Public Interest Energy Research (PIER) Program
FINAL PROJECT REPORT

Potential Gains in Appliance Efficiency and Recommendations for a Center for Consumer and Office Electronics and Appliance Efficiency

Prepared for:
Public Interest Energy Research Program
California Energy Commission

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NOVEMBER 2010
CEC-500-99-013

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Contract Number: 500-99-013,
Work Authorization BOA 241

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ACKNOWLEDGMENTS

This work was funded by the California Energy Commission, through a work authorization under the Commission's Interagency Agreement No. 500-99-013 with the California Institute for Energy and Environment, and that Institute's subcontract to the University of California, Irvine (UCI). At UCI the project was conducted and administered by the Irvine Division of the California Institute for Telecommunications and Information Technology (Calit2).

The four-part outline structure of the report is as requested by the Energy Commission staff, and the staff members have provided additional guidance in many discussions. Section A of this report was written primarily by a team from the Paul Merage School of Business -- Dr. Alladi Venkatesh, professor of management; Dr. Shivendu Shivendu, assistant professor of information science, and Sumit Deo, a graduate student in business. Support in writing, research and editing for the other parts of the report was provided by Stuart Ross, Kristen Gamble, Crystal Le, Mike Dang, and Mark Tameta.

The Irvine Division of the California Institute for Telecommunications and Information Technology (Calit2) and the Advanced Power and Energy Program (APEP) contributed additional staff and administrative support to the production of this report.

By the nature of this work, substantive contributions have been received from dozens of persons in industry, government, and academia – through reading their work, hearing their presentations, or talking with them personally. This report has incorporated their ideas, comments, corrections, and assistance in many places and many ways, trying to do so correctly. It is not possible to retrace all their connections and contributions, but their names appear in various parts of the text, graphics, references, and appendices. The authors thank them all.

PREFACE

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace. The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California. The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions. PIER funding efforts are focused on the following RD&D program areas:

Buildings End-Use Energy Efficiency

Energy Innovations Small Grants

Energy-Related Environmental Research

Energy Systems Integration

Environmentally Preferred Advanced Generation

Industrial/Agricultural/Water End-Use Energy Efficiency

Renewable Energy Technologies

Transportation

This document is the final report for Interagency Agreement 500-99-013 with the California Institute for Energy and Environment, via a subcontract to the University of California, Irvine, under Basic Ordering Agreement BOA 241. The information from this project contributes to PIER's Buildings End-Use Energy Efficiency Program by assessing the priorities and needs for achieving energy efficiency in residential and commercial appliances and electronic devices.

For more information about the PIER Program, please visit the Energy Commission's website at http://www.energy.ca.gov/research/index.html or contact the Energy Commission at 916-654-5164.

ABSTRACT

Energy use in the residential and commercial sectors in California for appliances and electronic devices is growing rapidly -- by most accounts those items already constitute more than 10percent of energy use in the residential and commercial sectors. Government action to promote energy efficiency and conservation has been less rigorous for this load, especially for small appliances and electronic devices, not only because the load has historically been smaller but also because it derives from a wide variety of technologies and manufacturers, some of them quite new, and because the vagaries of consumer behavior play so large a role in the problem. Yet the technologies, the behaviors, and the realities of personal finance do tie these uses together as a group. For these reasons substantial marginal gains in efficiency could be made by improving coordination. This report recommends establishing a new center to coordinate the necessary efforts in research, demonstration, education, testing standards, and protocol development.

This report reviews the markets, the energy consumption, and the emerging technological developments for many such devices, primarily for electric-powered devices – the so-called plug load. Only secondary consideration is given to industrial settings, to built-in systems such as HVAC, or to lighting. The report reviews recent and current actions by government, the utilities, and the manufacturers. The focus is on California, but given the nature of the industries and the regulatory processes, attention to the national level is necessary also. The information is based on a review of the literature (academic studies, trade publications, government reports, conference proceedings, news releases, web sites) and on discussions with many persons.

The report discusses the priorities a center should address, the activities it should pursue, and the form it should take. The idea for a center is shaped by the Commission's success in establishing major research centers on other energy topics.

Keywords: PIER, energy research, California, energy efficiency, plug load, appliances, consumer electronics, white goods, utilities, decoupling, smart grid, demand response, Title 20, regulations, rulemaking, CPUC, CEC, home area networks,

Please cite this report as follows:

Li, G.P. (University of California, Irvine), G. Scott Samuelsen (University of California, Irvine), 2010. *Potential Gains in Appliance Efficiency and Recommendations for a Center for Consumer and Office Electronics and Appliance Efficiency.* California Energy Commission, PIER Energy-Related Research. CEC-500-99-013.

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EXECUTIVE SUMMARY

Background

Energy use in the residential and commercial sectors in California for appliances and electronic devices is growing rapidly -- by most accounts those items already constitute more than 10percent of energy use in the residential and commercial sectors; by some definitions the estimate would be closer to 20percent .

California has been a leader in establishing energy efficiency standards for many appliances, and it has begun to do so for electronic devices, most notably in 2009 for televisions. The federal government and other states have taken similar measures, usually following California's lead.

Nonetheless, those technical and political efforts do not define the problem, for several reasons. First, there is such a variety of energy loads that residents and businesspeople bring into their buildings – not just refrigerators and televisions but also mobile phones, copiers, cash registers, freezer cabinets, portable lamps, hair dryers, electric can openers, garage door openers, gas barbecues, and more. Second, consumer behaviors in using these devices is also quite varied – it varies by region, age, and appliance type, at least – and consumers typically have little knowledge about the energy consumption of each activity. Third, particularly for electronic devices, the load is growing rapidly – cell phones are replaced every year or two, second refrigerators are common, homes that once had five electronic devices now have twenty. It is a social problem as well as a technical problem. Finally, even the category definitions keep shifting – BluRay replaces DVD and CD, which replaced VHS; telephones converge with electronic cameras.

As a result, one of the fastest growing energy loads is also the least well defined, least regulated, and most difficult to regulate. That fact bodes ill for California's energy future.

PIER has found for other energy problems that it helps to establish a research center at a university or national lab that can integrate research, demonstration, and education on the problem. These centers include for example the California Lighting Technology Center, the Demand Response Research Center, the Smart Grid Research Center, and the Western Cooling Efficiency Center. These organizations have proved useful as neutral sources of expertise available to the public, the industry, the utilities, and the state government. Several significant projects that advance energy efficiency can be traced to the initiative and assistance provided by these organizations. By their neutrality, expertise, and success they have also been able to garner financial support from other sources to supplement the baseline support from the Energy Commission.

So PIER began to consider establishing such a center for this emerging problem. PIER asked the California Institute for Telecommunications and Information Technology ("Calit2") at the University of California, Irvine to undertake such a task. Calit2 is an interdisciplinary center with a track record of applied as well as basic research pertaining to electronic devices; UC Irvine has a good record of energy conservation and cooperation with its local electric utility, Southern California Edison; UC Irvine has established expertise on the use of information technology in the home and office. The work was contracted as a work authorization through an existing contract with the UC system's Center for Energy and Environment, at UC Berkeley, which subcontracted to UC Irvine.

Purposes

The PIER staff sought to determine whether a special research center on efficiency in appliances would indeed be helpful in addressing the problems; how such a center might be organized and funded; and what the action priorities for such a center should be. Illuminating those issues is the purpose of this report.

Ojectives

In particular, PIER wanted the contractor to:

- Determine the nature and definition of the problem;
- Examine the markets for appliances and consumer or office electronics;
- Describe the extant structures, standards, and organizations that pertain to energy efficiency in appliances and consumer or office electronics;
- Examine the social and economic aspects of the problem as well as the technical and engineering aspects;
- Highlight significant opportunities for energy savings;
- Detail the topics and schedules that should be priorities for such a center;
- Estimate the funding that would be needed for such a center and potential funding sources;
- Provide conceptual designs for a center's facilities;
- Provide a bibliography on behavioral issues surrounding residential energy conservation.

PIER asked Calit2 to conduct the work not through original research but through reviewing the existing literatures and seeking input from all the types of stakeholders --utilities, state agencies, manufacturers, consultants, and environmental groups. PIER asked Calit2 to document its own actions, data searches, readings, and consultations in the report. Calit2's work included two workshops for over 100 persons each, extensive literature reviews, and many visits to sites in Northern California and Southern California (detailed in Section B and the bibliographies).

Conclusions and Recommendations

Recognition of this problem is emerging, but there is little consensus on the definition or the size; this problem is not like counting refrigerators or even 'deemed savings'. It is sometimes called the 'plug load', but that excludes gas appliances. Some approaches include installed items like water heaters; other approaches exclude them. Some definitions are by function (heating, cooking, entertainment) but those categories are not useful for defining policy actions. The emergence of plug-in electric vehicles complicates the definition further; household energy use was once considered quite separate from the transportation sector. Attempts to address the devices or component economic sectors – such as the appliance industry and the electronic device industry, televisions but not speakers – will falter because of the many behavioral and technical links between the devices in a real household or office. These ambiguities cannot be defined away; a center will have to establish central themes and ideas but always be open to alternative definitions.

Here are some important differences between the electronic device industry and the appliance industry:

- The electronics industry is much bigger than the appliance industry, as measured in retail sales (about $100 billion per year as opposed to about $40 billion per year, by one estimate).
- The electronics industry is much less concentrated than the appliance industry; in the appliance industry the top four manufacturers represent about 80percent of the market.

- The appliance industry has grown accustomed to formal regulation for energy efficiency; the electronics industry has not.
- Radical product changes are more frequent in the electronics industry. A washing machine produced in 2010 has roughly the same appearance and same functions as one produced in 1990 and has about the same social functions, in spite of many new features and improvements. A mobile phone produced in 2010 looks quite different and is a different social phenomenon than one produced in 1990. Setting formal standards for efficiency may be too slow and cumbersome a process in such a setting.
- The electronics industry affects, and is aimed at, a different set of end users than the major appliance industry. In particular, children and teenagers use electronic devices more than they use major appliances. Their different uses and different purchasing patterns affect the possibilities for setting standards and applying rebates.

However, these similarities are important also:

- The two kinds of problems are increasingly linked with one another – major appliances now have substantial electronic circuitry for monitoring and control, and their status can be communicated to phones, computers, or televisions.
- For both kinds of devices, rebates are important tools. For electronic devices especially, rebates to manufacturers and retailers may be more effective than rebates to end-use customers.
- For both kinds of devices, evaluating efficiency programs is very difficult and will require significant resources.
- Both industries have a problem with ‘standby’ modes of energy consumption, although that problem has been addressed by regulation more thoroughly for appliances than for electronic devices.

The center should focus first on these problem areas:

- Set-top boxes. These devices have long been recognized as an energy problem, but an unusual market structure and rapid technological change make conventional solutions inappropriate.
- Medical devices. From household health gadgets to major hospital equipment, these devices are very numerous and have hardly ever been subjected to review for energy efficiency.
- Audio and entertainment systems. Speakers, amplifiers, DVDs, and related gadgets have rarely been subject to measurement or regulation, yet like televisions they are growing in size and in number.
- Home area networks. There is now a booming market for smart strips, wireless control systems, and networks for monitoring or controlling energy consumption in the home. Unfortunately there is little comparative technical testing by neutral parties and even less understanding of how well various systems work in real settings. Many ‘smart’ systems are little more than on-off controls tied to some timer or sensor; higher levels of intelligence are needed.
- Self-monitoring appliances. Appliances should not only be networked to each other and to the grid; they should also monitor themselves and their usage.
- Computers and game consoles. There has already been considerable attention to the efficiency and the use of these devices – there are voluntary industry standards, behavioral studies, and new circuit and chip designs. But the size of the problem demands continued attention, the customer expectations for performance increase

rapidly, there are possible savings not yet well explored (energy consumption ratings for software), and a lack of formal regulations.

The report notes other areas that are worthy of attention: broad behavioral studies, large-scale networks, server rooms and data centers, communication networks, plug-in vehicles, distributed generation, public education, television, and USB-powered devices. Although some of these rank high in energy consumption, they rank lower for a center's attention because there are substantial ongoing efforts by other organizations, less immediate connections to household or office use, or less likelihood of short-term results.

Although a few structural problems surfaced, as in the responsibility for efficiency in set-top boxes and in federal-state relations, in general the structures did not seem to be the problem. The roles of the Energy Commission and the Public Utilities Commission in the search for efficiency are understood; decoupling has motivated the utilities to encourage energy efficiency among their customers; the utilities coordinate their efforts formally and informally.

The problem is rather one of perspective: There must be a place for a holistic view of energy use in appliances and electronic devices in residences and places of business, a place where multiple technical problems and policy problems can be addressed together. The establishment of a separate center would therefore be an effective complement to the existing structures. The problems require that kind of flexibility with research, demonstration, and education; and the problems require an interdisciplinary approach. The required staffing and organization can readily be accommodated in a university structure, perhaps through shared personnel. Based on the consultations made during this study, a funding structure similar to the others seems quite feasible – if the Energy Commission can provide a foundation or base of $1 million or $1.25 million (shown in Section D) then formal memberships can be obtained, and because of the importance of energy conservation there are many possible sources of additional grant or contract funding.

Introduction

Gains in energy efficiency have been made in many sectors of the economy, such as transportation and building design, spurred on by concerns about independence from foreign oil and concerns about greenhouse gases. However there is a problem area for which the data, the tools, and even the concepts have lagged behind the general progress. That is the energy use by people inside their buildings, in their daily routines -- the energy used by the appliances, electronic devices, and tools that residential and commercial consumers connect to their buildings. There is not yet much consensus on how to think about this load; it is divided into categories in many different ways. This load is usually conceived of as a remainder, after lighting, central HVAC, and water heaters are taken care of; those categories (typically installed rather than just plugged in) have already received considerable attention as energy uses.

There are various estimates of the size of this load, but the estimates agree that this load now represents 10 percent to 20percent of energy use in the residential and commercial sectors and that this load is growing rapidly. The Energy Information Administration reports that 18 percent of the energy used in commercial enterprises in 2003 was for computers, office equipment, and 'other' (EIA CBECS Table E5A). A report by Calwell (2008) indicates that the electric part of this load represents 15percent to 20percent of residential electricity use. The Consortium for Energy Efficiency states that "Estimates of consumer electronics electricity use range from 11 percent to 13 percent, according to the Consumer Electronics Association (CEA) and the Environmental Protection Agency (EPA) respectively. EPA predicts this percentage is expected to increase to 18 by 2015" (CEE 2010). A presentation by the Electric Power Research Institute states that the energy used by the commercial and residential sectors is growing faster than the energy use by the industrial sector (Mansoor 2008). The IEA expects that energy use by these devices will double by 2022 and increase threefold by 2030 (IEA, Gadgets and Gigawatts, 2009). This load can no longer be ignored. Many studies on different aspects of the problem do suggest that further attention to these matters would be of great benefit (e.g., Meyers et al. 2008; Moorefield et al. 2008; Sanchez et al. 2007; Sanchez et al. 2008; Bernstein et al. 2000; Sudarshan and Sweeney 2008; Granade et al. 2009; CPUC 2008; Neubauer et al 2009; Horowitz, Calwell, and Foster 2005).

This report is about the idea of establishing a new center in California to coordinate research, demonstration, and education on that 'other' load -- a center dedicated to efficiency in appliances and electronic devices in residential and commercial settings. As requested by the Energy Commission, this report addresses the need for such a center, the priorities it should address, the activities it should pursue, and what form it should take. Not surprisingly, the plans for a center presented here are shaped by consideration of the Commission's existing research centers on related energy topics.

Yet the organizations and policies with authority over decisions about energy efficiency have generally not considered the whole set of appliances and devices in a household or a business -- even though in each case the group is recorded as one unit by a meter and controlled by the behavior of one household or organization. Factors that should be addressed, such as the tradeoffs and combinations within the group and the behaviors associated with the appliances, have too often been left for someone else to handle, at some other time. The Energy Commission itself has funded less than ten projects on plug-load issues, as separate projects, out of over 50 projects on energy efficiency and demand response.

The continued growth of energy usage and the continued pressure for energy efficiency are forcing attention to this remainder category. AB32 and other programs for zero-net-energy are now forcing a holistic view, but even there the attention is usually on the building rather than its contents and inhabitants.

The electric part of this load is usually called the 'plug load'. The range and variety of 'plug load' devices for home and workplace is considerable – from pencil sharpeners to clothes washers, from cell phone chargers to vending machines, from ice cream makers to multifunction copiers. There appears to be no precise technical or legal definition of the term 'plug load', and that problem accounts in part for the diversity of figures encountered in the literature. This study uses these characteristics to define the plug load: (a) it consists of devices that plug in to wall outlets, as opposed to being hard-wired; (b) it does include traditional categories such as lighting or installed HVAC, and (c) it does not include industrial equipment (some of which may use wall plugs). This approach would also include gas appliances, such as clothes dryers, range tops, room space heaters, pool heaters and more, but not furnaces, in the work of the Center. Thus it is a wider definition than some others, such as Calwell (2008). This report, however, will focus primarily on electric appliances.

Special attention is needed for the category of consumer and office electronics (Ecos Consulting, EPRI Solutions, and RLW Analytics 2008), for several reasons.

First, the sector is growing rapidly, and here has been little formal regulation of energy efficiency (the biggest energy users, televisions, just came under regulation in 2009, in one state). The growth of total energy use by televisions and computers far outpaces that of refrigerators, freezers, and lighting (Calwell 2008).

Second, technological change in this category has been rapid; the devices themselves are dramatically different now, and new categories of devices emerge frequently (such as netbooks, smart phones, and 3D televisions). A homeowner might buy a ten-year-old washing machine, but only a collector would want to buy a ten-year old cell phone. Additional waves of transformation seem likely – the inventors and users of the IBM PC did not foresee the changes wrought by Facebook and Second Life. By contrast, 'white goods' like dishwashers and refrigerators are still recognizable and about the same size despite having acquired new features and being more efficient, and their social effects are only slightly changed. The transformations wrought by these devices have been absorbed as stable patterns of life in the mature economies. The Consortium for Energy Efficiency makes this summary assertion: "While consumer electronics represent a significant savings opportunity for efficiency programs, the product category also presents a unique challenge due to its fast changing nature and the dispersion of end-uses in the home each representing an often small share of total electronics energy end-use" (CEE 2010).

Third, many electronic devices have another characteristic that has grown increasingly important as the device multiply: they draw some power even when they are not in use. Examples include battery chargers that are left plugged in even when not charging anything and computers left in 'standby' mode. This drain is often referred to as 'vampire' power. Minimizing the use of standby power while preserving quick availability is a major regulatory and technological challenge; there are both general approaches and device-specific problems to tackle. The International Energy Agency, for example, has proposed a "1-Watt Plan" to be adopted by all countries for all devices (IEA 2010).

Finally, both residential and business consumers access electronic devices through a wide variety of channels: from retail stores, web sites, manufacturers, and service providers.

Fortunately, the progress in electronics that has created new burdens on the electric grid can also be applied to the development of 'smart' power efficiency management – using sensors, controls, and networks in ways that were not feasible just a decade ago. Utilities are installing 'smart meters'; many firms are crowding into the market for home-area networks, single power strips can control several appliances at once, energy-using devices can communicate with one another, and chip designs are being made more efficient.

The California Energy Commission (CEC) was given authority to regulate various kinds of energy use, and it has led the country in doing so, most notably for refrigerators but also for other appliances, including notably external power supplies and, just recently, for televisions. California's leadership has been the result of farsightedness but also of leverage; manufacturers cannot afford to ignore the California market. The record shows that California has made considerable progress in energy conservation. A simple and frequently noted summary of this situation is the so-called 'Rosenfeld Curve', a graph that shows California has maintained about the same per-capita electricity use over the last few decades, while in the rest of the nation it has increased. Total energy use in the state has increased substantially of course, but the increases in energy demand have been largely met by gains in energy efficiency rather than by increases in energy supply (Ehrhardt-Martinez and Laitner 2008, Mansoor 2008).

The California Public Utilities Commission (CPUC) has played an important role as well. It initiated the process of 'decoupling', under which the investor-owned utilities (IOUs) are rewarded financially for achieving energy efficiency in their loads – driving consumption below a baseline, no longer automatically given larger returns for larger loads. In 2007 the CPUC directed the creation of a single statewide energy efficiency plan for the period 2009-2020 (CPUC 2008). Under AB32 the state government has directed that by 2020 all new residential construction must meet certain zero-net-energy standards. The CPUC also oversees the investor-owned utilities' plans for promoting energy efficiency.

There are also many national regulations and programs that encourage, reward, or require improved energy efficiency. The U.S. Department of Energy (DOE) has promulgated national standards on several appliances; the federal rating system called ENERGY STAR is well known; utilities and government agencies offer rebates to stimulate the purchase of energy-efficient appliances and have labs for testing new technologies. National and international organizations such as the Green Building Council, the IEEE and the International Electrotechnical Commission are developing standards, protocols, and certification programs of their own. Other states have also implemented their own efficiency standards, rebate programs, and public education efforts.

The thesis of this report is that the time is right for a holistic view of controlling energy use in appliances and electronic devices. California has long been the leader among the states in matters of energy efficiency (ACEEE 2009; Harrington, Murray, and Baldwin 2007), and California can again be the leader by establishing a Center specifically for appliances and electronic devices, as it has done for lighting and cooling and demand response. The Center would be a neutral and respected resource for testing, education, research, and assistance in writing both legal codes and voluntary standards. The Center would be valuable as the place where others can seek answers about appliances and electronics. The Center should be where engineering, economics, social science, and policy can work comfortably together to solve one of California's major problems.

A. Market Structure and Stakeholders

A.1 Introduction

The purpose of the market section of this report is to 'define market structure and stakeholders' as mentioned in Task 1.a of 'Roadmap for the Development of the California Appliance Efficiency Center' (Task 1 of the contract with the California Energy Commission). Energy consumption in this sector continues to grow and so the market will change, most likely through the proliferation of new electronic devices. Data for appliance efficiency are scattered in various places in the literature and stated in many different ways. Differences in estimates are common; data is often expressed in ranges; category definitions differ; different units may be used; energy use by devices in the same category may vary widely if they differ in size or features. Data on new individual items under test conditions are provided by manufacturers and testing organizations. For those reasons the study begins with data primarily from one comprehensive source of energy data, the U.S. Department of Energy, and a few comprehensive sources of industry data. For further market information, there are many sources such as *TWICE* (This Week in Consumer Electronics), *Datamonitor*, *SBI Energy*, and *Dealerscope*. The report presents current developments relating to energy efficiency and consumer electronics and is divided into five parts.

Section A.2 presents market settings based on data collected from the U.S. Department of Energy (DOE), including especially the Energy Information Administration (EIA), and other sources. The different market settings that have been analyzed are the residential, commercial and industrial/manufacturing. There is a breakdown of the energy use based on segments for the settings and a breakdown based on appliances and consumer electronics is also included.

Section A.3 identifies important manufacturers and organizations that represent the major appliance and electronics industry and important organizations in the wholesale and retail sectors of the marketing of appliances and electronics.

Section A.4 classifies the types, quantities and distribution of appliances and electronics by sector and includes estimates of current and projected energy use patterns.

Section A.5 details selected appliance and electronic efficiency standards at the state and federal levels.

A.2 Market Settings

This review looks at the residential and commercial settings, primarily based on data from the Energy Information Administration (EIA), part of the U.S. Department of Energy, for both the U.S. and the state of California. EIA data is comprehensive and detailed, gathered from large-scale surveys every four years; at time of this writing the 2009 data set was not yet fully available.

