theoretical model best accounts for the evidence.

8. The most important practical applications of psychological interventions to behavior in the home probably lie in niches between powerful contextual variables. Psychological variables make the most difference when behavior is not strongly constrained by regulation, habit, matters of economic cost and convenience, and the like. Thus, it may be that psychological variables matter enough to be of practical use only in very limited situations. But they may be very important, nevertheless, because some of the choices made in these situations, particularly the purchase of major household equipment and the establishment of environmentally significant habits, determine the environmental impact of many future behaviors.

9. The most productive approach to understanding and influencing environmentally significant behavior in the home is an interdisciplinary one that seeks to understand the full range of causes of behavior and their interactions, and to base interventions on that understanding.

4.4 Decision Models Assessed

In the review article "Models of Decision Making and Residential Energy Use," Wilson and Dowlatabadi (2007) evaluate four distinct perspectives in the residential energy consumption sector. These perspectives are: *neoclassical and behavioral economics*, *technology adoption and attitude-based decision-making*, *social and environmental psychology*, and a *sociological perspective*. For each, the authors attempt to identify the most valuable lessons for intervention strategies in the residential energy realm.

The first area relates to the conventional economic theories of *consumer choice* and *behavioral economics* concepts. The conventional theory generally defines individuals as consumers seeking maximum utility under a budget constraint, where *utility* is defined as a measure of consumer preferences. The behavioral economic notions of *consumer choice*, on the other hand, deviate from the utility model in the areas where its limits have been made apparent by findings from psychological and economic experiments. Ideas imported into the utility model address issues of *time inconsistency*, *framing*, *reference dependence*, and *bounded rationality*.

Time inconsistency, as Wilson and Dowlatabadi observe, has been seen when people overestimate or underestimate costs and benefits in the near and far future. Specifically, people seem to have a very difficult time *optimizing utility*. Furthermore, consumer behaviors are affected by different *frames of reference*, meaning how one frames the issue can affect consumer adoption or rejection. And persons cannot readily acquire, analyze, and trade off all the alternative options before making the decision because it is burdensome to gather and process that information. Therefore, they may not choose an optimal solution because of imperfect information or because they reached their minimal satisfaction level before an optimal solution is perceived.

In fact, Wilson and Dowlatabadi believe that studies in the conventional and behavioral economic realm suggest that there is a benefit in using (or eliminating) particular frames of reference, and that *intervention expectation* should be framed properly. For example, they suggest that default temperature settings on appliances or thermostats should be eliminated because a few studies have shown that elimination of default settings did reduce energy consumption in a house. Also, how people process information should be considered, so that intervention approaches are congruent with the mental accounting systems that consumers use when considering energy efficiency product choices. For example, if people are more sensitive to losses than gain, as some studies show, then interventions cannot expect short-term monetary incentives to outweigh perceived losses in comfort or service quality.

The second literature reviewed relates to the technology adoption and attitude-based decision models. Here, Wilson and Dowlatabadi examine the *Diffusion of Innovation* (DoI) model, in which social communication through media or via person-to-person interaction is assumed to affect behavior. Essentially, knowledge – assumed to be obtained through information – can affect object-specific attitudes and this effect can result in behavioral changes. Hence, an understanding of attitude-based decision-making behavior is valuable to the DoI model. Wilson and Dowlatabadi also review other attitude-related theories, but the main idea of using information to affect behavior remains consistent throughout their review.

The third literature relates to *social decision models* and *environmental psychology*. The authors' findings reinforce Lutzenhiser's and Stern's arguments, and stress the importance of contexts of choice and non-psychological factors. They also discuss the forms taken by information and the conditions under which psychological factors interact with context.

The fourth literature reviewed involves *sociological perspectives* on decision-making. Echoing Wilhite et al. (2001), energy demand is seen as socially constructed and strongly influenced by larger systems in which the household is embedded. Consumption behaviors are highly heterogeneous, however, meaning that patterned differences in household energy demand may relate to social lifestyles, which link energy use with social and cultural identities. They also note that energy demand is shaped by norms of comfort, cleanliness, and convenience, while being conditioned by the supply chain for energy services. This suggests that individual decisions about energy services are highly constrained by both social factors and socio-technical energy systems. Wilson and Dowlatabadi observe that these multi-leveled *socio-technical regimes* may need to be addressed though large-scale policies because they are the most complex, far-reaching, and institutionalized, and have not been fully considered in energy efficiency research and policy.

After reviewing the four distinct approaches to household demand represented in these literatures, Wilson and Dowlatabadi conclude that questions about residential energy consumption remain complex, with individual decision-making behavior and social energy consumption intimately tied to each other. Hence, integrating disciplinary findings will be required to help policymakers and practitioners design better interventions.

4.5 Progress Toward Integrated Models of Residential Consumption

In the review article "Evaluating the Applicability of Integrated Domestic Energy Consumption Frameworks in the UK," Keirstead (2006) analyzes a series of domestic energy consumption (DEC) models proposed over the past two decades. The phenomenon of *interest* – residential energy consumption and conservation/efficiency choice – is produced by multiple physical, technological, and behavioral factors, organized within the building/occupant system and influencing it in multiple complex ways. Keirstead asks how widely the kind of interdisciplinary approach clearly called for has been pursued by analysts, both inside the energy system and in academic/scientific settings. He finds that they have had little effect in energy policy discussions in the UK. We think, since his methodology is not limited to cases in the UK, that his findings likely have much broader applicability as well.

Keirstead finds that DEC models have been predominately influenced by the research in the engineering, economic, psychological, and sociological realm. In short, most DEC models are variants of the PTEM, with psycho-social amendments. He defines the more desirable *integrative* DEC models as those that go significantly beyond engineering and economics assumptions. He then identifies five integrative DEC models in the published literature – models that vary a good deal in their emphasis in terms of application (focus on theory or practice), form (focus on structure, process, or both) and scale (narrow or broad). To assess these models, Keirstead examines published studies of household energy consumption, using a well-accepted multi-disciplinary citation index (ISI 2004) covering the period from 1981 to 2004. His methodology provides for a broad-based search for relevant articles, as well as studies of patterns of citation of earlier works in those articles. He organizes the articles into categories developed by Lutzenhiser (1992), allowing comparisons to the latter's earlier findings.

The results reveal a growth of international and engineering studies since the 1980s and early 1990s, with fewer studies being published from sociology, anthropology, psychology, and consumer behavior, compared to what Lutzenhiser found in 1992. This indicates a shift in the literature. Also, he finds that *disciplinary* studies have become more common than efforts at *integrative* studies. When comparing the citations of the two most prominent integrative models proposed – Lutzenhiser's (1992) cultural model and Raaij and Verhallen's (1983) behavioral model – he found that the former has been cited primarily by energy economists, whereas the behavioral model has mostly had its influence in psychology, consumer behavior, and marketing. Interestingly, the behavioral model was cited primarily in the 1980s and early 1990s, whereas the cultural model has been cited more recently. While the pattern would suggest that the papers had their greatest influence in the decade following their publication, the lack of evidence of much impact on reported energy analysis of either is the more striking finding.

4.6 Energy Efficiency Programs, Policy Frames, and Criticisms in the EU and UK

As noted above, this white paper also considers developments in Europe because differences in program models and implementation may be of use in assessing California residential energy efficiency policy. Carbon abatement is a key energy efficiency policy goal for the State of California. This is also an area that has been of great concern and urgency in the European Union (EU) over the past decade. Therefore, we might expect to find some important insights there.[15]

In their efforts to achieve a 20% increase in energy efficiency by 2020, European governments have been focusing on implementing policies that encourage the adoption of energy-efficient technologies in the home through incentives, regulatory instruments, and voluntary measures. According to Atanasiu and Bertoldi (2008), "Better equipment efficiency is one of the fastest and most cost-effective responses to limiting growing demand for electricity and at the same time to reduce CO_2 emissions." Several important regional policies attest to this commitment, such as the European Commission's (EC) *Green Paper on Energy Efficiency* (2005) and the EU's *Energy Efficient Action Plan* (2006).

A key EU initiative was the SAVE program (1991-2006), which aimed to stimulate energy efficiency measures through supporting wide-ranging programs and projects in areas including awareness-raising, interactive information, and market transformation. This general policy orientation is replicated at the national level.[16] The UK's *Energy White Paper*, for example, places considerable emphasis on greater energy efficiency in pursuit of the commitment to reduce carbon dioxide emissions by 60% by 2050 from 1997 levels (Department of Transport and Industry 2007). It is estimated that around £2.6 billion is currently spent on *energy consumption* programs annually (NAO 2008) in the UK. Programs focus on incentives for the installation of energy efficiency in homes, voluntary improvements in the labeling of appliances, the regulation of standards of energy efficiency in dwellings, and influencing household behavior through information.[17]

The implications of this orientation and the wider benefits and costs of reliance on this techno-economic approach have been the subject of much debate among European energy researchers, policymakers, and practitioners. While numerous initiatives have sought to promote the uptake and use of energy efficiency products, it has been suggested that the rate at which they are being adopted is not making a significant impact on the reduction of carbon emissions needed to meet

[15] Heather Chappells is the team member with considerable UK and EU experience, who was the lead researcher and author in this area.

[16] This has included: information campaigns, energy-focused Eco-labels (e.g., Scandinavia) and subsidies for high efficiency appliances (refrigerators, compact fluorescent lighting, condensing boilers, etc); see EEA (2001). An inventory of national policies and programs on energy efficiency is provided in European Commission (2004).

[17] A recent study by Oxera (2006) evaluated policies for energy efficiency in the UK household sector, including an evaluation of the economic literature of what affects energy efficiency uptake by households and in-depth interviews with more than 1,000 homeowners.

current targets through the Kyoto Protocol (Faiers et al. 2007). It has been argued that there is a lack of coordination between regulatory and voluntary instruments for energy efficiency, as well as a disconnect between different national and regional policy approaches (EurActiv 2008a). EU law now requires member states to put forward national energy efficiency action plans (NEEAPs). However, it has been argued that these lack coherence and differ widely in effectiveness. Commentators have suggested that energy efficiency is not taken seriously enough by some member states and that current initiatives are unlikely to produce long-term changes in residential energy use of the magnitude required to meet climate change goals (EurActiv 2008b). On this latter point, future policies and the programs that they support are seen to depend on a better understanding of social and cultural influences on energy behavior.

For example, the assumption – as articulated in the EC (2005a) *Green Paper on Energy Efficiency* – that significant energy-saving potential can be achieved through the diffusion of the new, more efficient technologies to replace outdated appliances in households needs to be carefully balanced with an understanding of how these technologies can also create new consumer expectations and standards. With relation to the *market transformation* agenda, Boardman argues that the programs adopted so far in the EU and UK have been successful with existing products, but have been accompanied by the development of new, profligate equipment (Boardman 2004). Consumers are being offered, and are buying, an ever increasing range of products that use large amounts of energy (e.g., larger appliances, or a range of new consumer electronics, some with standby functions). This limited success demonstrates the need for European policy to be more forceful and for programs to involve engagement with manufacturers about the products they are planning to introduce, rather than to rely on individual consumers to select among different models.

4.6.1 Focus on Information

EU policy also supports the view that the most important barrier to increased energy efficiency is a lack of information (e.g., on availability of new technology or on costs of personal energy consumption; EC 2005b). This information-biased approach supports several assumptions and activities. First, there is a built-in understanding that current pricing systems for energy products do not point consumers towards patterns of consumption that are more economical or efficient (EC 2005b, 13). Innovations in electricity tariffs and interactive metering are considered an important component of programs designed to stimulate the efficient use of electricity and to reflect the real cost of the electricity infrastructure (Atanasiu & Bertoldi 2008). Second, shortcomings in information and education of consumers are emphasized in support of the assertion that "consumers themselves will also have to be mobilized in order to develop and spread habits which will incorporate more energy efficiency in everyday life" (EC 2005a). At the EU level, this has spurred on the development of a broad public awareness campaign on sustainable energy across member countries.[18]

[18] See Sustainable Energy Europe Campaign (2008). In the UK, the Energy Savings Trust and the Green Homes Service run a range of information provision programs promoting energy saving in households. According to the

Continued

Among European energy researchers and policy advisors, there is widespread support for a focus on improved information and feedback.[19] Boardman argues that informed, concerned, active consumers are needed if the market is going to be pulled towards greater energy efficiency. For this to occur, it is suggested that people have to be made more aware that there is a direct link between energy-related behavior and climate change (Fawcett et al. 2002). This argument is supported by a review of 38 feedback studies, carried out over a period of 25 years, that showed savings ranging from 5% to 20% (Boardman & Darby 2000). Innovations in billing and smart metering may be central to the success of such programs (Logica 2007). The potential for having a personal carbon allowance for each individual, to cover all direct consumption of fuel – gas, electricity, and petrol – is another innovative feedback mechanism being examined (Fawcett 2003). Critics have highlighted the limits of feedback and information, including whether understanding the energy problem will necessarily induce lifestyle change or spending on energy-efficient options (e.g., Bartiaux 2008).

While these measures may be regarded as a step in the right direction, there are some major challenges and oversights. First, obligations to promote energy-saving measures have been successful in targeting vulnerable homes or new housing stock, but there are concerns about the capacity of the energy efficiency industry to meet required installation rates of key measures in "harder to reach" households and in older existing housing stock. The National Audit Office (2008) reports that 43% of homes in England have at least one feature associated with the *hard-to-treat* housing stock, which raises problems for the implementation of standard energy efficiency measures.[20] Second, it is recognized that programs will need to address householder behavior. In this regard, there is currently limited information about the outcomes of information programs (in terms of a discernible shift in consumer attitudes and behaviors), about their (program) cost-effectiveness, or about how they could be better designed in the future. In particular, there is considerable uncertainty over the likely impact and cost-effectiveness of smart metering.

In short, the toolkit of energy efficiency policies and programs being developed in the EU and in individual member states largely represents economic instruments, product standards, and information (Boardman 2004). The limitations of these approaches have been widely debated, yet the continuation of these program strategies (albeit improved and better targeted) as a dominant approach is largely accepted (Eyre & Staniaszek 2005). Many of the suggested solutions reinforce the notion that future energy use will be determined by improving the contexts for consumer choice. These include improved labeling of products and appliances,

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National Audit Office (NAO 2008), the current expenditure is in the range of £18 million (about $25 million), with a likely further spending on Green Homes of £32 million (about $50 million).

[19] Several national and international surveys and analyses have been conducted which support this orientation (e.g., Henryson et al. 2000; Lindén et al. 2006).

[20] The UK Building Research Establishment (BRE 2008) defines *hard-to-treat* homes as those "that for a variety of reasons cannot accommodate 'staple energy efficiency measures'" (p.2). They may include homes that are off the gas network, homes with solid walls, homes with no loft space, homes in a state of disrepair, high-rise blocks, etc.

interactive metering and feedback, and personal carbon allowances.[21] The implications of these measures for changing consumer behavior (or indeed for creating new distributional inequalities) are as yet uncertain.

4.6.2 Movement Toward Lifestyles and Segmentation

The reorientation of national and international environmental agendas towards the issue of sustainable consumption is reflected in a range of recent policies and programs.[22] These include the Organization for Economic Cooperation and Development's (OECD) program on sustainable consumption and production that offers a comprehensive evaluation of recent household consumption patterns and drivers, and their associated environmental impacts (OECD 2002). Rather than seeking to influence market choice for specific products, such initiatives focus on how to transform lifestyles that support more energy-intensive services and practices. Social instruments of information provision and participatory decision-making are seen as critical strategies for promoting sustainable consumption.

Sustainable Consumption and Production (SCP) is now a central component of the EU environmental policy agenda and is reflected in initiatives of individual member states (EEA 2005). The European Environment Agency (EEA) identifies the need for an understanding of how, at an individual level, consumption patterns are shaped by needs, abilities, and opportunities, as well as being shaped by a desire to identify with different lifestyle groups. Within this framing, the factors that determine consumption patterns are assumed to be complex, interrelated, variable, and not always fully understood, such that making European consumption more environmentally-friendly and sustainable is regarded as a difficult challenge. In particular, many of these factors are social and cultural in nature, which makes it difficult to agree on how to influence consumption behavior effectively at a general level.

Exemplary of commitments to an emerging European agenda on sustainable consumption is the recent program on *Pro-Environmental Behaviors* initiated by the Department for Food and Rural Affairs (DEFRA) in the UK. Several studies have been commissioned under this program to identify the potential for behavior change across a range of lifestyle groups (Barr et al. 2006; Darnton et al. 2006; Uzzell et al. 2006). These research activities have identified specific barriers to participation in environmentally responsible behaviors, how these vary across lifestyle groups, and how different audiences require tailored and targeted interventions. The broad value of such programs is to recognize that "there is no one silver bullet but a multiplicity of actions needed to support greener lifestyles." The aim is therefore to design a variety of possible interventions that are better coordinated and more effective to the needs of specific groups, rather than to the

[21] For more on personal carbon allowances, including discussion of distributional effects and social equity, see: Fawcett et al. (2002), Fawcett (2003), and Roberts and Thumim (2006).

[22] The *World Summit on Sustainable Development* in Johannesburg (2002) underlined the need to "encourage and promote the development of a 10-year framework of programs in support of regional and national initiatives to accelerate the shift towards sustainable consumption and production … to promote social and economic development within the carrying capacity of ecosystems."

average or *rational* consumer favored in existing policy approaches. In the framework developed by DEFRA, *headline behavior goals*, selected after a process of stakeholder engagement, have helped to identify a range of low/high impact and easy/hard behaviors, some of which could potentially engage large numbers of people (e.g., better energy management at home), and others which would be more appropriate for targeting particular segments (e.g., installing micro-generation). This *consumer segmentation* approach appears to be similar to U.S. marketing initiatives discussed in the next section.

4.7 Summary

The social science reviews of research on energy efficiency are all highly critical of the PTEM policy frame, whether explicitly identified by that term or not. We can see from our program review, that this approach is actually a product of regulatory policies. That point had not been clearly articulated in earlier work, although both Stern (1986) and Lutzenhiser (1993) laid the conceptual groundwork.

Critics disagree with nearly every element of the PTEM, including its focus on devices, purposive behavior, costs, calculation, rationality, information, program accountability, energy services, and averages. Despite being rooted in strong paradigms from engineering and economics, the model fares poorly when considered in the light of empirical data on actual energy-use behaviors, efficiency choices, and levels of energy demand.

In the real world, there is considerable variability in energy use. This is correlated with differences in consumer demographics (e.g., age, ethnicity, income, family size), cultural backgrounds, and local social influences – which, in turn, correlate with different choices in housing and domestic technologies. Because it is invisible, persons are ordinarily not conscious that they are using energy. Also, a good deal of energy use is actually habitual and built into routines. Routines, in turn, are not individual and rationally selected, but social. Knowledge is shaped by normative understandings (*folk models*), and the need for particular energy services is not given in nature, but a socially defined and organized business. This means that *needs* are highly variable.

When choices are explicitly made regarding energy use and energy-using equipment (which is rare), choice often applies only to a limited degree (a narrow choice set). Also, non-economic considerations tend to dominate energy choices, which are strongly shaped and conditioned by the *upstream systems*, or levels of social and economic organization beyond the individual and household. Market transformation programs, which focus on various upstream and midstream levels of supply chains, tend to focus narrowly on technology adoption and, furthermore, on only the energy component of technology adoption. But doing so, they overlook the processes of the social shaping of the devices themselves, as well as the shaping of wants, needs, and standards of comfort and convenience.

When we consider empirical research on how energy efficiency programs affect consumers and their choices, we find that the programs tend to mirror the PTEM frame that justifies them, but with elaboration. There is considerable emphasis on information, including messages related to costs, benefits, and some environment goods. We saw from our program review in the previous section that the California programs are deploying a mixture of mass information, direct information, inducements, gifts, and supply-chain focused (market transformation) interventions.

However, Stern's (2008) review of the social psychological literature on how consumer choices are affected by various intervention approaches shows that information on how to save energy, delivered through various channels, probably has little effect on energy consumption. He argues that energy use and efficiency choice in the household are complexly determined by a combination of social, contextual, and psychological factors. The pattern of influences – which factors matter most – can vary greatly across behaviors and places, with the strongest influences often being contextual. He reinforces earlier findings that efficiency choice is infrequent and is rarely carefully considered. Stern also notes that the effects of psychological variables are often indirect and may matter only in limited situations. However, he argues that some can potentially affect a wide range of behaviors, and others can potentially have significant impacts if they result in purchases of highly efficient equipment or the adoption of persistent habits.

Stern concludes that the more a behavior is shaped by technology, infrastructure, regulation, financial cost, convenience, and other contextual factors, the weaker the effect of psychological variables. Also, he sees an interdisciplinary approach to understanding and influencing environmentally significant behavior as the most productive. This is an approach that seeks to understand the full range of causes of behavior and their interactions, and to base interventions on that understanding. We discuss the implications of this for future programs and research agendas in California in Section 6.

Wilson and Dowlatabadi (2007) observed that multiple disciplinary domains and alternative models all point to complexity, but there is no clear way forward without further research and efforts to integrate models that focus on different levels of analysis, and emphasize different sets of variables. Keirstead (2006) examines the fates of several efforts to integrate theories and sets of causal factors in household energy analysis. Rather than finding progress along these lines, he observes greater emphasis on disciplinary approaches in recent published studies. He is particularly concerned about the state of knowledge in the UK, but draws upon a global literature to assess the status of integrated models.

Our review of recent developments in the UK and the rest of the EU provides some support to Keirstead's view, but also suggests a few emerging developments that merit attention in the U.S. Europe has had its own version of the PTEM, with concerns about failures to increase the penetration of more efficiency technologies – an *efficiency gap* that has often been chalked up to an *information-deficit*. However, broadcast campaigns focused on increasing the uptake of better equipment have also been accompanied by direct feedback experiments and a growing interest in the effects of consumer behavior on demand.

In European policy circles, there seems to be a more widespread discussion of sustainable consumption and consumer lifestyles than in the U.S. There is a growing recognition in both policy contexts that there is, in reality, no "average" consumer or "rational choice-maker." There also seems to be a growing recognition in the EU of our limited understanding of how consumption patterns are shaped by needs, abilities, and opportunities, as well as by desires to identify with different lifestyle groups. New EU government initiatives to promote *pro-environmental behaviors* are being accompanied by research to determine just how behavior change potentials vary across lifestyle groups and how appeals, offers, and interventions might be targeted.

At the same time, recent research on the effectiveness of energy information raises questions about how well even customized information might work (Bartiaux 2008), shifting attention to socio-technical networks and socio-cultural conventions (discussed in the next section). This movement mirrors U.S. findings regarding the complexity of household consumption behavior and echoes Stern's observations about the relationship of information to a host of other factors under conditions of choice within context constraint. However, it seems that efforts to construct policies and programs that focus on larger systems in a market-transformative mode remain as limited in their development in the EU as in the U.S.

5. Alternative Models and Innovations

In this section, we consider five emerging developments that offer alternatives to the PTEM approach and that show promise for expanding the conventional energy efficiency policy frame in ways that may take consumer behavior and technology choice more realistically into account. All of these alternatives have been identified in the critiques covered in the previous section. We consider them in greater detail here. They include insights into consumer behavior and choice from behavioral economics, cultural and economic anthropology, sociological studies of status and lifestyle, consumer segmentation approaches, and new themes focused on broader systems being proposed by social scientists and energy analysts in the UK and the EU.

Hopefully, some of these more "cutting-edge" ideas and proposals, combined with the host of insights identified in the previous section, can contribute to improvements in policies and programs that will produce greater energy savings and greenhouse gas emissions reductions. However, there are no "magic bullets" in these alternatives. We still have no *integrated model* that binds together insights from across the disciplines critical of the PTEM approach and its variants. But we do find some potentially actionable suggestions that can inform policy discussions, program experimentation, and research agendas (discussed in Section 6).

5.1 Considering Behavioral Economics

Behavioral economics is a relatively new field that critiques neoclassical economic theory on its own terms, challenging neither its rationalism nor (generally) its focus on individuals and their decisions in isolation from social context. Camerer and Lowenstein (2004) argue that "behavioral economics increases the explanatory power of economics by providing it with more realistic psychological foundations." They outline comprehensively what has been gained to date from the work of behavioral economists, as well as the contributions that we might expect from them in the future. While Camerer and Lowenstein (and the field of behavioral economics generally) don't specifically address environmentally significant decision-making, their review is a useful source for understanding the behavioral critique of neoclassical economics and its potential to help us move beyond the PTEM in energy efficiency programs and policy.