A.2.1 Residential Setting

A.2.1.1 Energy Consumption

Regarding the residential market for energy consumption, the average energy expenditure per U.S. household has increased from $1,670 per year to $2,120 per year from 1990 to 2008 as per the Specialists in Business Information (SBI) estimates in the Market Research Report on Energy-Efficient Home Renovations Market (SBI 2009). This is a growing concern and in 2008, states such as California and New York spent over $200 million per year on energy efficiency programs as per the U.S. Environmental Protection Agency. The total energy consumption and expenditure data as per the U.S. Department of Energy shows that in 2005, for 111.1 million U.S. households with an average of 2.57 members per household, the total U.S. energy consumption was 10.55 quadrillion BTU and per U.S. household was 94.9 million BTU. The total U.S. expenditure was $201.07 billion. For the state of California, with 12.1 million households and 2.75 members per household the energy consumption was 0.81 quadrillion BTU and 67.1 million BTU per household, which is less than for most other states, and the energy expenditure per household was $1,396 per year, also less than for most other states. California's total energy expenditure in 2005 was $16.89 billion, so its proportion of the national energy expenditure is less than its proportion of households. The above information is summarized in **Table 1**.

Table 1: Residential Energy Consumption and Expenditure (2005)

Energy Consumption/Expenditure (2005)	US	California
Energy Expenditure per Year per Household	1990: $1,670 2008: $2,120	
Energy Efficiency Expenditure per year	2010: $ 6 billion	2010: > $200 million
No of Households	111.1 million	12.1 million
Avg Household Size	2.57 members	2.75 members
Total Energy Consumption	10.55 quadrillion BTU	0.81 quadrillion BTU
Total Energy Consumption per Household	94.9 million BTU	67.1 million BTU
Total Expenditure	$201.07 billion	$16.89 billion

Source: EIA, RECS, Table US1 and others

A.2.1.2 Breakdown of Energy Consumption by Devices

A breakdown of the residential energy usage data shows that the space heating and cooling accounted for 42 percent of home's energy costs followed by water heating (14%), lighting (10%), refrigeration (8%), electronics (8%), clothes/dishwashers (6%) and cooking (5%) in the year 2005). **Table 2** shows data for 2005 from SBI Energy (2009), credited to DOE; DOE's figures for 2005 are similar, in a separate published report (DOE 2008c). So by this accounting appliances and electronics account for 27% of the residential load.

Table 2: Residential Energy Consumption by Device Category (2006)

Energy Consumption Category	Breakdown

Space Heating/Cooling	42%
Heating	30%
Cooling	12%
Water Heating	14%
Lighting	10%
Refrigeration	8%
Electronics	8%
Clothes/Dishwashers	6%
Cooking	5%
Others	7%

Source: SBI Energy, *Energy-Efficient Home Renovations Market*, December 2009, Figure 1-7

Next it is worth looking at the energy usage for each of the segments and also the components for some of these segments based on the data from the Energy Information Administration in the U.S. Department of Energy (full data for year 2005 was released in 2008.

The space heating energy consumption data (in billion kWh) for the U.S. and California reveals that California households consumed 4 billion kWh of Electricity and 140 billion cubic feet (cu.ft.) of natural gas. The total U.S. consumption of these fuels is 80 billion kWh and 2870 billion cu.ft. respectively.

The air-conditioning equipment energy consumption data (in billion kWh) for the U.S. and California reveals that: California households consume 9 billion kWh of energy for air-conditioning use. The corresponding figure for the total U.S. consumption is 268 billion kWh.

The water heating equipment quantities and energy consumption data for the U.S. and California shows that California households use 3 billion kWh of electricity, 243 billion cu.ft. of natural gas and 240 million gallons of LPG. The corresponding U.S. figures are 122 billion kWh, 1368 billion cu.ft. and 119 million gallons.

An overview of home appliances energy consumption data for the U.S. and California is in **Table 3.** All the 12.1 million California households have appliances and lighting; all the households need electricity for the refrigerators, other appliances and lighting. 5.4 million households (46%) use natural gas for their fuel as well. For water heating Californians use natural gas much more than the rest of the nation does. The total electricity usage by California households for appliances and lighting is 69 billion kWh out of which refrigerators account for 13 billion kWh and other appliances and lighting account for 56 billion kWh.

Table 3: Residential Energy Consumption by Fuel Type Category (2005)

Category	Total Usage (# of households in millions)	Major Fuels Used				
		Electricity (billion kWh)	Natural Gas (billion cu.ft.)	Fuel Oil (million gal)	Kerosene (million gal)	LPG (million gal)
Space Heating						
US	107.6	80	2870	5251	127	3521
California	10.7	4	140			
Air Conditioning						
US	94.4	258	NA	NA	NA	NA
California	6.6	9	NA	NA	NA	NA

Water Heating						
US	109.8	122	1368	986	NA	1642
California	12.1	3	243	NA	NA	240
Appliances and Lighting						
US	111.1	813	416	NA	NA	578
California	12.1	69	94	NA	NA	369

Source: EIA EMEU/RECS Tables AP2, WH3, SH3, AC2

Next, look at the number of households that have various consumer electronic devices and appliances, in the U.S. and in California (**Table 4**).

Table 4: Appliance Distribution - U.S./California (2005)

Appliance	US	California	
	# in millions	# in millions	% of U.S.
Personal Computers	50.3	9.0	17.9%
Laptops	22.5	5.8	25.8%
Monitors (CRT/LCD/Laptop)	45.0	4.8	10.7%
Printers	65.4	7.9	12.1%
Televisions	109.7	12.0	10.9%
Cable/Satellite Dish Antennas	87.9	9.4	10.7%
VCRs, DVDs, VCR/DVD	89.4	6.5	7.27%
Game Systems	34.7	3.8	10.7%
Stereo Equipment	80.0	9.0	11.3%
Mobile/Cellular Phone	84.8	10.1	11.9%
Cooking Appliances	111.1	17.0	15.3%
Refrigerators	111.1	12.1	10.9%
Dishwashers	64.7	6.7	10.4%
Washers/Dryers	91.8	4.9	5.3%
Battery-operated appliances	54.9	7.3	13.3%

Source: EIA RECS, Tables HC3.10, HC2.11, HC15.11, HC15.10

The key highlights are (for 2005):

- The U.S. residential data computer equipment and televisions, and the corresponding California data, reveal the following (for 2005):
  - In California, 9.0 million households (77 percent of the California total) own at least one desktop PC and 3.6 million households own at least one laptop. 4.8 million (40 percent) households have CRT/standard monitor, 1.9 million (16 percent) own LCD monitors and 2.4 million (20 percent) own flat-panel monitors.
  - 7.9 million (65 percent) California households own a PC printer and out of these 3.4 million (28 percent) have a built in fax/copier.
  - 12 million (99 percent) California households own a color TV set; 4.6 million (37 percent) own 2 TV sets and 2.7 million (22 percent) own 3 TV sets; 4.0 million (33 percent) have large screen TV sets and 0.6 million (4 percent) have Plasma TV sets.
- The U.S. residential data for television accessories, stereo equipment, telephone and office equipment is as follows:
  - 9.4 million (79 percent of California households) have Cable/Satellite Dish Antennas, 9.6 million have VCRs, 10.2 (80 percent) million have DVD players, 3.7 million (29 percent) have VCR/DVD combination and 3.8 million have TV based game systems.
  - 9 million households have stereo equipment.
  - 10.1 million households have a cell phone and 9.7 million have a cordless telephone.

- The data on U.S. cooking appliance, refrigerators, dishwasher, clothes washers/dryers and battery operated tools are the following:
  - 11.7 million (93 percent) California households use a conventional oven, 10.3 million (80 percent) use a microwave oven, and 6.3 million (49 percent) use an electric coffee maker. 2.7 million (24 percent) use an electric toaster.
  - Only 3.8 million (2.5 percent) use an ENERGY STAR refrigerator. 2.5 million (22 percent) use a second refrigerator.
  - 6.7 million (51 percent) California house units have a dishwasher but only 1.9 million (16 percent) have an ENERGY STAR dishwasher.
  - 9.2 million (76 percent) California households have a clothes washer out of which only 3 million are ENERGY STAR washers.
  - 7.0 million (58 percent) California housing units have ceiling fans.
  - 5.9 million (49 percent) have battery operated appliances, out of which 1.3 million are plugged in all the time and 4.3 million (30 percent) are recharged as needed.

The percentage of residential renovations dipped in 2007 and increased in 2008, but the energy-efficient renovations peaked in 2007. In 2003 only 9.6 percent of residential renovations were energy efficient renovations (SBI 2009). The number in 2008 is 11 percent. The energy-efficient appliance renovations have remained constant from 2005 through 2008. Refrigerators have the biggest share followed by clothes washers and dishwashers.

From 2002 through 2008 the compound annual growth rate in new installations in the case of refrigerators has remained the same but has dipped in the case of freezers and increased slightly for dishwashers and water heaters, as shown in **Table 5**.

Table 5: Home Appliance Installations in Recent Years
(in thousands of units) (shipments-exports+imports)

	2002	2004	2006	2008	Compound annual growth rate
Refrigerators	15,075	14,857	18,861	15,328	0.30%
Freezers	2,535	2,516	2,148	2,081	-3.20%
Clothes Washers	8,542	10,020	10,632	9,556	1.90%
Dishwashers	6,207	7,195	7,629	6,827	1.60%
Water Heaters	12,344	10,940	11,162	13,089	1.00%

Source: SBI 2009

Table 6: Relative Criteria for Energy Efficiency (2008)

	Percentage Below Federal NAECA Energy Use			
	ENERGY STAR	**CEE Tier 1**	**CEE Tier 2**	**CEE Tier 3**
Refrigerator/Refrigerator-Freezer	20%	20%	25%	30%
Compact Refrigerator/Refrigerator-Freezer	20%	20%	25%	30%
Freezer	10%	na	na	na
Compact Freezer	20%	na	na	na

Source: SBI 2009, ENERGY STAR, CEE, ACEEE

A sample of the different criteria and standards, for selected appliances as of 2008, is given in **Table 6**. Shown are the basic ENERGY STAR standards and the three tiers of efficiency set by the CEE, expressed as percentages by which they exceed the federal standards set in the National Appliance Energy Conservation Act (NAECA).

A.2.2 Commercial Setting

A.2.2.1 Energy Consumption

The next review is of the commercial setting data, from the Energy Information Administration for energy consumption as of 2003. The commercial sector consists of business establishments and other organizations that provide services. The sector includes service businesses (e.g., retail stores, hotels, and restaurants), public and private schools, correctional institutions, and religious and fraternal organizations. Excluded from the sector are the goods-producing industries: manufacturing, agriculture, mining, forestry and fisheries, and construction. When the trends in the number of commercial buildings and the amount of floor space are examined, the data show they have increased from 1979 to 1992, while total energy consumption remained flat. Electricity and natural gas consumption greatly exceeded other major sources from 1979 to 1995; and by 1986, the consumption of electricity exceeded natural gas. Energy sources used for specific end uses changed over the period. For example, the use of electricity for space heating increased and use of fuel oil declined, while the use of natural gas and district heat remained constant. In 1999, the sector had more than 4.6 million buildings that comprised more than 67 billion square feet of floor space and in 2003 the sector had nearly 4.9 million buildings with almost 72 billion square feet of floor space. The total electricity consumption for all buildings that use electricity has been increasing over the years and hence the use of energy-efficient appliances and devices gains importance. The total energy consumption from electricity was 1,043 billion kWh, natural gas was 743 billion kWh, fuel oil was 275 billion kWh and district heat was 101 billion kWh.

A.2.2.2 Breakdown of Energy Consumption by Activity

The total electricity consumption for all commercial buildings is summarized in **Table 7**. The total electricity consumption was 1,043 billion kWh. Lighting was the single most important segment, which used up 393 billion kWh of electricity, followed by cooling, ventilation and refrigeration. Computers and office equipment used up 66 billion kWh of electricity. While **Table 7** does not summarize by the commercial sectors, the same EIA table shows that the mercantile, office and education sectors are the three biggest users with 215 billion kWh, 211 billion kWh and 109 billion kWh respectively.

Table 7: Commercial Energy Consumption by Activity (Measured in Billion kWh, 2003)

Energy Consumption Category	Consumption	% of Total
Space Heating	49	5%
Cooling	141	14%
Ventilation	128	12%
Water Heating	26	2%
Lighting	393	38%
Cooking	7	1%
Refrigeration	112	11%
Office Equipment	20	2%
Computers	46	4%
Others	122	12%
Total	1043	100%

Source: EIA CBECS Table E5A

Heating equipment by number of buildings by principal activity shows that out of 4.6 million non-mall buildings, 3.98 million buildings were heated buildings. 476,000 buildings had heat pumps; 1.964 million buildings used furnaces; 819,000 used individual space heaters; 579,000 used boilers and 953,000 used packaged heating units.

Cooling equipment data by number of buildings by principal activity shows that out of 4.6 million buildings, 3.6 million buildings were 'cooled buildings'. One million buildings had residential type central air-conditioners; 492,000 buildings used heat pumps; 742 thousand buildings used individual air conditioners; and 1.6 million used packaged air conditioning units (EIA CBECS Table B40).

Water heating equipment by number of buildings by principal activity reveals that out of 4.6 million buildings, 3.5 million buildings had water heating equipment (EIA CBECS Table B42).

Refrigeration equipment by number of buildings shows that out of 4.6 million buildings, 3.1 million buildings have refrigeration. One million buildings had commercial refrigeration while 2.3 million have other types of refrigeration (EIA CBECS Table B45).

Regarding the commercial energy use, space heating and lighting are used in the most buildings. By activity, offices, educational institutions and warehouses have the largest number of energy-using buildings.

Some of the above findings are shown in **Table 8.**

Table 8: Commercial Energy Use by Building Activity (2003)

Category (# of buildings in thousands)	Total	Heating	Cooling	Water Heating	Lighting	Refrigeration
Education	386	382	352	298	384	254
Food Sales	226	188	210	186	221	212
Food Service	297	282	283	297	296	296
Health Care	129	124	129	127	129	116
Lodging	142	142	130	142	142	126
Retail	443	408	406	314	442	319
Office	824	802	790	733	824	643
Public Assembly	277	258	213	227	264	210
Public Order and Safety	71	70	61	70	68	67
Religious Worship	370	359	308	315	370	271
Service	622	515	370	418	582	362
Warehouse and Storage	597	316	266	243	414	225
Other	79	67	57	55	73	51
Vacant	182	69	52	47	88	24

Source: EIA CBECS 2003, Tables B11, B13, B45

A.2.3 Industrial Setting

The net demand for electricity for the U.S. manufacturing setting in 2002 was 977,422 million kWh. **Table 9** highlights the key findings. The breakdown is shown based on the standard three-digit NAICS codes. The data is from 2002, compiled and published in 2006; the next round of data was not completely available at time of writing. The consumption for the West region is also shown. Net demand figures account for transfers, sales, and on-site generation. The chemicals industry, primary metals industry, the paper industry, and the food industry have the greatest net demand for electricity. By comparison with those industries, computer and electronics manufacturing is not a major user of electricity.

Table 9: Industrial Energy Demand by Industry Category (U.S. & Western region)

Category	Establishments (US)	Net Demand for Electricity (US) (million kWh)	Net Demand for Electricity (West) (million kWh)	West as % of U.S.
Food	15,089	78,003	13,710	17.58%
Beverage and Tobacco Products	1,595	9,480	2,473	26.09%
Textile Mills	2,247	19,753		
Textile Product Mills	3,457	5,972	104	1.74%
Apparel	5,500	2,560	147	5.74%
Leather and Allied Products	685	413	22	5.33%
Wood Products	10,486	28,911	6,532	22.59%
Paper	4,257	122,168	21,135	17.30%
Printing and Related Support	20,200	60,149	917	1.52%
Petroleum and Coal Products	1,915	56,543	12,361	21.86%
Chemicals	8,909	207,107	9,829	4.75%
Plastics and Rubber Products	10,538	53,423	3,767	7.05%
Nonmetallic Mineral Products	11,593	44,783	6,787	15.16%
Primary Metals	4,166	139,985	12,341	8.82%
Fabricated Metal Products	35,349	42,238	5,135	12.16%
Machinery	17,381	32,733	1,393	4.26%
Computer and Electronic Products	9,238	27,542	10,612	38.53%
Electrical Equip, Appliances, and Components	3,886	12,772	720	5.64%
Transportation Equipment	7,653	57,704	5,191	9.00%
Furniture and Related Products	10,941	9,362	544	5.81%
Miscellaneous	15,605	9,677	1,615	16.69%

Source: EIA MECS 2002 Table 1.4 and Table 11.1

A.3 Manufacturers and Organizations

In this section, there is summary market information and lists of manufacturers fofr appliances and consumer electronics, drawing primarily on Datamonitor and IBISWorld Reports (2009, 2010). Current news in CE marketing is available through *TWICE* (This Week in Consumer Electronics) and *Dealerscope*. Although there are many possible categorizations and definitions to pursue in a market analysis, refining those is not the point here. The intent is only to give a sense of the players, the degrees of market concentration, and other characteristics.

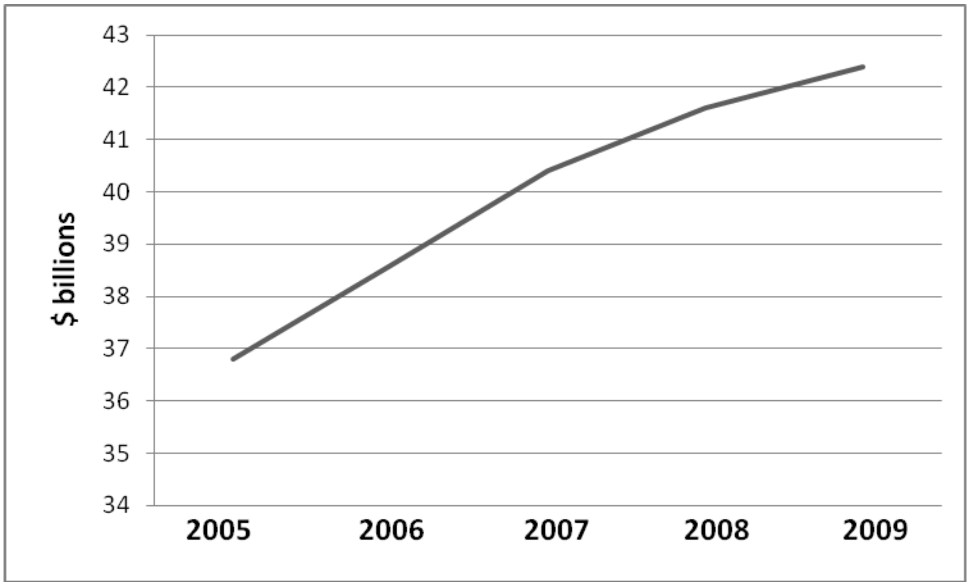
A.3.1 Appliances

A.3.1.1 Market Definition

The data from DataMonitor is used for this summary (Datamonitor 2010a). In their categorization the household appliances market includes: refrigeration appliances, cooking appliances, washing appliances, room comfort and water heater appliances vacuum cleaners and other cleaners, and dishwashers. (More detail about the definitions is available in the report.) The values shown are derived from retail selling prices. **Figure 1** shows the growth of the total market in recent years; there are annual variations in the growth rate, but the compound annual growth rate for the period is about 3.5 percent per year.

According to the DataMonitor report, the U.S. household appliances market generated total revenues of over $42 billion in 2009, representing a compound annual growth rate of 3.6 percent since 2005 (as shown in **Figure 1**).

Figure 1: U.S. Household Appliances Market: 2005-2009

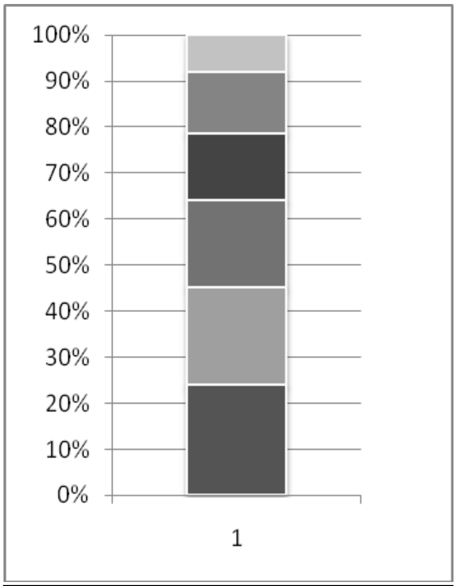


Source: Datamonitor, *Household Appliances in the United States*, June 2010

A.3.1.2 Market Segmentation & U.S. Market Volume Forecast

Refrigeration appliance sales were the largest share of the United States household appliances market, generating total revenues of $8.2 billion, about 24 percent of the revenues. Washing appliance sales account for a further 21 percent of the revenue (See **Figure 2**). In 2014, the United States household appliances market is forecast to have a value of $47.4 billion, a deceleration to about 2.2 percent growth per year.

Figure 2: U.S. Household Appliances Market Segmentation, % Share by Value, 2008



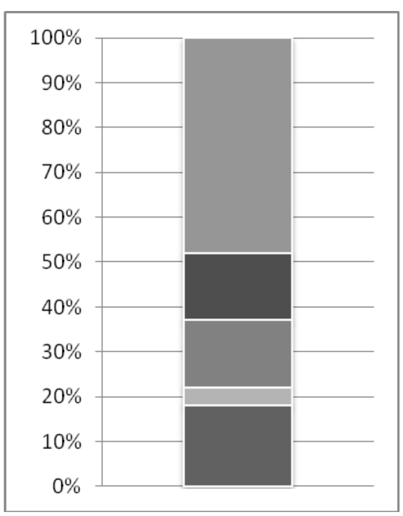
Dishwashers	8.2%
Vacuum Cleaners	13.1%
AC & Water Heating	14.7%
Cooking	18.8%
Washing Appliances	21.2%
Refrigeration Appliances	23.9%

Source: DataMonitor, *Household Appliances in the United States*, June 2009

A.3.1.3 Largest Appliance Manufacturers in the U.S.

White goods manufacturing is more concentrated than the computer industry; the top four companies account for about 82 percent of the market. Those manufacturers are shown in **Figure 3** (Data from IBISWorld Industry Reports – *Major Household Appliance Manufacturing in the US*, #33522). Additional major players are Rheem, BSH, Fisher & Paykel., Bradford White, Lochinvar, The Haier Group, Sanyo, and LG. Note that Whirlpool produces several of the well-known brands, such as Maytag, KitchenAid, and Jenn-Air.

Figure 3: U.S. White-Goods Appliance Manufacturers in the U.S. (2009)



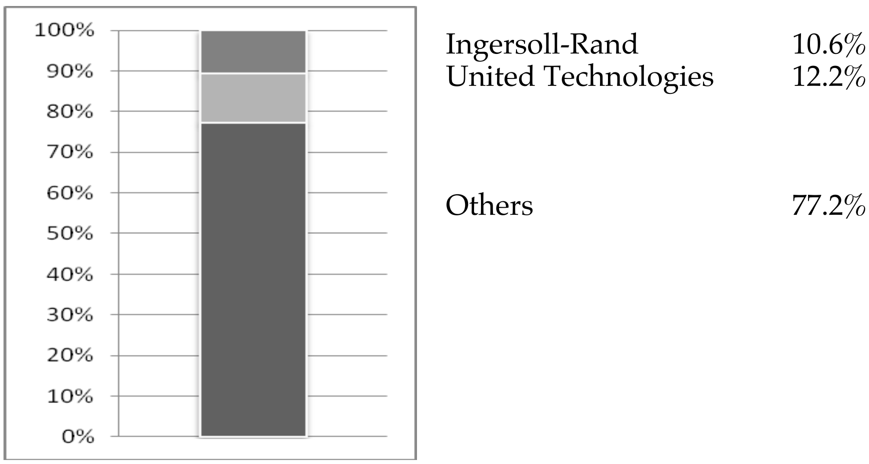
Whirlpool	48%
AB Electrolux	15%
GE	15%
A.O. Smith	4%
Other	18%

Source: IBISWorld Reports

To a greater extent than in the computer industry, major manufacturers of white goods also produce items sold under other brand names (e.g., Kenmore appliances sold at Sears).

The largest heating and air conditioning equipment manufacturers by rank are the following **(Figure 4):** United Technologies Corporation (which includes Carrier), Ingersoll-Rand, Johnson Controls, Lennox International, Goodman, NTK Holdings, and Air System Components (IBISWorld Reports – *Heating and Air Conditioning Equipment Manufacturing in the US*, #333431, September 2010)

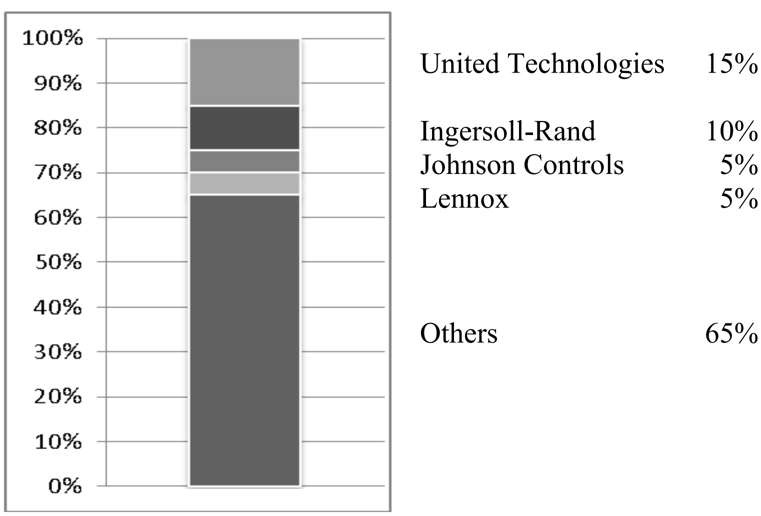
Figure 4: U.S. Heating and Air Conditioning Equipment Manufacturers in the U.S. (2009)



Source: IBISWorld Reports

The largest refrigeration equipment wholesalers are shown in **Figure 5:** United Technologies Corporation/Carrier, Ingersoll-Rand PLC/Hussmann/Thermo-King, Johnson Controls, Manitowoc, Emerson Electric (*Refrigeration Equipment Wholesaling in the US*, #42174, December 2009).

Figure 5: U.S. Refrigeration Equipment Wholesalers



Source: IBISWorld Reports

The ten largest retailers and wholesalers of appliances and white goods as per TWICE Magazine (2008) are the following: (1) Sears (Sears Holdings), (2) Lowe's, (3) The Home Depot,

(4) Best Buy, (5) Wal-Mart, (6) P.C. Richard & Son, (7) H.H. Gregg, (8) BrandsMart USA, (9) Conn's, and (10) Costco Wholesale.

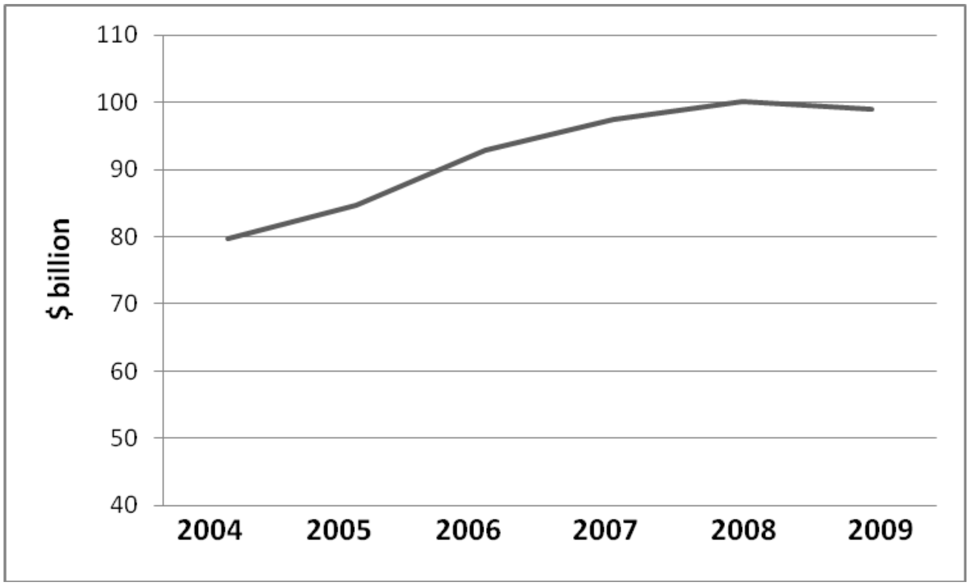
A.3.2 Consumer Electronics

A.3.2.1 Market Definition

The consumer electronics market consists of the total revenues generated through the sale of audio visual equipment and games console products designed primarily for domestic use. The audio visual equipment includes CD players, DVD players /recorders, hi-fi systems, home theatre, in-car entertainment systems, portable digital audio, radios, televisions and video recorders, in the categorization used by Datamonitor's *Report on Consumer Electronics in the United States* (DataMonitor 2010). The U.S. consumer electronics market between 2004-2009 experienced fluctuating growth. **Figure 6** shows the figures through 2009. Note first that by the Datamonitor definitions the consumer electronics market is about twice as large, in revenues, as the household appliance market. According to Datamonitor, the market generated total revenues of almost $99 billion in 2009, representing a retreat of almost 2% from 2008, but still representing a compound annual growth rate of about 4.3% for the period spanning 2004-2009. Presumably growth will return as the whole economy recovers in the near future; the Datamonitor report forecasts growth of 1% to 2 percent per annum in the 2012-2014 range. The United States market for consumer electronics represents about 39 percent of the world market.

The Datamonitor report looks at many characteristics of the market. The report concludes that the five characteristics of buyer power, supplier power, new entrants, substitutes, and rivalry are all "moderate" compared to other industries. Unusual characteristics include a high cost of market entry (capital costs), ease of brand switching for consumers and retailers, and easy substitution of many components, but there are many such factors counterbalancing each other. Electrical and electronics retailers captured most of the market, about 60 percent, whereas hypermarkets, supermarkets, and discounters represented less than 20 percent.

Figure 6: U.S. Consumer Electronics Market Value: 2004-2009



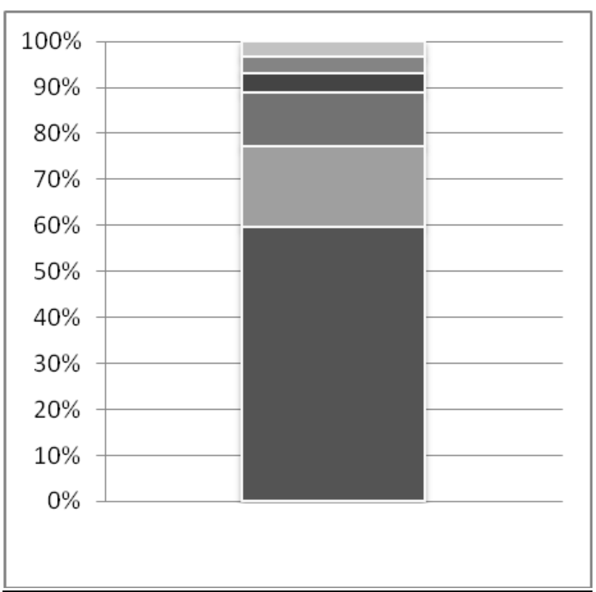
Source: DataMonitor, *Consumer Electronics in the United States,* May 2010

California is extremely important to the consumer electronics industry in the U.S. – California is the home of Silicon Valley, Hollywood, two ports that are leaders in trade with Asia, and major concentrations of game companies and biomedical device companies.

A.3.2.2 Market Segmentation & Market Value Forecast

Figure 7 gives the market segmentation. The growth of the market is forecast to decelerate, with an anticipated compound annual growth rate of 0.3 percent for the five-year period 2008-2013,

Figure 7: U.S. Consumer Electronics Market Segmentation, % Share by Value, 2008



Other	3.3%
Music/Video/Books/Stationery Stores	3.6%
Department Stores	4.2%
Discount/Variety/General Retailers	11.8%
Hypermarkets/Supermarkets	17.4%
Electrical/Electronics Retailers	59.8%

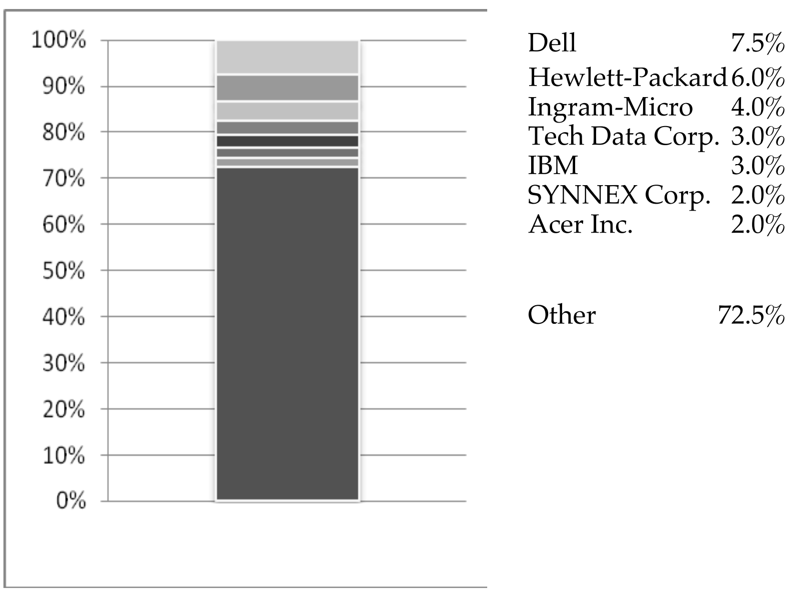
Source: DataMonitor, *Consumer Electronics in the U.S.*, August 2009 which is expected to drive the market to a value of $101,947 million by the end of 2013. In 2013, United States consumer electronics market is forecast to have a value of $101.9 billion, an increase of 1.7 percent since 2008.

Next the review turns to consumer electronics manufacturing in the U.S., drawing primarily on data from IBISWorld Reports. Because much of the manufacturing in these industries is outsourced to other countries, the manufacturing, wholesaling and retailing lists are not always similar. But manufacturing in the U.S. is usually easier to control for compliance with standards.

A.3.2.3 Largest Consumer Electronics Manufacturers and Wholesalers in the U.S.

The manufacturing and distribution of computers and peripherals are clearly not dominated by one or even a few companies; the largest ones each have less than 10 percent of the market. The largest are as shown in **Figure 8** (data from IBISWorld Industry Reports -*Computer, Peripherals & Packaged Software Wholesaling in the US*, #42143, 2010). Manufacturing alone is somewhat more concentrated; the top five companies represent 48% of the market – Dell, HP, IBM, EMC, and Oracle (IBISWorld Industry Reports –*Computer and Peripheral Manufacturing in the US*, #33411, 2010).

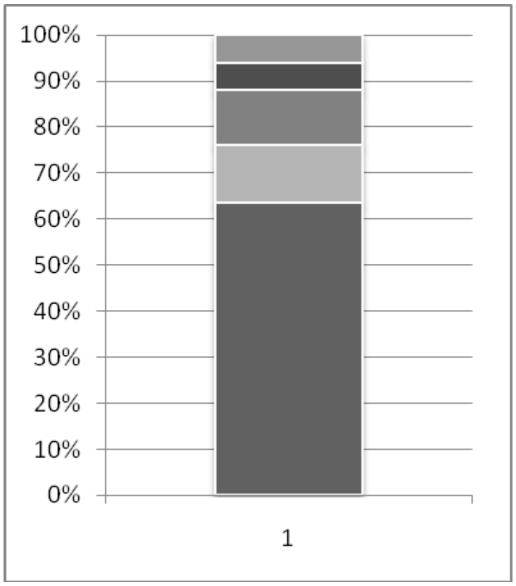
Figure 8: U.S. Computer and Peripherals Wholesalers (2009)



Source: IBISWorld Reports

The largest Audio and Video Equipment manufacturers in the U.S. are Bose Corporation, Harman International Industries, Panasonic, and Klipsch Group. Others include Hitachi, VIZIO, Pioneer, Sanyo North America, Apple, LG Electronics, Philips Consumer Electronics North America, Sharp Electronics, Samsung Electronics America, and Kenwood USA **(Figure 9).** Sony was listed in 2009 but closed its plant in the U.S. (IBISWorld Reports – *Audio and Video Equipment Manufacturers in the US* - #33431, October 2010).

Figure 9: U.S. Audio & Video Equipment Manufacturers (2009)

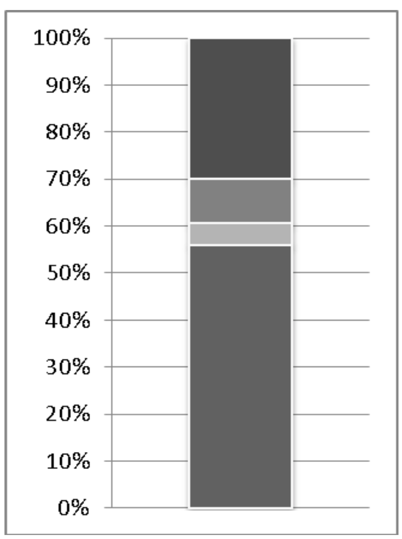


Panasonic	6.0%
Klipsch Group	6.0%
Harman Int'l	12.0%
Bose	12.5%
Others	63.5%

Source: IBISWorld Reports

The largest Communication Equipment manufacturers as per the IBISWorld Industry Report (*Communication Equipment Manufacturing in the US, 2009*) are the following **(Figure 10)**: Motorola, Harris Corporation, and Alcatel-Lucent – together they account for about 44 percent of the market. Other important manufacturers included ADR, Tyco Electronics, Nokia, Ericsson, and Cisco. (IBISWorld Reports – *Communication Equipment Manufacturers in the US*, # 33422, June 2010)

Figure 10: Communication Equipment Manufacturers in the U.S. (2009)



Motorola	30%
Harris	9.5%
Alcatel	4.5%
Others	56%

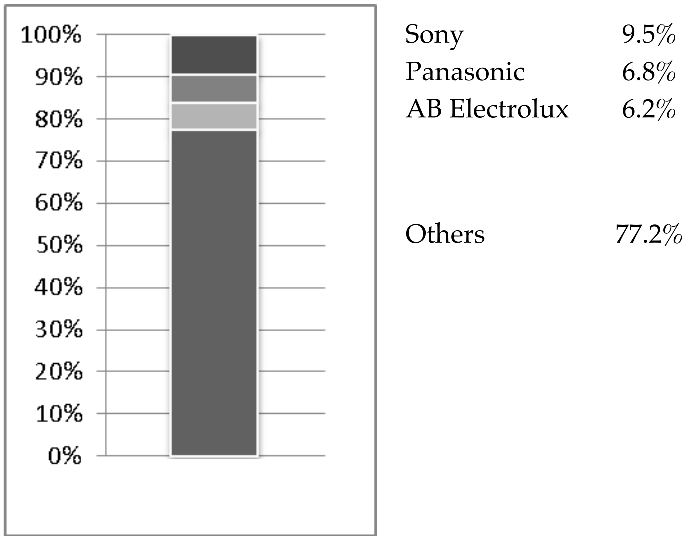
Source: IBISWorld

The largest radio and TV broadcasting equipment manufacturers as per the IBISWorld Industry Report (*Communication Equipment Manufacturing in the United States, 2009*) are the following: (1) Broadcast Electronics Inc, (2) Matsushita Electric Corporation of America, (3) Thompson Multimedia, and (4) Sony.

The largest home-entertainment manufacturers are the following **(Figure 11)**: Sony Corporation, Panasonic, GE, AB Electrolux, Koninklijke Philips Electronics NV, and Matsushita Electric Industrial Co Ltd. (IBISWorld - *Home Entertainment & Appliance Wholesaling in the United States*, #42162, October 2010).

The 10 largest retailers and wholesalers of consumer electronics goods as per *Dealerscope* estimates (North American Publishing Company, 2009) are the following: (1) Dell, (2) Best Buy, (3) Walmart, (4) CDW Corporation, (5) Staples, (6) GameStop, (7) Target, (8) Apple Computer Retail Stores, (9) Costco, and (10) Amazon.com.

Figure 11: Home Entertainment Wholesalers (2009)



Source: IBISWorld

A.3.3 Organizations

Table 10 lists many of the important organizations a Center would work with. These are grouped by the formal type of organization rather than by their orientation to energy efficiency issues. The decision as to which organizations are 'important' is of course subjective and open to dispute, but some such decision is forced by the available space. The criteria are their likely interactions with an ENERGY COMMISSION center; frequency of contacts, breadth of contacts, and formal authority. The names of prominent manufacturers are already given above.

Table 10: National and California Organizations Prominent in CE and Appliance Efficiency

Name	Primary Scope	Organization Type or Activity
INDUSTRY ORGANIZATIONS		
Air-Conditioning, Heating and Refrigeration Institute (ACHRI)	National	The primary industry association for the field. Includes members of the former Gas Appliance Manufacturers Association Also a standard-setting organization
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)	National	Professional association; standard-setting organization
American National Standards Institute (ANSI)	National	Standard-setting organization
ASTM International (formerly American Society for Testing and Materials)	International	Standard-setting organization
National Electrical Manufacturers Association (NEMA)	National	Industry Association; standard-setting organization
IPSO Alliance	National	Promotes the use of IP for 'Smart Objects'
Gas Technology Institute	National	
Consumer Electronics Association (CEA)	National	The primary industry association for consumer electronics
Association of Home Appliance Manufacturers (AHAM)	National	The primary industry association for the field; standard-setting organization
IEEE (formerly Institute of Electrical and Electronics Engineers)	International	A professional organization for research and organization; standard-setting organization
International Electrotechnical Commission (IEC)	International	Standard-setting organization
Continental Automated Building Association (CABA)	International	
Association of Energy Services Professionals	National	
Telecommunications Industry Association (TIA)	National	
Portable Rechargeable Battery Association	National	
NONPROFITS		
American Council for an Energy Efficient Economy (ACEEE)	National	
Consortium for Energy Efficiency, Inc. (CEE)	National	Member organizations from industry, government, utilities
European Council for an Energy Efficient Economy	International	
Alliance to Save Energy	National	
International Energy Agency (IEA)	International	Publishes research and statistical reports; implements international agreements
California Measurement Advisory Council (CALMAC)	California	Develops measurements of energy efficiency program effectiveness
Demand Response and Smart Grid Coalition	National	

Efficiency Partnership	California	Member organizations from industry, government, utilities
Green Building Council	National	
Northwest Energy Efficiency Alliance	Pacific Northwest	
Energy Foundation	National	
Continental Automated Buildings Association	North America	
The Energy Coalition	California	
Green Electronics Council	National	A program of the International Sustainable Development Foundation
Natural Resources Defense Council (NRDC)	National; offices in California	
Regulatory Assistance Project	National, international	
Sierra Club	National; offices in California	
Collaborative Labeling and Appliance Standards Program	National	
Greenpeace	National	
Appliance Standards Awareness Project (ASAP)	National	A joint venture of ACEEE, Alliance to Save Energy, Energy Foundation, and NRDC
CONSULTANTS		
CTG Energetics	National; HQ in California	For-profit consulting on energy use in buildings
Cadmus Group, Inc.	National	For-profit consulting
TIAX	National; offices in Irvine	For-profit consulting
Ecos Consulting	National; offices in CA	For-Profit Consulting on environmental matters
McKinsey Consulting	National; offices in Los Angeles	For-profit, consulting firm on many management issues
GOVERNMENT		
California Energy Commission (CEC)	California	Sets formal efficiency standards
U.S. Department of Energy (DOE)	National	Sets formal efficiency standards
U.S. Environmental Protection Agency (EPA)	National	
National Institute of Standards and Technology (NIST)	National	A central coordination point for the technical side of Smart Grid development
California Public Utilities Commission (CPUC)	California	Regulates the Investor-Owned Utilities (IOUs)
California Air Resources Board	California	Sets standards for air pollution sources
Federal Trade Commission	National	Requires labeling for energy consumption
ENERGY STAR -	National	A joint effort of DOE and EPA. Rates products by their energy efficiency
Federal Energy Regulatory Commission (FERC)	National	
New York State Energy Research and Development Authority,	New York	One of the other leaders in state government research and action.
ELECTRIC AND GAS UTILITIES		
Sacramento Municipal Utility District (SMUD)	California	Municipal Utility

San Diego Gas and Electric Company (SDG&E)	California	Investor-Owned Utility, a division of Sempra Energy
Southern California Edison (SCE)	California	Investor-Owned Utility, a division of Edison International
Southern California Public Power Authority	California	Joint powers authority
Pacific Gas and Electric Company (PG&E)	California	Investor-Owned Utility
Northern California Power Agency	California	Not-for-profit joint powers agency
California Municipal Utilities Association (CMUA)	California	Association representing municipal utilities
Los Angeles Department of Water and Power	California	The largest municipal utility in California
Southern California Gas Company (The Gas Company)	California	Investor-Owned Utility, a division of Sempra Energy
Sempra Energy	California	Parent company of SDG&E, Southern California Gas Co., & other energy firms
RESEARCH CENTERS		
California Institute for Energy and Environment	California	Part of University of California Energy Institute; coordinates UC several research projects
Electric Power Research Institute (EPRI)	National; HQ in California	Industry-sponsored research institute.
Gas Technology Institute	National	Industry-sponsored research institute
Lawrence Berkeley National Laboratory (LBL)	National (HQ in California)	National Laboratory, managed by UC for DOE.
California Lighting Technology Center	California	At UC Davis
California Smart Grid Center	California	At Sacramento State University
Western Cooling Efficiency Center	California	At UC Davis
Demand Response Research Center	California	At Lawrence Berkeley National Laboratory
Precourt Energy Efficiency Center	California	At Stanford University
Pacific Northwest National Lab	National	National Laboratory
Advanced Power and Energy Program	National	At UC Irvine

Source: Calit2

A.4 Appliances and Electronics Sectors

The analysis so far has been about the types, quantities and distribution of appliances by residential and commercial settings, including estimates of current and projected energy use patterns, based on data from the Energy Information Administration and major market studies. **Table 11** below presents some of the additional data available for consumer and office electronics, focusing more on the energy use of particular devices, gathered from several individual studies. Not all of these represent original research; some refer to earlier studies. Different studies may have used different methods and definitions.

The variety itself is the main point here; only very general comparisons between devices could be drawn from this sampling. Energy usage in active mode is not only larger than energy use in passive mode but more variable – depending on many circumstances of use. The multiple definitions, categories, features, and measurement methods make generalizations difficult.

There are a few televisions that draw less power on standby than many clock radios; refrigerators vary in kWh/year by more than a factor of eight. Efforts to extrapolate savings based on models or surveys must be very well grounded. Excellent summaries on these points are the works by Peters et al. (2010) and Roth and McKenney (2007b).