The central insight of behavioral economics is that more realistic psychological assumptions will lead to more realistic theories of behavior. However, there is a tradeoff. Because behavioral economics concerns itself with deviations from the neoclassical model, a degree of confidence is often sacrificed. Still, many of its insights find practical application in at least some real-world contexts.

We can use the example of the behavioral economic concept of *loss aversion* to demonstrate this trade-off. If I have $100 in my wallet, neoclassical models would predict that my aversion to losing $50 of it would be equal in magnitude to my desire to gain $50 more. In fact, experiments (and simple intuition) demonstrate that humans are quite loss-averse, so that losing $50 tends to hurt more than gaining $50 helps. In other words, there can be a great disparity between the strong aversion to losses and the weaker desire for gains. This insight detracts from the simple elegance and rationalism of the neoclassical model. In the case of purchase decisions related to energy efficiency products, it might suggest that quality and resale value considerations – scarcely, if ever, mentioned in energy efficiency program appeals – might outweigh consumers' value for a $50 rebate coupon.

On reflection, it seems obvious that psychology and microeconomics, with their shared focus on the individual, might be more closely allied fields. In fact, early economists were quite aware of the importance of psychology, and many of the key insights of behavioral economics are not new, but are simply being rediscovered. Adam Smith, equal parts economist and psychologist, wrote important treatises on both subjects. *The Wealth of Nations* is clearly better remembered, but his *The Theory of Moral Sentiments* offers many insights that presage those of behavioral economics, including the idea of loss aversion.

The rejection of academic psychology by economists began with a neoclassical revolution at the turn of the 20th Century. Psychology was undergoing a rather "unscientific" period in its intellectual trajectory, while economics was simultaneously reorienting itself towards a strict positivism. The disciplinary goal became to make economics like a natural science, which involved (claims to) the rejection of normative assumptions and their replacement with testable theories and models that could reliably predict human behavior. While there were certainly detractors, economists on the whole embraced an extremely simplified model of human psychology and didn't reopen the case for many decades.

The reunion of psychology and economics began in the latter part of the 20th Century. Psychologists such as Daniel Kahneman and Amos Tversky were among the pioneers, using economic models as benchmarks against which to contrast their psychological models. Their seminal paper "Prospect Theory: Decision Making Under Risk" (Kahneman & Tversky 1979), documented violations of utility theory in economics and proposed a formal alternative theory, grounded in psychological principles, to explain the variations. The opening of economics to psychology, and vice versa, progressed from there (although certainly not to universal acclaim).

Neoclassical economics is built atop just a few foundational ideas. Principle among them are that individuals act so as to maximize their personal utility, that markets create the greatest efficiencies in allocation, and that markets tend toward equilibrium in pursuit of that efficient distribution. The limited injection of psychology into economics that behavioral economists espouse does not challenge these basic premises. Rather, behavioral economics is interested in amending them, focusing most intently on "correcting" utility maximization. These amendments are not radical, as they generally involve relaxing simplifying assumptions that are not central to the neoclassical approach anyway.

In taking a new look at utility maximization, behavioral economics has drawn most readily from the psychological field of *behavioral decision research*, which parses its interest into two categories: *judgment* and *choice*. Whereas neoclassical economics assumes decisions are made more or less in a vacuum, behavioral economists have embraced the notion that *context* might influence the way people judge their options and the choices that they subsequently make among them. Taking note of persons' frequently observed "errors" in judgment, behavioral economists have proposed a new model termed *quasi-Bayesian reasoning*, in which people are acknowledged to often mis-specify hypotheses and encode new evidence incorrectly when attempting to evaluate new information in light of past experience.

Choices are seen as the processes people use to select among actions, taking account of any relevant judgments they may have made. Neoclassical economists would claim that preferences among options are *reference independent* or, in other words, that the context of choice is irrelevant. But Camerer and Loewenstein (2004, 15) argue that:

> "Preferences are not pre-defined sets of indifference curves as represented in microeconomics textbooks. They are often ill-defined, highly malleable and dependent on the context in which they are elicited."

One example of such malleability is that choices can be influenced by superficial changes in the way options are described – a *framing effect*, of which marketers have been long been aware.

Another new direction in behavioral economics is the effect of emotional states on choice. For example, Damasio (1994) found that people with relatively minor emotional impairments have trouble making decisions and, when they do, they often make disastrous ones. How to incorporate subjective psychological states into testable economic models is still an open question. In the case of energy efficiency technology choice, the role of emotions would seem to be quite important when homeowners experience a heating system breakdown, a water-heating emergency, make a new home purchase, or settle on a remodeling plan under tight time and financial constraints.

While the importance of social norms, rules, roles, and organizational structures on economic decision-making has been the realm of another critique of neoclassical economics made by *institutional* economists, *behavioral* economics offers related observations with its consideration of fairness and social preferences. A behavioral economist would not go so far as to say that behavior is actually socially determined, or to suggest (as a social-psychologist would) that common behaviors might actually have different *motivations* than narrow economic self-interest. But there has been recognition of the possible existence of a social utility function, as well as some thought about the social institutions that support self-interested transactions.

These illustrations touch only briefly on the myriad ways in which people *actually* seem to think and behave differently from how neoclassical economics assumes that they do. In that sense, a major contribution of behavioral economics is to pull the curtain back on the *implicit psychology* assumed by neoclassical economics. Behavioral economics aims to bring that psychology to the forefront and fine-tune it in the interest of better science. To use a torturous metaphor: if neoclassical economics is imagined to be the drill – the universal tool for the job – behavioral economic insights are drill bits, providing improved precision for a diversity of contexts.

Relevant to residential-sector energy efficiency policy and programs, we find that behavioral economics has raised serious questions about underlying neoclassical economic assumptions at the heart of the PTEM. The amendments offered by behavioral economists may be helpful in thinking about the actual nature of energy efficiency choices in their *economic* aspects. But the model remains individualistic and rationalistic, and, while it brings by degrees behavioral uncertainties to the fore, it cannot *on its own* account for the wide variability in *real-world choices and behaviors.*

5.2 A Cultural View from Social and Economic Anthropology

Anthropologists working in this area argue that economic explanations of human behavior, judgment, and choice – with or without a behavioral economics amendment – tend to over-simplify all of these processes. With the incorporation of an anthropological perspective emphasizing the importance of social relations, cultural context (including material culture) would lead to an understanding of energy use – and *economic* choices related to energy use – as cultural choices. Costs, benefits, and risks are important in decisions about using energy, but are only one set of considerations in a decision process that involves things like the cultivation of family and social relationships, creating a solid and aesthetically pleasing home, getting clean, getting around, and so on.

Anthropologists argue that the notion of energy itself should be considered a cultural creation. Thinking of energy as a purely technical phenomenon (e.g., electron flows or Btus) obscures the fact that energy is what Wilhite (2005) has called *the quintessential social good* that is produced, delivered, and consumed through a series of social arrangements. In this view, people do not "use energy" per se; they use culturally-approved goods and services made possible because of energy, such as warmth, cooling, iced drinks, television shows, and hot dinners (Wilhite et al. 2001). The extent to which people use services and goods of one sort or another depends upon social norms and cultural traditions. These norms and traditions include shared notions of appropriate behavior. When household practices involve energy flows (as they nearly always do), the cultural considerations determine the desirable level of consumption.

Anthropologically, this makes perfect sense. Since energy is invisible, persons are rarely able to make conscious connections between energy use and the cultural goods it provides. This form of "inconspicuous consumption" (Shove & Warde 2002) of energy directly enables, however, multiple forms of *conspicuous* (visible, socially meaningful) consumption. Purchasing a larger home, for example, is a form of conspicuous consumption, in that (among other things) it signals to the neighbors the wealth of the buyer, while the energy it will take to heat such a home is likely a minor consideration (or perhaps an added bit of evidence of economic success). Visible signs of prosperity are provided by house size, materials, the numbers (and brands and newness) of cars, outdoor lighting, pools, and so on. Most of these probably have dubious cost/benefit ratios and returns on investment. However, they generate social benefits and also communicate important cultural information about success, affluence, respectability, diligence, thrift, and a history of wise choices that reflect on the neighbors, as well as the occupants.

Anthropologists also point out that consumption is a collective accomplishment of household members. Their energy use follows from their joint activities, which are organized in ways that are culturally appropriate in regard to gender, age, and parental roles, as well as in terms of peer pressures and the expectations of kin and neighbors.[23] And the cultural organization of routine activities in these groups is also quite relevant when it comes to changes in energy-use behavior. For example, anthropologists have found that *gender*, which has been largely ignored by other energy researchers, is involved in a variety of energy-using and energy-saving behaviors. A Swedish study found that women were much more likely than men to be negatively impacted by lowering indoor temperatures and decisions to take fewer baths (Carlsson-Kanyama & Linden 2007). That study also found that conserving household energy has the potential of increasing workloads for women, since they do the majority of household work (such as laundry, cooking, and cleaning). Other research has found that energy conservation tasks that rely on changing everyday behaviors in the household are more likely to be undertaken by women than men (Roehr 2001).

Cultural threats to the entire household can result from other conservation behaviors. Anthropologists point out that efforts to conserve energy can be considered lower-status activities (frugality is equated with poverty). One example of the social sanctioning of a conserving practice is the case of hanging laundry out to dry on clotheslines. In many communities in the U.S., outdoor clothes drying is considered unsightly, dirty, inconvenient, an infraction of private-public boundaries, and something that only poor people without access to a dryer would consider doing. The visible signs of such activity are, therefore, believed to call into question the cultural judgment and social standing of both the perpetrator and the neighbors.

Another example concerns the equation of the "normal" family with car ownership. In a study of car sharing[24] in Norway, members indicated that, while they were very satisfied with doing without owning a car (and not dealing with depreciation, insurance, maintenance, parking, and so on), they had serious problems in defending their decision not to have a car. They experienced constant insinuations from family, friends, and colleagues that their not having a car was evidence that something was wrong, either with their economy or their sense of judgment (Attali & Wilhite 2001).

Finally, anthropologists also point out that the needs and wants that are reflected in the purchase and deployment of energy-using (and energy-embodied) goods are continually evolving (Wilhite et al. 2001). The ways that energy consumption evolves are understudied and under theorized. One facet of this evolution involves how people "domesticate" new devices (refrigerators, thermostatic devices, washing machines). Another facet that has gotten less attention is how new devices, once situated in household practices (such as heating, cleaning, eating) form technology-practice clusters (frozen food regimes, air conditioned-based comfort regimes, multiple-point – as opposed to ceiling – lighting and so on). Once routinized, experience shows

[23] Even in the increasingly common case of the person living alone, "outside" cultural expectations and obligations exert considerable influence.

[24] Car-sharing organizations buy or lease cars and place them in parking lots around the city. Members order a car by telephone or the Internet for periods from an hour up to several weeks. Members pay a small yearly fixed fee and for the amount of kilometers they drive. Studies from several countries show that car-sharing members reduce their car usage on average about 50% after joining.

that these clusters can be very difficult to change. Nonetheless, that which is socially constructed, culturally variable, and in flux can imaginably be influenced. Although there is ample evidence that "information" alone does not do the trick, the potential for cultural change clearly seems to exist, since we can observe cultural evolution taking place. The processes are not well understood, however, and warrant further research. We return to this point in the conclusions.

Second, since much of the recent evolution of cultural needs and wants seems to be in the direction of greater consumption, successes in one sphere of efficiency can be swamped by growth of other demands (economists refer to this as the *rebound effect*). Third, pro-efficiency choices that are culturally optimal are not necessarily energetically or environmentally optimal. This final point is illustrated by anthropological studies of efficiency technology choices by households. For example, Wilk and Wilhite (1985) found that highly effective and low-cost choices that are invisible and mundane, such as weatherstripping, were often devalued, even when promoted in efficiency messages, while highly visible and costly investments, such as solar panels, were preferred. Programs to promote either weatherstripping or residential solar systems ought to understand that the needs and wants involved – even when focused on energy savings – may not have all that much to do with energy or savings, let alone the nuances of loss aversion, reference prices, or other imaginable behavioral economics amendments to the PTEM.

5.3 Social Structure and Lifestyles

Lifestyle perspectives from sociology to an important degree build upon the insights of anthropologists about cultures and choices by pointing to cultural *differences within a society*. The language of social structure and demographics is used to distinguish subgroups of persons and households within the U.S. In *marketing* – and particularly the practice of *market segmentation* – theory and research from anthropology and sociology on culture, social structure, and demographics provides a basis for differentiating consumer groups for sales purposes. Lifestyle concepts and their application to energy efficiency are discussed in this subsection. Segmentation is discussed in the following subsection.

Socio-demographic differences in energy use and behavior, even within economically similar groups, have been well established over the last 30 years. Sonderegger (1978) found that roughly 54% of the variance in consumption could be explained by physical features, while the remaining 46% of the variance resulted from the behavior patterns of occupants (Sonderegger 1978). Similar studies in California elaborated those findings.[25] Subsequently, researchers Hackett & Lutzenhiser (1991), Lutzenhiser (1992), Lutzenhiser (1997), Wilhite & Wilk (1987), and Erickson (1997) documented a range of other significant socio-economic and behavioral differences among households associated with energy use and provided explanations for those differences.

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[25] See Vine et al. (1982), Cramer et al. (1984), and Cramer et al. (1985).

As noted, household members, within the larger social context of shared cultural expectations, negotiate what makes a "good home" through everyday social practices and routine habits. For instance, expectations about comfort and cleanliness, as well as the convenience of carrying out everyday energy-consuming tasks, vary across households.

As social researchers studying energy use found, the way people live accounts for a high variance in household energy use, and, as a result, the term *lifestyle* began to be used as a way to capture and explain some of the differences among individuals, the types of technologies in the home, and the way people use those technologies in their everyday routines (e.g., Schipper et al. 1989). Social expectations associated with different lifestyles can influence the types of material goods and technologies that are purchased; they also shape the ways in which these technologies are used in the home.

Marketers have been extremely successful in targeting their products to specific groups by creating lifestyle market segments, or *clusters*, based on demographics, values, attitudes, and geography (Michman 1991; Newell 1997; also see Lutzenhiser & Gossard 2000 for a review). Again, segmentation strategies will be considered in greater detail below. For the present discussion, however, it is important to note that marketing lifestyle categories are often created based on rough demographics and individually focused consumer behavior data. As a result, there is an underlying implicit assumption that consumer preferences are individually structured. Accordingly, marketing models of lifestyles often fail to see that social aspirations and tastes are an outcome of culture and social structure, and, therefore, can offer little or no theory about the development, change, or persistence of consumer behaviors (Bourdieu 1984; Lutzenhiser & Gossard 2000; Schor 1998).

In this respect, social theory has been better able to account for differences in consumer behavior and in more sophisticated ways. Social class has long been a central concept in sociology – nearly every known society practices some form of stratification where those in the higher strata have greater access to resources and power than those in the lower strata. Different ways of living, which characterize different classes of people, tend to be hierarchically related to one another, and the conspicuous consumption of goods, housing, clothes, and leisure is an important means by which higher social groups are able to make their standing and power visible to themselves and others (Veblen 1931). In social stratification theory, status displays through consumption are an integral element of social hierarchies and a *style of life* – the way in which individuals express prestige – must be adopted by all those belonging to, or wishing to belong to, certain status circles (Weber 1946). Status groups not only maintain and reproduce certain lifestyles, but social positions can confer privilege or punishment upon individuals based on their display of certain styles of life.

Economic resources and social networks are basic elements of social position, but learned cultural tastes and behaviors create and maintain distinctions between people and social groups – distinctions that reify social identities and class memberships (Bourdieu 1984, 1986; Lamont 1994). Together, material goods, social practices, and tastes communicate symbolic meanings within and across social groups that serve to establish and maintain social differentiations (Veblen 1931; Bourdieu 1984; also see Douglas & Isherwood 1979, and McCracken 1998 for anthropological accounts of social structures). For instance, social expectations and cultural understandings influence acceptable behavior (e.g., the way public transportation is used and viewed by different social groups) and the types of material goods that meet the expectations of a particular lifestyle (again, the size or type of house one should have, the style of car one should drive, and the like).

Lifestyle may also be recognized though understanding the visual symbols that people use to pattern their everyday lives. Semiotic codes (e.g., signs and symbols) provide culturally intelligible ways to pattern one's behavior and can be internalized, reproduced, and patterned around distinct lifestyles (Swidler 1986, 2001). For example, publicly promoted status codes can be either positive (e.g., owning a mini-van signifies being a good parent) or negative (e.g., brown grass says you are not a good homeowner). Even codes of recent origin can be culturally powerful and provide cultural meanings that shape action (Swidler 2001, 163). For example, even renewable energy technologies, such as solar panels, could be viewed as aesthetically unappealing (e.g., they may not fit in with the aesthetics of the neighborhood) in some status locations, while they may represent a symbol of social concern for the common good, clean air, and future generations in others. Therefore, codes can carry powerful meanings – sometimes with moral components – that sustain their status significance for a particular social group.

Energy analysts have defined lifestyle as *patterns of human activities* (Schipper et al. 1989, 275), *persistent behavior patterns of occupants* (Sonderegger 1978, 227) and *the set of values, behaviors, practices, and possessions that are characteristic of a family* (Gladhart et al. 1986, 17). More recently, Lutzenhiser and Gossard define lifestyle as "distinctive modes of existence that are accomplished by persons and groups through socially sanctioned and culturally intelligible patterns of action (Lutzenhiser & Gossard 2000:215)." In other words, lifestyles can be seen as fundamental building blocks of complex societies.

Greater knowledge of various lifestyles may be particularly effective for: understanding energy use (Lutzenhiser 1993); socially-negotiated levels of comfort, cleanliness, and convenience (Shove & Warde 1997); considerations about the types of technologies to be purchased for the home (Cowan 1989); and the innovation and adoption of new trends (Lamont 1994). In addition, by using lifestyle as a conceptual framework, meaningful questions can be asked about the ways in which social practices and artifacts intersect to produce distinctive patterns of energy use, and why there may be extreme social differences in a person's opportunity to consume and conserve.

Therefore, lifestyle research, grounded in sociological theory, may be a particularly good way to inform energy programs that can be specifically aimed at groups in various life circumstances. Programs may benefit by better addressing the needs of "hard-to-reach" groups such as low-income, ethnic minorities, or rural households, and, therefore, be more effective for reducing energy consumption. Low-energy use lifestyles may be identified and used as "models" in advertising campaigns, while lifestyle groups with high levels of energy use can be specifically targeted for intervention. Lifestyle research may also draw attention to *middle* groups that may be left out of current energy programs. For example, programs such as energy bill assistance or home weatherization are targeted to low-income families and are not available to those in lower-middle-income brackets. Similarly, many energy-efficient equipment rebates are set at nominal levels, even for high-end (and highly expensive) devices that are out of reach for many consumers. Consequently, looking at the situation through a sociological lifestyle/status lens may lead to seeing a large *middle* group who cannot take advantage of rebate programs on equipment, nor do they qualify for low-income utility programs, such as those for weatherization or bill assistance.

More generally, the lifestyle perspective opens the door for larger energy efficiency-relevant questions about the *sources of lifestyles*, the means by which lifestyles are *reproduced and maintained*, and the influences and conditions of *lifestyle change*. All of these topics are now appearing in EU conversations about *sustainable lifestyles*, as well as the nature of habits and practices, and creating change in large-scale, socio-technical systems. We take up those topics in the final part of this section. However, first we consider one of the most common applications of the lifestyle perspective in U.S. and EU energy efficiency programs – *customer segmentation* for marketing purposes.

5.4 Marketing Segmentation

In assessing the prospects of moving from a theoretical understanding of social distinction and lifestyles to a workable strategy for *segmenting* consumers into different target groups for the purposes of changing their energy-use behaviors, Shove and Wilhite (1999) take a pessimistic view:

> "Reflecting on conventional economic approaches, Douglas and Isherwood (1979, 907) make the following observation: '… it would seem then that the clue to finding real partitioning amongst goods must be to trace some underlying partitioning in society.' Pursuing this theme, considerable attention has been paid to the terms in which social distinctions are drawn and to the deliberate (or retrospective) positioning of people's consumption, one with respect to another. This is relevant for energy analysis if it can be shown that some groups of people, that is some lifestyle segments, of the population, consume more energy than others. Going a step further, comprehensive analysis of all lifestyle segments, and associated patterns of energy demand, promises to reveal much of relevance for the analysis of energy consumption. If it were possible to also analyze the dynamics of these segments (i.e., how people move from one segment to another, and how whole segments change), it should then be possible to predict future energy demand. [We have] concluded that this was a vain hope for a number of reasons."

Some of their reasons remain valid, including concerns about data, methods, capturing change over time, lack of theoretical underpinnings, and mismatch between the segments identified and policies. We do not argue here that the practice of segmentation should be rejected out of hand. It is being pursued by utilities in serious efforts to better understand, communicate with, and provide program benefits to customers. Also, the segmentation perspective on differences across consumer populations can contribute to new policy conversations and ideas. However, we conclude that the practice of consumer segmentation is anything but straightforward and is actually fraught with problems that need to be better acknowledged.

5.4.1 Segmentation Basics

The importance of distinguishing customer types has been obvious to electric utilities from their beginnings, particularly in terms of efforts to guide system-load management, tariff development, and marketing. A variety of segmentation approaches can be found in use. The most common approach is probably the basic *residential* vs. *non-residential* sectoral distinction. Within the residential sector, it is also common to differentiate *single-family detached* dwellings from *multifamily* units (sometimes further subdivided into duplexes, triplexes, condos, and apartments). Also, separating dwelling owners from renters in program planning makes considerable sense for targeting treatments and crafting communications.

Users can also be classified in terms of their energy demands (e.g., low, medium, or high levels of consumption). It is also possible to go further and categorize customers on the basis of observed load shapes using statistical clustering techniques, neural networks, or other measures (Chicco et al. 2003). Finally, segments can be associated with technologies, such as all-electric homes and those with pools, and with unique rates (e.g., time-of-use, green power rates).

In the marketing literature, the first evidence of segmentation seems to be Wendell Smith's (1956) proposal for a formal segmentation of customers (although this has certainly been practiced informally by astute merchants and their salesmen for millennia). Since that time, a range of different segmentation approaches has been advanced to help market a host of non-energy-related goods. These approaches have variously differentiated consumers on the basis of demographics (age, sex, income, ethnicity), as well as purchase patterns, media exposure, attitudes, and lifestyles (the latter usually some combination of attitudes and demographics).

Beginning at least in the 1980s, utilities have experimented with customer classifications for general communications and to more effectively market energy efficiency programs. They have used a variety of geographic, demographic, and energy-use segmentation schemes. However, an advantage of lifestyle segmentation over simpler geographic and demographic approaches is that lifestyle segmentation helps to address the reasons behind what is observed – rather than simply who, what, and where (Feldman & Mast 2000). We should also note a special category of customer for both utilities and regulators, which consists of households on energy-assistance programs and others who may be hard to reach for non-income reasons (e.g., ethnicity, rural residence). These customers often receive customized treatment in terms of both utility information and services (CPUC 2008b).

Segmentation is an intuitively appealing idea, which may go a long way in accounting for its popularity in marketing (Sjöberg & Engelberg 2005). The allure derives at least in part from the fact that classifying things and people is a fundamental cognitive activity in everyday life. In presenting profiles based on observable characteristics that purport to map to future behavior, these segments hold the promise of tipping prospects' hands, as do archetypes in narrative or the intuitive work of a skilled salesperson figuring out what to sell to whom and how. Results can be quite solid when looking at extreme groups, e.g., niche markets (*super-conservers*, or *unchangeable*). But going beyond that is more difficult, especially in an increasingly diverse "post-traditional" society. As far as we can determine from the general marketing literature, scans of segmentation schemes in common use in the marketplace, the energy efficiency literature, and expert interviews, even the most seemingly sophisticated segmentation typologies have only tenuous groundings in social science theory (e.g., the work on class, culture, and lifestyle discussed above).

This means that despite its popularity, or possibly because of it, customer segmentation results may often be more artistic than scientific. Some of the statistical issues are discussed in the next section. Market segmentation is usually done privately and the results, much less the statistical analyses used to derive the results, are rarely subjected to public view and review. The modes of analysis, classification algorithms, and underlying data are proprietary – as they should be in a commercial context. Why would one give away intellectual property that supplies value? Statistical analysis for identifying customer segments is more difficult than it seems at first, but it probably can be done well, and the marketing companies have many years of experience and vast amounts of private data to draw upon. Thus, there is no reason to suppose that they do not do it well. However, one of the crucial problems is *applying* the results of the segmentation, no matter how well it is done (discussed below).

Nevertheless, there are uses for this information beyond the statistical results themselves. The process of segmentation can create a focal point, drawing attention to customer perspectives and the texture of the population of interest, which otherwise may be seen primarily as averages or dominant stereotypes. What detailed lifestyle customer segmentation might do best is to help to combat the tendency of planners to think in the abstract model of rational, context-less decision-making, as well as give rough estimates of the relative presence of various types of situations. Segments can also be used to help to construct desirable *images*, with which customers can be encouraged to strive to identify (e.g., the hero of a purchasing narrative), certainly a very common advertising strategy. And we have learned of utilities that use segment types to sensitize their employees about the differing needs, desires, and priorities of different groups of customers.

5.4.2 Statistics and Statistical Interpretation

The statistical basis of market segmentation is a set of multivariate techniques, most of which are descriptive, some predictive. The descriptive methods attempt to classify a set of data – that is, a set of cases (typically representing a customer), each consisting of an identifier and values for an array of specific parameters – into groups, such that the groups are distinct from each other and that the cases within each group are homogeneous.

For example, a case could consist of a name, address, basic demographic information, and the results of an attitude survey. This may be done for a sample (as in the case of an attitude survey) or for a population, if sufficient data are available. Group construction is traditionally done using cluster analysis, a collection of statistical techniques that impose measures of *distance* between every pair of cases. This is a form of pattern seeking. Distance is very abstract here, especially for categorical variables (e.g., race); the analyst must decide what metric to use and this can have a critical impact on the results. The segmentation specialist must also decide the number of clusters – too many clusters risks fragmentation and the creation of spurious groups (i.e., based on sample anomalies); too few clusters and the resulting groups may be too heterogeneous.

Furthermore, the data may often be transformed before analysis (Dolnicar 2003), which also introduces subjectivity. The results, in the forms of coefficients, tables, and labels, have convincing solidity as far as the most likely naïve consumers of typologies are concerned. What appears scientific is actually subjective, especially in the hands of analysts who are not experienced statisticians. The crucial interpretive problem is that, given sufficient cases and variables for each case, modern statistical techniques make it nearly impossible not to identify clusters. In any particular segmentation, many or all of these groups may be meaningless in terms of how they relate to the issues of original interest, especially insofar as they add anything over a simpler, intuitive, classification (e.g., single-family home vs. apartment). That is, rather than revealing underlying characteristics, the method can impose them (Dolnicar 2003). From a statistical perspective, there are four main questions:

1. *How distinct are the groups and how homogenous are the cases within each group?*

2. *What items of interest do these groups map to and how well? Why do the classification at all?*

3. *Related to both of the above questions, how reproducible are the results?*

4. *How well can they be used beyond the sample, if at all? How actionable are the results?*

The first three questions are matters of accounting for the effects of randomness. The latter (as well as the third), refers to the relationship between the sample and the customer population – and how well the results from the original sample can be applied to the population.

Translated to the problem of segmenting utility customers, the questions correspondingly become:

1. ***Do the groups identified really represent distinct types of customers (i.e., customers who are similar enough within each group, and distinct enough among groups, to warrant different approaches for various groups)?***

2. ***If so, how consistent and predictable are the behaviors of customers within the group, relative to the utility's questions?*** In particular, do the groups really relate to the questions of ultimate interest (e.g., uptake of a particular energy efficiency program, propensity to respond to a particular type of incentive)? Descriptive methods, discussed below, help assess predictive power. But the ideal goal of most segmentation is to predict how customers will *react* to a program (i.e., future behavior), rather than to simply predict current and observable characteristics.

3. ***Are attitudes of segments relevant to energy efficiency programs?*** Almost always, attitudes (or other survey data for which the clusters are constructed) are collected only for a sample of the population of interest. From a statistical perspective, the sample may not be representative of the population (no matter how large the sample is). From a broader analytical perspective, it is unclear whether arrays of responses on attitudes map to any cohesive types, even if (by definition) they correspond to response tendencies. Statistical pattern-recognition techniques were originally designed for analyzing physical characteristics of phenomena. Attitudes (at least as recorded on survey instruments) may not even map to energy-relevant behaviors (Gillingham et al. 2004).

4. ***How can programs or policy instruments use this information to incrementally improve which customers are targeted, and with what approaches or incentive structures?*** Segmentation, if well done, permits improvements over undifferentiated mass marketing, but most policy approaches are still blunt relative to the intricacies of the customer behavior. Even so, there are likely cost efficiencies in refining definitions of target markets.

We do not claim that any particular segmentation approaches available for use in differentiating and targeting residential energy consumer populations are especially strong or weak on the dimensions discussed. We do not have the data (nor could we likely obtain it) to answer that question. However, it is instructive to consider a few of the segmentation approaches that have been used, are in current use, and/or are under consideration by utilities in California and elsewhere.

As noted, market segmentation is usually done in the private sector. Claritas *Prizm*™, Experian *MOSAIC*™, ESRI *Tapestry*™, and SRI *VALS*™ are all well known residential segmentation systems, each defining various *lifestyle* classifications and providing mappings of these lifestyles to geographic locations. The Electric Power Research Institute's (EPRI) *CLASSIFY*™ segmentation is a somewhat different classification system, developed in the 1980s, that was once especially popular in the energy efficiency field. Utilities and other organizations interested in energy use, use any number of segmentation schemes in conjunction with their own customer data (on loads, from attitude surveys, etc.) to derive customized segments for targeted marketing. Some examples of the geographic lifestyle segmentations and of their application to energy consumption or carbon emissions are reported in Appendix B.

5.4.3 Considering Segmentation and Lifestyle Change

We have only scratched the surface in considering segmentation strategies and their roles in utility energy efficiency programs in California. While we believe that all of the utilities are using or have used various approaches to customer segmentation, there is probably not a clear agreement across utilities (or within different units of specific utilities) about the relative merits, problems, and benefits of: (1) segmentation in general; or (2) particular segmentation approaches, as noted below.

- *Problem:* Customer segmentation is appealing and popular, but the underlying theoretical foundations are unclear and probably, in most cases, are non-existent.
- *Problem:* There is plenty of room to go wrong in underlying statistical analysis – particularly in the *art* of variable selection, measurement, transformation, and application of statistical techniques.
- *Problem:* Results are usually developed on a sample population for which special data have been collected. In order to successfully extend results to the population of interest, there must be observable linking variables. Postal codes are the most obvious example, but this raises the question of whether the segmentation is an improvement on simpler demographic methods, especially since direct mail may not be a very effective way of targeting decision-points. The extent to which the additional detailed information can be

managed to target and effect change, as compared to more intuitive or simpler approaches, is unclear.

- *Problem:* Policy instruments and program delivery methods may be too broadly focused to effectively use the results.
- *Benefit:* The quality and applicability of statistical analysis aside, the process of segmentation can help draw attention to the diversity of customers and their needs. It can also often identify important niche markets (e.g., customers who are nearly impossible to influence).
- *Benefit:* Segmentation can serve as a basis for policy conversations and program innovation focused on differences between consumer subgroups and across the state.

However, segmentation as commonly practiced – despite offering often intuitively-appealing descriptions of various lifestyles – tends to treat differences in ways of life as either being voluntary (i.e., a matter of "lifestyle choice") or rooted in individual psychological traits. In fact, many segmentation schemes are explicitly understood as *psychographic* exercises in which personal characteristics are sifted and sorted. In our view, these particular understandings of lifestyle and approaches to segmentation are too weak to support serious efforts to change lifestyles.

5.5 Lifestyles Embedded in Social Systems

As noted above (see Section 4.6), European policymakers have begun to focus on the need for action to *change lifestyles* and *promote sustainable consumer behavior*.[26] Traditional approaches have supported programs that focus on encouraging voluntary behavioral change by influencing individual knowledge and/or perceptions, rather than changing contextual factors that may determine households' decisions (Abrahamse et al. 2005). These interventions have met with varying degrees of success. Information tends to result in higher knowledge levels, but not necessarily in behavioral changes or energy savings – the so-called *attitude-behavior gap*.[27] The appeal of older models of behavioral change, such as *information-deficit*, is that they seem to promise relatively simple solutions (Owens & Griffill 2006).

But when it comes to dealing with more complex concepts of social practices, lifestyles, or systems of provision as the target of policies and programs, the factors involved are not so easily translatable into policy levers. Yet, addressing such complexities is clearly required. In a recent survey of user behavior in EU energy-efficient home projects, only 23% of households interviewed were found to use heating systems in ways that responded with policy expectations,

[26] Again, Heather Chappells was the primary team researcher in this area.

[27] European studies exploring the inconsistent relationship between environmental knowledge and practice with relation to energy and water behavior include: Dulleck and Kaufmann (2004), Gilg and Barr (2006), and Moreau and Wibrin (2005).

while 50% used systems in a way that was "efficient" from their own perspective and suited their lifestyle (Pett & Guertler 2004).

Current policies and programs towards sustainable consumption are generally rooted in the need to find ways of making sustainable consumption attractive to the millions of diverse individuals who are often lumped together as *the consumer* (DEFRA 2003). Delivering improvements in sustainable consumption requires sophisticated policy packages tailored to specific consumers and circumstances, rather than single or *one-size-fits-all* tools. This involves using combinations of economic instruments, voluntary measures, regulation, and information tools.[28] In addition to segmentation approaches similar to those used in the U.S., social scientists in the UK and EU have begun to think more broadly about the embeddedness of lifestyles in social systems and the implications of this for sustainable consumption policies.

5.5.1 Emerging Social Science Perspectives on Consumer Lifestyles and Social Systems

The importance of conceiving of the residential energy user as a social and cultural creature who is part of larger shaping and constraining systems is stressed in several strands of European research. We examined the relevant literature and consulted key reviews of social science theory and research on energy consumption and behavior change in order to identify relevant themes.

Since the late 1990s, an emerging sustainable consumption and lifestyles agenda has highlighted a variety of tensions related to the question of continuing growth in material and energy consumption, despite well-established programs to improve efficiency.[29] Different concepts of lifestyle, their significance in explaining household consumption patterns, and some of the problems encountered have all been addressed (Jensen 2008).

Within many lifestyle studies, questions have focused on whether growth in consumption is the result of expanding societal aspirations and expectations, or a function of institutional and technical *lock-in* (Røpke 1999; Shove 2002). The answer likely lies somewhere in between, and involves understanding both changes in modern consumer lifestyles and in institutions that support energy-intensive ways of life. To this end, several integrative models have been developed and empirically tested in the EU water and energy sectors that analyze this relationship. Of particular relevance to energy consumption is Spaargaren and van Vliet's *social practices* framework that conceptualizes changes in both lifestyles and in *systems of provision* that support energy practices (Spaargaren & van Vliet 2000).

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[28] See also the Lyndhurst report (2007) that evaluates the effectiveness of consumer segments defined in DEFRA's model in understanding real-life behavioral differences and how consumers in different lifestyle groups have responded to interventions to improve policy effectiveness (e.g., smart meters, differentiated tariffs, personal carbon allowances).

[29] Useful reviews of this field are provided by Jackson (2004) and Ropke (2005).

The issue of how to better understand consumer behavior in order to motivate change in a more sustainable direction is another area that has received increasing attention. In reviewing the literature in this field, Jackson (2004) finds support for the argument that much environmentally significant behavior is routine in nature. It is, therefore, vital for sustainable consumption policy to find ways of addressing and renegotiating habitual behavior. This is not an easy task, since consumers appear to be locked into unsustainable patterns of consumption through a mixture of habit, institutional constraints, and social norms. Yet, to date, lifestyle interventions still seem to be focused on achieving change through influencing consumer behavior by relying rather heavily on a notion of consumer choice or the active consumer as a driver or agent of change.[30] Sociological and anthropological studies of domestic consumption suggest that people's behaviors and choices are more deeply *embedded* in social, cultural, and technological systems than imagined in "compartmentalizing" lifestyle models (which tend to see structural factors as *external* impacts on individual behavior, rather than as integral parts of consumer cultures).[31] This limitation has inspired recent studies designed to explore the origins of underlying values and norms that structure daily routines and habits of ordinary consumption (Gronow & Warde 2001).

Three related, but still distinct, approaches to understanding the relationships of consumers, households, and environmentally significant consumption to larger structures and systems are found in: (1) the sociological view of *social practices*; (2) human-technology interaction studies; and (3) socio-technical systems research. The following three subsections briefly consider each of these in turn.

5.5.2 Focus on Social Practices

Sociologists have begun to apply a *practice* approach to empirical investigations of energy and water consumption (Hand et al. 2003), although this has yet to translate into a significant program of research.[32] Here, practice generally refers to a *routinized type of behavior*, the establishment and reproduction of which is dependent on the interconnectedness of many elements. These include forms of bodily activity, mental activity, things and their use, background knowledge, and emotions (Reckwitz 2002).

Diverse routines, such as showering, cooking, doing laundry, heating, and so on depend upon shared conventions and understandings, and are bound up with concepts of propriety and waste, along with material infrastructures and culturally significant interpretations of what it is to be a *normal* member of society. Instead of examining environmental attitudes and motivations toward

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[30] See Jensen (2008) for a discussion of different *lifestyle* approaches and their relative reliance on individual/ structural factors.

[31] For example, in identifying the range of potential factors that can influence lifestyle and consumer choice, Bin and Dowlatabadi (2005) distinguish between individual determinants (e.g., attitudes and perceptions) and the *external* environment of regulation, technology, culture, and social class.

[32] Two recent UK research programs – *Sustainable Technologies* (ESRC) and *Cultures of Consumption* (AHRC-ESRC) – have, however, supported some projects that represent a step in this direction.

energy saving, the practices approach focuses on the ordinary and everyday contexts in which normal consumption occurs and evolves. This means thinking about energy in terms of what people are *doing* and what it enables them to accomplish socially – focusing attention on *activities* rather than on energy itself (Shove 2003).[33]

A practice orientation leads towards a different conceptualization of change than that invoked in lifestyle approaches. The perspective does not suppose that lifestyles can be changed by force of political, moral, and environmental commitment or persuasion. A practices approach understands changing conventions of everyday life to be the result of collective, contingent, and emergent processes of socio-technical co-evolution (Shove 2005). There are several policy implications of this insight. First, humility about lifestyle change aims is clearly indicated. Second, a *co-provision* perspective – one that sees social consumers, market actors, and policymakers as collaborators and co-contributors to energy system change – seems to be supported. We consider the idea of co-provision in greater detail in the final section of the white paper.

5.5.3 Considering Human-Technology Interactions

A related perspective focuses on human-technology interactions. It is not fundamentally different from the practices view, but it explicitly recognizes the importance of the *technological* dimensions of change. However, it does not subsume devices into practices, nor does it elevate technical elements above social and cultural ones – as is often done in energy efficiency policy. Human-technology interaction studies highlight the codependent relationship in everyday life between humans, technologies, and the built environment (Røpke 2001; Wilhite 2008). Domestic energy consumption is understood to be part of a complex of occupants, activities, technologies, and values. Devices are *used* and found *useful* only as humans introduce them, manage and control them, and neglect and discard them. This is similar to a practices view. But human-technology interaction studies are also particularly interested in *change* in systems taking place at the household level.

Household technologies and associated behaviors are always on the move. Røpke remarks on “the ever widening range of consumer goods” in contemporary households where “known products are differentiated, specialized products are developed for every conceivable purpose, new products for hitherto unknown activities appear” (Røpke 2001, 417). As science and technology studies have shown, the design and marketing of consumer goods and the services that support them can actively encourage the growth of energy-intensive behaviors.[34] For example, examining the burgeoning UK consumer home electronics sector, Crosbie (2008) finds that modern flat-screen television sets restrict consumer choice and, at the same time, open up a range of uses other than viewing television programs at set times during the day. They are now also used to play electronic games, search the web, watch DVDs and videos, listen to the radio,

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[33] One might comment, “Oh, yes, the ‘energy services’ perspective.” But, in reality, the focus on practices and meanings is a much richer and more realistic depiction of reality than that ordinarily imagined in the language of *services*, which can easily convey a mechanical and deterministic quality that everyday routines rarely display.

[34] See, for example, Bijker (1995), Cowan (1983), and Cockburn and Ormrod (1994).

and watch films and sporting events on demand, via satellite and cable broadcasts. Many of these so-called “added-value” functions support more energy-intensive practices – for example, the use of televisions for listening to digital radio. Questions of how to promote change in energy behaviors in these contexts become a matter for regulation in production, manufacturing, retailing, and distribution, as much as being rooted in mechanisms of consumer choice. What is remarkable, Crosbie suggests, is that until relatively recently, concern over the energy used by consumer electronics has been largely overlooked by UK energy policy and energy-saving initiatives.

In both the UK and EU, questions of global convergence in technologies and practices have also arisen. For example, the importation and adoption of goods, such as much larger American-style refrigerators, can serve to generate new routines of daily consumption that replace more energy-saving habits (Shove & Southern 2000). Looking behind these trends, it is apparent that the co-definition of new cultures of consumption and provision of an array of supporting technologies are shaping increased levels of energy consumption in the home.

These studies of human-technology interactions point to an intertwining relationship between humans and their physical world. Buildings, ventilation and heating systems, and thermal control devices both influence and are influenced by habits and ideas among designers, builders, and users of these technical artifacts (Henning 2006). Rather than trying to change people's habits or promote technologies that are energy-efficient in a mere technical sense, the challenge highlighted by sociologists and anthropologists is how to promote technologies that can tap into cultural diversity and support existing, less energy-demanding habits.

5.5.4 Socio-Technical Systems

The third perspective focuses on *socio-technical systems*. It is best developed in the UK and EU, but also is being used in some social science research in the U.S. Socio-technical systems studies are related to those on lifestyle, social practices, and human-technology interactions. But they tend to concentrate at the system level rather than on households. In this way, they share some perspectives with the U.S. market-transformation tradition, but go beyond the relatively simple *upstream actor* and *supply chain* concepts that inform market-transformation *program theories* and *market assessments*.

Large technological systems, such as energy infrastructures, are now so integral to everyday lives that consumers have effectively become part of these systems (Guy & Marvin 2001). This inter-dependent relationship, reinforced every time a light is switched on, means that consumer behavior needs to be understood as a wider consequence of energy systems (van Vliet at al. 2005; Spaargaren 2004). The theoretical argument is that socio-technical interdependencies shape the contexts in which needs evolve and actions are structured (Wilhite et al. 2001). This view of consumer choice stresses constraint and limitations on the range of individual action and household behavior. There are several different directions this new wave of *systemic* thinking has taken that reflect differences in the meaning of “energy systems” and how relationships and dynamics between consumers, providers, and infrastructures are understood (Chappells 2008).

For example, a goal of systematically transforming the contexts of energy demand might argue for a strategy based on improving the efficiency of entire supply and distribution systems through which particular services are provided to consumers. The focus here is not on the consumer per se, but on the *organizational networks* ("supply chains") through which goods and services are produced, delivered, accessed, used, and disposed of (van Vliet at al. 2005). But what happens in one part of the supply chain also influences what happens elsewhere. This has been demonstrated most dramatically in the situations where resources are in short supply. For example, in times of fuel shortage, EU utilities have sometimes asked consumers to save energy, effectively engaging them as co-managers of the supply system and co-providers of energy and efficiency. The beginnings of new systems of *co-provision* of renewable energy supplies can also be found in households fitting solar panels to roofs and community-level energy grids. These developments open up a range of possibilities for system innovation, including the establishment of new principles of demand management (e.g., intermittent supply, based on the availability of local sources).

All of the emerging perspectives discussed here, and the analyses that they support, have challenged conventional wisdom about where the responsibility for delivering energy efficiency or achieving more sustainable consumption patterns lies. Rather than a matter of individual choice, the focus is on the multiple points of institutional, infrastructural, and cultural intersection through which opportunities for changing consumer behavior might be structured. We believe that practices, human-technology interactions, and socio-technical systems views all capture different qualities of the systems involved at multiple levels of organization. A particularly promising line of thinking is captured in the UK and EU imagery of *co-provision*, which we consider in the California policy context in Section 6.

5.6 Summary

In this section, we evaluated five alternative developments that show promise for expanding the conventional energy efficiency policy frame in ways that may take consumer behavior and technology choice more realistically into account. They included insights into consumer behavior and choice from the perspectives of behavioral economics, cultural and economic anthropology, sociological studies of status and lifestyle, consumer segmentation approaches, and new themes focused on broader systems being proposed by social scientists and energy analysts in the UK and the EU.

We found that behavioral economics seeks to provide neoclassical economics with more realistic psychological foundations. We should note that the simplified *proto-economics* of the PTEM is not strictly equivalent to neoclassical economics. The latter has a more complex and nuanced view (although one that is often so abstract and macro-focused that it paints a very simplistic picture of technologies, as well as persons). Some useful insights from behavioral economics that might contribute to improving the PTEM involve areas of consumer perception, judgment, and choice that involve risk assessment, loss-aversion in cost/benefit calculation, commonly observed patterns of judgment while assessing choices, reference values in choice, the role of emotions, and normative understandings of fairness (although without attention to the normative and cultural foundations of judgments and choices).

However, an anthropological view of culture and *economic* choice present a starkly different picture. In this view, because energy is invisible, many aspects of *energy consumption* are not subjected to conscious reflection about energy flows. Energy makes possible the consumption of cultural goods that arrive in homes bearing social biographies that are shaped by commercial interests and public policies, the bulk of which encourages consumption. And unlike the PTEM's (and economists') taken-for-granted assumptions that individuals are doing the consuming and choosing, economic anthropologists see energy being used and conserved by households and other groups and networks. In these social groups, *culture* dominates and shapes (and makes intelligible) behaviors through social roles, norms, relationships, and so on.

Furthermore, the consumption of some important cultural goods (such as houses, appliances, and cars) that are also heavily energy-consuming items is connected with the visible display of success (i.e., social performance). These forms of consumption are also reinforced by a range of pressures, both formal and informal. In terms of energy efficiency behaviors and choices, anthropologists point to gender imbalances within the household in the distribution of energy efficiency costs and benefits. Also, pursuing energy efficiency can be status-threatening (e.g., in line-drying clothes) and good energy intentions may lead to less-than-best energy outcomes (e.g., solar panels vs. weatherstripping). But culture is also continuously evolving, so interventions that help to shape cultural codes and social norms are imaginable.

To sociologists who are interested in group differences in consumption, including the consumption of energy in households, cultural patterns can be seen as *lifestyles* that are socially structured. Focusing on social classes, social status hierarchies, and other ways that consumers' lives are organized, sociologists argue that it is not just whim or arbitrary *group-think* that produces and enforces cultural patterns. Instead, real social *work* is being performed by status displays of houses, cars, appliances, clothes, and the rest. Important distinctions are being made, and relative power and influence is being exercised. In this view, variability in energy use follows lifestyle status differences. We also linked this research to a less social structural-lifestyle tradition in energy analysis that has argued for the examination of lifestyles in order to understand consumer differences that are salient to policymaking and program targeting. And we noted that when we use the notion of lifestyle in this way, we may be able to see where particular social groups are inadvertently overlooked in current energy efficiency offerings.

We also examined the use of segmentation in energy efficiency program marketing and identified some inherent problems that have to do with connections to underlying theory, including incorrect theory (e.g., individualistic/psychographic) and absence of theory. We also discussed problems related to data and models, with specifying consumer types with any confidence, and with alignment of segments with policy instruments. However, we concluded that segmentation is widely practiced in energy efficiency program marketing, where it represents an important acknowledgment of variability in customer populations (and a commitment to take diversity into account), and can provide a basis for program innovation and new conversations about policy and programs.

In terms of cutting-edge thinking in Europe, we found questions about the adequacy of the energy efficiency paradigm to address significant carbon reduction goals – particularly, in the face of rising energy demands at the same time as efficiency programs have been producing gains. Notions of *average*, *normal*, and *baseline* levels of consumption are being replaced by an appreciation of variability and difference. The desire for sustainable lifestyles is coming to be seen less as a matter of influencing *individual choice* than of confronting the force of expanding societal aspirations and expectations.

In this regard, the diffusion of the new, more efficient technologies to replace outdated appliances in households needs to be carefully balanced with an understanding of how these technologies can also create new consumer expectations and standards. Technologies and supporting institutions/policies can be seen as *lock-in* influences.

New models of change include Spaargaren and van Vliet's (2000) *social practices* framework that conceptualizes simultaneous changes in both lifestyles and in *systems of provision* that support energy practices. In this view, *lifestyles* are linked to norms, routines, and habits; patterns of energy use are related to patterns of social routines. This is equivalent to the meaning of cultural patterns in anthropology. But this definition of *normalcy* locates inertial forces in larger social and technical systems, as well as households and neighborhoods.