Table 11: Energy Usage by Consumer and Office Electronics in California (Estimates from Several Sources)

Type of Device	# sold (millions)	# in use (millions)	Power (W) Consumed in Standby	Power Consumed In Use (W)	Unit Energy Consumption (kWhr/yr)
TV – all	27 U.S.[2] 3.2 CA [9]	240 TVs in US [2] 27 CA [9]	3.9 avg all TVs [9]	86 -= 234 [2]	184-455 all models [2]
TV - CRT			28 [2]	198 [1] 274 [2]	~ 220 [12]
TV - LCD			1.8 [1]	211 [1]	132 [7]
TV - Plasma			3.6 [1]	263 [1]	
Type of Device	**# sold (millions)**	**# in use (millions)**	**Power (W) Consumed in Standby**	**Power Consumed In Use (W)**	**Unit Energy Consumption (kWhr/yr)**
Set-Top Boxes		77 cable [3] 70 satellite[3]	15 cable [3] 14 satellite [3]	16 cable [3] 15 satellite [3]	150 [4] standard ~ 100 [12] satellite
DVR (alone)	2.4 [9] CA	10.6 CA [9]	2.3 [9]		~200 [4] 37 [14]
Game Systems	17 [6]	64 [3]	36 [3]	36 [3] 16 – 150 [6]	27 – 1596 depending on model & usage [6] ~ 50 [3]
Compact Audio		5.8 CA [9] 76 U.S. [15]	~ 3 [9] 0.1 – 4 [11]		20 [13] 81 [14]
Computer Speakers					74 [8] 21 [13]
Computer Projector					204 [8]
Cable/DSL Modems					~50 [12]
External Power Supplies	38 CA [9]	160 CA [9]	0.25 – 0.38 [8]	<5 to >100 [9]	

Desktop PCs		90 U.S.[3]	4 [3]	75 [3]	236 average incl. monitor [13] 106-1747 range incl. monitor [13] 407 [7] 224 [15]
Battery Chargers		130 CA [5]	1W-250W [5]		
Router					350 [13]
Projector					204 [6]
Cordless Phones		179 U.S. [3]	3.1 [3]	3.4 [3]	28 [3]

Type of Device	# sold (millions)	# in use (millions)	Power (W) Consumed in Standby	Power Consumed In Use (W)	Unit Energy Consumption (kWhr/yr)
Telephone Answering Machine		25 U.S. [3]	4 [3]	4 [3]	35 [3]
Laptops				25 [15]	~74 [4] 59 [15] 96 [7]

SOURCES:
1. (Carbon Footprint 2010)
2. (Ostendorp et al. 2005)
3. (Roth & McKenney 2007a)
4. (May-Ostendorp, undated; Ostendorp & Horowitz 2007)
5. (Bendt et al. 2008)
6. (Neugebauer et al. 2008)
7. (Efficient Products)
8. (Calwell 2006)
9. (TIAX 2006)
10. (Neubauer et al. 2009)
11. (ENERGY COMMISSION Appliance Database 2009)
12. (Calwell 2008)
13. (Sator 2008)
14. (CEE 2008)
15. (Roth & McKenney 2007b)
16. (Peters et al. 2010)

The trends over the last few years and the estimates for the year 2010 and 2011 based on studies conducted by the Energy Information Administration show that the electricity consumption reached a peak of 10.75 billion kWh per day in 2007 and then decreased in 2008 and 2009. It is expected to increase in 2010 and 2011.

It should be noted that year-to-year changes in the consumption of electricity and gas are driven in part by the weather as well as by market changes. For example, for January 2010, heating degree-days in the South Census Region, where about 60 percent of households use electricity as their primary space heating fuel, were 13 percent higher than in January 2009. Consequently, residential electricity sales in the South region also increased by about 12 percent to an average of 2,250 Gigawatt hours per day. Temperatures across the United States for summer 2010 were expected to be about 2.5 percent cooler than last summer, limiting overall growth in electricity sales. In addition, low snowpack levels in the Pacific Northwest are likely to reduce hydropower generation and boost natural gas consumption, as noted previously. However, offsetting these increases, the projected higher price of natural gas compared with last year reduces its attractiveness as a baseload fuel.

A.4.1 Trends in Residential Setting

Table 12 shows the expected trends in residential space heating. As can be seen from the table, the number of units of electric heaters and natural gas heaters is going to increase at the expense of space heaters using other forms of fuel. The number of electric heat pumps is projected to increase from 10.84 million units in 2010 to 12.85 million units in 2015; the number of other electric space heaters is estimated to increase from 23.65 million space units to 23.99 million units in 2015. All other types of heaters except geothermal heat pumps are expected to decrease during this period.

Table 12: Trends in Residential Space Heaters

Equipment Stock (million units)	2007	2008	2009	2010	2011	2012	2013	2014	2015
Main Space Heaters									
Electric Heat Pumps	9.64	10.03	10.37	10.84	11.19	11.59	12.01	12.43	12.85
Electric Other	23.46	23.52	23.56	23.65	23.69	23.75	23.81	23.89	23.99
Natural Gas Heat Pumps	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas Other	59.25	59.73	60.11	60.77	61.33	62.03	62.76	63.50	64.26
Distillate Fuel Oil	7.55	7.48	7.41	7.35	7.29	7.24	7.20	7.15	7.10
Liq. Petroleum Gases	6.36	6.33	6.30	6.29	6.27	6.26	6.24	6.23	6.22
Kerosene	0.68	0.67	0.67	0.67	0.66	0.66	0.65	0.65	0.64
Wood Stoves	2.84	2.82	2.81	2.79	2.78	2.76	2.74	2.73	2.71
Geothermal Heat Pumps	0.21	0.26	0.33	0.44	0.56	0.70	0.84	0.98	1.12
Total	109.99	110.84	111.56	112.80	113.77	114.99	116.26	117.55	118.90

Source: EIA, *Annual Energy Outlook 2010*, Supplement, Table 31

Table 13 shows the number of units of space cooling equipment for the residential setting. The number of room air conditioners is expected to grow from 51.08 million units in 2010 to 51.42 million units in 2015. Electric heat pumps involved in cooling are expected to increase more rapidly, from 10.84 million units in 2010 to 12.85 million units in 2015.

Table 13: Trends in Residential Space Coolers

Space Cooling (million units)	2007	2008	2009	2010	2011	2012	2013	2014	2015
Electric Heat Pumps	9.64	10.02	10.37	10.83	11.19	11.59	12.01	12.43	12.85
Natural Gas Heat Pumps	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Geothermal Heat Pumps	0.21	0.26	0.33	0.44	0.56	0.70	0.84	0.98	1.12
Central Air Conditioners	58.15	59.04	59.80	60.87	61.78	62.83	63.90	64.99	66.12
Room Air Conditioners	51.18	51.12	51.06	51.08	51.11	51.18	51.26	51.34	51.42
Total	119.18	120.44	121.56	123.22	124.64	126.29	128.01	129.73	131.51

Source: EIA, *Annual Energy Outlook 2010*, Supplement, Table 31

Table 14 shows the trends in cooking equipment. The number of electric and natural gas cooking equipments are going to increase at the expense of LPG (Liquefied Petroleum Gas)

Table 14: Trends in Residential Cooking Equipment

Cooking Equipment (million units)	2007	2008	2009	2010	2011	2012	2013	2014	2015
Electric	66.91	67.68	68.34	69.40	70.21	71.21	72.25	73.30	74.40
Natural Gas	38.88	39.01	39.11	39.32	39.51	39.76	40.03	40.29	40.57
Liquefied Petroleum Gases	5.60	5.56	5.51	5.48	5.45	5.41	5.38	5.35	5.33
Total	111.39	112.25	112.96	114.20	115.17	116.39	117.66	118.94	120.30

Source: EIA, *Annual Energy Outlook 2010*, Supplement, Table 31

Table 15 shows the trends in residential clothes dryers. The number of units of electric clothes dryers is expected to increase more rapidly than the number of gas dryers.

Table 15: Trends in Residential Clothes Dryers

Clothes Dryers (million units)	2007	2008	2009	2010	2011	2012	2013	2014	2015
Electric	68.59	69.41	70.15	71.28	72.24	73.38	74.56	75.75	76.99
Natural Gas	19.62	19.75	19.86	20.06	20.24	20.48	20.73	20.97	21.22
Total	88.21	89.15	90.01	91.34	92.48	93.86	95.29	96.73	98.21

Source: EIA, *Annual Energy Outlook 2010*, Supplement, Table 31

Table 16 has the trends in refrigerators and freezers. The number of units of refrigerators is expected to increase from 143.19 million units in 2010 to 151.52 million units in 2015. For freezers, the Energy Information Administration expects the number of units to increase from 40.17 million units in 2010 to 42.95 million units in 2015 – a slightly more rapid increase than for refrigerators.

Table 16: Trends in Refrigerators/Freezers

Other Appliances (million units)	2007	2008	2009	2010	2011	2012	2013	2014	2015
Refrigerators	139.51	140.62	141.56	143.19	144.53	146.20	147.95	149.70	151.52
Freezers	39.04	39.37	39.67	40.17	40.62	41.18	41.76	42.34	42.95

Source: EIA, *Annual Energy Outlook 2010*, Supplement, Table 31

A.4.2 Trends in Commercial Setting

Table 17 provides the energy consumption trends for the commercial setting by activity.

- The energy consumption for buildings used by Food Sales and Food Service will be fairly constant at 0.28 and 0.44 quadrillion Btu respectively in both 2010 and 2015.
- For healthcare, the energy consumption will increase from 0.48 quadrillion Btu in 2010 to 0.51 quadrillion Btu in 2015.
- The biggest activity is the mercantile/service segment with 1.50 quadrillion Btu consumption in 2010 and an estimated 1.56 quadrillion Btu in 2015.

Table 17: Commercial Energy Consumption Trends by Activity

Energy Consumption (quadrillion Btu)	2007	2008	2009	2010	2011	2012	2013	2014	2015
Assembly	0.52	0.52	0.53	0.54	0.54	0.54	0.54	0.54	0.54
Education	0.88	0.89	0.92	0.94	0.95	0.95	0.95	0.95	0.95
Food Sales	0.27	0.27	0.27	0.28	0.28	0.28	0.28	0.28	0.28
Food Service	0.43	0.43	0.44	0.44	0.44	0.44	0.43	0.44	0.44
HealthCare	0.45	0.45	0.46	0.48	0.48	0.49	0.50	0.50	0.51
Lodging	0.54	0.54	0.55	0.55	0.55	0.54	0.55	0.55	0.56
Office - Large	0.72	0.72	0.74	0.76	0.77	0.77	0.77	0.78	0.79
Office - Small	0.57	0.58	0.59	0.60	0.61	0.61	0.61	0.61	0.62
Mercentile Service	1.43	1.45	1.49	1.50	1.51	1.52	1.53	1.54	1.56
Warehouse	0.42	0.43	0.43	0.43	0.43	0.43	0.42	0.42	0.43
Other	0.48	0.49	0.50	0.51	0.52	0.53	0.53	0.54	0.55
Total	6.70	6.77	6.93	7.03	7.08	7.08	7.10	7.16	7.24

Source: EIA, *Annual Energy Outlook 2010*, Supplement, Table 32

Table 18 gives the commercial floor space trends by activity, which indirectly predicts energy consumption. The food sales and food service segment will show only marginal growth. The healthcare segment is projected to have 2.44 billion square feet occupied in 2015 as compared to 2.24 billion square feet in 2010. The education segment will have 12.33 billion square feet occupied in 2015 as compared to 11.61 billion square feet in 2010.

Table 18: Commercial Energy Consumption Floor space Trends by Activity

Commercial Building Floorspace (billion square feet)	2007	2008	2009	2010	2011	2012	2013	2014	2015
Assembly	8.07	8.16	8.25	8.31	8.38	8.44	8.52	8.60	8.68
Education	10.88	11.13	11.38	11.61	11.80	11.95	12.08	12.20	12.33
Food Sales	1.36	1.38	1.40	1.41	1.42	1.42	1.44	1.45	1.47
Food Service	1.79	1.83	1.85	1.86	1.87	1.88	1.90	1.92	1.95
HealthCare	2.10	2.15	2.20	2.24	2.28	2.32	2.36	2.40	2.44
Lodging	5.53	5.67	5.78	5.82	5.85	5.89	5.95	6.04	6.13
Office - Large	7.11	7.20	7.28	7.34	7.36	7.38	7.41	7.46	7.54
Office - Small	6.91	7.00	7.10	7.17	7.20	7.23	7.28	7.34	7.43
Mercentile Service	16.77	17.17	17.46	17.66	17.80	17.97	18.16	18.38	18.63
Warehouse	10.88	11.10	11.27	11.35	11.35	11.36	11.41	11.52	11.65
Other	5.87	6.00	6.13	6.24	6.35	6.46	6.57	6.70	6.82
Total	77.27	78.79	80.09	81.01	81.65	82.31	83.08	84.01	85.07

Source: EIA, *Annual Energy Outlook 2010*, Supplement, Table 32

Table 19 presents the Stock Average Equipment Efficiency data for all commercial buildings, which is calculated using floor space and energy consumption data by segment. These data are for the 'reference' case, assuming no major changes in technology or regulation. Space heating and cooling stock average equipment efficiency due to electricity use is expected to increase from 2010 to 2015. Water heating, ventilation and cooking stock average equipment efficiency due to electricity use will remain fairly constant. Refrigeration equipment efficiency in electricity use is expected to increase from 2.11 in 2010 to 2.42 in 2015.

Table 20 provides the current expectations for total electricity generation and consumption by sector through 2011. Residential electricity use and commercial electricity use are clearly larger than industrial electricity use, although industrial use is currently expected to increase faster than either commercial or residential electricity use (just over 8 percent compared to 3-4 percent). Use of electricity for transportation is currently almost negligible by comparison, but with the arrival of PEVs and PHEVs that will almost certainly change.

Table 19: Stock Average Equipment Efficiency Trends, Commercial Sector

Stock Average Equipment Efficiency	2007	2008	2009	2010	2011	2012	2013	2014	2015
Space Heating									
Electricity	1.25	1.29	1.31	1.33	1.36	1.38	1.41	1.43	1.45
Natural Gas	0.75	0.76	0.76	0.77	0.77	0.77	0.78	0.78	0.78
Distillate Fuel Oil	0.76	0.80	0.80	0.81	0.81	0.81	0.81	0.82	0.82
Space Cooling									
Electricity	2.83	2.87	2.90	2.95	2.98	3.01	3.04	3.07	3.10
Natural Gas	0.85	0.87	0.88	0.89	0.89	0.90	0.90	0.91	0.92
Water Heating									
Electricity	0.99	0.99	0.99	1.00	1.00	1.00	1.01	1.01	1.01
Natural Gas	0.82	0.83	0.84	0.84	0.84	0.85	0.85	0.85	0.85
Distillate Fuel Oil	0.78	0.79	0.79	0.79	0.79	0.80	0.80	0.80	0.80
Ventilation (cubic feet per minute per Btu)									
Electricity	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.54
Cooking									
Electricity	0.72	0.73	0.74	0.74	0.74	0.75	0.75	0.75	0.75
Natural Gas	0.52	0.53	0.53	0.53	0.53	0.53	0.53	0.53	0.53
Lighting Efficacy									
(efficacy in lumens per watt)									
Electricity	43.75	45.31	46.71	47.97	48.89	49.61	50.45	51.04	51.55
Refrigeration									
Electricity	1.97	1.99	2.05	2.11	2.17	2.23	2.29	2.36	2.42

Source: EIA, *Annual Energy Outlook 2010*, Supplement, Table 32

The assumptions and notes for the calculations are available at http://www.eia.doe.gov/oiaf/aeo/assumption/commercial.html.)

Table 20: Electricity generation and consumption by sector (in billion kWh per day)

Year	2009	2010	2011
Electricity Supply	10.92	11.38	11.38
Electricity Consumption	10.25	10.73	10.72
Residential	3.73	3.96	3.88
Commercial	3.62	3.70	3.73
Industrial	2.42	2.57	2.62
Transportation	0.02	0.02	0.02
Direct User	0.45	0.49	0.47

Source: EIA, *Short-Term Energy Outlook*, November 9, 2010, Table 7a

A.5 Appliance and Electronics Efficiency Standards

The federal government has established many appliance efficiency standards under the National Appliance Energy Conservation Act (1987), the Energy Independence and Security Act (2007), and the Energy Policy Act (2005). In addition the ENERGY STAR program, managed by the Environmental Protection Agency, sets standards for recognizing efficient models of appliances (see the tables below). Reading the cited notices of rulemaking in the *Federal Register* gives an appreciation for the complexity of the processes and the decisions. The Appliance Standards Awareness Project (ASAP) web site (www.standardsasap.org) provides a useful summary and history of the federal standards and links to the formal federal documents. Some of the source citations below are to the formal documents; others are to various pages of that web site; all the ASAP pages are referred to simply as 'ASAP 2010'.

In California, the power to set efficiency standards was given to the Energy Commission by the Warren-Alquist Act (1974) that established the Commission. The Energy Commission's regulations are in Title 20 and Title 24 of the state's code of regulations. The California Energy Commission maintains an appliance database covering appliances that are "currently certified to the California Energy Commission by their manufacturers as meeting currently-applicable efficiency standards. Appliances shown … either meet federal efficiency standards or, where there are no federal efficiency standards, meet California Energy Commission efficiency standards." The data presented in the database are very detailed, model-by-model, but miss many types of devices that do use energy but have not been covered by California, federal regulations, or ENERGY STAR **(Table 21).**

The similarities and differences in efficiency standards between the federal government and California for a few different residential and commercial appliance categories are presented below, drawing on sources from the Department of Energy and the Energy Commission. In the space available only a sampling can be provided, to show the variety of appliances, standards, and criteria that exist and that would be of concern to a center on appliance efficiency. For more general background on federal-state relations on appliance regulations, see section C.2 below.

Note that "standby" usage for white goods typically refers to the energy required for maintaining the temperature of goods above or below room temperature, not to electronic circuitry needs.

Table 21: Selected Efficiency Data from Energy Commission Database Document 2009

Device Category – Electronics (4230 entries)		
Compact Audio with Clock	0.2W – 4.0 W standby	
Compact Audio without Clock	0.1W - 2.0W standby	

DVD Player	0.1 W– 3.0 W standby	
DVD Recorder	0.2W – 2.9W standby	
Television	0.0W – 3.0W standby	3.0W idle, 411W operating
Device Category – Cooking & Washing Products		
Clothes Dryers (Electric or Gas)	1.6 – 8.0 cu.ft.	2.4 - 3.9 Energy Factor
Clothes Washers	0.77 – 2.9 Modified Energy Factor	
Dishwashers (1132 entries)	5-16 place settings	0.29 - 1.35 Energy Factor
Commercial Cooking, Gas & Electric (range tops, warming cabinets, ovens)	Energy Input Rate 0.1 – 31.2 kW	Energy Input Rate 14.0 – 82,472 Btu/Hr
Device Category – Refrigeration Products		
Refrigerated Beverage Vending Machines	3.5 – 6.68 kWh/day	
Automatic Icemakers	0.6 – 12.8 kWh/100lb	
Noncommercial Refrigerators	145 – 855 kWh/yr	1.3 cu.ft. – 30.7 cu.ft.
Commercial Refrigerators	0.21 - 61.14 kWh/day	0.7 - 120.9 cu.ft.
Water Dispensers	0.2 – 1.2 kWh/day standby	
Device Category – Pool Products		
Portable Electric Spas (532 entries)	87 – 593 W standby	2 – 11 people
Residential Pool Pumps (253 entries)	35% - 92% motor efficiency	

Source: CEC Appliance Database, http://www.appliances.energy.ca.gov/

A.5.1 Residential Setting

A.5.1.1 External Power Supplies

The U.S. standards are shown in **Table 22**.

Table 22: U.S. Standards for External Power Supplies

Active Mode	
Nameplate Output	**Minimum Efficiency (decimal equivalent of a percentage)**
<1 Watt	0.5 times the nameplate output
1 to not more than 51 Watts	The sum of 0.09 times the natural logarithm of the nameplate output and 0.5
>51 Watts	0.85
No-Load Mode	
Nameplate Output	**Maximum Consumption**
Not more than 250 Watts	0.5 Watts

Source: ASAP 2010

According to the ASAP web site, a revised federal standard is due to be issued in 2011. The California standards (**Table 23**) are the same except that California includes all wattage levels in the requirement for the maximum consumption in no-load mode

Table 23: California Standards for External Power Supplies

Active Mode	
Nameplate Output	**Minimum Efficiency (decimal equivalent of a percentage)**
<1 Watt	0.5 * Nameplate Output

1 to not more than 51 Watts	0.09*Ln(Nameplate Output) + 0.5
>51 Watts	0.85
No-Load Mode	
Nameplate Output	**Maximum Consumption**
Any output	0.5 Watts

Source: CEC AER 2009, Table U-3

Neither California nor the federal government has yet established energy-efficiency standards for battery chargers.

A.5.1.2 Ceiling Fans and Ceiling Fan Light Kits

Although lighting standards will not be a central concern for the Center, this set of standards is included for illustration. In this case the U.S. standards and California standards are the same:

(1) All ceiling fans manufactured on or after January 1, 2007, shall have the following features:
- (i) Fan speed controls separate from any lighting controls;
- (ii) Adjustable speed controls (either more than 1 speed or variable speed);
- (iii) The capability of reversible fan action, except for—
  - (A) Fans sold for industrial applications;
  - (B) Outdoor applications; and
  - (C) Cases in which safety standards would be violated by use of reversible mode.

(2) (i) Ceiling fan light kits with medium screw base sockets manufactured on or after January 1, 2007, shall be packaged with screw-based lamps to fill all screw base sockets.
- (ii) The screw-based lamps required under paragraph (2)(i) of this section shall—
  - (A) Meet the ENERGY STAR Program requirements for Compact Fluorescent Lamps, version 3; or
  - (B) Use light sources other than compact fluorescent lamps that have lumens per watt performance at least equivalent to comparable configured compact fluorescent lamps meeting the energy conservation standards described in paragraph (2)(ii)(A) of this section.

(3) Ceiling fan light kits with pin-based sockets for fluorescent lamps manufactured on or after January 1, 2007 shall—
- (i) Meet the ENERGY STAR Program Requirements for Residential Light Fixtures version 4.0 issued by the Environmental Protection Agency; and
- (ii) Be packaged with lamps to fill all sockets.

(4) After January 1, 2009, ceiling fan light kits with sockets other than medium screw base or pin-based for fluorescent lamps shall not be capable of operating with lamps that total more than 190 watts and shall be packaged with lamps that do not total more than 190 watts.

(Item #4 was the standard given in the legislation and was accepted by DOE when it appeared that rulemaking could not be completed before the deadline.)

A.5.1.3 Room Air-Conditioners

Table 24 shows the U.S. standards require a minimum energy efficiency ratio (EER) for classes of room air conditioner.

Table 24: U.S. Standards for Room Air Conditioners

Product Class	Effective 1/1/90	Effective 10/1/2000
1. Without reverse cycle, with louvered sides, and less than 6,000 Btu/h	8.0	9.7
2. Without reverse cycle, with louvered sides, and 6,000 to 7,999 Btu/h	8.5	9.7
3. Without reverse cycle, with louvered sides, and 8,000 to 13,999 Btu/h	9.0	9.8
4. Without louvered sides, with reverse cycle, and 14,000 to 19,999 Btu/h	8.8	9.7
5. Without reverse cycle, with louvered sides, and 20,000 Btu/h or more	8.2	8.5

Source: *Federal Register*, Vol. 62, No. 185, p. 50124

"Room air conditioners were regulated by several states in the 1970s and 1980s and became federally regulated in 1987. The standard varies as a function of cooling capacity and other features, but for the most common type of unit (an 8,000–13,999 Btu/hour unit with side-vents) the 1987 law required an efficiency of 9.0 EER, effective 1990. In 1997, DOE published the most recent standard for room air conditioners, which became effective October 2000. For the most common unit, the EER must be at least 9.8" (ASAP 2010).

The California standards (**Table 25**) are now the same, although formatted somewhat differently.

Table 25: California Standards for Room Air Conditioners

Appliance	Louvered Sides	Cooling Capacity (Btu/hr)	Minimum EER
Room Air Conditioner	Yes	< 6,000	9.7
Room Air Conditioner	Yes	≥ 6,000 – 7,999	9.7
Room Air Conditioner	Yes	≥ 8,000 – 13,999	9.8
Room Air Conditioner	Yes	≥ 14,000 – 19,999	9.7
Room Air Conditioner	Yes	≥ 20,000	8.5
Room Air Conditioner	No	< 6,000	9.0
Room Air Conditioner	No	≥ 6,000 – 7,999	9.0
Room Air Conditioner	No	≥ 8,000 – 19,999	8.5
Room Air Conditioner	No	≥ 20,000	8.5
Room Air Conditioning Heat Pump	Yes	<20,000	9.0
Room Air Conditioning Heat Pump	Yes	≥ 20,000	8.5
Room Air Conditioning Heat Pump	No	< 14,000	8.5
Room Air Conditioning Heat Pump	No	≥ 14,000	8.0
Casement-Only Room Air Conditioner	Either	Any	8.7
Casement-Slider Room Air Conditioner	Either	Any	9.5

Source: CEC AER 2009, Table B-2

A.5.1.4 Dehumidifiers

Federal and California standards are the same. As happened with several other appliances, DOE codified the standards prescribed in EISA 2007 and did not exercise further regulatory discretion. The U.S. standards are shown in **Table 26**.

Table 26: U.S. Standards for Dehumidifiers

EPACT Standards effective October 1, 2007		EISA standards effective October 1, 2012	
Dehumidifier capacity Pints/day	EF liters/kWh	Dehumidifier capacity Pints/day	EF liters/kWh
25.00 or less	1.00	Up to 35.00	1.35
25.01 – 35.00	1.20	35.01 – 45.00	1.50
35.01 – 54.00	1.30	45.01 – 54.00	1.60
54.01 – 74.99	1.50	54.01 – 75.00	1.70
75.00 or more	2.25	Greater than 75.00	2.50

Source: DOE Technical Support Document, March 2009; *Federal Register*, March 23, 2009

The California standards are presented in a slightly different format (**Table 27**).

Table 27: California Standards for Dehumidifiers

Product Capacity (pint/day)	Minimum Energy Factor (liters/kWh)	
	Effective October 1, 2007	Effective October 1, 2012
25.00 or less	1.00	1.35
25.01 – 35.00	1.20	1.35
35.01 – 45.00	1.30	1.50
45.01 – 54.00	1.30	1.60
54.01 – 74.99	1.50	1.70
75.00 or more	2.25	2.50

Source: CEC AER 2009

A.5.1.5 Dishwashers

In the U.S. standards, the energy factor (EF) of a standard-size dishwasher must not be less than 0.46 cycles per kilowatt-hour (kWh) and that the EF of a compact-size dishwasher must not be less than 0.62 cycles per kWh (10 CFR 430.32(f)). These measures have been in place since 2004. EISA 2007 also established maximum energy and water use levels for dishwashers manufactured on or after January 1, 2010. Under the amended statute, a standard-size dishwasher shall not exceed 355 kWh/ year and 6.5 gallons of water per cycle, and a compact-size dishwasher shall not exceed 260 kWh/year and 4.5 gallons of water per cycle.
The California standards are the same (**Table 28**):

Table 28: California Standards for Residential Dishwashers

Appliance	Effective May 14, 1994	Effective January 1, 2010	
	Minimum Energy Factor (cycles/kWh)	Maximum Energy Use (kWh/year)	Maximum Water Use (gallons/cycle)
Compact Dishwashers	0.62	260	4.5
Standard Dishwasher	0.46	355	6.5

Source: 42 U.S.C. 6295(g)(10); CEC AER 2009, Table O

A.5.1.6 Residential Clothes Washers

"In December 2007, Congress enacted EISA, setting the first minimum water efficiency requirements for residential clothes washers. Minimum energy efficiency requirements, however, were left unchanged from the existing levels set by DOE in 2001, which became effective in January 2007" (ASAP 2010). Thus the U.S. standards for residential clothes washers manufactured on or after January 1, 2007 are shown in **Table 29**. More stringent federal standards will become effective January 1, 2011. All top-loading or front-loading standard-size residential clothes washers manufactured on or after that date have to have a Modified Energy Factor of at least 1.26; and a new criterion, the water factor (gallons per cycle per cubic foot), must not exceed 9.5 (10 CFR 430.32). The California standards are the same.

Table 29: U.S. Standards for Residential Clothes Washers

Product Class	Modified Energy Factor (cu.ft./kWh/cycle)
Top-loading, compact	0.65
To-loading, standard	1.26
Front-loading	1.26

Source: 10 CFR 430.32

A.5.1.7 Refrigerator-Freezers

The U.S. and California current standards for non-commercial refrigerators, refrigerator-freezers, and freezers manufactured on or after July 1, 2001 are expressed simply as a maximum level of energy consumption for various types and sizes of device. See **Table 30**. ("AV" refers to an adjusted measure of the volume of the device, as explained in the last row.)

Table 30: U.S. and California Standards for Residential Refrigerator-Freezers

Appliance	Maximum Energy Consumption (kWh/yr)
Refrigerators and Refrigerator-Freezers with manual defrost	8.82AV + 248.4
Refrigerator-Freezer - partial automatic defrost	8.82AV + 248.4
Refrigerator-Freezers - automatic defrost with top-mounted freezer without through-the-door ice service and all refrigerators - automatic defrost	9.80AV + 276.0
Refrigerator-Freezers - automatic defrost with side-mounted freezer without through-the-door ice service	4.91AV + 507.5
Refrigerator-Freezers - automatic defrost with bottom-mounted freezer	4.60AV + 459.0
Refrigerator-Freezers - automatic defrost with top-mounted freezer with through-the-door ice service	10.20AV + 356.0
Refrigerator-Freezers - automatic defrost with side-mounted freezer with through-the-door ice service	10.10AV + 406.0
Upright Freezers with manual defrost	7.55AV + 258.3
Upright Freezers with automatic defrost	12.43AV + 326.1
Chest Freezers and all other Freezers except Compact Freezers	9.88AV + 143.7
Compact Refrigerators and Refrigerator-Freezers with manual defrost	10.70AV + 299.0
Compact Refrigerator-Freezers - partial automatic defrost	7.00AV + 398.0
Compact Refrigerator-Freezers - automatic defrost with top-mounted freezer and compact all refrigerators - automatic defrost	12.70AV + 355.0
Compact Refrigerator-Freezers - automatic defrost with side-mounted freezer	7.60AV + 501.0
Compact Refrigerator-Freezers - automatic defrost with bottom-mounted freezer	13.10AV + 367.0
Compact Upright Freezers with manual defrost	9.78AV + 250.8
Compact Upright Freezers with automatic defrost	11.40AV + 391.0
Compact Chest Freezers	10.45AV + 152.0
AV = adjusted total volume, expressed in ft^3, as determined in 10 CFR, Part 430, Appendices A1 and B1 of Subpart B (2008), which is: [1.44 x freezer volume (ft^3)] + refrigerator volume (ft^3) for refrigerators; [1.63 x freezer volume (ft^3)] + refrigerator volume (ft^3) for refrigerator-freezers; [1.73 x freezer volume (ft^3)] for freezers. Note: Maximum energy consumption standards for refrigerator-freezers with internal freezers are same as those for refrigerator-Freezers with top-mounted freezers.	

Source: *Federal Register*, Vol. 62, No. 81, p. 23116, April 28, 1997

As of late 2010 DOE has issued a Notice of Proposed Rulemaking to amend these standards, in response to a petition by several states, utility companies, and interest groups. See section C.2 of this report, below.

A.5.1.8 Televisions

The California standards have for several years required many electronic devices to draw no more than 3 W in idle mode. In November 2009 California enacted the nation's first regulations of power usage by televisions in active use (**Table 31**). One level is effective in 2011 and a stricter level will be implemented in 2013. The regulations apply only to televisions with screens that are less than 58" diagonal. There are no similar federal standards for televisions.

Table 31: California Standards for Televisions

Effective Date	Screen Size (area in sq. in.)	Maximum TV Standby/Passive Mode Power Usage (Watts)	Maximum Active Mode Power Usage (P in Watts)	Minimum Power Factor (for P ≥ 100 W)
January 1, 2006	All	3 W	na	na
January 1, 2011	A ≤ 1400	1 W	P ≤ 0.20 X A + 32	0.9
January 1, 2013	A ≤ 1400	1 W	P ≤ 0.12 X A + 25	0.9

Source: AER 2009 Table V; ASAP 2010

"Power Factor" refers to the relationship between the useful or used power and the power drawn into or by the system. Differences in the circuit components used can make large differences in the Power Factor. (Clearly, televisions do not have tangible output measures available in quite the way that cooling or lighting devices do.)

A.5.2 Commercial Setting

A.5.2.1 Commercial Air-Conditioners and Heat Pumps

"Packaged terminal air conditioners and heat pumps (PTACs) are combined heating and cooling assemblies typically found in motels. They are intended for mounting through the wall and include a prime source of refrigeration, separable outdoor louvers, forced ventilation, and heating availability by hot water, steam, or electric resistance heat. Federal standards for PTACs were set under the Energy Policy Act of 1992. This legislation adopted standards originally set by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) in 1989" (ASAP 2010). In 2008 stricter standards were adopted for such commercial air conditioners and heat pumps (PTAC, PTHP), as shown in **Table 32**.

Table 32: U.S. Standards for Packaged Terminal Air Conditioners and Heat Pumps

Equipment	Category	Cooling Capacity (Btu/hr)	Energy Conservation Standards (minima)
PTAC	Standard Size	<7,000 7,000 – 15,000 >15,000	EER = 11.7 EER = 13.8 – (0.3 X Capacity) EER = 9.3
	Non-Standard Size	<7,000 7,000 – 15,000 >15,000	EER – 9.4 EER = 10.9 – (0.213 X Capacity) EER = 7.7
PTHP	Standard Size	<7,000 7,000 – 15,000 >15,000	EER = 11.9 COP = 3.3 EER = 14.0 – (0.3 X Capacity) COP = 3.7 – (0.052 X Capacity) EER = 9.5 COP = 2.9
	Non-Standard Size	<7,000 7,000 – 15,000 >15,000	EER = 9.3 COP = 2.7 EER = 10.98 – (0.213 X Capacity) COP = 2.9 – (0.026 X Capacity) EER = 7.6 COP = 2.5

Source: *Federal Register*, Vo. 73, No. 195, October 7, 2008, pp. 58829-30

The standards became effective October 1, 2010 for non-standard sizes and October 1, 2012 for standard sizes (as defined in the regulations). (Capacity in kBtu/hr is also defined in the regulations.) The standards for larger commercial units are much more complicated and are not reproduced here.

For either EER or COP, higher numbers represent more efficiency. Wikipedia, accessed in June 2010, offered these definitions of the terms. "The Energy Efficiency Ratio (EER) … is the ratio of *output* cooling in Btu/Hr and the *input* power in watts W at a given operating point …The COP of a cooling product is determined by dividing the cooling load by the electrical power needed to run the coolant pump, with both powers measured using the same units, e.g. watts. This differs from the EER … because COP is unit-less. Therefore a COP is universal and can be used in any system of units, whether metric or English…However, the COP is an instantaneous measure (i.e. a measure of power divided by power), whereas both EER and SEER are averaged over a period of time (i.e. they are measures of energy divided by energy). The time duration considered is several hours of constant conditions for EER".

A.5.2.2 Commercial Clothes Washers (CCWs)

"EPCA, as amended by EPACT 2005, prescribes energy conservation standards for CCWs manufactured on or after January 1, 2007. (42 U.S.C. 6313(e)) These standards require that CCWs have an MEF of at least 1.26 cubic feet of capacity (ft^3) per kilowatt-hour (kWh) and a WF of not more than 9.5 gallons of water (gal) per ft^3. (*Id.;* 10 CFR 431.156)" (*Federal Register*, Vol. 75, No. 5, p. 1126)

Effective January 8, 2013, stricter standards will apply. The U.S. standards for commercial washers are shown in **Table 33**.

Table 33: U.S. Standards for Commercial Clothes Washers

Equipment Class	Required Levels	
	MEF, cu.ft./kW	WF, gal/cu.ft.

Top-loading commercial clothes washers	1.6	8.5
Front-loading commercial clothes washers	2.00	5.5

Source: *Federal Register*, Vol. 75, No. 5, p. 1172, January 8, 2010

The ASAP web site provides this summary: "Standards for commercial soft-mount clothes washers, previously set by EPAct 2005, were amended with the issuing of a final rule on January 8, 2010. The new standards are set at 1.60 modified energy factor (MEF) / 8.5 water factor (WF) for top-loading washers and 2.00 MEF / 5.5 WF for front-loading washers. There is no federal or state standard for hard-mount clothes washers….There are 2 to 3 million commercial washers in the United States, which are replaced at a rate of about 10 percent per year. The vast majority of new commercial washer sales are top-loading (~80 percent)" (ASAP 2010). (Soft-mount washers are those that do not require attachment to a firm foundation, typically because they have their own built-in suspension system.)

There are presently no federal or state efficiency standards for clothes dryers, but the Energy Commission staff and the IOUs have had various discussions about establishing such standards.

A.5.2.3 Commercial Ice Makers

Effective January 1, 2008 the California standards were that the daily energy use and the daily condenser water use of automatic commercial ice makers manufactured were required to be no greater than the applicable values shown in **Table 34**. Effective January 1, 2010 the federal government adopted the same standards, so California and Federal standards became the same.

Table 34: California Standards for Commercial Ice Makers

Equipment type	Type of cooling	Harvest rate (lbs ice/24 hours)	Maximum energy use (kWh/100lbs ice)	Maximum condenser water use* (gal/100 lbs ice)
Ice Making Head	Water	< 500	7.80-0.0055H	200-0.022H
Ice Making Head	Water	≥ 500 and < 1436	5.58-0.0011H	200-0.022H
Ice Making Head	Water	≥ 1436	4.0	200-0.022H
Ice Making Head	Air	< 450	10.26-0.0086H	Not applicable
Ice Making Head	Air	≥ 450	6.89-0.0011H	Not applicable
Remote Condensing (but not remote compressor)	Air	< 1000	8.85-0038H	Not applicable
Remote Condensing (but not remote compressor)	Air	≥ 1000	5.1	Not applicable
Remote Condensing and Remote Compressor	Air	< 934	8.85-0.0038H	Not applicable
Remote Condensing and Remote Compressor	Air	≥ 934	5.3	Not applicable
Self Contained	Water	< 200	11.40-0.019H	191-0.0315H
Self Contained	Water	≥ 200	7.6	191-0.0315H
Self Contained	Air	< 175	18.0-0.0469H	Not applicable
Self Contained	Air	≥ 175	9.8	Not applicable
H = Harvest rate in pounds per 24 hours. *Water use is for the condenser only and does not include potable water used to make ice.				

Source: CEC AER, Table A-5

A.5.2.4 Commercial Refrigerators and Freezers

Effective January 1, 2010 the U.S. and California current standards are the same (**Table 35**).

Table 35: U.S. and California Standards for Commercial Refrigerators and Freezers

Category	Maximum Daily Energy Consumption (kilowatt hours per day)
Refrigerators with solid doors	0.10V + 2.04.
Refrigerators with transparent doors.	0.12V + 3.34.
Freezers with solid doors	0.40V + 1.38.
Freezers with transparent doors.	0.75V + 4.10.
Refrigerator/freezers with solid doors.	the greater of 0.27AV–0.71 or 0.70.
Refrigerators with self-condensing unit designed for pull-down temperature applications	0.126V + 3.51

Source: CEC AER 2009, Table A-4

where V is the volume in cubic feet and AV is an adjusted measure of the volume.

The DOE has published stricter and more detailed standards to become effective January 1, 2012. (*Federal Register*, January 9, 2009)

A.5.2.5 Commercial Water Heaters

The categories of "water heaters" cover large commercial installations, typical household storage heaters, tankless 'instant' water heaters, office water dispensers, and more. The regulations and categories need not all be captured here. For "large" water heaters (defined in the regulations by heat input), the U.S. and California regulations are as shown in **Table 36**.

Table 36: U.S. and California Standards for Large Commercial Water Heaters

Product	Size	Energy conservation standard [a] (products manufactured on and after October 29, 2003) [b]	
		Minimum thermal efficiency	Maximum standby loss [c]
Electric storage water heaters	All	N/A	0.30 + 27/Vm (%/hr)
Gas-fired storage water heaters	≤155,000 Btu/hr	80%	$Q/800 + 110(Vr)^{1/2}$ (Btu/hr)
	>155,000 Btu/hr	80%	$Q/800 + 110(Vr)^{1/2}$ (Btu/hr)
Oil-fired storage water heaters	≤155,000 Btu/hr	78%	$Q/800 + 110(Vr)^{1/2}$ (Btu/hr)
	>155,000 Btu/hr	78%	$Q/800 + 110(Vr)^{1/2}$ (Btu/hr)
Gas-fired instantaneous water heaters and hot water supply boilers.	<10 gal	80%	N/A
	≥10 gal	80%	Q/800 + 110(Vr) 1/2 (Btu/hr)
Oil-fired instantaneous water heaters and hot water supply boilers.	<10 gal	80%	N/A
	≥10 gal	78%	$Q/800 + 110(Vr)^{1/2}$ (Btu/hr)
Product	**Size**	**Minimum thermal insulation**	
Unfired hot water storage tank	All	R-12.5	

a) Vm is the measured storage volume and Vr is the rated volume, both in gallons. Q is the nameplate input rate in Btu/hr.
b) For hot water supply boilers with a capacity of less than 10 gallons: (1) the standards are mandatory for products manufactured on and after (Insert date one year after date the rule is published), and (2) products manufactured prior to that date, and on or after October 23, 2003, must meet either the standards listed in this table or the applicable standards in Subpart E of this Part for a ''commercial packaged boiler.''
c) Water heaters and hot water supply boilers having more than 140 gallons of storage capacity need not meet the standby loss requirement if (1) the tank surface area is thermally insulated to R–12.5 or more, (2) a standing pilot light is not used and (3) for gas or oil-fired storage water heaters, they have a fire damper or fan assisted combustion.

Source: *Federal Register* Vol. 69, No. 203, October 21, 2004, p. 61985

B. Partnerships and Consultations

In preparing this report the study team consulted with a wide spectrum of people and organizations that are potential stakeholders in such a Center. Because appliance and CE markets are national and California markets are larger than in other states, the range of stakeholders is national as well as statewide. The substantive results of the discussions are reflected in the other sections of this report; this section records the patterns and nature of the contacts and interactions.

In Appendix 3 there are letters of support for the idea of such a center. While the organizations expressing support cannot be expected make specific tangible commitments without further information and discussion, these letters do indicate a general agreement on the need for such a Center and the willingness of many parties to consider providing assistance.

B.1 Planning Workshops

Calit2 organized and hosted a day-long workshop on plug load energy efficiency on April 1, 2010. The workshop included presentations on related work at UCI and on the views of utilities, manufacturers, and regulators. Ample time was provided for discussion of the potential priorities and activities of a Center for plug-load efficiency. The agenda is included below as **Figure 12**. Over 110 persons attended, representing utilities, manufacturers, consultants, the CPUC and the Energy Commission, research centers, and academics. The list of attendees is shown in Appendix 2.

A second workshop, an evening event, was held on November 10, as part of Calit2's twice-yearly series called "Igniting Technology." The principal speakers were David Kirkby (UCI), James Meacham (CTG Energetics), Jack Brouwer (UCI), Lee Cooper (PG&E), and Wendell Brase (UCI). Over 100 persons attended, and six commercial companies had exhibit tables at the event (APS Development, Enova Water, Ether2, Greenwave Reality, Knobbe Martens Olson Bear, and MelRock Corporation).

B.2 External Consultations

The study team has visited and/or consulted with the following persons and groups, via personal meetings or e-mail or conference calls. All of these persons expressed positive interest in participating in the activities of such a Center.

- *Manufacturers*: Toshiba (Chris Harrington), Vizio (Ken Lowe, Rob Brinkman), Broadcom (Nicholas Ilyadis, Wael Diab), Fujitsu (Kevin Krejci), Dell (Paul Prince), Intel (Stephen Harper, Lorie Wigle), Philips (Andy McMillan), Whirlpool (Thomas Catania), Tower.Jazz (David Howard), Panasonic (David Thompson, Mark Sharp), EcoTek (John Wilkins), Precision Data Systems (Doug Goaley), Embertec (Rod Williams), Lockheed Martin (Thomas Zimmerman), Verde Power Supply (Robert Arnon), Greenwave Reality (William Diehl), American Power Conversion (John Tuccillo). HEMS Technology (Bill Melendez)

Figure 12: Agenda for the April 2010 Planning Workshop

9:00 – 9:15	**Welcoming Remarks & Workshop Objectives** -G.P. Li, UCI Calit2 director
9:15 – 9:35	**Current UCI Advanced Power and Energy Program (APEP) Research & Smart Grid Demonstration Project** -Scott Samuelsen, UCI APEP director
9:35 – 9:55	**UCI Campus Energy Efficient Smart Building Initiative** - Wendell Brase, vice chancellor, UCI administrative & business services
10:00 – 10:15	Moderated Audience Q & A
10:15 – 10:30	Break
10:30 – 11:30	**Challenges & Opportunities for the New Center** *"Perspectives from the California Lighting Technology Center"* -Michael Siminovitch, UC Davis CLTC director *"Market Settings and Market Structure for Appliances and Energy Consumption"* - Alladi Venkatesh, UCI professor of marketing *"Engineering Challenges for Energy Efficiency in Consumer and Office Electronics"* -G.P. Li, UCI professor of engineering *"Designing for Behavior Change: The uci@home Project"* -David Kirkby, UCI professor of physics and astronomy *"The Economics of Plug Load Efficiency"* -David Brownstone, UCI professor of economics
11:30 – 12:15	Moderated Audience Q & A
12:15 – 1:00	Lunch in Calit2 Building Atrium
1:00 – 2:00	**Incentives, Policies & Standards for Efficiency** *"The Role of Utilities in Advancing Energy Efficiency Agendas"* -Gregg Ander, Southern California Edison chief architect "*PIER Funded Research in Consumer and Office Electronics*" -Bradley Meister, California Energy Commission senior mechanical engineer "*LEED: Current Impact and Future Opportunities*" -Jim Meacham, Advanced Energy Services director
2:00 – 2:20	Moderated Audience Q & A
2:20 – 2:30	Break
2:30 – 3:30	**Industry Perspectives on Plug Load Energy Efficiency Needs & Challenges** "*Energy Efficiency Approaches, Challenges and Opportunities in Consumer Electronics*" -Douglas Johnson, Consumer Electronics Assoc. (CEA) technology policy VP "*Data Center Energy Efficiency with Ethernet Technologies*" -Nicholas Ilyadis, Broadcom Enterprise Networking Group VP & CTO *"Energy Considerations in the Context of Overall Business Management"* -Christopher Harrington, Toshiba America Information Systems, Inc. VP
3:30 – 3:50	Moderated Audience Q & A
3:50 – 4:30	**Potential Research Center Structure and Focus** *A facilitated discussion led by Virginia Lew, Brad Meister and Chris Scruton from the California Energy Commission for workshop participants to share their interests, needs and research focuses for a plug load energy efficiency center*
4:30 – 6:00	Networking Reception in Calit2 Building Atrium

Source: Calit2

- *Associations*: National Electrical Manufacturers Association (Evan Gaddis, Paul Molitor, Bobby Bilicki), Consumer Electronics Association (Douglas Johnson), Continental Automated Buildings Association (Ron Zimmer)
- *Distributors*: Best Buy (Leo Raudys), DKO International (Thomas Kim, Keith Edwards, Richard Oh)
- *Utilities*: SCE (Gregg Ander, Paul Thomas, Paul De Martini, Ramin Faramazi, Scott Mitchell, Percy Haralson, Michael Montoya), SDG&E, PG&E (Lee Cooper, Patrick Eilert, Janice Berman, Robert Davis), Sacramento Utility District (Bruce Baccei, Jim Parks, Vikki Woods), Sempra Utilities (Jerine Ahmed), ConEdison (Eileen Egan-Annechino)
- *Energy Efficiency Consulting Companies*: CTG Energetics (Malcolm Lewis, Jim Meacham), Ecos Consulting (Catherine Mercier, Ryan Rasmussen, Gregg Hardy)
- *Agencies*: California Energy Commission (Chris Scruton, Brad Meister, Virginia Lew, Norm Bourassa, Anthony Eggert, Phil Misemer, Ken Rider, Harinder Singh, Jeffrey Byron); CPUC (Ayat Osman); Palm Desert Redevelopment Agency (Catherine Walker)
- *Energy Research Centers*: Lawrence Berkeley National Laboratory (Rich Brown, Karina Garbesi, Mary Ann Piette), California Lighting Technology Center (Michael Siminovitch); Demand Response Research Center (Vikki Wood), National Renewable Energy Laboratory (Lieko Earle); California Institute for Energy and Environment (Karl Brown, Karl Johnson, Ken Krich)
- *Others*: Carboncontest.com (Ravi Mikkelsen), Google (Michael Terrell), A2 Energy Ventures (Mark Bold), Northeast Energy Efficiency Partnership (Edward Schmidt), Pew Center on Global Climate Change (Andre de Fontaine), Comcast (Richard Kirsche)

B.3 Attendance at Conferences, Meetings, and Facilities

- Stuart Ross and Goran Matijasevic attended the Consumer Electronics Show in Las Vegas, in January 2010.
- Stuart Ross attended the Going Green Expo in Newport Beach in November 2009.
- Stuart Ross visited the California Lighting Technology Center in July 2009.
- Four UCI personnel visited SCE's Technology Test Center in Irwindale, January 2010, for discussions and a tour.
- G.P. Li and Stuart Ross attended the SCE Public Workshop on ZNE Research in May 2010.
- G.P. Li attended EE Global, the Global Forum on Energy Efficiency organized by the Alliance to Save Energy, in Washington D.C. in May 2010.
- Gregory Gallardo (Calit2 facilities manager) visited SCE's Technology Test Center, April 2010.
- G.P. Li and Stuart Ross attended the Fujitsu Symposium on the Smart Grid in June 2010.
- As part of the same trip they toured PG&E's Technology Test Center and the food service center managed for PG&E by Fisher-Nickel.
- G.P. Li attended the Consumer Electronics/Plug Load Summit on Advanced Power Strips, in June 2010, hosted by the Northeast Energy Efficiency Partnership.
- Stuart Ross attended Connectivity Week in Santa Clara, CA, May 2010
- G.P. Li and Stuart Ross attended the Emerging Technologies Summit in Sacramento in early November 2010. Dr. Li made two invited presentations.