This has implications for energy efficiency policy and intervention. Rather than suppose that lifestyles can be changed by the force of political, moral, and environmental commitment or persuasion, a practices approach understands changing conventions of everyday life to be the result of collective, contingent, and emergent processes of socio-technical co-evolution (Shove 2005). Careful attention is required as to how technologies, devices, and appliances regularize/concretize routines, carry meanings, and force behavior to adjust. And the fact that they are not acquired and used solely as a result of individual preferences and choices, forces attention to regulation in production, manufacturing, retailing, and distribution, along with consumer choice.

And this, in turn, requires a better understanding of how consumers have become parts of large technical systems, such as energy infrastructures, that are now so integral to everyday life. The focus turns to *commodity chains*, through which goods and services are produced, delivered, accessed, used, and disposed of. This is the *upstream* world of market transformation interventions, but the European variant has as its aim a much broader agenda.

Going beyond simply understanding supply-chain actors' motivations and needs in order to influence them to feature approved products (such as CFLs), the *systems of provision* perspective suggests that interventions should also take place at the point of design, product mix determination, etc. The objective would be to more fully understand the *how* and *why* of technology decision-making, and the exercise of control in the supply chain in order to pro-actively influence the actual shaping of technologies before they come to market.

This is not something that can be effectively done by social scientists or technology-oriented officials any better than the current market arrangements that deliver technologies by the container load, accompanied by cultural encouragements intended to stoke consumer *demand* for what we are now coming to realize are too often – in energy and environmental terms – inferior goods. [35]

What is needed is continuing critical conversation about technology that more fully incorporates the long-term interests of consumers, ecosystems, and governments, in addition to those of investors, managers, production workers, and supply-chain intermediaries.

[35] A modest exception might be some government procurement policies that hope to encourage energy-efficient product offerings.

6. Conclusions and Recommendations

In this final section, we do not repeat the contents of the entire white paper, but step back and try to take a larger and longer view. We have presented a considerable amount of detail. In some areas, we are fairly certain about what we know – "we" in this sense being the social science and policy communities. In other areas, we have similar confidence about where we've been wrong. In still others, a good deal of uncertainty remains.

To be more specific, we know that energy use and efficiency choice are complexly molded by a variety of influences (enumerated above). We also know that the narrow PTEM policy frame and its variants serve important policy goals related to accountability and prudent expenditure. However, the model and its underlying assumptions are fundamentally incorrect in the sense that they do not offer anything close to an accurate depiction of the dynamics of real-world energy consumption and conservation action. As for the uncertainties, there are many. Examples include the interactions among determinates of demand (e.g., values, behaviors, and building performance), program realities vs. policy positions (e.g., slow upstream change and immediate kWh savings), and the viability of alternative approaches to achieving higher levels of efficiency. And, in relation to the latter, a major question before us is, *Can we get there from here?* – where *there* is the accomplishment of Assembly Bill 32 carbon reduction targets (AB32 2008a) and *here* is the current residential energy efficiency policy frame and program practice.

This concluding section of the white paper presents some of the authors' high-level thinking about the implications of our findings for future policy discussions and research agendas (subsections 6.2-6.4). On the way, we briefly revisit the PTEM policy approach and its real-world implementation. This time, however, we also draw on additional information obtained from our interviews with utility program staff when we asked for their *forward-look*ing views about the possibilities for new approaches to consumers and the constraints on these sorts of program innovations.

We then consider the need for new thinking about energy, behavior, and policy intervention that follows from California's ambitious climate-change mitigation goals. We also discuss possible new approaches to residential-sector energy efficiency program design and implementation. We do so by first identifying uncertainties in our knowledge of underlying systems and presenting some behavioral research needs identified by the California Air Resources Board and the National Academies. We conclude by discussing the potential for program experiments and next-generation pilot interventions.

6.1 Conclusions: Policy Frame and Program Practice

As noted in the previous sections of this paper, a basic *physical-technical-economic model* (PTEM) has oriented energy efficiency policy and programs since the mid-1970s. Social scientists and a number of energy analysts have been highly critical of the PTEM policy frame and its narrow focus on devices, purposive behavior, costs, calculation, rationality, information, program accountability, services, averages, and so on. We also noted that the PTEM is rooted in strong paradigms (from economics and engineering) and is the product of regulatory imperatives.

6.1.1 The Regulatory Context

The PTEM has provided the necessary legitimacy for energy efficiency program spending in the regulated utility environment. It is clearly not just an artifact of history and the influence of dominant disciplines and professions, but a regulatory policy innovation. And it is important to note that the PTEM's spartan focus on devices, measures, services, investments, and rates of returns is articulated in official policy documents cited in this report. These represent foundational legal statements with which utility program planners and evaluators are required to comply.

The utility staff that we interviewed voiced an appreciation by the utilities of the limitations of the model. The interviewees suggest that it is not a lack of goodwill or poor knowledge that leads them to couch their program activities in overly simplified terms, but regulatory requirements that focus on devices and paybacks.

Those interviewed also pointed out that financial incentives associated with energy efficiency equipment encouraged the utility to directly attribute the outcome to their action. In the program evaluation environment, it is important to demonstrate that the program actually had an influence on equipment choice. So encouraging investments in specific measures makes it easier to justify the cost and to earn credit for the program expenditure.

In their view, the policy context also has a strong bias against directly *incenting* changes in usage behavior. As one interviewee said, "It's believed to last only two days or something. Behavioral change doesn't count." And followed up with, "Read the manuals" (e.g., the CPUC *Standard Practice Manual*).

From the regulator's point-of-view, there are a variety of reasons why the PTEM model has *worked* for several decades of *resource acquisition* activity. First, the legalized context of utility regulation opens all policies to challenge, encouraging economic and mechanical problem framings that link well with accounting practices and administrative law defenses. Second, and as important, the goals of energy efficiency policy have long been based on framing energy efficiency as a *least-cost supply of energy*. These goals have been quite *modest* in the sense that their *big picture* payoff is the delay of power plant construction through modest efficiency improvements.

Looking at small marginal gains doesn't require a depth of knowledge or understanding about consumers, choices, and the complexities of how demands are structured. In fact, it apparently can be done through the use of weak and even incorrect models (in terms of social science theory and research). However, the downside comes from the fact that this sort of regulatory framework and goal setting implicitly *denies the need* for a richer understanding of behavioral effects in the program context, and discourages efforts to optimize program outcomes. As one interviewee put it, "Small goals and low historical funding meant you just did some measures, focused on incremental influence and measure installation." In other words, you *do what you need to and not very much more*.

6.1.2 Evolving Program Approaches

In an evolving policy and program context since the 2001 California and West Coast electricity supply crisis, expansions of the basic policy frame have taken place, both in terms of formal program representation (e.g., in Program Implementation Plans [PIPs]) and in actual program practices that now deviate somewhat from characterizations in documents.

After interest in the 1990s in addressing *barriers* to choosing energy efficiency, a noted *efficiency gap*, and a turn to market transformation approaches, restructuring in California took center stage, and energy efficiency became less relevant and, in some cases, persisted only at very modest funding levels. The 2001 crisis resulted in a retreat from markets (and, ironically, from market transformation) and a return to the logic of energy efficiency as a least-cost, *demand-side* source of supply. Following a ramp-up in DSM activities and some third-party innovation in 2002-05, a major expansion of energy efficiency programs under the management of the utilities began in 2006-08. It is planned to continue in a 2009-11 set of programs that build on the current programs, but extend them as part of the CPUC's strategic plan for market transformation.

In some of the programs that are now in operation, utilities are working within *market channels* to influence upstream actions in hardware supply chains. There is an increasing emphasis on influencing markets and trade allies as a more cost-effective way to intervene than to "touch" millions of individual consumers directly. However, there are some measurement issues when working with market channels that were frequently cited by interviewees. These relate to the fact that, for market transformation-style interventions, "…it's hard to tie information directly to installed action or measures."

A frequently cited example is the experience of residential lighting programs intended to increase the numbers of compact fluorescent lamps (CFLs) in use. As one interviewee put it, "You get more bang for the buck with upstream environment influence. But [you] need to have hands in the end-user side [e.g., with advertising] as well." However, whether spending on the *upstream* or *downstream* (customer) side of the market, there remains an *attribution problem* of how to link programs to market changes. Evaluation research has addressed this problem. In fact, over the past few years, an increasingly complex conversation has developed around market-related energy efficiency issues. Concepts such as *market effects*, *free-riders*, *rebounds*, *spillovers*, and *maturing markets* are being sketched out, and some focused attention is being given to particular submarkets. But the context is largely that of *impact evaluation* or the measurement of energy savings attributable to more efficient hardware.

Continued exploration of market-level processes can be helpful. But this is a slow route to better understandings of demand and supply chains, and the economic and mechanical foundations of the discussion seem to be an echo of PTEM operating at a higher level of aggregation. Some evaluators involved in the discussion about market changes, interventions, and attribution are beginning to raise questions about the ultimate value of concepts such as the *free-rider* (e.g., Peters & McRae 2008). But it is an open question whether these sorts of market-focused evaluation discussions filter down to program operators. Some of the market transformation *market characterization* studies are likely of greater value, and a number of fairly detailed studies of this sort have been commissioned in the past by the CPUC and utilities. The currency and depth of knowledge in these reports (all archived on the CALMAC website) seem to be much stronger in some traditional program target areas (e.g., CFLs and lighting in general) than others in others (e.g., home retrofits).

6.1.3 Program Practice and Craft Knowledge

There is evidence of increased attention in programs to information supplied to consumers via multiple channels (and some evidence of targeting messages to subgroups of consumers or *segments*), as well as market transformation interventions *upstream* and at the point-of-purchase of energy efficiency products (primarily light bulbs, but also HVAC systems). Interviews with utility staff show that they generally view new forms of customer communication and supply-chain intervention as important innovations that warrant continued development. However, they repeatedly cite regulatory requirements as obstacles, particularly *attribution* problems for non-device-centered expenditures or "expenditures that cannot be directly traced to an end-user and a meter."

The utility program staff interviewed repeatedly claim success for market transformation activities. They cite changes in manufacturers' choices, better product offerings in the marketplace, higher quality, willingness to stock items that were earlier considered "risky," greater retailer receptivity, and transformed consumer expectations. They say that close working relationships with supply-chain actors means that "both sides learn to work through issues over time" and that "we come to understand businesses, the business cycle, and how stable relationships with the utility are important for large businesses."

These relationships and accumulated practical knowledge of supply chains are believed by utility staff to pay dividends over time. This organizational learning is rooted in the experience of individual program managers and implementers. As a result, learning and experience are uneven and cannot be taken for granted due to turnover of staff or if any significant expansion of programs is called for, resulting in an influx of inexperienced personnel.

Despite existence of *program theories* and *logic models*, energy efficiency programs are not strictly speaking *theory-based*. The connections to formal knowledge are weak to non-existent. Where explicit statements of theory and logic have been made, they are as likely as not constructed by evaluators as an idealized model to which program activities can be compared. We do not claim that programs work better with formal theories. However, without them, we have to trust that the program managers and operators are using valid lay theories based on experience. This means that the implementation system relies upon *craft knowledge*. Again, there is nothing wrong with this. Numerous businesses, government agencies, and non-governmental organizations (NGOs) are quite successful operating in this mode. There is ample evidence that craft knowledge is a crucial underpinning of formal knowledge, even in the history of the natural sciences (Price 1984). And we can't recommend that all utility planning staff and program operators become social scientists!

However, it is important to recognize the limitations of craft knowledge and to ask what the implications might be for successful energy efficiency programs. As noted earlier, craft knowledge is *carried* by (and owned by) individuals, with some sharing within organizations. But specialization and staff turnover mean that it is also somewhat fragile and can be lost very quickly and unexpectedly. It does not easily *transfer* to new staff, whether coming in as replacements or as part of program expansions. The military has an enormous ongoing training operation that includes both formal/technical knowledge and practical craft knowledge. The energy efficiency industry has nothing like this.

Also, craft knowledge can be partial, biased, and even flat-out incorrect. How would we know this? Possibly through program failure. But that depends upon major failure to reach goals and pointed evaluation results. Evaluations are not usually very pointed in their reports of *weaknesses* and *limitations*. More important, if they were, the feedback from evaluation to program design and operation is diluted by time lags and disconnects in program implementation, assessment, revision, and authorization (Vine 2008). Otherwise, program knowledge and knowledge problems are not open to scrutiny, peer-review, criticism, and modification in the same way as are formal (e.g., scientific, theoretical) knowledge claims.

6.2 Conclusions: Reframing Policy Conversations

Social scientists and energy analysts in both the U.S. and Europe, as well as utility program staff and the regulators who have approved the current program plans, are in agreement that larger systems within which consumer choices are made need to be an important focus of attention.

6.2.1 California's Bold Policy Initiatives

The California Public Utilities Commission recently took a forceful position that larger systems in which consumer choices are made need to be an important focus of attention in the *California Long-Term Energy Efficiency Strategic Plan: Achieving Maximum Energy Savings in California for 2009 and Beyond* (CPUC 2008a), referred to below as the EESP.

In the introduction to the plan, the CPUC states that:

> "In October 2007, the California Public Utilities Commission (CPUC) created a framework to make energy efficiency a way of life in California by refocusing ratepayer-funded energy efficiency programs on achieving long-term savings through structural changes in the way Californians use energy."

The planning process included the CPUC, the CEC, California utilities, other policy agencies, local governments, business, and environmental and citizen groups. Of this group, the CPUC says:

> "Every participant in this process recognizes the formidable task that lies ahead. Every participant also recognizes, however, that ever-increasing energy prices and the urgent threat of climate change require that California set the bar high and move forward quickly and purposefully to realize the full extent of efficiency opportunities statewide and achieve deep reductions in energy demand and usage."

The process that was intended to produce a series of "big, bold ideas" resulted in a vision and set of goals for energy efficiency that focus on large systems and significant changes in how energy is used. Goals in the *residential* sector include:

- **New construction will reach *zero net energy* (ZNE) performance** (including clean, on-site distributed generation) *for all new single and multifamily homes by 2020*.

  Timeline: By 2011, 50% of new homes will surpass 2005 Title 24 standards by 35%; 10% will surpass 2005 Title 24 standards by 55%. By 2015, 90% will surpass 2005 Title 24 standards by 35%. By 2020, all new homes are ZNE.

- **Homebuyers, owners, and renovators will implement *a whole-house approach to energy consumption*** that will guide their purchase and use of existing and new homes, home equipment (e.g., HVAC systems), household appliances, lighting, and *plug load* amenities.[36]

  Timeline: Energy consumption in existing homes will be reduced by 20% by 2015 and 40% by 2020 through universal demand for highly efficient homes and products.

- ***Plug loads will be managed*** by developing consumer electronics and appliances that use less energy and provide tools to enable customers to understand and manage their energy demand.

  Timeline: Plug loads will grow at a slower rate and then decline through technological innovation spurred by market transformation and customer demand for energy-efficient products.

- **The residential lighting industry will undergo substantial transformation** through the deployment of high-efficiency and high-performance lighting technologies, supported by state and national codes and standards.

  Timeline: Utilities will begin to phase traditional mass-market CFL bulb promotions and giveaways out of program portfolios and shift focus toward new lighting technologies and other innovative programs that focus on lasting energy savings and improved consumer uptake.

The *strategies* for achieving these goals are familiar ones:

1. **Building Innovation:** Drive continual advances in technologies in the building envelope, including building materials and systems, construction methods, distributed generation, advanced metering infrastructure, and building design, and incorporate technology advances into codes and standards.

2. **Comprehensive Solutions:** Develop, offer, and promote comprehensive solutions for single and multifamily buildings – including energy efficiency measures, demand

[36] "Plug load amenities" include home appliances, office equipment, entertainment systems, etc. that are connected to the grid through electrical outlets.

management tools and real-time information, and clean distributed generation options – in order to maximize economic decision-making and energy savings.

3. **Customer Demand:** Create high levels of customer demand for progressively more efficient homes through a coordinated statewide public education campaign and incentive programs.
4. **Statewide Solutions:** Collaborate with state agencies and organizations to advance development and to align state efforts on buildings.
5. **Financing:** Work with the financial community to develop innovative financing options for energy and retrofits.
6. **Codes and Standards:** Develop progressive minimum standards for buildings and code compliance and enforcement, tiered voluntary energy efficiency to pull the market along, and subsequent standards.

The accompanying discussion of implementation activities is, appropriately, at a fairly high level of generality, so details remain to be filled in. Presumably, current energy efficiency programs and future variants, at increasing levels of activity and spending, will play an important role in implementing the plan. If the utilities' market transformation capacities are as large as claimed, the current program delivery system may be able to make some significant contributions. We believe that the movement on the energy efficiency front to approach AB32 targets (e.g., reducing CO_2 emissions to 1990 levels by 2020) will also require thinking *outside of the energy efficiency policy box*. Some of this directly involves new thinking about consumers, as well as an exploration of a range of policies and policy instruments that move considerably beyond past thinking and actions.

There has been little need in the past for very nuanced understandings or assumptions about consumers, behavior, or choice in the residential sector. Stereotypes have sufficed to *pick low-hanging fruit*. Despite some policy expectations and exhortations for *theory-based* activities, particularly in the market transformation context, there has been little to show for theory in program design.

Ongoing discussions among evaluators and policymakers about consumer and institutional barriers, market failures, spillover, market effects, non-energy benefits, and so on – coded talk about attempts to broaden the PTEM policy frame from within – have not resulted in major changes in how programs are conceived and conducted. New environmental, economic, and policy conditions may provide a more productive environment for those discussions. However, this is not enough.

The EESP's goals and AB32's ambitious statewide carbon emissions reduction targets require serious consideration of consumer behavior and choice in real-world contexts. A first step is to rethink the PTEM in terms of fundamental assumptions and applicability in a complex and dynamic environment. Presumably, this white paper can serve as a starting point for beginning that review. Rather than assume a stereotyped rational consumer, it will be useful to consider how we might base policies and interventions on more realistic – and *empirical* – understandings of how behavior and choice take place.

Policy deliberations related to residential-sector energy efficiency should also consider options that may not be part of the CPUC's statutory toolkit (and may not be best deployed by the utility regulator). For example, tax policies, building code enforcement, government expenditures, or public-private partnerships in technology development and marketing do not rely upon ratepayer funding, utility regulatory policy models, or electric and gas utility delivery systems.

By thinking more broadly about social goals and legislative imperatives, we can better consider what the most important policy approaches and effective policy instruments might be. It is legitimate to ask: *Who should pay for AB32 implementation?* and *How should consumers, producers and governments share the responsibility?* The fact that energy usage is highly variable will have implications for the sharing of costs and benefits. Policy approaches, and payments and burdens, should be different in tackling building upgrades vs. encouraging and supporting behaviors that reduce emissions.

6.2.2 Policy Evolution: *New Imagery* and *Co-Provision*

Kunkle et al. (2004) proposed that some important lessons for energy efficiency policy could be learned from the consumer response to the 2001 California crisis. That response included significant voluntary conservation and concern about long-term energy and environmental problems in the state (see Lutzenhiser et al. [2004] for an overview of the findings). The title of the Kunkle et al. paper suggested that *new imagery* was called for in energy efficiency policy framing. We also argue that this imagery is much like that proposed in the language of *co-provision* in the UK and EU.

Kunkle et al. cite Mazmanian and Kraft's (1999) conclusion that environmental policy in the U.S. had passed through two earlier *epochs* and had entered a third at about the same time as the California crisis. These epochs of environmental regulation were characterized by changes that could be considered at least modest "paradigm shifts" in which policy approach changed from: (1) regulating *hardware* with *end-of-the-pipe* solutions; to (2) *pollution prevention* programs and *market-based* incentives; and, most recently, to (3) *systems dynamics* and *sustainable development* approaches. Learning from both policy successes and limitations has led to policy innovation and the evolution of environmental policy frames – e.g., in U.S. Environmental Protection Agency (EPA) approaches and other policy arenas (Mazmanian and Kraft 1999). In reality, of course, elements of regulation from each of the earlier periods continue to operate in the current *systems* and *sustainability* context.

The analogous periods that Kunkle et al. identify in the energy efficiency case are those in which policy focus has shifted from: (1) a strict concern with *devices and measures*; to (2) *market interventions*; and, finally, to (3) complexes of *people and technologies*. The authors accurately predicted the current growing interest in *energy and behavior* that is evidenced by the recent CIEE/ACEEE/Stanford *Behavior, Energy and Climate Change* (BECC) conferences. We also note that, as in the EPA case, elements of the first two periods (PTEM and market transformation) not only continue, but also continue to dominate in the period of the emerging policy context.

In fact, research for this white paper also shows that considerable work – both theoretical and programmatic – remains to be done before new large-scale policies and programs (e.g., focused on carbon reduction, as well as energy efficiency) are able to take advantage of the insights about the complex, multi-leveled, and interdependent socio-cultural and technological systems involved in *people and technologies*. But we do see ways that the *new imagery* for energy efficiency policy that comes out of the California crisis experience is similar to the notion of *co-provision* being developed in the EU.

What are the lessons from the California crisis? Kunkle et al. found that, contrary to views of energy users as self-interested or passively self-indulgent (undoubtedly true in some cases), Californians primarily responded to conservation requests with collective good will and altruism. Hearing appeals to adopt energy efficiency hardware in the face of an energy supply crisis, consumers most often opted for a variety of behavioral actions that produced significant energy savings, particularly at system peaks, when they were most needed. Kunkle et al. concluded that four residential-sector energy efficiency policy lessons could be learned from the experience – all supporting a new understanding or *policy reframing* of people and technologies. They are:

1. **Moving beyond the efficiency *measures* framework to consider the effects of behavior on energy use**, and to consider new possibilities to target, support, and reward *new behaviors* as a source of energy efficiency.

2. **Recognizing that conservation behavior is part of how households *routinely manage* everyday life**. It is endemic and not unusual, although certainly not evenly distributed across the population.

3. **Understanding that conservation action is fairly *widespread,* but also is *evolving***. It may be a latent resource to be taken seriously and should be better understood.

4. **However, the *capacities* of households to take pro-environmental actions *can be enhanced* by external influences**, if the levels of interest (*concern*) and conditions (Stern's *context*) are supportive.

In a *co-provision* view, the energy user is an active agent in the management of his or her own domestic scene. The action needn't be economically oriented or rational and intentional (and probably rarely is), and it is constrained and shaped by a variety of actors and institutions outside of the control of the energy user. But the end-user, nonetheless, is much more than a *recipient* of energy services; she or he is a competent cultural actor who provides for himself or herself as best they can, as they understand it should be done. Thus, in this view, the California energy user who incorporates conservation into his or her routines is *provisioning* (providing) the energy system with certain kinds of loads and limits, while the utility system is *provisioning* the household with electrons or therms of natural gas as responsibly as it can.[37]

In this world, where efficiency also has value, the regulator acts to assure that the loads are reasonable and the supply is prudently available. Energy efficiency interventions in this world can take the shape of *support* and *coordination*, as well as the more traditional forms of *control*, *inducement*, and *information delivery*. One of the utilities that we interviewed is pioneering just such a *compact with the customer*, in which the utility pledges to better understand consumer sentiments and needs, so that both parties recognize what the other brings to energy sales and efficiency transactions. It is important to note that the logics of *compact* and *co-provision* are not necessarily identical, and both differ from a *social marketing* approach in which consumers are assumed to be *uninformed* and in need of persuasion, normative control, and influence designed to consciously or subconsciously induce a *green* response from someone who is otherwise *oblivious* or *incompetent*.[38]

6.3 Recommendations: Knowledge Gaps and Research Needs

Much of *epoch three* thinking (see previous section), and other efforts to broaden policy frames and expand the reach of energy efficiency policy discussions, require improved knowledge of consumer behavior and its complex constitution in multi-leveled environments.

The existing programs and plans are guided by both explicit and implicit behavioral and social assumptions that have not been well established by research in field situations. Modifications and improvements in programs can be imagined – and are desired by energy efficiency industry actors. But we stress the importance of modifying programs and plans so that they build on better supported assumptions. When evidence is lacking on *which* assumptions are valid, or *where* assumptions are valid, we need to determine the answers empirically. In short, programs to change behavior should be grounded in behavioral science, as well as in technology and economics.

In this subsection, we discuss some critical *areas of needed behavioral research* identified by the National Academies' National Research Council and by the California Air Resources Board. We draw directly from the language of their reports, but take the liberty of weaving their research priorities together, since they are highly complementary.