B.4 On-Campus Consultations

Through individual meetings, advisory groups, seminars, conference presentations, and white papers the authors have received valuable input from the following UCI faculty and staff members (in alphabetical order): Nader Bagherzadeh (Electrical Engineering), Wendell Brase (Vice Chancellor, Administration), James Bobrow (Mechanical Engineering), Jack Brouwer (APEP), David Brownstone (Economics), Pai Chou (Electrical Engineering), Linda Cohen (Economics), Rui de Figueiredo (Electrical Engineering), Nikil Dutt (Computer Science), Ahmed Eltawil (Electrical Engineering), John Graham (Marketing), David Kirkby (Physics), Fadi Kurdahi (Electrical Engineering), Sharad Mehrotra (Computer Science), Walt Scacchi (Institute for Software Research), Shivendu Shivendu (Management), Dennis Silverman (Physics), Keyue Smedley (Electrical Engineering), William Tomlinson (Informatics), Alex Veidenbaum (Computer Science) and Alladi Venkatesh (Management).

C. Efficiency Opportunities

C.1 Detailed Analysis of the Appliance and Electronics Market

A numerical assessment of the market based primarily on the most recent comprehensive federal data is shown in Section A. The formal state standards and programs are discussed in C.2 below, and other forms of standards or certifications are discussed below in C.4. Further aspects of the markets are discussed here, based on the April ,1 2010, workshop and other communications since the market task report, which will influence the need for an Energy Commission center and shape its operations.

Plug loads are an important target for achieving energy efficiency, because they currently account for 15 percent to 20 percent of the load in the residential sector and in the business sector, and those portions are growing rapidly. (Various percentage figures are in the literature, depending on dates and definitions.) Moreover, many plug load appliances, especially consumer electronic devices, have received less regulatory attention than major white goods, and therefore substantial marginal gains in efficiency can be made. The CPUC energy efficiency strategic plan, along with many other sources, set a strategy (Goal 3-4) to "continuously strengthen standards…to codify advances in plug load management" (CPUC 2008).

The market for consumer electronics is more complex than the market for white goods, because of the diversity of devices, manufacturers, distributors, and users. CE devices encompass a wider range of users and situations than do white-goods appliances; replacement cycles are often only a few months long; many of the devices are designed for mobility; and devices are combined in new ways. Although some electronic devices are only available through service providers (e.g. cell phones and set top boxes), most are available through retail stores, wholesale distributors, manufacturers and on the Internet, including from out-of-state vendors, in ways that typically do not occur for white goods. In California, the consumer electronics industry is also a major industry, as noted by the Energy Commission in its profiles of industries (CEC Profiles 2008), so the effects of standards on manufacturers would be important to the state.

The rapid pace of change in the CE market continues to be both a problem and an opportunity for achieving energy efficiency. It is a problem because regulatory procedures and public education programs will need to be more nimble than in the past, using up-to-date information on current and prospective products; it is an opportunity because (unlike the case with white goods) both customers and manufacturers make changes more often and therefore are more often open to new influences. As noted in the ASAP quotation above, the stock of clothes washers experiences only about 10 percent turnover per year. (The market changes in electronic goods are not all increases; as technology improves some items lose market share rapidly – eight track players and 5.25" disk drives are examples.) CE devices typically now produce more 'output' (teraflops, bytes, pixels) with less energy consumption per unit than they did a decade ago, a rate of change largely unmatched by white goods, as electronics industry managers like to point out. Nonetheless, within most categories of electronics the number of devices has increased, the energy consumption per device has increased, and the portion of input energy wasted is still unnecessarily high – so the energy problem for the state remains.

Achieving changes in consumer behavior is important and challenging. The importance of working for such changes has been recognized now by the CPUC, which recently decided that the IOUs could count energy savings from certain limited behavioral studies in their energy efficiency portfolios and cautioned against the danger of double-counting if savings from behavior have already been counted as a result of technology changes. All parties acknowledge that there have not been enough studies of real consumer behavior; the plug-load problem covers a wide range of devices, physical settings, and demographic groups. Many devices are on the market that attempt to accommodate or improve consumer behavior to achieve energy conservation – display panels, motion sensors, smart plugs, and so on – but few if any are complete solutions. Behavior change interventions will need to incorporate social and behavioral mechanisms with the emerging technological advancements.

Promoting the production and purchase of new efficient plug-load devices is essential; otherwise the installed base will keep efficiency low. If frequent replacements or additional acquisitions are initiated by the consumer, as noted above, the need is to influence choice; but for longer-lived items like white goods and set-top boxes the need is to stimulate choice, a different task. Government standards requiring higher levels of efficiency are an important tool in this process. In addition, many rebate programs and educational programs have been established by the California utilities since decoupling was established, some with success and some with unexpected consequences, as detailed below. Most utilities have established programs to work with retailers, as part of their energy efficiency portfolios. Some retailers have established special centers for selling "green" products, including energy-efficient appliances, and some web sites focus on "green" products, but retailers vary widely in how and whether they promote energy efficient products.

There is a serious lack of data about energy consumption in use for residential and commercial appliances and electronic devices, because usage patterns vary widely among households and between residential and commercial settings, yet the studies and tests by manufacturers and regulators must include real usage data as well as laboratory data. The consumers need better data too, about their energy use in real time, if they are to make changes in behavior. Building-level meters and monthly bills are not sufficiently focused to stimulate consumer action. Of course, metering every appliance and providing real-time data readouts to the customer merely add equipment costs and additional effort, and they may confuse the user with too much information. Achieving the right balance will be critical to further progress. While other business models use pricing as a way to maximize demand (e.g. cell phones and Internet access), in this case reduction of demand is one of the goals (Hayes and Cone 1977, Hayes and Cone 1981, Meier and Eide 2007).

The expected growth in use of plug-in electric vehicles (PEVs) will create substantial changes in electricity consumption for utilities and for households; PEVs are plug-in appliances like no other. For homeowners, the predicted power needs for charging a car are the same order of magnitude as the entire rest of the electric system and charging sessions that take hours would pose scheduling problems for access to the car or other appliances. For a utility, the extra drain would likely require more frequent maintenance on a grid circuit (e.g., transformers would get less cooling at night) and, in the long run, rebalancing the utility's supply curve. Recharging will not always occur at home -- it may occur at workplaces or other residences or commercial charging stations; the prospect of major loads moving around is new. However, concerns about greenhouse gases and dependence on foreign oil will maintain the pressure to implement PEV systems. At least one utility is encouraging the conversion to PEVs and tying it to time-of-use pricing -- San Diego Gas & Electric and ECOTotality have announced a program offering a free home charging system to the first buyers of a Nissan Leaf (Tweed 2010). In the context of the total California electric market, the additions of plug-in vehicles will be very small at first. But because such purchases are likely to be concentrated among early-adopters in high-SES neighborhoods, the changes may be substantial in those areas.

The growing use of distributed generation with renewable energy sources, perhaps using DC circuits direct to appliances, complicates the calculations about total consumption on the grid and the efficiency of appliances. If a device or a home can be completely powered by its own sources (such as solar, wind, or biomass), then perhaps its efficiency need not be a concern of the state. Inverters are now available on the market that allow a DC source to be converted to

110V AC usable in regular household circuits, so locally generated renewable power could simply be used to lessen demand on the grid. The use of distributed generation will increase rapidly, as a result of lower prices for solar arrays, wind generators and fuel cells, and as a result of zero-net-energy requirements in California. The climate-change focus will remain on total consumption from carbon sources, but the electric-grid focus will shift to net consumption.

Shifting the time of use of appliances via Demand Response (DR) programs can at least avoid the need for more power plants and enable the use of more efficient generation resources. DR is formally considered to be high in the 'loading order' for California utilities, and the Energy Commission was a leader in establishing the technology for Auto-DR. Automated Demand Response (ADR) approaches are based on sending price signals to the home or commercial establishment, for response by specially equipped appliances. ADR will be more complicated for appliances in residences and small businesses than for large installed devices such as HVAC or major industrial equipment because of the variety of devices and behaviors. Appliances equipped to respond to DR signals have begun to appear on the market. Open-software ADR (OpenADR) is being developed but is not universally established, and ADR is not yet sufficiently coordinated with AMI (Advanced Metering Infrastructure), which has developed separately as part of the Smart Grid movement. It is conceivable that future appliance standards could require appliances to be equipped for demand response signals. Another form of DR is effected by aggregators, companies that as intermediaries between supplies and consumers, that contract to provide various levels of power reduction. A leading example is EnerNOC, Inc. (www.enernoc.com). Many utilities have already implemented DR for major installed items like central air conditioners, securing permission from customers to turn off air conditioning units remotely at times of extreme demand. The Demand Response Research Center (DRRC) at LBL is a leader in promoting ADR and in coordinating with AMI; the DRRC is funded by the Energy Commission as one of its centers. See for example the DRRC publication *Home Network Technologies and Automating Demand Response* (McParland 2008) and the center's summary of OpenADR (DRRC 2010). A summary of different demand-response alternatives is available in a white paper by ENERNOC (ENERNOC 2009),

C.2 Ongoing Activities at the State Level Relative to Title 20

C.2.1 Background

The Energy Commission began establishing appliance efficiency standards before the other states and before the federal government. Regulation of domestic refrigerators began in 1978 and deserves mention as one of the main success stories of energy efficiency (Neubauer et al. 2009). Now new high-efficiency models use one fourth to one third the power used by models built in the 1970s.

The Commission's legal authority stems from Division 15 of the Public Resources Code, the Warren-Alquist Act, which established the Commission in 1974 and gave it certain powers of regulation over energy conservation and energy efficiency. California's power in these matters derives primarily from the size of the California market – neither the federal government nor manufacturers cannot afford to neglect it. Action in California in the 1970s was motivated by the oil crisis and also by the concern over the large number of new power plants that would have been needed to meet forecasted demand. In 1978, the Energy Commission incorporated Title 24 to the California Code of Regulations, setting efficiency standard for buildings as well. California has continued to establish various appliance efficiency standards, and other states have often followed California's lead with their own standards. California's Energy Action Plan in 2003 declared explicitly that energy efficiency should be considered an energy resource and should be the first resource in the loading order (EAP 2003).

In the late 1990s the CPUC ordered the four major IOUs to undertake new efficiency programs, using funds from the Public Goods Charge added to consumers' bills. The most recent allocation of funding for this purpose by the CPUC was $3.1 billion for three years. Although the requirements placed on the IOUs come from the CPUC, the Energy Commission is the standard-setting body. For both Title 20 and Title 24, the Energy Commission amends and re-issues the regulations in three or four year cycles (more regularly for Title 24 than for Title 20). Ideas for changes may come from the utilities, professional associations, research organizations, or the Energy Commission staff. In a winnowing process initial studies review the markets and technologies; standards are drafted and made available for comment; the IOUs answer follow-up questions from the Energy Commission; public and stakeholder comments are incorporated at several steps; and regulations are passed. In every case the standards will take some items off the market and will not affect some items that are already more efficient than the standard requires. Where to set the standard is often posed in terms of a classic technology adoption curve.

The current appliance regulations are in Division 2 of Title 20 of the California Code of Regulations. The California regulations and test procedures as of August 2009 are presented in full in the Energy Commission publication *2009 Appliance Efficiency Regulations* (CEC AER 2009). A tabular summary of California appliance regulations, the regulations of several other states, and the status of federal pre-emption as of late 2009 is available on the web site of the Appliance Standards Awareness Project (ASAP 2009).

In 1996 California established the Public Interest Energy Research (PIER) Program under the Energy Commission to fund energy-related research and development, emphasizing energy efficiency research after early efforts on market transformation (Eilert et. al. 2002). PIER was formed following deregulation of California's electric industry in 1996 and draws its funds from fees placed on investor owned utilities in the state; the fees are derived from the Public Goods Charge (PGC). The program served to ensure continuing funding of public interest research, development, and demonstration in energy-related issue despite change in the electric industry. The establishment of PIER was a model for other states. Under Energy Commission management, PIER supports research in Energy Efficiency and Demand Response, Advanced Transportation Technologies, Advanced Generation, Renewable Resources, Transmission and Distribution, and Climate Science and Energy.

The Energy Commission also maintains a publicly accessible database that lists efficiency data for all appliances currently covered by state regulations in Title 20. The database is accessible on the Commission web site (CEC Appliance Database 2009). The categorization used in the database is an artifact of the history of standard setting and therefore illustrative of the need for the proposed Center: There are many separate categories for major white goods such as water heaters, lighting products, and central air conditioners; few categories for other appliances; and a single category called "Electronics". Most of the other first-level categories have 3-5 subcategories; while Electronics has only one – 'audio and video devices'. In that one category the reader finds energy consumption data for over 440 manufacturer models of radio alarm clocks, DVD players, power supplies, televisions, and more. The data can be sorted on-line by manufacturer, by type of device, or by level of energy consumption. Both idle power levels and operating power levels are shown.

Several of the appliances regulated by the state are not usually considered part of the plug load and therefore are not proposed as topics for the proposed Center – such as central furnaces, boilers, luminaires, plumbing fittings, and traffic signals. Appliances considered to be medical devices are not completely under the Energy Commission's jurisdiction (the FDA also regulates those) but are considered in this report because most observers expect a rapid growth in the use of medical devices at home and thus substantial energy consumption as they relate to telemedicine.

Establishing and agreeing upon test procedures for devices will continue to be a problem for new electronic devices. Setting standards for an appliance category cannot succeed without a replicable and understandable test procedure that measures the actual power consumption in various circumstances, modes, and versions of the device. If no test procedure is widely agreed upon, a separate rulemaking may be necessary to establish one; obtaining agreement on test procedures is sometimes as difficult as obtaining agreement on the standards. The recent standards-setting process for both televisions and battery chargers had to give serious attention to specifying test procedures; federal and state appliance regulations typically specify the test procedures that are required.

The formal procedural requirements for rulemaking by agencies are summarized in a "How to Participate" publication by California's Office Administrative Law (OAL 2006)

C.2.2 Relation to Federal Regulations

The development of Title 20 regulations has taken place alongside the development of Federal regulations on appliance efficiency. The setting of appliance standards has become one of the most interesting stories in the study of federalism. A useful summary of the federal government's actions has been prepared by Lawrence Berkeley Laboratory (LBL Standards). A good summary of the federal-state relations may be found in a recent article by Carlson (2008) and the web site of the California Attorney General (Office of the California Attorney General 2010).

As noted above, many states followed California in developing energy agencies and efficiency standards. Nevertheless, in the 1970s and 1980s little progress was accomplished on the national level. The years following the energy crisis saw the introduction of a number of bills into Congress calling for formation of energy reserves and reduction of energy demands. One of the federal bills was the Energy Policy and Conservation Act (EPCA), passed in 1975. EPCA required energy consumption labeling and efficiency targets for a number of products. EPCA also included provisions for the states to form their own energy conservation programs and for federal assistance for such programs. Federal standards came after the first state actions. EPCA established the three primary review criteria for appliance efficiency: technical feasibility, cost effectiveness, and significance of energy savings. In this time frame the federal government made some motions towards appliance standards but did not actually finalize any.

By the late 1980s manufacturers were concerned that varying state standards would affect their ability to do business nationally and demanded uniform national standards. Manufacturers and energy efficiency advocates thus had common cause in negotiating at least some national policy; the result was the National Appliance Energy Conservation Act of 1987 (NAECA), adopted by Congress and signed into law. NAECA created standards for twelve appliance types. Five years later, Congress enacted another round of standards for light bulbs, electric motors, commercial heating, cooling equipment, and plumbing fittings under the Energy Policy Act of 1992 (EPACT). EPACT also directed the U.S. Department of Energy (DOE) to begin rulemaking for five other appliance types.

Thirteen years later, Congress created additional standards for sixteen appliances under the Energy Policy Act of 2005. In 2007, Congress passed the Energy Independence and Security Act (EISA), which created new or updated standards for thirteen appliances (in addition to many other changes in energy policy). EISA also proposed to phase out incandescent light bulbs by 2012-2014 and directed DOE to create regional standards for residential heating and cooling appliances. However, federal progress on minimum efficiency regulations was hardly steady. By the mid 1990s, political shifting in Congress led to delays in updating of standards and modifications to DOE test procedures reducing potential savings. States began again to take initiative in furthering energy efficiency by developing stricter state standards (Nadel and Goldstein 1996).

Currently, the Obama administration has placed a renewed emphasis on adopting and enforcing appliance efficiency standards. In early 2009, President Obama issued a memorandum ordering DOE to finalize the legally-required efficiency standards consistent with the proposed deadlines outlined in Epact and EISA, so the pace of rulemaking has increased. In April 2009, for example, new standards were established for residential gas ranges and ovens (although action was explicitly deferred on other items.) Last year, the Appliance Standards Improvement Act of 2009 (S.598, called ASIA) was introduced in the Senate to create new standards for portable light fixtures, improve current appliance standards, and reform the Energy Star program. This bill is currently being considered by the Senate.

Items regulated by California but not by the federal government include wine chillers, refrigerated vending machines, compact audio products, and DVD players and recorders.

Because federal law usually pre-empts state laws there has to be careful specification about what categories of appliances a state can or cannot regulate. "Under the general rules of federal preemption, states which had set standards prior to federal enactment may enforce their state standards up until the federal standards become effective. States that have not set standards for a product category that is now enforced by the federal government are subject to the federal standard immediately" (ASAP 2009). For manufacturers, the practicality of one national standard is important.

However, some court rulings in 2005 and 2006 have ruled in favor of state government interpretations over federal ones in regards to energy efficiency regulation.

In 2005, manufacturing companies sued the Energy Commission when it required manufacturers to put basic information about their products' energy performance on their appliances. The manufacturers argued that California's efficiency regulations need not be followed because they were preempted by the federal energy laws. The Ninth Circuit Court ruled that California and other states can require appliance manufacturers to provide information about the energy performance of their products. The manufacturers appealed to the Supreme Court, arguing that the court ruling will allow other states to impose conflicting obligations on manufacturers. The Supreme Court rejected the appeal.

In another 2005 proceeding, a coalition of states including California sued the U.S. Department of Energy for violating congressional mandates ordering DOE to adopt standards for 22 appliances, specifically for failing to meet rule-making deadlines established by EPCA. The DOE had missed many of the mandated deadlines outlined in NAECA and had fallen years behind schedule in adopting efficiency standards. The New York district court approved a negotiated settlement between the states and the federal department, in which the DOE agreed to a binding schedule to publish standards for large appliances. Massachusetts and other states filed suit again in 2007, when DOE attempted to reinterpret the legislations as forbidding it from updating efficiency standards. In face of the second lawsuit, Congress enacted the Energy Independence and Security Act of 2007 (EISA), legislating in favor of the state (Office of the California Attorney General 2010).

The states, rather than the federal government, have been the leaders in imposing and implementing stricter appliance efficiency standards; federal pre-emption generally follows after state standards and federal standards are generally more lax than state standards. California has been foremost among the states in establishing new standards; one reason California has been able to take the lead is its large population – manufacturers cannot afford to ignore the California market. (Corporate data centers need not be in California, but the manufacturers of the data equipment still need the California market.) The Energy Commission's publication of its set of appliance regulations (CEC AER 2009) distinguishes between (a) Federal and State Standards that are identical, for Federally Regulated Appliances (Section 1605.1), (b) State Standards that may apply if exemption is obtained from federal regulations (Section 1605.2), and (c) State Standards for Non-Federally Regulated Appliances (Section 1605.3).

In some cases ad hoc negotiations are needed to coordinate federal and state roles. In the case of walk-in refrigerators, for example, the federal government agreed to delay implementation of new standards and in return the California IOUs agreed to drop their objections to the federal standards, giving California time to develop its own new standards – which at least would be effective before federal pre-emption and might influence the new federal standards (Heschong Mahone Group 2008, p. 2). There are also procedures for exemption from federal preemption, but the procedures are difficult. In the first such request made, California filed for an exemption for its water conservation standards for residential clothes washers, and the request was rejected by DOE but later upheld by the Ninth Circuit Court of Appeals (CEC News 2009).

Federal standards for many appliances are detailed above in section A.5. See **Table 37** below for a schedule of Federal appliance regulations anticipated as of mid-2009 (some of the schedules may have changed since that time). The table is from Neubauer et al. (2009), which provides a general review of federal standards.

A similar and more detailed list is available online from the Appliance Standards Awareness Project (ASAP), at http://www.standardsasap.org/documents/DOE%20schedule%20-%202006%20to%202011%20oct%2009%20update.pdf. ASAP's web site provided some of the information shown in Section A.5 above.

C.2.3 Some Selected Appliance Standards Processes

The most prominent recent regulation effort under Title 20 has been related to **televisions** (Docket # 09-AAER-1C). Standards for passive (standby) power consumption had already been set in 2006. The new standards require new TVs smaller than 58 inches (diagonal) to be 33 percent more efficient starting in 2011 and 49 percent more efficient starting in 2013. The regulations were formally adopted in later 2009, after the prescribed series of notices, hearings, staff reports, and comment periods over about two years. (The new television regulations are therefore not

Table 37: DOE Final Rulemaking Schedule Through January 2013

Product	Final Rule Due Date	Effective Date
Incandescent Reflector Lamps***	June 2009	2012
Linear Fluorescent Lamps***	June 2009	2012
Commercial Boilers	July 2009	2012
Refrigerated Vending Machines	August 2009	2012
Commercial Clothes Washers	January 2010	2013
BR \ Exempted Reflector Lamps***	January 2010	2013
Small Electric Motors	February 2010	2013
Direct Heating Equipment	March 2010	2013
Pool Heaters	March 2010	2013
Residential Water Heaters	March 2010	2013
High-Intensity Discharge Lamps**	June 2010	NA
Residential Refrigerators and Freezers	December 2010	2013
Microwave Ovens — Standby Power	March 2011	2014
Residential Furnaces	May 2011	2015
Fluorescent Lamp Ballasts	June 2011	2014
Residential Clothes Dryers	June 2011	2014
Room A/C	June 2011	2014
Residential Central A/C and Heat Pumps	June 2011	2014
Battery Chargers	July 2011	2014
External Power Supplies	July 2011	2014
Residential Clothes Washers	December 2011	2015
Metal Halide Lamp Fixtures	January 2012	2015
Walk-In Coolers and Freezers	January 2012	2015
Commercial Reach-In Refrigerators and Freezers	January 2013	2016
Liquid Immersed Transformers	January 2013*	2016
Low-Voltage Dry-Type Distribution Transformers	January 2013*	2016
Residential Furnace Fans	January 2013*	2016

* We include these products because their large potential savings make them excellent candidates for completion earlier than is legislatively required.
** DOE must first determine by June 2010 whether standards are needed. If the determination is positive, standards could be issued by 2012 and effective some time later. We did not analyze this technology for this report.
*** DOE issued standards for general service fluorescent lamps and incandescent reflector lamps on June 26, 2009, when this report was nearing completion. DOE announced in early 2009 that it will start a new rulemaking for BR and other exempted reflector lamps. Although a due date for the final rule has not yet been set, bills in the House and Senate have targeted January 1, 2013 as the effective date.

Source: Neubauer et al. (2009)

included in the Energy Commission publication cited above on appliance regulations.) A few other states have followed California's lead and established efficiency standards for televisions.

The Energy Commission adopted appliance energy efficiency standards for **external power supplies** (EPS) in 2005, made effective in 2006. The regulations specified the minimum permissible efficiency in active mode and the maximum energy consumption in no-load mode. In 2005 the Energy Commission and the ENERGY STAR program together sponsored a competition for energy efficiency in external power supplies (CEC PIER 2006). PG&E and Ecos Consulting provided much of the background research, with PIER support. Under EISA the federal government adopted standards effective in 2008 that were the same as California's standards. A summary of the state, federal, and European standards is on the web site of XP Power at http://www.xppower.com/page.php?pagename=Energy&lang=EN. There is little or no separate market for external power supplies; for the most part they are provided with the powered devices – printers, fax machines, etc. Since the 1970s there has been a continuing trend toward using switch-mode devices instead of linear ones; switch-mode EPSs are inherently more efficient because they do not use lossy components to cut voltage. California adopted a voluntary standard for testing procedures in 2008 (Neubauer et al. 2009).

California adopted a voluntary standard for testing procedures for **battery chargers** in 2008 (Docket # 07-AAER-3), based on recommendations made jointly by PG&E and Ecos Consulting after several years of testing and research (Neubauer et al. 2009, Bendt et al. 2008, CEC 2007a). Other test methods are used as well. Battery chargers are an oft-cited example of 'vampire power'. The testing procedures have been enacted but the energy efficiency standards or energy design standards for battery charger systems are not yet enacted. As of May 2010, the DOE was proposing to amend its test procedures (Power Integrations 2010). EPA has established specifications in the ENERGY STAR program (EPA Battery Chargers 2010).

The Energy Commission has supported research on the efficiency of **internal power supplies**, carried out by Ecos Consulting, but "there are currently no standards to regulate the efficiency of internal power supplies, and there are no universally agreed-upon methods for determining their efficiency" (CEC PIER 2008). Mansoor et al. at EPRI proposed a test protocol in 2009 (Mansoor et al. 2009). The Energy Commission adopted standards for **external power supplies** in 2005, effective in 2006 (see section A.5.1.1 above).

California established standards for canned and bottled beverage **vending machines**, effective in 2007, and the U.S. Department of Energy instituted new (pre-emptive) standards in 2009 as part of Docket EERE-2006-STD-0125 (NRDC 2009; DOE 2009). Vending machines usually pose a classic principal-agent problem: the purchaser or owner of the machine is not responsible for energy bill; the user/lessee is (Meier and Eide 2007). A predictable result has been that vending machines lagged far behind in energy efficiency technology, and standard-setting was necessary. SCE's Refrigeration and Thermal Test Center in Irwindale CA developed prototype machines during the Energy Commission's regulatory proceedings, showing that great improvements in efficiency could be achieved by using alternative components that are already available on the market. SCE's 2003 fact sheet for owners or operators of the machines can be seen at http://www.sce.com/NR/rdonlyres/A152092A-9FC5-410C-80DC-F19257EC19EA/0/Refrigerated_Vending_Machine_Fact.pdf.

There are no state or federal efficiency standards for **desktop computers or game consoles or mobile devices,** although ENERGY STAR and EPEAT have set criteria for computers, at (http://www.energystar.gov/index.cfm?fuseaction=find_a_product.showProductGroup&pgw_code=MO. PG&E commissioned a 'Proposal Information Template for Monitors and Other Video Displays' in the 2008 round of appliance rulemaking in California (Chase 2008a). Computers and monitors together dominate energy office plug loads (Calwell 2008).

To a greater extent than for white goods or other electronic devices, computers are marketed as configurable collections of components – CPUs, hard drives, graphic cards, memory modules, and more, and they are available in a wide variety of form factors. Progress on efficiency is possible on several components – higher performance video cards can make a large difference in computer power consumption at idle; DDR2 memory has proved to be more energy efficient than DDR memory. Some new form factors and designs offer lower power usage, but some nominally low-power computer designs merely displace energy usage to external components. The wide variety of components and form factors for PCs therefore enables and requires a choice between setting standards for the pieces or setting 'black box' performance standards for specified collections of components. Most of the components are available separately on the market, and many users are capable of swapping components to build what they want, so relying on standards for the whole unit at retail would cover only part of the problem.

The market for game consoles in particular is oriented to power and performance; customers give little or no attention to energy efficiency and therefore manufacturers ignore it also, even for pause or standby modes. Neugebauer et al. (2008) argue that implementing automatic power-down features would effect a substantial reduction in usage. Progress on efficiency probably has to be on a component basis – improving internal power supplies, cooling systems, video cards, etc. The growing variety of game machines makes definition and regulation difficult – a Wii, an arcade game and a Nintendo DS are rather different machines.

Standby power is a major problem for computers and monitors; the problem is both technical and behavioral. Computer users often leave their monitors on when the computer has been turned off or has lapsed into standby mode. In one study of actual offices (Sanchez et al. 2007) monitors were found to be major users of 'vampire' power. Although LCD monitors typically draw less power than CRTs of the same size, larger and larger LCD monitors are being sold, which counteracts some of the savings.

C.2.4 Utility Programs

The most important change for the utilities has been the introduction of **decoupling** and the provision of financial incentives to utilities for achieving specified savings levels. Among the 50 states, California has been one of the most aggressive in providing incentives for efficiency. A detailed discussion of utility financial incentives and disincentives for efficiency (and comparisons among state programs) is provided by the National Action Plan for Energy Efficiency in *Aligning Utility Incentives With Investment in Energy Efficiency* (NAPEE 2007). Recent decisions about decoupling in Tennessee and other states have made clear that decoupling does not automatically result in savings for the consumer; careful construction of the program is needed. In California, publicly-owned utilities are required to set and meet efficiency targets similar to those of the investor-owned utilities, by AB2021 (CMUA NCPA SCPPA 2010).

As noted above, the utilities are expected to establish and promote a **portfolio of energy-efficiency programs**. The portfolios also include elements on education, training, and ensuring compliance, which by saving energy can themselves be considered as resources and evaluated as such. Some of these efforts are indicated below. The CPUC provides funding to the utilities to support the portfolio. See for example PG&E's portfolio plan for 2009-2011 (PG&E 2009). The CPUC also conducts formative and summative evaluations of the utilities' portfolios and programs, including their codes and standards programs (Eilert et al. 2008; CPUC 2010c). The results from the IOU portfolio reports are published on the CPUC web site. A Energy Commission center on energy efficiency in appliances would have to work closely with the IOUs in order to accomplish its goals.

Since the adoption of the California Energy Action Plan in 2003, the four IOUs and SMUD have joined with the Energy Commission to form the **Emerging Technologies Coordinating Council (ETCC)**, which meets regularly to review joint actions on new technologies for energy savings –

including new appliance technologies. The ETCC works closely with several companies and nonprofit organizations, such as the California Lighting Technology Center, the ACEEE, and energy consulting firms. American Gas Magazine recently provided a short review of emerging technologies for gas appliances (AGA 2010).

The four IOUs prepare studies for the standards-setting proceedings of the Energy Commission and take part in the proceedings, through both formal and informal interactions (workshops, surveys, testimony, training and document submissions). These **Codes and Standards Enhancement (CASE) studies** for each IOU are part of its portfolio effort. The first CASE study was filed by PG&E in 2000. Informally the IOUs allocate leadership roles among them for each topic area, to recognize comparative advantages and to avoid duplication of effort. See for example PG&E's work on battery chargers (Bendt et al. 2008), PG&E's information template on televisions (Chase 2008), PG&E's 2004 report on refrigerated vending machines (Davis Energy Group 2004),SCE's report on walk-in refrigerated storage (Heschong Mahone Group 2008), and the presentation by Rodrigues (2007). Each such report reviews the market, the alternative technologies, the testing procedures, and the potential energy savings. Each such report then becomes part of the Energy Commission's formal process for gathering input on the appliances in question.

SCE and other utilities have **test centers** of their own. UCI staff members have visited SCE's Technology Test Center (TTC) in Irwindale and PG&E's lab in San Ramon as well. In Irwindale SCE has done tests on open freezer cabinets and other kinds of thermal equipment. The TTC also has a lighting laboratory, including a full-scale mock home kitchen and mock office. Their lighting work is closely coordinated with the CLTC at UC Davis. The TTC also built prototype vending machines with improved efficiency, as noted above, and they work on HVAC and ZNE issues as well. PG&E's lab has tested water heaters, air conditioners, televisions, and commercial food service equipment.

The utilities also sponsor **research studies** outside the CASE structure. For example, SCE recently commissioned a major study of consumer electronics devices by Research in Action (Peters et al. 2010).

Several utilities offer **energy audits** to customers, at no cost, to help the customers identify and fix inefficient practices or equipment. PG&E and other utilities audit television sets in retail stores.

The IOUs and many public utilities conduct **education** campaigns for the public, for retailers, and for manufacturers. These include bill enclosures, web sites, workshops, and other approaches. PG&E conducts education and training at its Pacific Energy Center (http://www.pge.com/pec/), mostly about building efficiency.

The CPUC has begun programs of **dynamic pricing**, allowing utilities to charge more per kilowatt hour during peak load times (Rowland 2010). One review of several studies suggests that time-of-use pricing alone only reduces use by about 5 percent in peak demand, but such pricing combined with demand response controls can achieve 30% reductions (Newsham 2010). The CPUC oversees price-responsive DR programs by the IOUs; it generally does not count savings from the older remote-interruption programs (Harrington, Murray and Baldwin 2007).

The publicly owned utilities (39 of them) are not subject to the same CPUC regulations as the investor-owned regulations, but AB2021, signed into law in 2006, requires them to coordinate their energy efficiency efforts with the IOUs, the CPUC, and the Energy Commission (CMUA 2007, Parks 2007). Among the publicly-owned utilities, the Sacramento Utility District (SMUD) is the most active in promoting energy efficiency.

C.2.5 Rebate Programs

Utilities and state agencies around the nation have adopted many kinds of **rebates** to encourage the purchase of energy-efficient appliances. These demand-response programs can spark a considerable response in the market -- the federal 'Cash for Clunkers' program for cars is a familiar example in another industry, and many utility rebate programs have also stimulated sales of energy-efficient appliances. Utilities in California already provide rebates for ENERGY STAR appliances, point-of-purchase rebates in participating stores, free appliance recycling, and free installation for low-income customers (Rodrigues 2007). See for example the rebate programs offered by Southern California Gas, at http://www.socalgas.com/business/rebates/, or see the presentation by Reed (2009) about a program led by PG&E. For a summary of the rebate programs offered by California's publicly owned utilities, see their 2009 report to the Energy Commission (CMUA NCPA SCPPA 2010). For an IOU a rebate program requires extensive research on the market to set an appropriate target, followed by implementation and monitoring, and concluding with audits by the CPUC A compilation of all such economic incentives around the nation is available in a database called DSIRE, maintained for the DOE by North Carolina State University and the Interstate Renewable Energy Council (NCSU IREC DOE 2010). The SBI Energy report cited earlier also contains tables of details about rebates (SBI Energy 2009).

In 2009 the federal DOE announced a program of rebates amounting to $300 million, to be distributed through the states, under the American Reinvestment and Recovery Act. In addition to building retrofit programs and workforce development programs, funding was provided for appliance rebates. After internal planning and public comment, the Energy Commission announced the California portion of the program. It offered up to $100 on the purchase of refrigerators, room air conditioners, and clothes washers. The program, advertised on www.cash4appliances.org, could be used in combination with other rebates from industry or government. The program is for replacements only, not additions, and certification is required to show that the previous appliance was recycled. As of early September, the Energy Commission had received over 110,000 applications.

Rebates to retailers or manufacturers instead of to customers are another alternative being explored by PG&E, SMUD and others – smaller rebates to retailers or manufacturers may have important effects because those parties compare the rebates to their profit margin rather than to the total retail price. Negotiations directly with manufacturers or their associations allow closer attention to the details of energy/cost tradeoffs. Such programs would also alleviate consumer confusion if there were fewer rebate programs at point of purchase. PG&E has had various programs with retailers and manufacturers (Michel 2008); SMUD issued an RFP offering funding to programs proposed by manufacturers (CEE 2008). In some cases a group of utilities have coordinated their efforts in order to have more leverage with nationwide retailers and to avoid irritating retailers with multiple separate programs (Reed 2009).

Rebates and coupons for large appliance efficiency purchases save energy only to the extent that old energy-inefficient appliances are retired, preferably by recycling. Early rebate programs for energy efficiency proved counterproductive when customers kept the old appliances for secondary use (e.g. a refrigerator in the garage, or a second television in a bedroom). The newest California program has specific requirements for certification of recycling.

The use of rebates complements the adoption of formal standards, in at least two ways. First of all, rebates are cost-effective only for early and some middle adopters; reaching larger numbers of more reluctant (or more constrained) consumers would not be financially feasible. (Standards are usually set after the early adopters and some middle adopters have taken to a technology, but earlier implementations and later ones occur also.) Second, rebate and incentive programs bring about changes in perception, market shares, and consumer feedback that make compulsory standards easier to define and more acceptable. The rebate programs and the standards programs also at times are perceived as in opposition –higher standards force the adoption of new rebate programs; rebate programs typically aim for short-term results and standards aim for long-term results (Eilert et al. 2002).

The CEE has published a useful guide for utilities and other organizations on the conduct of energy efficiency programs, including both economic incentives and educational campaigns, with primary emphasis on 'upstream' work with retailers and manufacturers (CEE 2008). The guide includes several sidebar examples of actual programs implemented around the country. At least one company, PowerDirect Energy, advises utilities on how to improve the retail results for their energy efficiency programs; see http://www.powerdirectenergy.com/retail-promotions.html.

There is agreement in general that the savings from rebate programs are substantial -- according to one author, from 1975 to 2000 the savings from utility incentives and rebates (in GWh) roughly matched the savings from building standards and appliance standards together (Rodrigues 2007).

C.2.6 Evaluation

As noted above, most utility programs and agency programs are subjected to formal evaluation. However, how much energy the efficiency programs do save or could save is hard to determine precisely -- what would have happened without the programs cannot be known; there are multiple sources and sinks for energy in the manufacture, distribution, and sale of every appliance; and for every kind of appliance there are many models and circumstances of use. **Table 11** in section A.4 above indicates some of the variety among the devices. A good summary of the evaluation issues was made in a presentation by Marian Brown of SCE (2008) and a detailed review is in a Codes and Standards White Paper for SCE (Mahone et al. 2005).

One method of program evaluation is to track changes in the sales and shipments of models with various efficiency levels -- but sales figures are difficult to track across dozens of distributors and retailers, and the cause of the shifts can only be inferred (Skumatz 2007).

Many customers taking a rebate, for example, would have bought the item anyway; this 'free rider' problem is one of the complications. (In the absence of further information the CPUC simply assumes 30 percent free ridership.) The presence of multiple rebates for a given appliance – for example, from the utility and the manufacturer and the state – further complicates the evaluation of each rebate program. If the customer does not redeem the rebate that is due, then although the rebate program saves money an actual energy saving does not get attributed to the program.

Another approach is to track the 'upstream' market, for evaluation and for action, is the Business and Consumer Electronics program begun by PG&E and SMUD in 2009, joined later that year by the Northwest Energy Efficiency Alliance; agreements have been established with several major retailers that engage them with ENERGY STAR specifications.

Ideally, an evaluation of education programs would measure the amount of energy saved, but the circumstances make that virtually impossible. As substitute measures, evaluations should at least measure before-and-after knowledge, and in some projects they could measure the persistence of newly learned behaviors.

Evaluations would ideally also take into account the embedded energy in new appliances that replace older less efficient models, whether the old appliances are kept in use or recycled, the value of the resources recovered through recycling, and so on. There is energy embedded in the production of energy, and the gas industry often claims that gas is more efficient if source-to-use calculations are complete.

The estimates for rebate programs are usually made on the basis of deemed savings – using data from typical usage of typical older appliances as the basis for presuming that every replacement of such an appliance would save that amount of energy. Most public utilities use energy-savings estimation procedures provided by two companies, KEMA and E3 (Energy and Environmental Economics). The CPUC sponsors many contract studies of 'EM&V' (evaluation, measurement, and verification), and it maintains the Database for Energy Efficient Resources (DEER) that provides estimates of the energy savings and the cost of various technologies. DEER is specific to California. So far as our discussions went, it appears that neither the DEER database nor the E3 analyses have much information on electronic devices.

For thorough analyses of these estimation problems, see the works by Schiller (2007); Mahone et al. (2005); and Skumatz, Khawaja and Colby (2009). The California Measurement Advisory Council (CALMAC) is an organization dedicated solely to addressing the problems of evaluating energy efficiency; its web site is at http://www.calmac.org/.

Converting a figure on total energy savings to other measures -- such as cars taken off the freeway, power plants not built, or consumer dollars saved -- entails even more assumptions and estimates. A center on appliance efficiency might have to engage in those estimates for other audiences and comparisons, but this report has in most places avoided such efforts.

C.3 Major Efficiency and Demand Response Opportunities

The team sees the following areas of emphasis as useful short-term priorities for a Center:

Energy efficiency in **set-top boxes** must be improved and standards should be put in place. Set-top boxes are a good next candidate for standard setting in California for several reasons. First, individually and collectively they are major energy users – they are usually left on 24 hours a day because users don't like the delay of reprogramming on start-up; they use up to 15W even in idle mode; and they are almost as widely owned as televisions. STBs together are the third largest use of energy among CE devices, behind only televisions and desktop computers (Peters et al. 2010). Second, the market is unlikely to resolve the problem itself. Set-top boxes pose a classic principal-agent problem, in which the party that chooses the equipment is different than the party that pays the energy bill (Meier and Eide 2007). An executive for Comcast put it bluntly in a slide presentation: "None of the savings previously discussed accrue directly to Comcast" (Kirsche 2009). Third, set-top boxes work so closely with televisions (the two may soon be offered together in one appliance) that the Energy Commission's newly-developed expertise on television would be applicable. The IOUs regard STBs as a high priority item.

Different combinations of components (e.g., with or without HD capability, with or without a DVR) can change power usage by 50 percent or more (Peters et al. 2010). The trend is toward providing STBs with DVRs and/or Internet servers built in (May-Ostendorp, undated). Industry observers expect that more and more customers will switch from cable or satellite subscriptions to Internet television, most likely for cost savings and convenience but perhaps also for energy savings (if the new systems are indeed more efficient). A recent article claims that about one customer in eight will make the switch to IP STBs in the next year (Goldman 2010). If customers begin to adopt large-screen televisions for all of their Internet browsing, the energy implications would be quite significant.

Such variety and change on the market poses challenges. Regulators will find that combination appliances may prove harder to control by standard-setting. Television manufacturers must decide whether to incorporate web capability or cable capability (or both) into their devices. Cable companies and set-top box manufacturers will find themselves confronted with more competition than they are accustomed to and may therefore offer customers more choices.

The energy usage of **medical devices**, in the home and in medical practices has not been sufficiently investigated -- from large machines (CAT scans) to table-top devices (heart monitors) to handhelds (electronic thermometers). The focus has been on performance and safety, dominated by medical practitioners and regulated by the FDA. Although there is little data to date on total energy consumption by such devices, the sheer number of medical devices in use makes them an important target of investigation. In the health care industry as a whole, the concerns about energy usage have been primarily about the building systems (lighting and HVAC and patient safety), with some attention to conventional plug-load items (see for example Singer et al. 2009); utility-oriented studies by EPRI and others follow the same pattern.

Some devices that serve as components of medical equipment, such as image displays and external power supplies, are regulated separately by the Energy Commission or DOE; these components are in some cases exempted from the standards if used in medical equipment. The ENERGY STAR Program has targeted the medical device sector for further specifications (EPA 2010). A few medical-device companies have joined as Energy Star Partners (Welch Allyn 2009) and a few have made voluntary commitments (Biz Times 2010). European governments and companies appear to be ahead of the U.S. in this matter (Biz Times 2010).

The rapid growth of large screen HDTV consumer market is also resulting in a surge of upgrade purchases of **peripheral devices such as high-power speakers, stereo/surround-sound**, etc, as well as in usage of other home entertainment devices, even though overall audio sales have declined. According to the review by Peters et al. (2010), audio devices account for about 5 percent of residential plug-load usage. Like game consoles, speaker systems are marketed for performance, not for energy efficiency. Standard-setting, code development, and even labeling for these consumer electronics is weak – half of the major audio manufacturers don't have any Energy-Star certified models; the Energy Commission has standards only for 'compact audio' devices; the existing ENERGY STAR specification is out of date (Peters et al. 2010).

Home Area Networks Total-home-monitoring systems of various kinds are appearing rapidly on the market. These are systems of sensors, controls, and displays that could allow the homeowner to control (and presumably reduce) the use of energy in a home. Examples include, but are hardly limited to, Control4, ZigBee Alliance, Z-Wave, and HomePlug Alliance. Full implementation of such systems would extend far beyond the plug load, and useful implementation would require considerable investment in research on consumer behavior. A few projects are under way to gather survey data on experiences with energy feedback devices, and some projects include a usability study with the purpose of testing prototype energy monitoring devices capable of both plug-load and aggregate level data collection.

A smaller implementation is to control a group of appliances that typically work together and/or are under the control of a single person at one time. Primary examples are the kitchen, the entertainment center, and the home office. In the case of the entertainment center and the home office, one appliance is central (TV, computer). In these cases control over the appliances could be coordinated to maximize energy savings. On-site control over such a group can be achieved more simply than either control over the individual items separately or over the whole household. This approach is encouraged in the CPUC Strategic Plan: "Encourage use of smart plug strips to shut off home entertainment and home office ancillary loads when prime load shuts off or goes to sleep" (CPUC 2008, 3-26). Several smart plugs and control systems are on the market now and more can be expected, but for the most part these have not been subject to rigorous testing. Some provide manual control over groups of appliances; some provide for Internet control from remote locations. For a review of the market as of 2007, see the report published by the ACEEE (ACEEE 2007). A 2010 workshop held by the Northeast Energy Efficiency Partnership (NEEP) reviewed the current status. A further possible development in the technology, real-time communication systems among the appliances themselves, has hardly been explored.