The National Resource Council (NRC) was asked to develop an agenda of research priorities that would address crucial knowledge deficiencies in environmental decision-making (NRC 2005). The panel that studied the question was highly interdisciplinary and broadly representative of the

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[37] The UK/EU terminology is a bit awkward, but we maintain it for now, at least, because it brings a new sense of collaboration into the policy discussion that familiar U.S. concepts such as *supply* and *demand* do not have.

[38] For some examples of these sorts of social marketing consumer categories, see several of the segmentation examples in Appendix B.

social and behavioral sciences. The members were experts in the knowledge bases of their respective disciplines. The NRC panel approached the problem with a very broad policy frame. They treated household decision-making as one of a number of forms of environmental decision-making by a multiplicity of actors and groups. They concluded that links from individual behaviors to their environmental consequences can be indirect, and choices are subject to larger forces and constraints from institutions and the socio-technical matrix. They also found that, perhaps because these complex relationships are not well understood, policies and programs aimed at altering environmentally significant behavior have performed poorly on the whole. The NRC outlined four broad areas for future research: *developing* consumption indicators; *influencing* information systems; *integrating* information and other policies; and *improving* knowledge of consumer choice and constraint. The authors suggested that the research in the first and last areas were likely to have the most significant and lasting impact.

The California Air Resources Board (ARB) identified a related set of behavioral research questions that were more narrowly focused on residential consumers and energy efficiency (ARB 2008b). They focused on issues related to: the determinates of consumption, upstream (supply chain) influences, choice processes, informing judgment, decoupling beliefs about consumption and well-being, and improving alignment of consumer behavior and policy goals. The first three are empirical projects, while the latter are programmatic and change-oriented.

The combined NRC and ARB research topics can be woven together into three major themes: (1) understanding consumption in context; (2) communicating and influencing choice and action; and (3) creating a collaborative set of private and public outcomes rooted in behavior change and choice.

6.3.1 *Theme 1:* Research on Understanding the Fundamentals of Consumption and Choice

A Fundamental Understanding of Consumer Choice and Constraint. A greater understanding of the interaction among information, incentives, constraints, and opportunities, as well as values, beliefs, and social contexts in the shaping of consumer choice in complex, real-world situations is vital. We know that choice is situated and severely constrained by elements of social, economic, and physical context, but which of these factors is most crucial? Moreover, what is the relative weight of contextual factors to personal ones, like values and beliefs? More empirical studies of particular consumers' behaviors in a variety of settings are needed, but this research will be most useful if it can build bridges across segregated disciplinary boundaries. (NRC 2005, 78-81)

What determines household consumption of energy, water, natural gas, and transportation resources? Comparable households in California – with apparently similar perceptions and experiences regarding quality of life – can vary by an order of magnitude or more in consumption of these resources. Moreover, pilot research in California suggests that behavioral and demographic factors determine at least half of the variability in consumption patterns. Understanding these social factors will be critical in replicating low- or no-cost household behavioral changes and crafting effective social marketing campaigns (ARB 2008b, 5).

How do choices upstream of households affect home energy efficiency? Research is needed to clarify how home energy efficiency is shaped by decision-makers, such as homebuilders, home equipment manufacturers, mortgage lenders, rental-housing owners and managers, heating and cooling system contractors, and appliance retailers and repair personnel (ARB 2008b, 5).

What determines household choices among available homes and equipment? Little research has been done to clarify an important, but little understood, trend driving home energy use – the trend of housing units to grow in size and to contain more and larger energy-using appliances, even while the number of people per household decreases. In particular, research is needed to clarify the role that climate change, energy use, and energy cost considerations might play in the choices underlying these trends (ARB 2008b, 5-6).

6.3.2 *Theme 2:* Research on Improving Communications and influence

Indicators of Environmentally Significant Consumption. Although there is longstanding evidence that people would like to reduce the environmental impact of their choices, actual consumer behavior contradicts these intentions. This apparent paradox could be due to the difficulty individuals often have in estimating the complex environmental effects of their choices. Green-minded consumers would benefit from indicators of environmentally significant consumption that compare products and behavioral choices, e.g., possibly a *scaling down* of existing indicators, such as Wackernagel and Rees' (1996) *ecological footprint* (NRC 2005, 71-74).

Information Transmission Systems. Information has not always reached its potential in environmental programs because it has not been disseminated effectively. We know that information that is actionable – understandable, memorable, timely – is more effective, but how can these insights be integrated into message design for environmentally significant behavioral change? More generally, how do notions such as trust in information sources, the presence of intermediaries between the audience and source, the use of multiple sources, the existence of a multiplicity of audiences, and the presence in most information environments of multiple, sometimes conflicting, messages affect information transmission (NRC 2005, 74-76)?

How can better systems be designed to inform consumers about their best options for improving home energy efficiency and reducing their carbon footprints? Effective outreach requires identifying mistaken beliefs about behaviors with significant mitigation potential, developing and testing ways to correct them, and crafting systems for delivering trustworthy, clear information to consumers at the time of purchase choice (ARB 2008, 6).

6.3.3 *Theme 3:* Research on Supporting Joint Private/Public Action

Integrating Information with Other Policy Instruments. While information is important, it can be quite ineffectual if recipients have weak incentives to use it. How can information be more effectively combined with other policy instruments? Most useful would be applied research that looks at how information could be supplied in "complex policy contexts that allow persons to assess the social significance of their individual actions and effectively consider their policy and market options," as well as alter their choices in concert with other actors and participate effectively in decision-making processes (NRC 2005, 76-78).

What can be done to decouple energy consumption from perceptions (and misperceptions) of well-being? This important fundamental research question is of long-term relevance in California with regard to home energy use, as well as transportation. Subjective well-being is linked much more closely to meeting needs than to energy consumption (per se), and it is imperative to decouple the two (ARB 2008b, 6).

How can improved government links to energy users promote policy goals? The most effective outreach is a two-way street: not only does it deliver information to users, but it also serves as a source of insight into what information would be useful. For example, research into consumer behaviors during the 2001 electricity deregulation crisis showed that behavioral change was instrumental in curtailing blackouts, but that the critical behavior (turning off the air conditioner) was not the behavior (slightly raising the thermostat) prescribed by outreach campaigns. Knowing what behaviors are actually practiced by citizens would facilitate more effective outreach campaigns (ARB 2008b, 6).

6.3.4 Moving from Research to Program Innovation

We can see that both the NRC and ARB research priorities reinforce the findings of our research and the conclusions of this white paper, but at higher levels of generality. A common concern is working toward better understanding of consumer behavior and choice – the contexts of choice and influence, of embedded choice and action in larger social-economic-technological systems – and the role of information, policies, and programs at various levels in the system. The goal in each case is large-scale change in human-environment interactions. The challenge that confronts policymakers and public advocates, however, is how to translate current knowledge and new knowledge from social science research into effective program designs and implementation strategies. In the following section, we consider two possible approaches.

6.4 Recommendations: Experiments and Pilots for Program Innovation

We believe that research in all of the areas identified by the NRC and ARB would contribute to better programs and energy efficiency policy plans. To those topics, we would add a somewhat more specific focus on the elements of improved program design and delivery. The overarching question that we pose to the CPUC and utilities is: *How can targeted research translate into program outcomes?*

A number of future energy efficiency program innovations can be imagined, and the purpose of this white paper is not to lay out a roadmap to California's residential-sector energy efficiency program future. We have noted that program evolution is underway within the utilities, and the shape of the programs in the future will be worked out through formal deliberations and informal negotiations among the stakeholders. But California's significant energy efficiency and climate-change policy goals, coupled with the limitations of the current regulatory policy perspective and the significant knowledge gaps identified in this report, lead us to say at least a few things about the possibilities to accelerate innovation in prudent ways. The two most promising program innovation tracks are *program experiments* and *pilot market transformation programs.* Both focus on linking the behavioral knowledge base and ongoing research with program design and implementation. Their primary differences are in scale and system-level focus.

6.4.1 Program Experiments

We considered experiments in the design and delivery of energy efficiency programs to see whether taking behavioral factors more explicitly into account might result in more effective interventions, greater consumer response to appeals and inducements, larger energy savings, etc. We explored the possibilities for the use of experiments in energy efficiency program innovation and identified prospects and problems. First, it is important to understand some basics of the experimental approach.

An experimental approach to program design and delivery adopts the attitude, if not all of the methods, of controlled experiments. In the social sciences, experimental methods are most often used by psychologists. In the ideal case, behavioral experiments are based upon well-developed theories of behavior that are expressed in terms of formal theoretical statements, with hypothesized relationships among variables, and that focus on the specific effects of some factors upon others, along with efforts to control (or randomize) the effects of all other possible factors. The controlled introduction of an experimental stimulus is involved, with systematic observation and measurement of outcomes before and after the introduction of the stimulus. The results are frequently expressed in terms of statistical probabilities and *cause* is attributed to the experimental stimulus when subsequent *effects* are observed in outcome measures on other variables. The results are often reported in scientific articles, where other investigators learn enough so that they can attempt to replicate the experiment to see if they get the same results.

Psychological experiments are modeled upon the logic of biological experiments, where a phenomenon such as wheat growth can be studied under conditions in which light, water, temperature, nutrients, and so on can be controlled, while other factors such as genetics, pests, and other stresses can be induced, varied, and measured. Taking either sort of research out of the laboratory and into the field – whether this is the wheatfield or the playfield – reduces the level of control and introduces a variety of other effects that are difficult to predict and measure. Under these conditions, statistical methods can be used to estimate the magnitude of the effects of the independent variables upon the dependent variables, controlling for the simultaneous influences of other measured and unmeasured factors that produce variations in the measured impacts.

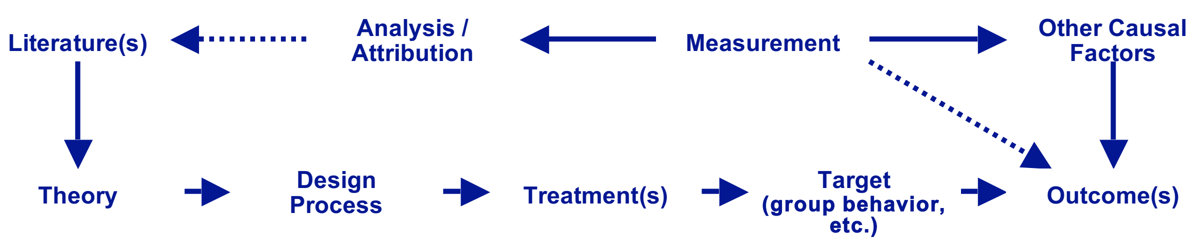
An important strategy to try to assure that the influence of extraneous factors is not what is truly responsible for outcomes attributed to the experimental treatment is to attempt to *randomize* their effects. This often involves randomly assigning research subjects (whether mice or men) to *treatment* and *control* groups, with the former receiving a measured intervention and the latter no intervention at all, or, in the case of drug trials, a *placebo* – an inactive substance that appears the same as the treatment substance. In a *double-blind* study, neither the research subject nor the researcher knows whether the active ingredient is being delivered at the time.

Quasi-experimental research designs are more common in the social sciences, particularly in cases where random assignment is not possible. For example, we cannot randomly jail persons to study the effects of isolation or teach some children to read and not others. We can, however, find circumstances where people are being jailed and vary the conditions of their imprisonment, and we can use different methods to teach reading in similar classrooms. The research design problem is the same as in "purer" forms of experimentation – namely, to know which factors are likely to influence the outcome that we wish to induce – to administer the intervention in a controlled way, to measure any changes in the dependent variable(s) we hope to affect, and to either control the effects of other factors (and randomize effects that we cannot control), or simultaneously measure their variability in order to use statistical controls in the analysis.

In the energy efficiency program case, experiments would almost necessarily be field studies built upon existing programs, or possibly new programs designed specifically to test intervention effects in relation to other variables. Applying the principles of experimental design, outlined above, to an energy efficiency program would require several steps: identifying relevant theory; generating hypotheses; creating experimental conditions with appropriate controls and/or measures of other causal factors; delivering an intervention treatment or stimulus; observing and measuring the results; and analyzing the resulting data to estimate effects.

A fundamental understanding from the various literatures reviewed in this white paper is that complex consumption systems do not seem to respond (at least not very directly) to simple interventions, including prices and technical information. Experimental changes in programs designed much like current utility energy efficiency programs could be introduced in an effort to optimize the impacts of conventional treatments – such as prices, rebates, and information – fine-tuning them along lines suggested in the psychological and behavioral economics literatures. For example, applying a psychological frame – such as Stern's multi-level *choice-in-context approach* (Stern 2008) – would suggest a focus on decision-making and information processing, but with attention to social influences and a variety of context factors. Experiments could attempt to affect certain factors, while controlling for others. The model would predict that different sets of factors are likely to be important for different technologies, behaviors, or outcomes. Figure 3 is a graphic showing the major elements of the experimental design and research process.

Figure 3: Experimental Design Elements



Conducting experimental intervention in this vein would involve a sequence of design questions, including:

- ***How important for energy and emissions do we imagine this device, behavior or system to be? What energy reductions might realistically be achieved by real changes in this area?***

  This is traditionally the territory of conventional *efficiency potential* studies, but these tend to strictly focus on single devices, one at a time, and do not consider behaviors, technology sets, or supply chains as targets (see the related white paper by Moezzi et al. 2009).

- ***What do we know about the multiplicity of factors that are likely involved at the personal, household, and context levels for each target device, behavior, or system?***

  The literatures that we have reviewed offer variables to consider for applying to interventions. Variables can be drawn from different theories and might include considerations such as: costs, subjective assessments of outcomes, influential social norms, personal norms, level of effort required, knowledge and skill, cultural pressures, constraints, and influences in supply chains, etc. The list would also include whatever *barriers* to change might be identifiable. Not all of the variables that may turn out to be important are highlighted by social science theories and some remain to be discovered and/or pointed out by experienced program staff.

- ***What innovative energy efficiency intervention approaches can be designed to: (1) make use of behavioral knowledge from theory and research; and (2) test the relative importance of factors specified in advance? How well do they perform?***

  The goal would be to actually design and implement new program approaches whose elements can be stated clearly in program theory, and whose implementation and outcomes can be assessed, both for conventional evaluation purposes, as well as for deeper insights about behaviors and programs that can be used to refine program designs and delivery.

- ***How can we detect causal effects? How can we measure their magnitudes?***

  Attention to actual specification, operationalization, and measurement issues is crucial. Are we measuring what we think we're measuring (referred to as *internal validity*). Also, can we avoid researcher contamination such as *Hawthorne effects* (in which the subject's knowledge that they are being studied itself improves the performance that would be attributed to the program).

With this overall approach, we might expect there to be a different story – a different set of design issues, causal factors, experimental treatments, and outcomes for different devices and behaviors. The question then becomes: *Can we generalize findings from one case to another?* This is referred to as the "external validity" question.[39] The answers will likely vary across intervention targets.

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[39] Both internal and external validity are discussed in the context of energy efficiency programs and policy in another white paper in this series by Sullivan (2009).

For example, simple home retrofit actions (weatherstripping and insulation) have fairly simple sets of product attributes (although they may not be simple to implement). We may know from past experience that large price increases and incentive subsidies could have an effect, but mostly for particular subgroups. On the other hand, comprehensive home performance upgrades involve considerably more complexity in choice and execution, where constraints and context factors are much more powerful.

Seemingly simple appliance purchases may actually involve greater challenges as consumers sort through alternatives of complex choice sets within which energy efficiency and environmental considerations may play a small role. Experimental approaches might test a few levels of incentives and/or possibly targeting incentives at different points in the supply chain. Also, incentives might be coupled with alternative marketing strategies, including delivery systems that might include local non-energy groups, as well as market actors.

Issues in Implementing an Experimental Design Approach

Coupling experimental energy efficiency intervention with embedded observation and measurement is likely to hold some appeal for utilities and implementers, since it can build upon existing program components, making adjustments that systematically vary stimuli or treatments. It has the look and feel of science and can, therefore, confer credibility on results. The approach also has some important issues that need to be acknowledged from a research design point-of-view. We consider some of these.

First, treatments need to be carefully considered and, to the extent possible, be based upon credible theory. As noted, the applicable knowledge will vary across different behaviors, technologies, and circumstances. Therefore, there are real up-front time and planning costs to serious experimental design. Experimentation is not equal to simply "trying out something new," such as a *larger brochure*, *more frequent radio ads*, or "*spiffing" (paying) the appliance salesman*. These may be quite reasonable implementation tactics, and they may be considered in treatment design and selection, but more is needed in the way of systematic thinking and rigorous execution.

Selection of the targeted energy-use behavior, technology, and/or context is an important consideration. With limited resources and, more important, limited time and attention capacity to mount multiple simultaneous experimental interventions, care will be required in selecting targeted behaviors, technologies, contexts, etc. For example, do we want to choose areas where we have the greatest experience and have had past success? Lighting and CFLs come to mind as a current high-investment area that might be mined more fully. On the other hand, should we turn serious attention to areas where the demand savings may be large, such as air conditioning control behavior in hot places at hot times of the day? The California crisis experience showed that significant behavioral savings were possible under unusual conditions. How about under routine and normal conditions? Can the definitions of *routine* or *normal* be renegotiated with customers?

We might want to focus on an area where the annual energy savings are potentially the greatest – e.g., in turning off computers and other pieces of equipment that are always in an *on* or *ready* state, or disconnecting DC power supplies (*vampires*) when not in use. This might involve both purely behavioral, as well as technological, changes. Finally, we might want to focus on areas where results might generalize most readily to other end-uses, geographical locations, and customer populations, such as in appliance purchase and/or use.

Partly related to target behaviors, technologies, and contexts, but also to some degree independent, are a series of experimental design questions. These include the following, but not exhaustive, list of questions:

- *Are we interested in trying to induce and examine short-term changes or long-term changes? Just what sorts of changes?*
- *Are we interested in simple single behaviors, or routines, usage patterns, etc.?*
- *Are we interested in habits or consciousness choices, in expertise, commitment, concern, and competence?*
- *What will we vary in terms of treatment and how will we conceptualize it?*
- *Are we providing information, education, knowledge, or learning from experience?*
- *If we're tweaking information delivery – which seems to be an element of almost all current energy efficiency program offerings – do we vary message form, content, delivery system, frequency, duration, the messenger, the delivery context, the situation or circumstances? All of the above? In combination? If combined, can we differentiate the effects?*
- *If we're interested in motivating change with policies and market inducements beyond information, how do we conceptualize those treatments?*
- *Will we vary incentives, inducements, costs, prices, or subsidies? What are the potentially important variables for each – e.g., amounts, timing, recipient, delivery system, etc.?*
- *In terms of the latter, where, when, and how do we deliver the treatment – at point-of-sale, through the mail, website, utility bill, gift bag, express delivery?*

Again, there are issues about combinations of treatments and attributing effects. But also:

- *Should we be focusing upstream, midstream, or downstream?*
- *Are we interested in spillover effects in the supply chain, the household, or the neighborhood?*

In every case, the experiment must be carefully controlled in terms of treatment delivery, the control of other influences and confounding factors, and the careful measurement of all factors. The less control, the greater the need for measurement of other factors and the larger the needed sample in order to detect and estimate treatment effects with any degree of confidence. The larger the scale of the experiment, the more salient equity and legal issues become when some customers – possibly randomly selected or possibly selected non-randomly – are offered *better* inducements, prices, or other advantages. What happens when customers who have limited means are randomly assigned to rate designs with potentially high costs – for example, in critical-peak-rate experiments?

The bottom line, in our view, is that while program experiments can be imagined and might be quite valuable, they are much easier to imagine than they are to plan, design, execute, analyze, and have confidence in the findings – and have findings that are useful, powerful, and/or generalizable. But these are not insurmountable challenges, and they may be worth the cost and time for us to arrive at improved programs and policy mechanisms.

6.5 The Adaptive Theory-Based Pilot Program Approach

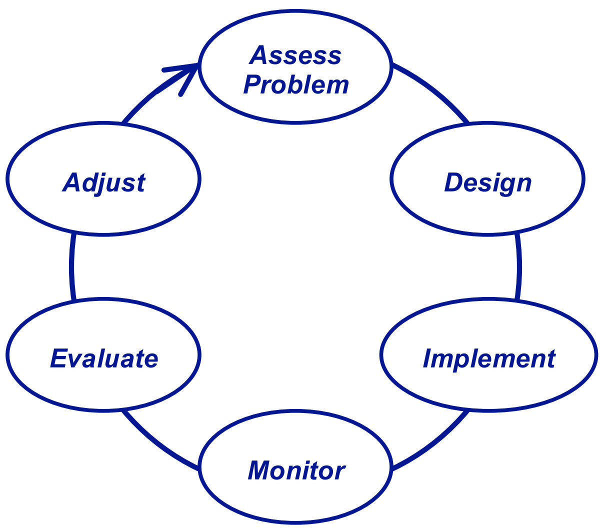
A related approach also builds on current programs and proposed ideas for new programs. It stresses innovation, experimentation (in a somewhat looser sense than in experimental design, as discussed above), and integrated research in support of program evolution. It uses a *pilot* logic, but in a more rigorous form than previous pilot energy efficiency programs: these early pilots implemented a novel program approach for a small population, with conventional energy impact evaluation and possibly some process evaluation to document issues in implementation. The pilot program logic that we would advocate, first acknowledges the complexity and multi-dimensionality of the systems in which energy-use behavior and energy conservation behavior takes place. It explicitly sees change as challenging, the knowledge base as limited, and outcomes as multi-causal and uncertain. However, it is explicitly *experimental* in focus and relies heavily upon both an evolved form of current program evaluation practice and a supportive set of basic research activities. The approach relies upon *near-real-time* assessment and feedback to program implementers, ongoing and linked system-focused studies, and improved information and decision-support for program designers and policymakers. It allows programs to *fail* and still produce useful knowledge. It quickly identifies *successes* and allows for dissemination of that information and fairly rapid integration into other programs. And it promotes innovation and experimentation at all levels of program delivery.

The roots of this approach can be found in two quite different sources: *adaptive management* in federal and state natural resource policy and programs, and the *theory-based approach to market transformation* from the market transformation thinking in California prior to the energy crisis of 2001. Adaptive management (AM) is a well-established approach to dealing with uncertainty, interventions, and complex ecological systems. Pioneered by Hollings (1978), Walters (1986), and Lee (1993), adaptive management has been applied in a wide range of natural resource management situations, from forest ecosystems to fisheries, watersheds, and regional biosocial systems. We will not attempt to describe the approach in any detail here, but we will point out that its successes in managing behavior and technological change – often under contentious circumstances with competing interests and under conditions of uncertainty – are worth noting by the energy efficiency community. The U.S. Department of the Interior’s Bureau of Land Management has produced a useful technical guide that defines adaptive management in general terms as (Williams et al. 2007, 1):

> "Adaptive management as described here is infrequently implemented, even though many resource planning documents call for it and numerous resource managers refer to it. It … is much more than simply tracking and changing management direction in the face of failed policies, and, in fact, such a tactic could actually be maladaptive. An adaptive approach involves exploring alternative ways to meet management objectives, predicting the outcomes of alternatives based on the current state of knowledge, implementing one or more of these alternatives, monitoring to learn about the impacts of management actions, and then using the results to update knowledge and adjust management actions. Adaptive management focuses on learning and adapting, through partnerships of managers, scientists, and other stakeholders who learn together how to create and maintain sustainable resource systems."

A commonly-used graphic of the adaptive management process is shown in Figure 4. It may seem "obvious" that iterative learning is an aspect of thoughtful intervention and that energy efficiency programs likely "do this all the time." To some degree, this is true at the level of craft knowledge and program designer experience. However, the adaptive management approach explicitly features integrated research, continuous monitoring, adjustment of both knowledge and practice, and regular reassessment of the system and the problem.

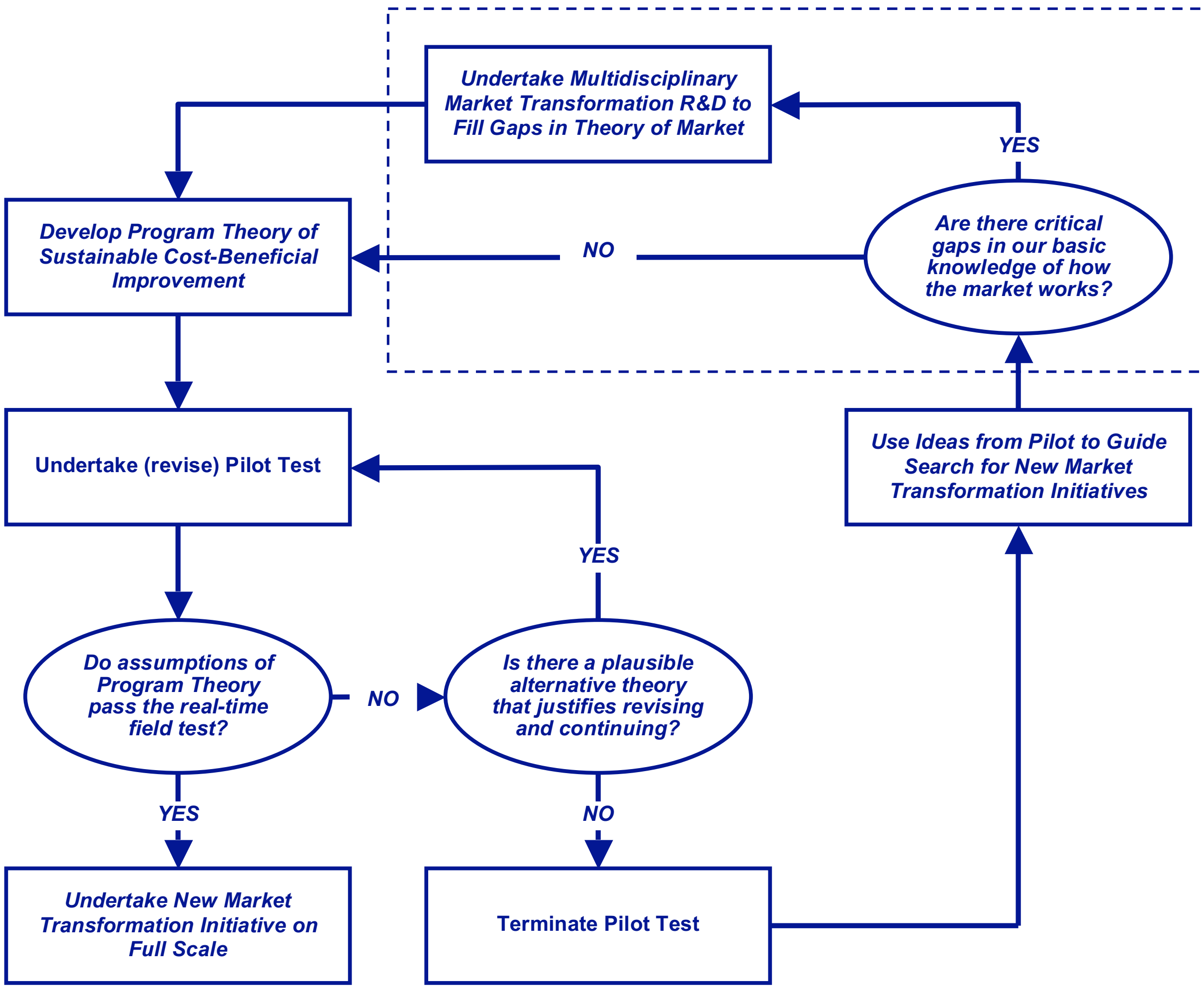
Figure 4: Adaptive Management Process



In the late 1990s, as market transformation initiatives proliferated with the restructuring of electric utility regulation, a line of thought similar to adaptive management developed in the market transformation context. As utilities, regulators, and environmental NGOs paid more attention to market systems and potentials for interventions *upstream* from points of technology choice and end-use, the need for better knowledge of market systems became apparent. Also, the need to intervene in markets took place in the absence of detailed knowledge of market arrangements, the behaviors and interests of market actors, and of the probable effects of various intervention approaches. At the very least, the need for "a good story" on which to base market transformation program designs was recognized by early market transformation agencies, such as the Northwest Energy Efficiency Alliance (NEEA).[40] Linking to the tradition of *theory-based evaluation* (e.g., Weiss 1997), Blumstein, Goldstone, and Lutzenhiser proposed a *theory-based approach to market transformation* that shares a number of characteristics with adaptive management (Blumstein et al. 2000).

Figure 5 presents a graphic of the overall logic of the theory-based approach.

Figure 5: Theory-Based Market Transformation Approach



Adapted from Blumstein et al. (2000)

The goal of this approach was strategic interventions in market systems that would build upon existing formal knowledge and craft knowledge, promoting innovation, but with real-time monitoring and evaluation feedback, program improvement, and growth of knowledge.

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[40] NEEA continues in the market transformation business after others have moved away from it. Interestingly, the organization identifies its planning and implementation approaches as *adaptive management* (see NEEA 2009, 3).

However, Blumstein et al. also anticipated that the work in which we wish to intervene may well be different than we imagined – also, that it is in flux and may change in important ways while the intervention is in the field.

Programs may turn out to be adjustable, or end up as failures and will need to be terminated. However, a considerable amount of knowledge can be gained from "failures." So they are hardly a waste of resources and something for program implementers to deny and conceal. Rather they may be gold mines of information about markets and actors. Blumstein et al. also saw an important need for market-focused research in parallel with and linked to real-time evaluation. Knowledge gaps exist before we enter a market, and they need to be addressed *while interventions are in the field*. Gaps will also need to be identified in the course of program implementation, adaptation, and modification, and will require new studies to inform subsequent policy development and program planning.

6.5.1 Implementing an Adaptive Theory-Based Pilot Program

While adaptive management and the theory-based approach to market transformation may seem deceptively straightforward and simple examples of good program design and execution, as in the experimental design case, there are a number of challenges that need to be acknowledged. In the pilot approach, while we are focusing on smaller interventions, we are still attempting to change complex multi-leveled and dynamic systems, about which we often have limited knowledge. We are talking about interventions that change developmental trajectories and alter patterns of behavior and interdependency – investing in some and discouraging others. And because of the seriousness of climate change problems, choosing not to act is not an option.

Hence, serious pilot interventions, even based in current programs and in well-known systems (e.g., the CFL marketplace), requires us to ask questions such as: *What do we really know about these systems? How well can we trust what we think we know? Do we know enough to act effectively?*"

To address these questions, we will need to inventory our knowledge in the social sciences, energy efficiency program evaluation, existing market studies, and craft knowledge. We will also need to undertake new knowledge-gathering efforts (Blumstein et al.'s *interdisciplinary R&D*). We will also have to carefully select target behaviors, technologies, systems, and locales, using existing energy efficiency potential studies, as well as modified approaches based on a broader range of theory and new research (see Moezzi et al. [2009] on the need for expanded energy efficiency potential analyses).

The design processes for pilot interventions should be more open and collaborative than traditional utility-based energy efficiency program planning. One of the possible reasons for successes in adaptive management may have to do with the fact that multiple stakeholders with significant expertise are continuously engaged in the process of planning, implementing, and monitoring the system effects of management strategies. While this may not be possible in the energy case, new sources of ideas and approaches (from within and outside of the energy efficiency program world) are clearly needed to expand energy efficiency activities, and increase the scale of interventions and impacts in a policy world that is increasingly dominated by concerns about carbon and climate change. The logic of *new imagery* regarding consumer roles and *co-provision* of environmental benefits would seem to argue strongly for a more open, collaborative, and dynamic energy efficiency planning and implementation process.

The actual implementation of pilots with real theoretical bases and near-real-time evaluation and feedback is not easy. The *logic models* and *program theories* that are produced for energy efficiency programs, where they exist, are often sketchy, simplistic, and, in many cases, simply *window dressing* intended for regulatory compliance, rather than program implementation and management. Often, program evaluators have to first generate theories and models for programs in order to have something to evaluate. Also, evaluators have been required to maintain arms-length relationships with the implementers of the programs that they are evaluating. While there is often friendly feedback to program implementers, and sometimes mid-program reports of evaluation work in progress, these interactions are not necessarily comfortable ones for either party. Either new forms of evaluation altogether, or new sorts of evaluator-implementer-regulator relationships will need to be explored in order for near-real-time monitoring and feedback to provide actionable information for program adjustment, or even possible pilot program redesign-in-process (e.g., see Vine 2008).

Finally, the relationship between research, implementation, evaluation, and policy development will need to be examined and redefined. At this point, research is conducted apart from programs, either by academic researchers or consultants that are directed toward particular problems by policy agencies. Examples are *market assessments*, energy efficiency potential studies, technology surveys (such as the California Residential Appliance Saturation Survey [RASS]), and customer polling. Surveys and energy-use data collected for evaluation purposes are rarely shared with researchers. Researchers are often either unaware of sources of routinely collected data, or dismiss them because they have are not interested in *applied* problems, or have issues with data quality.

Utility concerns about proprietary data ownership complicate research. Also, the fact that researchers, policymakers, program designers, implementers, and evaluators ordinarily operate in different orbits is not helpful for integration of research into applications as proposed in the Blumstein et al. model. Research results – particularly those found only in the scientific literature – are rarely used to inform program design or policy development. The basic studies proposed by both the NAS and the California ARB should not be assumed to necessarily have a direct or immediate impact on energy efficiency programs or policies in a world in which research is separated from practice (in the top box in Figure 5).

6.6 Final Thoughts

Experimental design and adaptive theory-based pilot programs are related, and it may be possible to incorporate elements of the former into the program design, implementation, and evaluation phases of the pilot program. However, the importance of control in experimental design versus the emphasis on adaptation in the pilot program approach suggests differences in thinking about time frames, evaluation, and investigator roles. Some of these issues have likely been worked out in the context of adaptive management, since the natural resource contexts in which adaptive management is applied are also informed by ongoing experimental and quasi-experimental natural science research. It is beyond the brief of this white paper to determine how the two approaches might be coordinated in the energy efficiency program world. That question remains to be addressed in policy discussions.

What seems clear, however, is that new program approaches based upon a broader policy frame are almost certainly required to address carbon reduction policy goals in California. Some of the basic elements of that frame can be found in current utility programs, but the complexity of the systems involved requires that interventions be based upon more than program craft knowledge. The social sciences can offer a number of valuable insights into the complexities of energy-related behavior and choice, but no unified theory. And some powerful ideas about consumers as potential co-providers of intelligent energy use and efficiency – rather than PTEM non-actors or stereotyped actors – can be refined and developed in the policy context. In addition, some useful tools for program improvement can be found in experimental design and adaptive theory-based pilot programs.

But it is important to realize that our knowledge of the systems and behaviors that climate policy must affect is far from complete. In the end, we will need to fill knowledge gaps of the sort identified by the NRC and ARB in order to mount effective and wide-reaching energy efficiency programs if we hope to come anywhere close to meeting the stunningly large carbon reduction goals. Behavioral research, program knowledge, evaluation, experimentation, and adaptive theory-based pilot programs all have crucial roles to play in developing new program approaches to complex systems under conditions of uncertainty.

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Appendix A: Program Descriptions

UTILITY NUMBER	TITLE	PROGRAM DESCRIPTION	CONSUMER PROBLEM ADDRESSED
SCE 2500	**Appliance Recycling Program (ARP)**	To remove operable, inefficient refrigerators (standard and "apartment sized"), freezers, and room air conditioners	Cost, convenience of removal, lack of information, availability
SCE 2501	**Residential Energy Efficiency Incentive Program (REEIP)**	To promote use of CFLs, replace inefficient refrigerators and air conditioners	Cost, insufficient information (e.g., benefits), availability, quality, retail (info, promotion, etc.)
SCE 2502	**Multifamily Energy Efficiency Rebate Program (MFEER)**	To motivate multifamily property owners (two or more dwelling units) to install energy-efficient appliances	Split incentives, lack of knowledge, out-of-pocket expenses
SCE 2502	**Comprehensive Mobile Home Program (under MFEER)**	To provide a comprehensive energy program to 7,500 mobile home customers; direct-install, no cost to the customer program (through 3rd party Synergy Companies)	Lack of knowledge, "hard to reach" groups (elderly, poor, foreign)
SCE 2503	**Home Energy Efficiency Survey (HEES)**	To fill the gap between consumer awareness and adoption of energy programs	Lack of knowledge, cost of upgrades
SCE 2505	**CA New Homes Program**	To increase energy efficiency above state standards in new single and multifamily homes; also tie in with appliance incentives (*Welcome Home* packet) to encourage efficient appliances	Lack of knowledge (newest technologies, design issues), cost of energy efficiency design
SCE 2507	**Comprehensive Packaged Air Conditioning Systems Program (CPACS)**	Portfolio of packaged air conditioning activities to address opportunities in the upstream, midstream, and downstream markets in a coordinated program that encompasses new construction, replacements, and services in the commercial and residential sectors	Cost and lack of knowledge for consumers, lack of knowledge for contractors, distributors will receive financial incentives and marketing materials to use
SCE 2513	**Education, Training, and Outreach (ET&O)**	To promote energy efficiency, to a variety of customer segments through energy centers, technology test centers, and other information and training program strategies	Lack of information/ knowledge, cost, "performance uncertainty," ESL

Continued

UTILITY NUMBER	TITLE	PROGRAM DESCRIPTION	CONSUMER PROBLEM ADDRESSED
SCE 2514	**Sustainable Communities (SCP)**	Program is a direct response to the growing interest in designing facilities and communities with sustainable design practices; initially it will provide incentives that encourage customers to design their project to exceed Title 25 energy standards by at least 20%	Cost, knowledge
SCE 2515	**Statewide Emerging Technologies (ET)**	To help accelerate a product's market acceptance through a variety of approaches, but mainly by reducing the performance uncertainties associated with new products and applications; the program targets all market segments	Cost, knowledge
SCE 2516	**Statewide Codes and Standards Program (C&S)**	In the process of transitioning from an information-only program to a resource-acquisition oriented program that advocates upgrades and enhancements in energy efficiency standards and codes; the program targets all market segments	Inadequate codes or regulations
SCE 2518	**Local Government Energy Action Resources (GEAR)**	Through primarily standard marketing techniques, to optimize the opportunities for jurisdictions and their communities to work toward the common goal of achieving short- and long-term energy savings, reduced utility bills, and an enhanced level of comfort in municipal and commercial buildings, as well as homes; help promote an energy efficiency "ethic"	Lack of information (more information to encourage participation in existing programs)
SCE 2519-2522	**Local Government Partnerships: Ventura County, South Bay, Bakersfield and Kern County, Santa Barbara**	Alliance between local governments and SCE to improve energy efficiency through: direct installation sweeps; marketing; education; outreach; administering residential energy surveys; best practices in local government energy efficiency activities	Lack of information, cost
SCE 2523	**Community Energy Partnership (Non-Resource)**	The program is a hybrid and multidimensional partnership for the delivery of sustainable energy efficiency in Southern California	Cost, lack of information, lack of energy "ethic"
SCE 2525	**San Gabriel Valley Energy Efficiency Program (SGVEEP)**	The program will provide energy education, retrofit assistance, retro-commissioning (RCx), as well as design consultation and energy analysis of new construction and renovation project plans	Lack of information, technical expertise
SCE 2533	**Energy Efficient Program Made Efficient**	Finding lost energy efficiency opportunities in HVAC	Lack of information, training

Continued

UTILITY NUMBER	TITLE	PROGRAM DESCRIPTION	CONSUMER PROBLEM ADDRESSED
SCE 2534	**Demand Response Emerging Tech**	Examines emerging technologies and will develop recommendations; it will build approximately 50 new homes with various combinations of demand responsive devices and emerging technologies, practices, and evaluation methods	Part of program is to evaluate market "barriers" and explore how to solve them
SCE 2542	**Affordable Housing Energy Efficiency Alliance**	To provide information to Public Health Authorities (PHA), housing leaders, and stakeholders who influence how properties are designed, built, rehabilitated, and maintained, and which policies affecting efficiency are adopted and implemented	Lack of knowledge or resources to seek out energy efficiency opportunities
SCE 2543	**Design for Comfort: Efficient Affordable Housing (DfC)**	The program uses a performance-based approach to encourage affordable-housing property owners to choose the most cost-effective measures to achieve a 20% energy improvement over existing building conditions (multifamily affordable housing retrofit market segment)	Lack of awareness, cost, perceived regulatory barrier, lack of funds
SCE 2545	**E-mail Based Energy Efficiency Program**	A personalized email/web-based information program, designed to subscribe a large segment of residential customers to an ongoing dialog of energy-use feedback and direction to programs and resources	Lack of information
SCE 2546	**Lights for Learning CFL Fundraiser**	Working with schools, foundations, and community youth organizations; participants sell ENERGY STAR®-qualified CFLs toraise needed funds	Lack of knowledge
SCE 2547	**Aggregation of Housing Agencies for Energy Retrofit and Management Program**	The program reaches out to small- and mid-sized public housing agencies to encourage them to participate in large-scale energy efficiency upgrades by providing communications, financial, and technical services to target participants	Lack of information, cost
SCE 2548	**Southern California Home Performance Program**	The program finds, screens, trains, and mentors qualified HVAC and remodeling contractors to deliver comprehensive home performance improvement packages tailored to the needs of each existing home and its owner	Lack of information, technical expertise
SCE 2550	**Innovative Pool Pump Technology Delivers Radical Efficiency Gains**	To encourage the installation of the Intelliflo variable speed drive pool pump system	Cost of pump, lack of information, new technology adoption
			Continued

UTILITY NUMBER	TITLE	PROGRAM DESCRIPTION	CONSUMER PROBLEM ADDRESSED
SCE 2552	**NightBreeze Energy Efficiency Program (NEEP)**	NightBreeze integrates HVAC with a fresh air ventilation system that saves energy, improves indoor air quality, and enhances comfort; it was designed to eliminate the need for air conditioning in mild climates and reduce the size of air conditioners in hotter climates, while providing improved indoor air quality and comfort	Cost, lack of information, new technology adoption
PG&E 2000	**Mass Markets (Residential and Nonresidential)**	This new program targets the combined segments of single-family and multifamily residential retrofit, commercial, and residential renters, and commercial customers who often lack information, time and resources for energy efficiency projects	Lack of information, time constraints
PG&E 2009	**Residential New Construction Program**	The programs objectives include increasing energy efficiency in new single-family and multifamily homes above state standards; to facilitate the continual improvement of California's minimum efficiency standards in new construction (Title 24), training will be provided to builders, contractors, and consultants to educate them on the new 2005 Title 24 requirements	Lack of information, training
PG&E 2011	**Emerging Technologies (ET)**	This is an information-only program that seeks to accelerate the introduction of innovative energy-efficient technologies, applications, and analytical tools that are not widely adopted in California; emerging technologies may include a range of products including hardware, software, design tools, strategies, and services	Cost, knowledge
PG&E 2016-2026	**"Energy Watch" Local Government Partnerships with: Association of Monterey Bay Area Governments (AMBAG), Bakersfield and Kern County, East Bay, Fresno, Madera, Marin Country, Merced/Atwater**	Residential and business customers in selected cities and county areas offered some or all of the following: energy efficiency information, direct installation of energy-efficient measures, design assistance, and financial incentives for energy efficiency retrofits and new construction projects	Lack of knowledge, cost
SDGE 3006	**Lighting Exchange Program**	Customers can exchange inefficient incandescent lighting for energy-efficient compact fluorescent lighting at no cost at special lighting exchange events at convenient neighborhood locations	Monetary, informational, linguistic
			Continued

UTILITY NUMBER	TITLE	PROGRAM DESCRIPTION	CONSUMER PROBLEM ADDRESSED
SDGE 3009	**San Diego Resource Center**	To educate customers on the significance of energy efficiency, as well as its "regional and individual economic benefits;" a collaboration between the California Center for Sustainable Energy and SDG&E, the SDERC is the region's single physical center for energy information, education and technical assistance	Lack of information, hard-to-reach groups, physical space for promoting energy efficiency, lack of access to diagnostic tools
SDGE 3014	**Residential Customer Education and Information program**	The program provides education and information through several components: Home Energy Efficiency Survey (HEES) a statewide education and information based program; Home Energy Comparison Tool (HECT); and the PEAK Student Energy Action Program (PEAK), a partnership program with the Energy Coalition	Information
SDGE 3015	**Limited Income Refrigerator Replacement Program**	The program provides refrigerator replacement at no cost to limited income customers that have a refrigerator that is at least 10 years old	Cost
SDGE 3017	**Multifamily Rebate Program**	To induce property owners and managers to install energy-efficient products in individual tenant units and common areas of residential apartments, mobile home parks, and condominium complexes	"Split incentive:" Tenants typically pay energy bill, while owners/managers are only responsible for facility improvements and have little financial incentive to upgrade
SDGE 3019	**On-Bill Financing Program**	The program facilitates the purchase and installation of qualified energy efficiency measures via easy monthly payments on term loans billed as part of the participating customer's utility bill	Monetary, transaction costs, information
SDGE 3024	**Residential Incentive Program**	The program works with retailers to offer discounts at the register to make it easier for customers to take advantage of the incentives available, and to encourage customers to consider energy-efficient products	Monetary, informational
SDGE 3028	**Appliance Recycling Program**	To remove operable, inefficient refrigerators, freezers, and room air conditioners from the power grid in an environmentally safe manner	Lack of information, no access to recycling services
			Continued

UTILITY NUMBER	TITLE	PROGRAM DESCRIPTION	CONSUMER PROBLEM ADDRESSED
SDGE 3031	**Advanced Home Renovation Program**	Dubbed the "Extreme Energy Makeover," the program will renovate a model home, demonstrate and measure improvements to its efficiency, and provide information to ratepayers and the renovation industry about the efficiency potential of pre-Title 24 homes	Information
SDGE 3032	**K-12 Energy Efficiency Education Program**	To educate young people in energy efficiency through locally-developed curriculum and SDGE-supported activities	Information, inconsistency across utilities
SDGE 3035	**Mobile Home Program**	To target customers in the manufactured and mobile home market and provide them a comprehensive set of energy efficiency measures	Linguistic, monetary, educational, reluctance from park managers and distrust from senior citizens
SDGE 3036	**Time of Sale Energy Check-Up**	The program trains realtors and home inspectors to recommend energy efficiency improvements to homebuyers and sellers at the time of sale; it also provides customers with energy efficiency kits; primarily, this program seeks to achieve its goals by influencing homeowner decisions during real estate transactions	Lack of information
SDGE 3038	**SUREFAST Energy Efficiency Savings**	Demonstration program and test marketing for SUREFAST, an emerging technology platform; SUREFAST integrates energy efficiency, energy management, demand response programs, and high-speed communications in a single "intuitive" platform that treats all building and end-user concerns – from communications, to energy cost, to comfort and convenience, to safety and surveillance – as a problem that can be addressed by a single solution	Complex systems, multiplicity of programming, esoteric information, "dumbness" of buildings, lack of consumer control
SDGE 3041	**CHEERS New Construction**	This is a new component of an established CHEERS program; CHEERS (California Home Energy Efficiency Rating Services) is a well-established non-profit organization dedicated to promoting energy efficiency	Feedback on savings, information
SCG 3502	**Advance Home Program**	The program works to incorporate emerging and innovative technologies in the early stages of design for various building demonstration projects that will showcase the potential for energy efficiency in residential new construction	Transaction costs for builders in gaining knowledge of energy efficiency technologies
			Continued

UTILITY NUMBER	TITLE	PROGRAM DESCRIPTION	CONSUMER PROBLEM ADDRESSED
SCG 3503	**Energy Efficiency Education & Training Program**	The program promotes energy efficiency to a variety of customer segments through energy centers (physical and virtual) and other informational programs; it also provides services to midstream and upstream actors	Cost, performance uncertainty, asymmetric product information
SCG 3504	**Energy Efficiency Delivery Channel Innovation Program (DCI)**	This is a marketing program within SoCal Gas, created to increase customer understanding of the utility's energy efficiency portfolio; DCI works closely with program managers to determine their marketing needs and acts as a strategic marketing advisor to all energy efficiency programs in SoCal Gas's portfolio	Information
SCG 3508	**Flex Your Power**	This is an energy efficiency program designed to educate Californians on the energy, financial, and environmental benefits of efficiency; serves as a statewide umbrella program for energy efficiency marketing and outreach, communicating across utility service areas; integrated demand response program (Flex Your Power Now!)	Information, inconsistency across utilities
SCG 3510	**Multi Family Energy Efficiency Retrofit Program**	The program encourages property owners and managers to install qualifying energy efficiency products in common areas for residential apartments, mobile home parks, and condominium complexes	"Split incentive:" Tenants typically pay energy bill, while owners/managers are only responsible for facility improvements and have little financial incentive to upgrade
SCG 3514	**On-Bill Financing Program**	The program facilitates the purchase and installation of qualified energy efficiency measures via easy monthly payments on term loans billed as part of the participating customer's utility bill	Monetary, transaction costs, information
SCG 3517	**Single Family Home Energy Efficiency Retrofit Program**	Rebates for replacing less-efficient gas-fired equipment with new energy-efficient equipment and weatherization	Monetary, informational
SCG 3524	**Energy Coalition Partnership**	This program is purposefully broad and continually evolving; educates participants and organizes communities to "fundamentally change the way people think about energy and other finite resources"	Informational, organizational
SCG 3529	**Energy Efficiency Kiosk Pilot**	To induce property owners and managers to install energy-efficient products in individual tenant units and common areas of residential apartments, mobile home parks, and condominium complexes	Lack of knowledge, monetary, transaction costs, performance uncertainties, inability to control costs
			Continued

UTILITY NUMBER	TITLE	PROGRAM DESCRIPTION	CONSUMER PROBLEM ADDRESSED
SCG 3530	**Portfolio of the Future (PoF)**	The program identifies, assesses, and promotes technologies that have the potential to become part of the SoCal Gas Energy Efficiency program within the next five years; based on criteria selected with SoCal Gas, PoF selects emerging technologies and best practices identified through a market scan	
SCG 3531	**PACE Energy Efficient Ethnic Outreach Program**	The primary objective of the program is to educate ethnic minority populations about energy conservation and the programs for which they might be eligible	Linguistic, cultural, informational
SCG 3532	**Custom Language Efficiency Outreach (Chinese) CLEO**	Educate Chinese-speaking customers about energy efficiency and the energy efficiency programs that are available to them	Informational, linguistic
SCG 3534	**LivingWise School Program**	The program is an educational module for K-12 students, as well as comprehensive implementation practices which track participation and collect results from students and families	Hassle or transaction costs, information and search costs, performance uncertainties, bounded rationality
SCG 3537	**Designed for Comfort Affordable Housing Program**	To help property owners understand how their buildings perform and how to select the best, most cost-effective energy efficiency upgrades through a holistic approach; monetary incentives are provided; emphasis is on thermal systems; tenants provided with EnergySmart paks (sample energy-saving devices) and educational materials	Informational, monetary
SCG 3538	**Cypress Gas Cooling Program**	Gas cooling units are installed in homes and small businesses throughout SCG service territory, replacing older gas units	Monetary
SCG 3539	**Comprehensive Manufactured-Mobile Home Program**	To target customers in the manufactured and mobile home market and provide them a comprehensive set of energy efficiency measures	Linguistic, monetary, educational, reluctance from park managers and distrust from senior citizens
			Continued

UTILITY NUMBER	TITLE	PROGRAM DESCRIPTION	CONSUMER PROBLEM ADDRESSED
SCE 2554 **PG&E 2013 &** **SDGE 3013**	**Statewide Marketing & Outreach – Flex Your Power**	The campaign is designed to educate Californians on the energy, financial, and environmental benefits of energy efficiency and to support the energy efficiency programs of the IOUs, third-party program providers and other organizations; serves as statewide umbrella program for energy efficiency marketing and outreach, communicating across utility service areas; integrated demand response program (Flex Your Power Now!)	Lack of information, inconsistent information, or information delivered through incorrect medium
SCE 2556	**Statewide Marketing & Outreach – Flex Your Power Rural Program**	The program is designed to encourage residential energy users in rural areas to make permanent upgrades to their homes and to participate in statewide gas and electric energy efficiency activities	Lack of information, inconsistent information, or information delivered through incorrect medium

Appendix B: Geographic Lifestyle Segmentations

EPRI CLASSIFY

In the 1980s and 1990s, the Electric Power Research Institute (EPRI) did extensive work on segmentation for energy efficiency marketing (Feldman & Mast 2000). Surveys of 24-48 questions were administered to residential customers, resulting in the identification of eight profiles corresponding to different customer needs (e.g., *Lifestyle Simplifiers* and *Technology Focused*); the questions and statistical techniques used to derive these profiles were developed as the EPRI CLASSIFY software package (Feldman & Mast 2000).

SRI VALS™

SRI VALS™ (Values and Lifestyles) defines a classification along two dimensions: *motivation* and *emotional, psychological and physical resources*. Specially designed survey items are used to collect information on personality traits that affect behavior in the marketplace. The VALS types include:

- ➡ **Innovators**
- ➡ **Thinkers**
- ➡ **Achievers**
- ➡ **Experiencers**
- ➡ **Believers**
- ➡ **Strivers**
- ➡ **Makers**
- ➡ **Survivors**

Experian MOSAIC™

This is a geo-demographic-lifestyle segmentation approach that identifies 60+ categories of consumer lifestyles, including the particular places where they can be found. It is based on a combination of U.S. Census data and proprietary surveys and records of consumer marketplace choices. This segmentation scheme is being used by at least one California utility in conjunction with their own surveying and analytic work on customer orientations to energy efficiency. *Only a few* of MOSAIC™ lifestyle types (selected from the *top and bottom two* of 12 major categories) are reported here for illustrative reasons. They include:

➡ **Affluent Suburbia**

- Dream Weavers
- White-Collar Suburbia
- Small Town Success

➡ **Upscale America**

- Status-conscious Consumers
- Affluent Urban Professionals
- Urban Commuter Families

➡ **Urban Essence**

- Unattached Multi-cultures
- Academic Influences
- African-American Neighborhoods
- Urban Diversity
- Getting By

➡ **Varying Lifestyles**

- Military Family Life
- Gray Perspectives

Claritas PRIZM^{TM}

This segmentation approach is similar to the previous geo-demographic example. It produces similar (but not identical) categories. Again for illustrative purposes, some of these include:

➡ **Elite Suburbs**

- Blue Blood Estates Elite, Super-Rich Families
- Winner's Circle Executive Suburban Families
- Executive Suites Upscale White-Collar Couples
- Pools and Patios
- Kids and Cul-de-Sacs

➡ **Urban Uptown**

- Urban Gold Coast - Elite Urban Singles
- Money and Brains - Sophisticated Urban Fringe Couples
- Young Literati - Upscale Urban Singles and Couples

- American Dreams - Established Urban Immigrant Families
- Bohemian Mix

➡ **Working Towns**

- Golden Ponds - Retirement Town Seniors
- Rural Industria - Low Income, Blue-Collar Families
- Norma Rae-Ville Young Families, Bi-Racial Mill Towns
- Mines and Mills

➡ **Rustic Living**

- Blue Highways - Moderate Blue-Collar/Farm Families
- Rustic Elders - Low-Income, Older Rural Couples
- Back Country Folks - Remote Rural/Town Families
- Scrub Pine Flats Older - African-American Farm Families
- Hard Scrabble

BC Hydro – Bottom-up Classification

In 2006, BC Hydro fielded a survey of residential electricity customers in British Columbia, covering not only standard questions on appliance holdings and usage, but also 60 questions on attitudes and behaviors (Pedersen 2008). Over 4,000 surveys were completed. Using statistical clustering techniques (factor analysis followed by k-means clustering), BC Hydro derived six psychographic segments from these survey results, drawing on data from 33 of the behavioral and attitudinal questions. The survey and segmentation also differentiated between the primary bill-payer and the household as an entity. The six segments derived were:

➡ **Tuned Out and Carefree (13%)**

➡ **Stumbling Proponents (20%)**

➡ **Comfort Seekers (9%)**

➡ **Entrenched Libertarians (5%)**

➡ **Cost-Conscious Practitioners (22%)**

➡ **Devoted Conservationists (26%)**

BC Hydro is continuing to work with these segments in developing direct marketing campaigns.

Climate Change

Several different segmentation schemes have been proposed for climate change and sustainability marketing over the past few years. A study based on a survey of 2,500 Canadians proposed four different segments with respect to sustainability communications (Hoggan 2006):

- **The Choir (15%)** – who are sold on sustainability
- **The Congregation (67%)** – who do not understand sustainability very well, but are receptive to it
- **The Heathen (16%)** – mostly young adults, who are oblivious
- **The Atheists (2%)** – who explicitly reject sustainability arguments and prioritize the economy

Though much more detail is provided on how these segments work, the general conclusion is that people are very enthusiastic, some appear immutable, and the biggest portion lies somewhere in between. Most studies might arrive at a similar basic result. The extent to which more elaborate classifications and how results are used (e.g., are efforts dedicated to getting people to jump to more favorable segments, and if so, how and with what limits?) are still open questions.

U.K. Energy Savings Trust

The U.K. Energy Savings Trust prepared a customer segmentation scheme for the U.K. using customer types developed in the Experian product MOSAIC™, overlaid with energy consumption and attitude data, and linkable to geo-demographic information, including postal codes. This resulted in 10 distinct types for the U.K. market, for example:

- **Environmentally Mature** – defined as being affluent, well-educated, and high energy consumers
- **Fixed Horizons** – defined as poorer families and elderly couples with below-average CO2 emissions
- **Ethnic Traditions** – which are described as having high importance on families, living in extended households, and often having high energy consumption)

Several of these groups were identified as being the most suitable for carbon emissions marketing, in part because of their apparent willingness to change (Wright 2007).

Appendix C: List of Abbreviations

ACEEE – American Council for an Energy-Efficient Economy

AM – adaptive management

ARB – Air Resources Board

CFL – compact florescent lamp

CPUC – California Public Utilities Commission

DSM – demand side management

ECEEE – European Council for an Energy Efficient Economy

EESP – Energy Efficiency Strategic Plan

EU – European Union

HVAC – heating, ventilation, and air conditioning

IEPEC – International Energy Program Evaluation Conference

IOU – investor owned utility

NGO – non-governmental organization

NRC – National Research Council

PG&E – Pacific Gas and Electric Company

PIP – Program Implementation Plan

PTEM – physical-technical-economic model

SCE – Southern California Edison Company

SCG – Southern California Gas Company

SCP – sustainable consumption and production

SDG&E – San Diego Gas and Electric Company

SMUD – Sacramento Municipal Utility District

ZNE – zero net energy (buildings)

ATTACHMENT V-2

Hydro One: In-Home Real Time Display

Customer feedback from a 30,000 unit deployment.

Giuliana Rossini
Director, Strategy &
Conservation Officer

Orlando April 2, 2009
Home Energy Displays
Conferences Connect

hydro one

Agenda

- 2005 Pilot Study - 500 homes – average 6.5% consumption savings
- 2006 Program Deployment – 30,000 units, largest program in North America – average 5.2% consumption savings
- 2007 TOU Pilot – 486 homes – up to 7.6% consumption savings plus up to 8.5% load shifting
- 2008-2010 Future Requirements

The Customer Experience

Ontario Facts at a Glance

- The province of Ontario has a population of 12.2 million
- Competitive electricity market
- Large scale transmission
- Fragmented distribution
- Summer Peaking province
- Record Peak Load 27,000 MW in July 2005
- Hydro One is a “wires only” company

hydro one

How big is Ontario?

- ✓ ***Ontario is about twice the size of Texas***
- ✓ ***415,OOO square miles***

The Supply vs Demand Gap

Conservation is a key element – 6,300MW

GOALS

- Shut down all coal fired generation by 2014
- Smart Meters and Time of Use rates for all customers by 2010
- Ban incandescent light bulbs by 2012
- Meet new load growth with Demand Side Management (DSM) + renewable generation
- Green Energy Act

- and lots of CONSERVATION!

hydro one

Hydro One's PowerCost Monitor™ Pilot Study - 2005

- Large comprehensive study
  - 5 regions in our service territory
  - 500 pilot customers followed over 2.5 year period
  - Statistically significant results (McMaster University)

BLUE line INNOVATIONS

hydro one

- PowerCost Monitor can be placed anywhere in the home
- Provides immediate feedback to consumers

Objective: does real time feedback empower customers to reduce consumption?

Customer Reduction in Electricity Consumption – 2005 Pilot

Results are Impressive (1.2 – 16.7%)

6.5% Decrease Overall

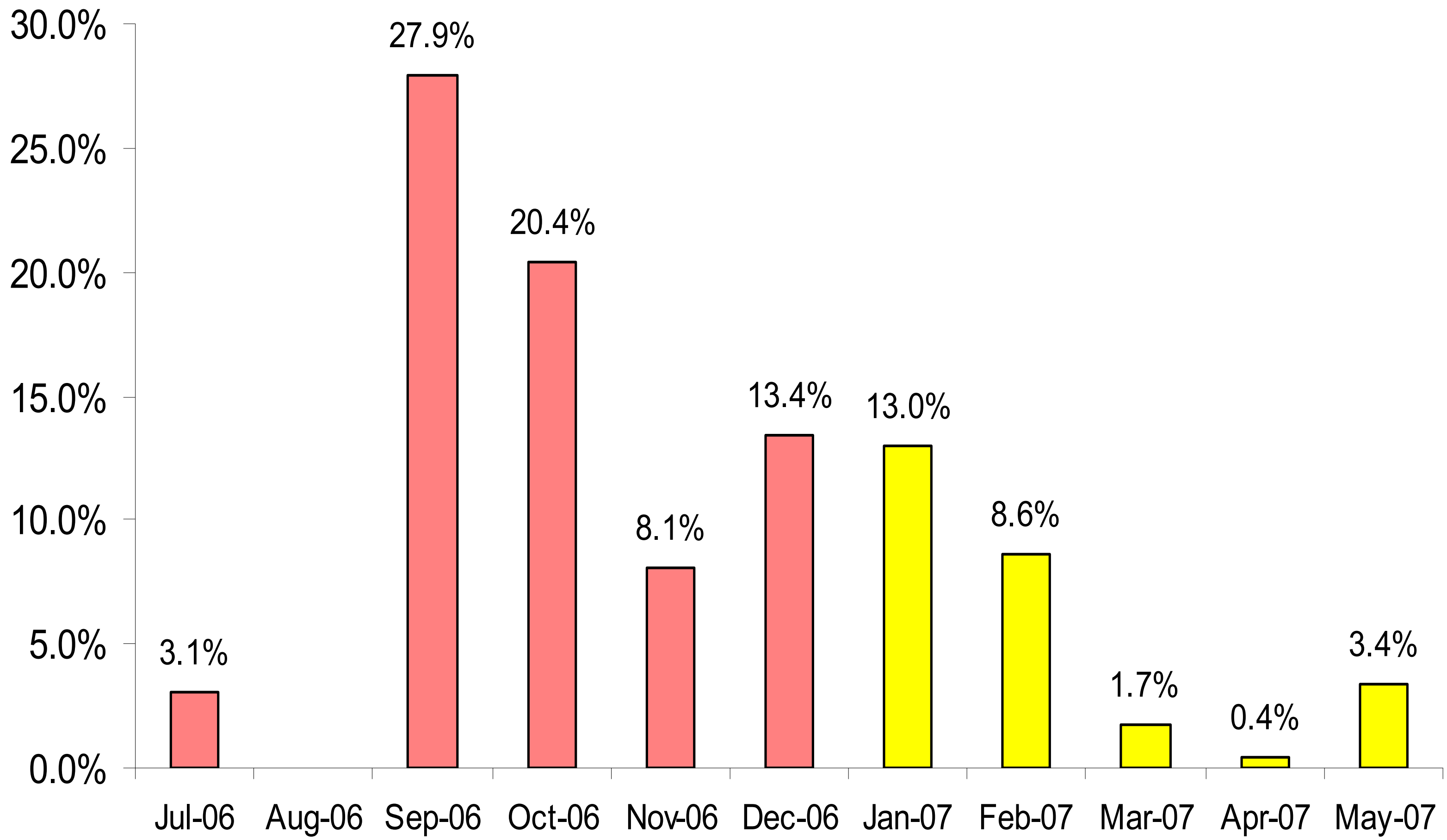
- w/o electrical space heating 8.2%
  - With electric water heating 16.7%
  - w/o electric water heating 5.1%
- With electric space heating
  - Cold geography 1.2%
  - Warm geography 3.4%

And customers love them…

30,000 Units Program Overview - 2006

- Pilot success prompted program rollout
- Residential customers in Northern Ontario – expected to be last to receive smart meters
- First 30,000 customers (~25%) to order receive IHD free of charge (value $C150). Customers pay shipping and handling ($C10)
- Third party delivery of program – Blue Line Innovations
- Marketed through bill channel, radio and newspaper advertising
- Program began July 2006; successfully completed April 2007 – “sold” 30,000 units in 9 months
- Budget $C5 Million

IHD Shipments – 30,000 Units



- **73% IHDs were sent out to customers in 2006**
- **27% IHDs were sent out to customers in 2007**

30,000 Deployment – 2 years later
IHD Survey - 2008

Survey Distribution - 3,200 surveys sent out in October 2008

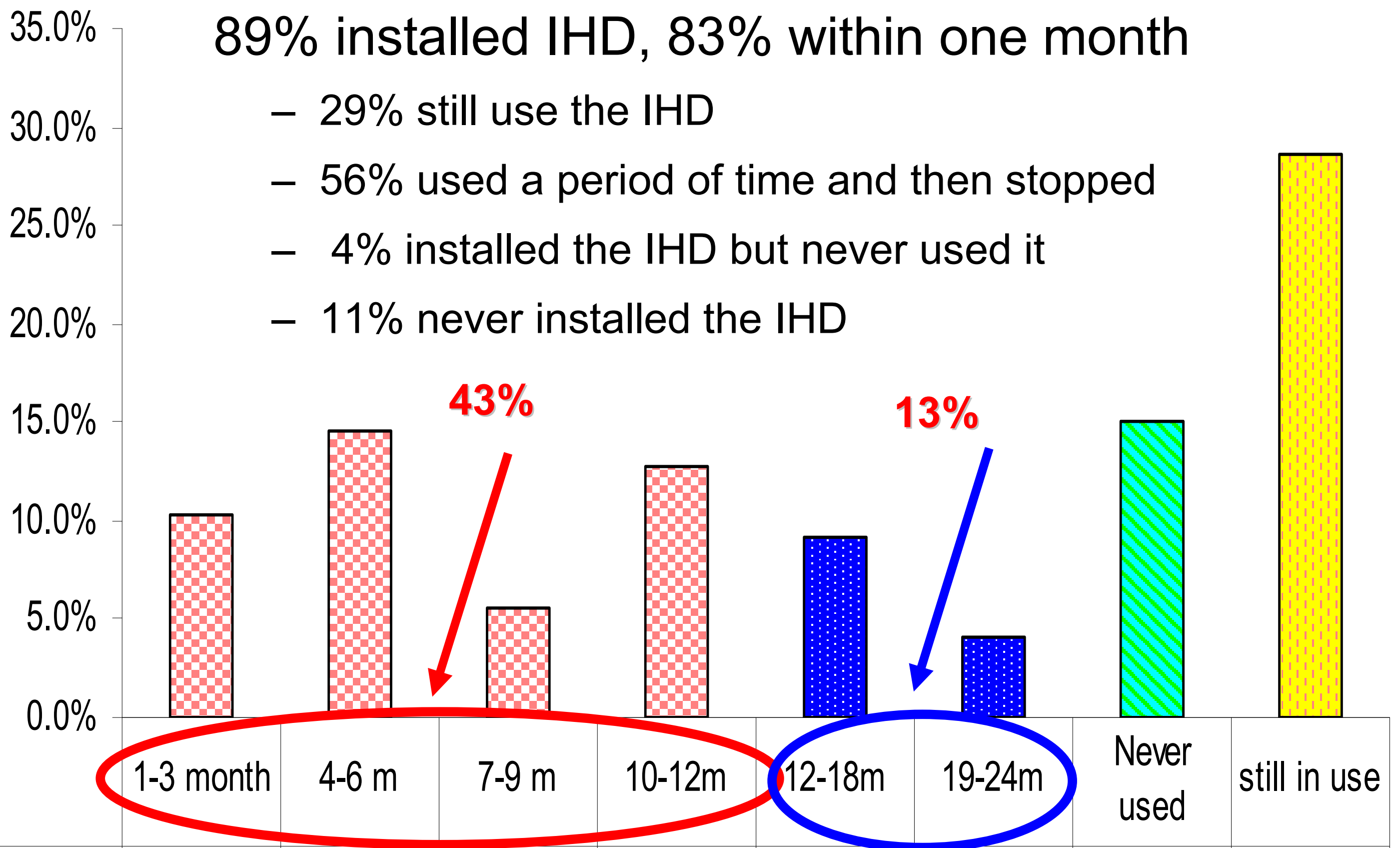
Survey Responses - 996 survey responses received
(response rate 31%)

Customer Response	**Qualitative/Quantitative Analysis**
• Installation and use	• Actions taken
• Why stopped using IHD	• Conservation impact
• When stopped using IHD	• Savings Profile
• Which IHD feature is useful	• Economic payback
• What other features desired	• Issues
• Would like a new IHD	• Implications

Customer Response: Installation and use

89% installed IHD, 83% within one month

- 29% still use the IHD
- 56% used a period of time and then stopped
- 4% installed the IHD but never used it
- 11% never installed the IHD



	1-3 month	4-6 m	7-9 m	10-12m	12-18m	19-24m	Never used	still in use
months of use	10.3%	14.5%	5.5%	12.8%	9.2%	4.1%	15.0%	28.6%

IHD Design Elements: eliminate need for installation and/or increase cost to customer to incent installation

Customer Response:
Why did you stop using the IHD?

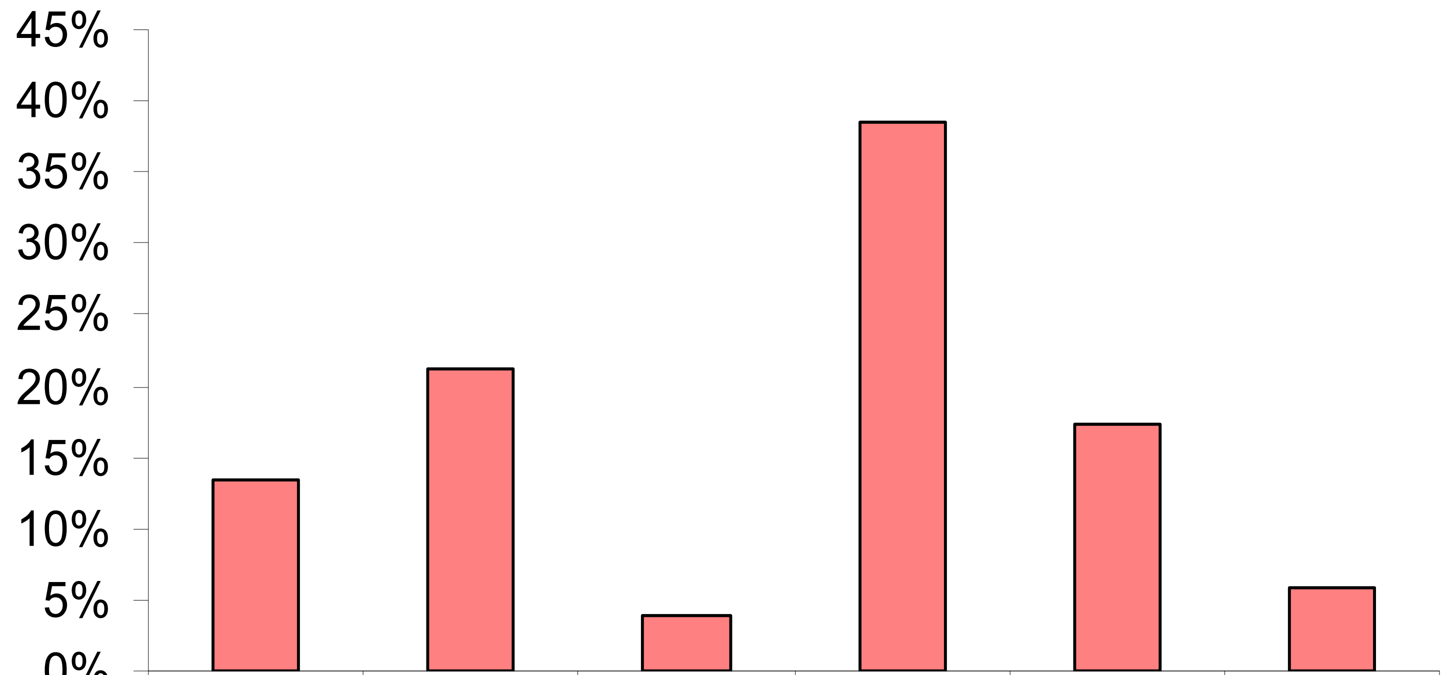
Of 56% who used the IHD for a period of time:

- IHD No longer works (78%)
  - Battery issues (58%)
  - IHD not working properly
  - Problems reprogramming
  - Not compatible with new Smart Meter
  - Did not know how to install and/or use
- Did not find IHD useful (20%)
- Have already made changes (14%)

IHD Design Elements: no batteries; 2-way communication; no programming required

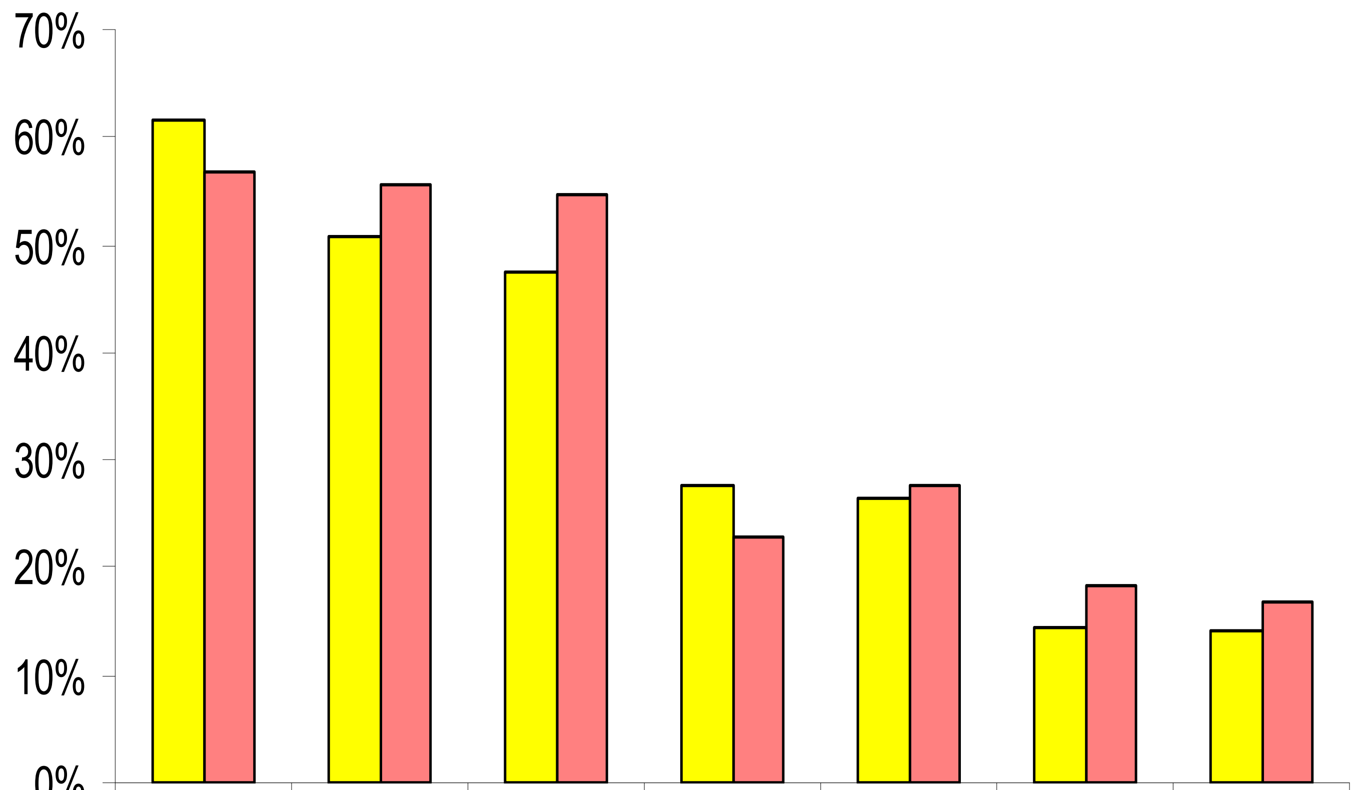
Customer Response: When were changes made?

No longer need IHD because already made changes within



	1 month	2 month	3 month	4-6 month	7-12 month	13-18 month
% customer	13%	21%	4%	38%	17%	6%

Customer response:
Which IHD features are useful?

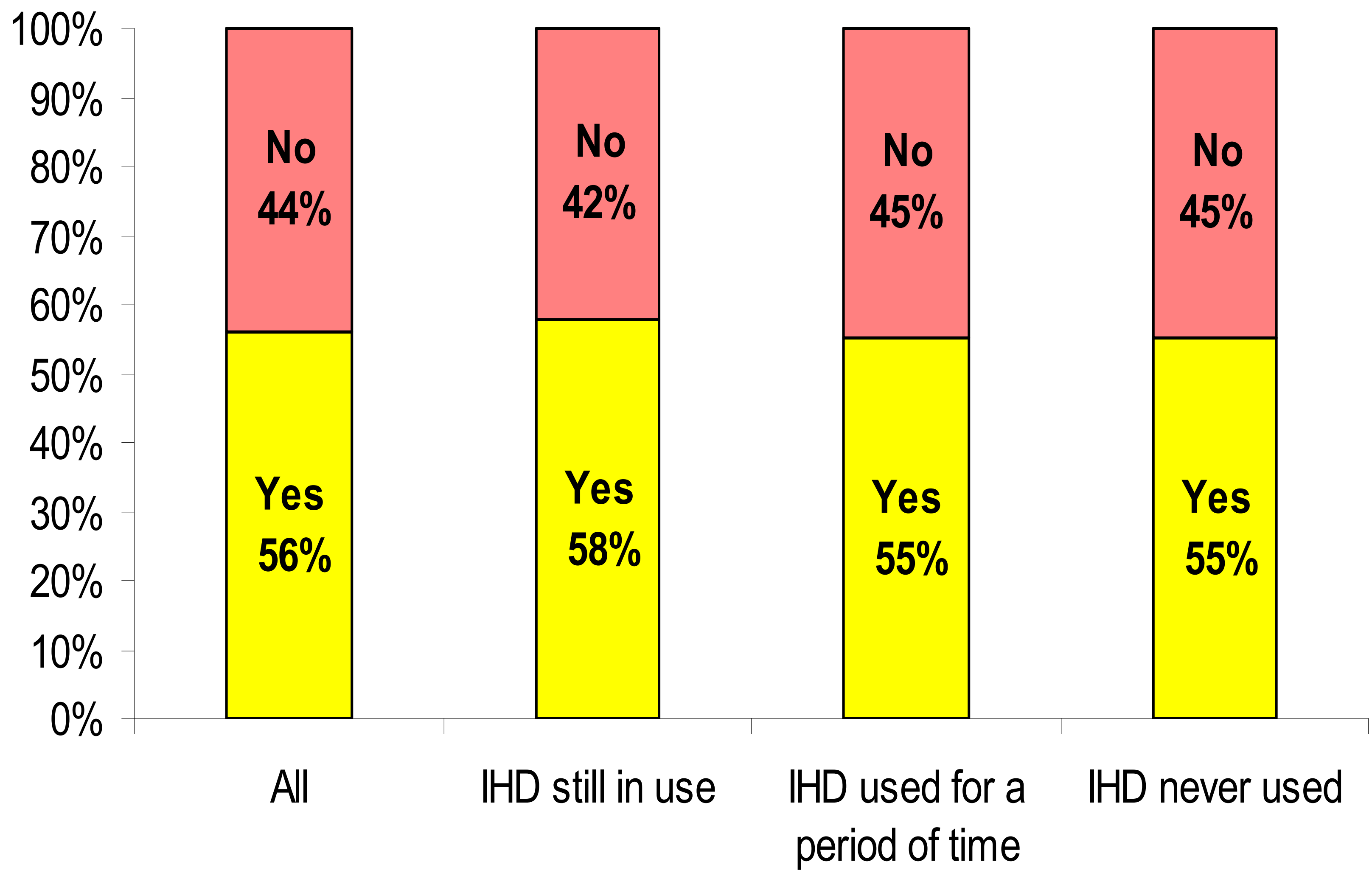


	Dollars/Hr	Outside Temp	kW/Hr	kW	Dollars	Predicted Dollars	Predicted kW/Hr
IHD still in use	62%	51%	47%	28%	26%	14%	14%
IHD used for a few months	57%	56%	55%	23%	28%	18%	17%

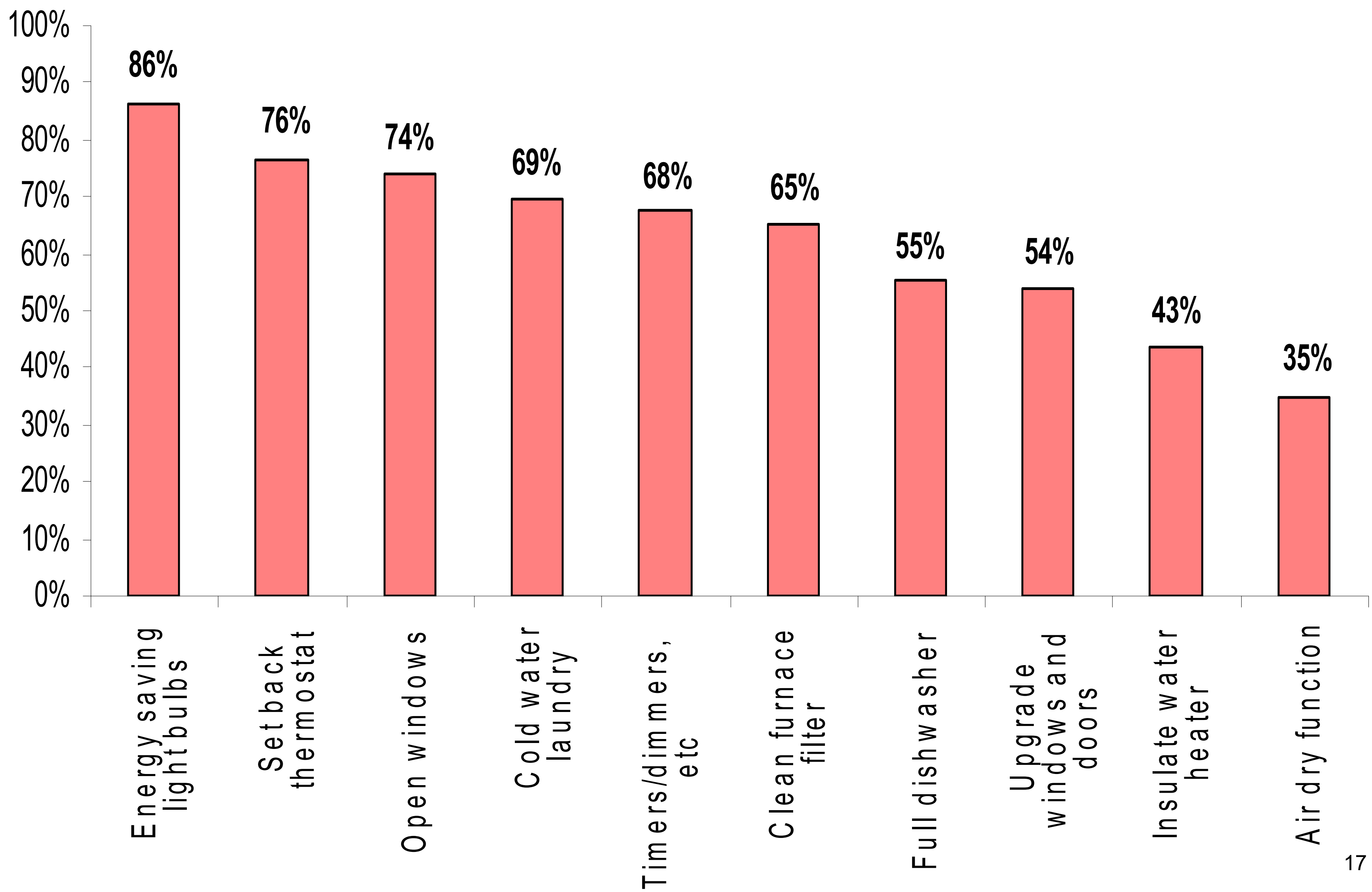
Customer Response: What additional features are desireable?

- Battery Related
  - Low battery indicator
  - The battery that last longer, especially in cold weather
  - Standard batteries that are affordable and easier to find
- Additional indicators
  - Indoor temperature, humidity, pressure and time
  - Show electricity consumption summaries (daily, monthly, yearly) and individual appliance electricity consumption
- Able to work with a smart meter
- More user friendly

Customer Response:
Would you like a new IHD?



Qualitative Analysis:
What conservation actions you have taken?



Quantitative Analysis:
Conservation impact for all participants

Quantitative Load Analysis

	% Customers	Energy Impact	Net IHD Impact
IHD Still in use	28.6%	-6.7%	-5.2%
IHD used for a few months	56.4%	-4.5%	-3.0%
IHD never used	15.0%	-1.5%	

Savings profile by consumption group

Consumption (kWh/year)	Annual savings (kWh)	% saving
<6,000	388	7.6
6,000-10,500	617	7.0
10,500-15,000	1,187	8.6
15,000-21,000	1,262	6.7
21,000-30,000	1,110	4.2
>30,000	959	2.8
Overall	**841**	**6.7**

kWh savings remains relatively constant across a broad range of annual consumption = consistent "value" for utility.

Quantitative Analysis:
Economic payback for customers

Energy Consumption (kWh/year)	Volumetric Charge ($)	IHD conservation impact	Annual Savings $	Payback (years)
6000	595	7.60%	45	3.32
10,500	1,050	7.00%	73	2.04
15,000	1,537	8.60%	132	1.14
21,000	2,186	6.70%	146	1.02
30,000	3,160	4.20%	133	1.13

Assumptions: (1) Cost of IHD is $150 (2) Volumetric Charge ~10¢/kWh

(3) no/ negligible low operating cost

Issues with First Generation IHD/Program

- Customer must install IHD on meter
- No communication (IHD does not “talk” to network)
  - rate structure is fixed a time of deployment
  - does not support critical peak pricing
  - customer must manually update rates, reset cumulative consumption, etc.
  - no messaging capability
- Requires batteries in external unit that must be replaced
  - early units required special batteries that were expensive and customers had difficulty finding
  - Customers often did not get around to replacing batteries, even when units utilized common size
- Works with electromechanical, not all electronic meters – does not work with the majority of Hydro One smart meters

Implications for Future Generation IHD/Program

- Eliminate need for installation of IHD and batteries – deploy preconfigured, wireless IHD that "talks" to meter from inside the house
- Increase cost of IHD to customer – increases incentive to install/use once "purchased"
- Employ network enabled IHDs – 2-way communication enables remote updates; supports critical peak pricing; support messaging and acknowledgements
- Incorporate customer feedback on feature set for IHD - electricity consumption summaries; temperature; time; appliance information

Questions?

ATTACHMENT V-3

Home Energy Displays: Highlights from the Nevada Product Trials

Larry Holmes, NV Energy

Conferences Connect

2ND ANNUAL HOME ENERGY DISPLAYS CONFERENCE

Innovations in Energy Efficiency and Conservation

APRIL 1-2, 2009 | ORLANDO | WALT DISNEY SWAN AND DOLPHIN RESORT

Introduction

- Setting the Stage
- Selecting Devices
- Selecting Participants
- Installation Challenges
- The Test Period
- What the Customers Told Us
- Energy Savings
- What is Next?

SETTING THE STAGE

NV Energy

- **Service Territory:**
  - **1.2M Customers**
  - **7,800 MW Peak**

Early Commission Staff Involvement

- Pick-up unit mounted in meter socket
- Meter shop objections
- Five commission senior staffers recruited
- Claims of 20-30% energy savings
- Test program included in 2006 DSM plan

Prepaid Metering

- Meter and in-house unit
- Simple LED display
    - kW, kWh, and cost
        - Day and month-to-date
- Communicated via household wiring
- Quick response
- My experience

HED Objectives

- Expand and improve conservation and efficiency programs
  - contribute to meeting renewable portfolio standard (RPS)
  - prepare for automated metering infrastructure (AMI) and the home area network (HAN)
  - investigate reliable, cost-effective, and customer-satisfying new technologies
- Identify the role of HEDs among NV Energy's programs
  - identify features and functions that satisfy customers and correlate with customer changes in behavior and energy use

➔ Establish requirements for a HED Request-for-Proposal

HED Trial Objectives

1. Assess bill savings available to residential households through HEDs,
2. Describe the residential customer experience with HEDs,
3. Identify HED features and functions residential customers prefer
4. Indicate customer satisfaction with HEDs

Background

- Home Energy Display (HED) trials
  - Product trial began in late 2007
  - Product trial followed by market test and program launch
  - Research team included Paragon Consulting, the Boice Dunham Group, and the University of Nevada – Las Vegas
  - Input from Public Utilities Commission of Nevada Staff and the DSM Collaborative

→ Do HEDs have a place among NV Energy's programs?

SELECTING DEVICES

Product Trial Devices

- HEDs
  - Kill-A-Watt (P3 International)
  - PowerCost Monitor (Blue Line Innovations)
  - The Energy Detective – TED (Energy, Inc.)
  - Whole House Energy Monitor (Energy Monitoring Technologies)
  - The Energy Joule (Consumer Powerline)

- Did not include AzTech or other second generation devices (could not provision)

➔ HEDs operated on a standard rate without special customer training or information

SELECTING PARTICIPANTS

Identifying Potential Participants

- Target Customer Strata by monthly kWh consumption
  - 0-800
  - 801-1250
  - 1251-1750
  - 1751-2500
  - >2501
- Single-family households
- More than a year in residence
- No unusual electric equipment
- Include low income and senior citizen representation

Customer Recruitment

- A list of customers meeting selected criteria was extracted from the customer billing system
- UNLV Call Center solicited these customers to participate in the program
- Potential participant lists were forwarded to electrical contractors to make appointments and perform installations
- Making appointments was a rough spot

INSTALLATION CHALLENGES

Installation Challenges

- A number of issues delayed HED installations
  - utility and contract staff availability, training, and scheduling
  - device certification (e.g., building and electrical codes)
  - site conditions (e.g., panelbox)
  - customer instruction and service

➔ Numerous delays and replacements as the trial began

THE TEST PERIOD

Product Trial Research

- Changes in behavior
  - recruiter and installer interviews
  - three participant surveys spaced two months apart, conjoint maximum-difference feature comparison in final survey
  - focus groups (three) and in-home interviews (10 participants)
- Changes in energy use
  - bill analysis
  - energy strata and special segments

Test Group

- 93 initial participants
  - Single-family households with more than a year in residence
  - 36 north
  - 57 south
- 5 Low-income customers
- 10 senior citizens

Three Surveys

- The first survey investigated:
  - Participant and household information
  - Participant experience with the installation
  - Participant experience with instructions provided
  - Participant experience with the devices
- The second survey investigated:
  - Same as the first but included occupancy changes
- The third survey investigated:
  - Same as second but added feature analysis

Maximum-Difference Conjoint Analysis Ranks Feature Sets

- Participants were asked:
  - "of these five features, which is MOST important to you when deciding which Home Energy Display to select for your household, and which is LEAST important to you?"
  - 27 features were rotated through 15 sets and three versions of the questionnaire
- With enough participants, question sets, and questionnaire versions, maximum-difference conjoint analysis allows:
  - ranking of features into significant tiers
  - identification of significant distances between individual feature rankings

Maximum-Difference Conjoint Analysis Provides Index Rankings

- Conversion of scale values into index values makes for easier comparison of features
- If all features were equally likely to be MOST, all index scores would be 100
- Index scores can be compared as "odds ratios"
  - a feature with an index of 264 is more than five times more likely to be selected over a feature with an index of 55
  - a feature with an index of 201 is more than twice as likely to be selected over a "typical" (index = 100) feature
- The index difference between two features can be significant at a given confidence level (e.g., at 95%, if A is >1.52 B)

Maximum-Difference Conjoint Analysis for Home Energy Displays

- 65 of our 93 participants responded to the third survey
  - we asked 15 MOST/LEAST feature-ranking questions across a total of 27 features, ranked five at a time
  - we used three different version of the questionnaire (for statistical purposes)
- Top-tier features identified by the participants are significantly <u>more</u> likely than others to be MOST important
- Low-tier features identified by the participants are significantly <u>less</u> likely than others to be MOST important
- Many ranking comparisons of individual features were also significant

WHAT THE CUSTOMERS TOLD US

Customer Satisfaction With HEDs

(Third Survey)

- 86% Device performed well
- 83% Stated they know how to use the devices
- 79% Would recommend to friends and family
- 77% HED met their expectations
- 68% Supported utility providing HEDs at low or no cost to customers
- 14% HED had not performed well
- 12% Did no know how to use the device
- 12% Would not recommend it to friends or family

Savers

- Savers - Two thirds of the participants saved energy
- One third were non savers
- Savers
  - Understanding increased over time
  - Satisfaction increased over time
  - More household involvement
  - Increased awareness of costs and energy use led to action

Conjoint Feature Comparison: Top Tier

Rank Order	Home Energy Display Feature	Scale Value	Index Results
1	Accurately measures my cost and amount of energy used	3.40	264
2	Displays my cost and amount of electricity used for my whole house as of right now	3.32	243
3	Displays my cost and amount of electricity used during the current billing cycle	3.25	229
4	Provides instant real-time measurements of my cost and amount of electricity used	3.12	201
5	Displays the cost and amount of electricity being used at the moment	3.06	188
6	Displays my cost and amount of electricity used during the last 24 hours	2.92	164
7	Displays the cost and amount of electricity used for my individual appliances as of right now	2.84	152
	95% Confidence Interval	0.42	1.52
	Top tier if greater than		152

Conjoint Feature Comparison: Mid-Tier

Rank Order	Home Energy Display Feature	Scale Value	Index Results
8	Has an easy-to-read display screen	2.79	144
9	Is easy to use	2.59	117
10	Displays my peak electricity usage level and cost within past periods	2.51	108
11	Projects my cost and amount of electricity used for individual appliances across future periods	2.40	97
12	Displays my highest and lowest voltage levels of electricity within past periods	2.37	94
13	Is provided by my electric utility	2.35	93
14	Projects my cost and amount of electricity used for the whole house across future periods	2.29	88
15	Indicates how expensive electricity is right now by colors (red, yellow, green)	2.16	76
16	Has an easy-to-read display screen	2.14	75
	95% Confidence Interval	0.42	1.52
	Mid-tier if between		66-152

Conjoint Feature Comparison: Low Tier

Rank Order	Home Energy Display Feature	Scale Value	Index Results
17	Provides alerts of utility load control events and emergencies	1.99	64
18	Operates through wireless communications	1.92	60
19	Is easy to install	1.83	55
20	Is portable (from location to location within the home)	1.60	44
21	Provides weather information (e.g., current temperature at the meter)	1.43	37
22	Doesn't need a battery	1.01	24
23	Links to energy analysis software on my computer	0.98	23
24	Displays time and date	0.86	21
25	Sits on the counter or shelf	0.77	19
26	Hangs on the wall	0.20	11
27	Looks good in my house	0.00	9
	95% Confidence Interval	0.42	1.52
	Low tier if less than		66

Participant Feature Rankings

- Top-tier features are the accurate and timely measurement and display of my energy usage
  - cost and amount of use
  - whole house and individual appliances right now, in the last 24 hours, and during the current billing cycle

- Low-tier features are other kinds of information and a good fit in the home
  - utility events, energy analysis, weather/time/date information
  - wireless, portable, no battery, easy-install, sits or hangs, looks good

➔ Participants prefer a dedicated device

ENERGY SAVINGS

Changes in Energy Use

- Participants varied by energy usage strata:

Strata Descriptions (average kWh/month use)	South	North
1 - 000-800	16	10
2 - 801-1,250	11	7
3 - 1,251-2,500	18	4
4 - 2,501-3,500	3	10
5 > 3,501	9	5
Seniors	7	3
Low-income	2	3
Total	57	36

Billing Analysis Procedures

- February-July 2007 baseline comparison, usage by participating household
- Weather adjustment by degree days
- Monthly billing extracts from NV Energy Customer Information System
- Exclusions of adjustments and errors
- Baseline/test period comparisons

Billing Analysis Results

- Participant energy savings 5.22%
  - South: 7.24%, North: 2.60%
- Participant energy savings by strata varied
  - 1: (1.93%)
  - 2: 9.75%
  - 3: 7.03%
  - 4: 5.71%
  - 5: 4.41%

→ Savings were significant even without customer training

WHAT IS NEXT?

Key Results

- Ongoing customer care and education is needed to achieve full potential savings
- Better instructions are required
- Installation and maintenance issues adversely impacted results
- Customer selection is important to recruit those more likely to be savers

Key Results

- Cost and usage information is most important to customers
- Customers want a device that tells them usage for individual appliances
- Indications support the potential for a strong energy conservation program

Expanded Market Test

- Second generation devices selected based on customer preferences
- Develop and Test a Service Model
  - Procurement
  - Recruitment
  - Installation
  - Customer care
    - Instructions
    - Help line
    - Maintenance
- Determine Energy Savings Potential

Part of a Bigger Change

- Integrated with the AMI
- Integrated with future rate designs
- Empower customers with data and tools to use the data
- Move customers from the perception of being victims to a feeling of being in control

THANK YOU!

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