Evaluation of such systems in terms of energy saved would be very difficult, because of the wide variety of appliances that might be plugged it. Perhaps by assuming a typical set of appliances and behaviors a figure could be derived for comparison and for establishing deemed savings. More likely the evaluation would have to be limited to measuring the sensor and control features that are presumed to help save energy.

These control systems will be an important point of coordination between efficiency in the plug-load items and the efficiency of whole buildings as units of analysis (e.g. in LEED ratings and in Zero Net Energy studies) and the operation of electric grids. California's SB17, the state declaration of policy for the smart grid, explicitly authorizes and encourages "integration of cost-effective smart appliances and consumer devices." At present there is still no one consensus standard for such communications or even compatibility arrangements among the many standards, and this fact is slowing further implementation; NIST is leading the effort to establish standards for the Smart Grid (Merritt 2009, NIST PAP10 2010). For instance, an appliance could be under direct IP control from the grid and also under control of a local smart plug strip.

The Center's role would be primarily one of testing, coordinating, developing standards and trying different combinations of approaches – for example, determining which features of strips are most effective at helping consumers save energy, and helping utilities establish the data needed to design incentives to consumers for adopting smart plug strips. The Center could also serve as neutral ground for discussions and testing in the search for one or more standards in communication between the home networks and the utility grids. The Center should coordinate closely with the organizations that lead or study building management issues, such as Lawrence Berkeley National Laboratory and the Continental Automated Building Association.

Communication protocols will be important in major data centers, in utility grids, and inside the home. In each place there are networks of devices that need to exchange information and stay in synchronization with each other. There are two problems: the compatibility of protocols with each other and the energy efficiency of the protocols themselves. Compatibility problems remain among the many systems being promoted at the grid level and the home level (e.g., Open ADR and AMI, different systems using HDMI). Efficiency concerns are being addressed for Ethernet communications via the IEEE standard, 802.3az, and similar accomplishments should be possible in other networks. A variety of networks and protocols are just now defining the market for home use – Z-Wave, Zigbee, and HomePlug at least – but for the most part they consist of a centralized control system rather than peer-to-peer communications between devices.

Public education efforts must be expanded and improved, on two fronts. The first is educating the public about energy conservation itself; the second is educating all parties about the new associated business processes: ZNE, distributed generation, demand response, and dynamic pricing, and Smart Grid. There are many programs and projects under way, sponsored by different kinds of organizations, emphasizing different variables and measures – climate change, personal cost, foreign oil, self image; and tons of carbon, kilowatt hours, cars off the freeway. These include inserts in utility bills larger efforts like Flex Your Power, demonstrations at fairs and shows, school programs, web sites by nonprofit organizations (such as www.toptenusa.org), and more. While the total effort is useful, the lack of coordination creates high overhead costs and confusion for the consumers and for the retailers, and surveys still reveal insufficient understanding or effort on the part of consumers. Many consumers are even unaware which appliances in general use the most energy. The Center can research change in perceptions of energy waste and conservation as well as centralize efforts to inform the public about the most impactful changes that can be made. Targeting all members of the household in education efforts should have the most impact on both purchases and user behaviors.

In all these endeavors, small modifications to labels and products can sometimes produce large effects. The use of default conservation settings, low energy use technology and clearly understandable labeling needs more attention. Certification labels are more useful if the consumer is aware of the qualifications of the certification and of any graded levels of the certification (e.g., Silver or Gold) (Tarr 2010). Labeling indicating energy efficiency must be easily identifiable and be perceived as a desired attribute of the device by the consumer (Amann and Egan 2002). Pre-setting appliances in their energy saving mode as the default at point of sale requires less motivation from the consumer to obtain a reduction in energy use.

The Center would be capable of analyzing user perceptions of labels and preferences of default settings with market tests and laboratory research with users. In addition, the Center could aid in developing code standards or voluntary industry standards which are easily comprehended by the user.

C.4 Federal and Environmental/Energy Organizations

Here are many of the most prominent of the voluntary standards and review processes in use in the CE and appliance markets.

C.4.1 ENERGY STAR

ENERGY STAR is a federal program that provides recognition and certification for energy-efficient products – including new homes, commercial establishments, and industrial products as well as appliances. Beginning in 1997 the DOE and EPA administered the program jointly, each agency rating different categories of products. Manufacturer models that voluntarily meet certain standards are granted the ENERGY STAR designation, useful in advertising and in labeling at point of purchase. ENERGY STAR has been useful in providing regulators with guideposts concerning customer and manufacturer acceptance, measured by market shares and pace of compliance.

For many of the product categories, the specifications required for ENERGY STAR certification have been changed occasionally to increase the efficiency requirements, and in such cases the sales of ENERGY STAR qualified items declines until industry catches up to the new standard (Sanchez 2008). Within each version there may be a few different 'tiers' – the basic standard and also higher levels of efficiency that qualify for larger rebates or incentives. For the full range of ENERGY STAR products, see http://www.energystar.gov/index.cfm?fuseaction=find_a_product. For a sample comparison of ENERGY STAR and other standards, see **Table 6** above. Along the way, the ENERGY STAR program has had to address issues familiar in regulatory standard-setting – such as component specifications vs. black-box performance standards and reaching agreement on energy conservation metrics.

ENERGY STAR is by far the most widely recognized labeling and certification program for energy efficiency in market goods. A national survey in 2008 showed that 78 percent of households had a high or general understanding of the label's purpose (EPA Survey 2009). Another national survey conducted in December 2008 showed that 84 percent of the respondents were "highly aware" of the ENERGY STAR label (CEA 2009).

A detailed analysis of the ENERGY STAR program for appliances and the savings that have come from it is given in the report by Sanchez (2008). "ENERGY STAR has already proven successful in its established programs, having saved, by our estimates, more than 1.358 trillion Btus of energy and prevented carbon emissions of 22.4 million metric tons in 2007 alone. Based on our analysis, the continuation of these programs and the addition of new programs in appliances and home electronics have the potential to greatly reduce carbon emissions over the next 18 years. As the EPA and DOE continue to work to improve savings through consumer education, partnerships with manufacturers, new product labels, and tightening requirements for existing products, the ENERGY STAR program may be able to achieve even higher savings in the future."

In late 2009 DOE and EPA recently executed a new Memorandum of Understanding that restructured their coordination of the ENERGY STAR program. Broader authority over the design and operation of the program was given to EPA and testing responsibilities were lodged with DOE. "In a nutshell, the MOU clarifies which agency is the lead in which area. In the past DOE and EPA split up the specifications for various appliances. DOE covered the more traditional products, such as refrigerators, water heaters, and windows, while EPA covered all consumer electronics. EPA also managed Energy Star for buildings while DOE conducted its own building efficiency work that was only loosely related. EPA will now be taking the lead on all appliances and equipment specs while DOE will take more of a leadership role in buildings. DOE will also … manage all test procedures and metrics, all of which feed into Energy Star" (Burt 2009). More detail on the new arrangements can be seen in a 2010 presentation by the EPA (EPA 2010a).

Recently problems with the ENERGY STAR program have been in the news. It was alleged that some manufacturers have misused their discretion to determine if their devices qualify for the ENERGY STAR label; it was alleged also that the ENERGY STAR program has given approval without examination to bogus devices submitted in a sting operation.

Despite the recent difficulties it appears that ENERGY STAR remains a strong program with substantial recognition and is not likely to be changed significantly. DOE and EPA have stepped up their testing programs; the new system requires all products to be tested in approved third-party labs and subjects manufacturers to verification procedures. From a DOE press release in March: "Violations of the ENERGY STAR label tend to get big media attention, which is good – because it provides a strong disincentive for companies to skirt the system and risk a wave of negative coverage about their product. At the same time, consumers should be aware that in the past few years the number of violations has been quite small, especially given that more than 40,000 individual products carry the ENERGY STAR label. Last year, the EPA's independent Inspector General conducted a 'spot check' of the program, testing 60 ENERGY STAR products. 59 of the 60 products met or exceeded the ENERGY STAR requirements" (DOE 2010).

C.4.2 EnergyGuide

The Federal Trade Commission (FTC) requires certain appliances to carry a label at point of purchase that displays the energy consumption of the device. The EnergyGuide program provides for a bright yellow label that shows the estimated yearly electricity use in kWh and the estimated yearly cost of operating the appliance. Although these estimates depend on particular assumptions, the provision of the same estimation method for all appliances at the retail site provides the consumer with a useful way of comparing alternative models. The labeling requirements apply to clothes washers, dishwashers, refrigerators, freezers, water heaters, window air conditioners, central air conditioners, furnaces, boilers, heat pumps, and pool heaters. Effective with the passage of EISA in 2007, the FTC was also granted authority to apply the labeling program to apply to televisions, set-top boxes, personal computers, computer monitors and digital video recorders, but progress has been slow. The FTC system is managed independently of the ENERGY STAR rankings. The FTC labeling is a requirement for all appliances in certain categories, not a criterion for awards or incentives. White-goods appliances may or may not have ENERGY STAR ratings, but they are required to have the EnergyGuide labeling.

C.4.3 EPEAT (Electronic Product Environmental Assessment Tool)

"EPEAT is a program of the Green Electronics Council. EPEAT is a system that helps purchasers evaluate, compare and select electronic products based on their environmental attributes. The system currently covers desktop and laptop computers, thin clients, workstations and computer monitors. EPEAT largely follows the IEEE 1680 standards (http://grouper.ieee.org/groups/1680/). Standard 1680.1 applies to personal computers; 1680.2 applies to imaging equipment; 1680.3 applies to televisions. Desktops, laptops and monitors that meet 23 required environmental performance criteria may be registered in EPEAT; manufacturers in 40 countries take part. Registered products are rated Gold, Silver or Bronze depending on the percentage of criteria they meet above the baseline criteria; the baseline includes meeting ENERGY STAR requirements. EPEAT operates an ongoing verification program to assure the credibility of the registry" (EPEAT 2010). Thus EPEAT considers more than just energy efficiency; it also reviews other environmental issues such as the use of hazardous materials, wasteful packaging. Over 2000 models have been certified as bronze, silver, or gold. The Federal Acquisition Regulations include some specifications for EPEAT certification (EPEAT 2010).

C.4.4 80 Plus

80 PLUS is an electric utility-funded incentive program to integrate more energy-efficient power supplies into desktop computers and servers. Utilities and energy efficiency organizations have contributed financial incentives to manufacturers who produce qualified power supplies. Commercial and institutional consumers are often specifying 80 PLUS in their procurement policies at increasing rates. The title derives from the specification that a device must achieve 80 percent efficiency or better at 20 percent, 50 percent, and 100 percent of power. Like ENERGY STAR and EPEAT, 80 Plus also has special award classifications for products that exceed the basic standard. A review of the 80 Plus program has been published by the Northwest Energy Efficiency Alliance (West et al. 2008). The program was designed and is administered by Ecos consulting.

C.4.5 SEHA (Super-Efficient Home Appliances)

This initiative, a program of the Consortium for Energy Efficiency that was begun in 1997, is "a national program designed to stimulate manufacturer and consumer interest in highly efficient home appliances" (CEE SEHA 2009). It provides recognition for tiers of efficiency that exceed ENERGY STAR standards. SEHA covers refrigerators, room air conditioners, clothes washers, and dishwashers; approximately 20 firms are participants.

C.4.6 IEEE 802.3az – Energy Efficient Ethernet

The IEEE began in 2007 to develop a standard protocol that will reduce power consumption on an Ethernet connection during periods of low link utilization by reducing the amount of communication require to maintain synchronization and by sending packets in groups rather than separately. The new standard will include a protocol to coordinate the link's changes between high and low levels of activity. The task force last met in April; final approval occurred in September and implementation is under way. Lawrence Berkeley National Laboratory was a major participant in the IEEE process. Estimates are that the new standard will reduce power consumption during idle periods by 70 percent to 80 percent.

C.4.7 LEED (Leadership in Energy and Environmental Design)

LEED is a national program grants awards to new buildings and major retrofits on their environmental sustainability, giving points on a scale for such factors as the use of recycled materials and local materials, the provision of on-site renewable energy (typically solar or wind), and the use of natural lighting. Formal awards of Certified, Silver, Gold, and Platinum have now been given to over 25,000 buildings nationwide, accounting for over 600 million sq. ft. Since its inception, LEED ratings have become nationally accepted standards for environment-friendly and energy efficient buildings. The program currently has 35,000 project participants in 50 U.S. states and 61 countries. As detailed by James Meacham at the April 1 workshop, the LEED program continues to improve its rating system and will soon include appliance efficiency as part of a larger perspective on the energy use of a building. The LEED program was begun several years ago by the Green Building Council, a nonprofit trade association.

C.4.8 ASHRAE

The American Society of Heating, Refrigerating and Air Conditioning Engineers has established several standards for buildings. The most relevant for the recommended Center is ASHRAE 90.1, concerning the energy performance of buildings. The first version of the standard was established 35 years ago. In 2009, the 2004 ASHRAE standard was established by the DOE as the standard for state building energy codes for commercial buildings under the federal Energy Policy Act. However, ASHRAE 90.1 does not apply to plug-in appliances. ASHRAE also has certification programs for building energy assessment and building energy modeling, and it has published test procedures for several HVAC and commercial appliances. See www.ashrae.org.

C.4.9 HOME STAR

HOME STAR is the name given to a program in proposed legislation to create jobs in existing industries by providing strong short-term incentives for energy efficiency improvements in residential buildings. This initiative would establish a rebate program to encourage immediate investment in energy-efficient appliances as well as building systems and insulation, and whole-home energy efficiency retrofits. HOME STAR is intended to create jobs in both construction and manufacturing, while also saving families money on their energy bills. There would be Gold and Silver levels and contractors would require certification. A broad coalition of associations and companies has endorsed the effort; see http://homestarcoalition.org/HOME_STAR_Overview.pdf.

C.5 Prior Studies of Consumer Behavior and Energy Use

The behaviors of consumers, organized as households or businesses, are what define the energy uses within the plug load, and the behaviors are quite varied. As noted above, one of the primary conclusions from the April 1 workshop was a need for research on energy consumption behaviors. Many reports and articles agree; an annotated bibliography on consumer behavior is attached as Appendix 1 to this report.

In a report for the Energy Commission on behalf of the CIEE Behavior and Energy Program, Mark Sullivan stated: "Currently, California government and regulators sponsor substantial R&D designed to accelerate the rate at which more energy-efficient technology is available in the market. At the same time, almost no R&D is expended that is intended to improve the likelihood that customers adopt these technologies once they are commercially available. This is a significant gap in program development." (Sullivan 2009). It has been estimated that society can reduce at least 20 percent of energy use nationwide through behavioral-science-based strategies (Frank 2009). Nor is standard-setting itself sufficiently geared to behavioral considerations: the CPUC's draft action plan states that "Behavior and operational issues are difficult to regulate through the current processes, which focus on equipment and efficiency levels, rather than how and why the equipment is used or controlled" (CPUC 2010a, p. 3). "Significantly less investment in energy efficient technology is being realized than is possible due to the behavioral assumptions underlying energy efficiency programs. This situation continues in the presence of significant efforts by government-sponsored energy efficiency programs offered by electric and gas utilities" (Sullivan 2009a).

The results of particular studies are suggestive but not conclusive; the conclusions from the whole body of literature are more certain; the important general factors are indicated here. These findings would help guide the Center's market and behavioral research.

- **Providing more accurate and specific information about how actions in the home affect energy consumption.** Consumers typically do not know how much electricity their appliances are using at any moment or what using the appliance is costing them. Providing the consumer with real-time feedback has been shown to have the most consistent influence in reducing consumer energy use (Darby 2006, Parker et al. 2006). Using in-home feedback technology to provide users with relevant, timely consumption information has shown to be highly effective (10-15 percent energy savings on average) in curbing energy usage (Froehlich 2009). Studies of alternative data presentations have been made by Egan and others (Egan 1999, Egan et al. 1996). A more advanced study is now under way in homes near UCI; the "uci@home" project surveys homeowners and uses smart-plug devices that include sensors and signal lights, each connected wirelessly to a central hub for the home. The homeowner can access various data and controls via the Internet. (The homeowner survey may be found at http://uhills.org/pipermail/uhills_uhills.org/2010/003470.html.) Broad surveys will be needed; what works for 'early adopters' of interesting technology may not provide useful predictions for the population as a whole (ACEEE 2007). A review of the literature was published by EPRI in 2009 (Neenan and Robinson 2009).
- **Establishing energy efficient behavior as a social norm.** Campaigns can invoke the power of social norms by presenting energy-efficient behaviors as mainstream things that everyone does. "People are more likely to change their behavior if they believe that others are doing so, too, and most people harbor a strong desire to avoid being perceived as outside the mainstream" (Hummer 2010). In addition, social networking sites can play a role in providing accountability and pressure to be energy efficient (Froehlich 2009). Another way that utilities invoke social norms to promote energy conservation is by providing comparative billing data on how one household's energy consumption compares to similar homes in their neighborhood. It has been shown that energy use falls when neighbors compete (Clayton 2009).
- **Developing profiles of the consumer populations.** The Strategic Plan adopted by the CPUC in 2008 states this priority: "Research and develop (an) accurate customer profile for the state, which is essential for developing an accurate and credible awareness and education campaign" (CPUC 2008, p. 3-26). Customizing behavioral and education/outreach efforts specifically to users of electronic devices will be important. Compared to the users of white goods appliances, CE users include more male users, more young users, and more 'early adopters'. Outreach toward younger audiences is essential for plug-load technology, as the age range of plug-load users ranges from young children to the very old. Children exercise choices about entertainment devices at an early age; creating energy efficient habits in children is likely to have lasting effects into adulthood and possibly across generations. Consumers can be classified into different subgroups based upon demographics, environmental attitudes, and early adoption of new technologies (MMI 2009). All of these factors affect whether a consumer will buy more efficient electronics or conduct energy saving behaviors. Even pro-environmental attitudes do not correlate well with actual conservation behaviors (Hayes and Cone 1981). In the commercial sector, there are target audiences with purchasing power who need to be educated. See the EPA's educational materials for federal officials at the web page entitled "Environmentally Preferable Purchasing" (EPA 2010). A survey by Accenture in January 2010 revealed important differences among different groups of

consumers, and Accenture concluded that efforts aimed at a uniform mass market would not work well (Carson 2010a).

- **Consumer response to alternative pricing plans.** Many sources argue that residential consumers will not respond well to dynamic pricing, in part because of the attention and effort involved (e.g., Carson 2010a). PG&E has already engaged dynamic pricing for its largest commercial and industrial customers. Full implementation of new pricing systems will require regulatory changes, back-office changes, and consumer education (Rowland 2010, Waumbaugh 2010). Studies of this issue date back to the 1980s and those should be consulted, although meters were less sophisticated then (Aigner and Lillard 1984, Hirschberg and Aigner 1983). Charging residences more per KWh over certain levels of usage each month is established practice; but its effectiveness is hard to confirm; a further plan that has been proposed is to offer lower rates in response to actual cuts in usage.
- **Behavior at point of purchase**. What factors affect the consumer's attention to energy efficiency when at the point of purchase for CE devices? The team found virtually no literature on that particular topic but some literature on environmental decision-making at the point of purchase. For example, for criticism of manufacturer claims see "The Six Sins of Greenwashing" (TerraChoice 2007); for evidence from Australia see Soutar et al. (1994); for nutrition labeling see the summary by the UNC Center for Health Promotion (UNC 2007) and Seymour (2004).
- **Understanding that the home is different than the workplace.** Analysts should consider how electronic appliances are or are not designed for usefulness in the home. Refrigerators and TVs have long been designed as home appliances but desktop computers were not; they have gradually been forced into household roles. Behavior toward a PC may be different at home than at work. Devices designed for household-relevant computing are gradually being developed, and they are more likely to be embedded systems or networks. See among other works the articles by Alladi Venkatesh, a UCI professor (NOAH Publications).
- **Combining motivational approaches**. Achieving more efficiency in use will probably require a mix of strategies: personalized information and advice, general and specific commitments, social pressure, and constant and contextual energy use feedback (Frank 2009). The Center should conduct research to best differentiate between interacting variables which produce the most energy efficient behaviors among different consumer populations while also taking economic factors into consideration. The use of incentives, social norms, comparisons with in-groups and injunctive norms have all proven to be effective, but not sustainably (Schultz 2008). Coupling some of these techniques with one another may provide the largest reduction in residential energy use (Sexton et al. 1987; Siero et al. 1996).
- **Accounting for 'rebound effects'. –** If the consumer believes he/she is consuming less than the social norm of their in-group (Schultz, 2008), or when the consumer reasons that increased technical efficiency permits increased use with no ill effects, then usage may actually increase back to a higher level. (This latter phenomenon is also known as the Jevons paradox, after the economist who first noted it in the academic literature.) David Brownstone, professor of economics at UCI, reported at UCI's April workshop that rebound effects in transportation and energy result in savings about 10 percent less than projected.
- **Emphasizing field and lab experiments**. According to Sullivan, "a formal research and development (R&D) effort designed to find effective strategies for improving energy efficiency program performance must be undertaken. This effort should focus on discovering effective behavioral science-based strategies for improving the performance of existing programs and on developing new and more effective approaches to offering

these programs … Review of the literature in psychology, sociology, social psychology and behavioral economics suggests that some behavioral science-based approaches to improving the acceptance of energy-efficient products in the market show great promise. However, this promise has yet to be realized because practical field experiments are required to discover what works and what does not work and why, and these experiments have not been conducted" (Sullivan 2009). PIER has supported much of the extant work; the proposed Center should build on this research effort and be able to provide research in the end-user aspects of energy efficiency from a vendor-neutral perspective.

C.6 Roundtable Meetings With Relevant Stakeholders

In addition to the April workshop reported in Section B.1, efforts have been made to meet with stakeholders and identify key opportunities and priorities:

- Goran Matijasevic and Stuart Ross attended the CES exhibits in Las Vegas, January 2010.
- Stuart Ross attended a local event, the Going Green Expo, in Newport Beach in November, 2009. The event was sponsored by the Orange County Sustainable Business Leadership Council and brought together small businesses with an interest in sustainable practices and policies.
- Four UCI/Calit2 representatives visited SCE's Refrigeration and Thermal Test Center in January for discussions and a tour of the facility
- G.P. Li and Stuart Ross attended Net Zero energy efficient smart building workshop, sponsored by SCE in May.
- G.P. Li attended EE Global 2010 in Washington DC in May, hosted by the Alliance to Save Energy.
- Stuart Ross attended the Connectivity Week 2010 event in Santa Clara, California, in May.
- Stuart Ross and G.P. Li visited PG&E offices in San Francisco and PG&E labs in San Ramon in June; they also attended the Fujitsu Labs of America Technology Symposium in Sunnyvale.
- G.P. Li attended the Electronics-Plug-Load-Summit on Advanced-Power-Strips, sponsored by the Northeast Energy Efficiency Partnership, in June.

C.7 Academic Seminars

The following academic seminars have been held at UC Irvine as part of the development of this plan.

- November 18 2009
  Paul DeMartini, Vice President, Advanced Technology at SCE
  Dr. DeMartini spoke on "Transforming the Grid into the EnerNet". He provided an overview of Southern California Edison's Smart Grid 2020 Vision and development plan. He discussed the technological developments in storage and in control systems that will make the Smart Grid a reality.
- December 1 2009
  Jim Meacham, Director of Advanced Energy Systems, CTG Energetics
  Dr. Meacham gave a summary of issues, policies and data about energy consumption by the plug load. The audience was about 20 persons, primarily faculty members invited to begin the consideration of the idea for a center.

- March 12 2010
  Nicholas Ilyakis, Vice President/CTO for Enterprise Networking, Broadcom Corp.
  Dr. Ilyakis spoke to an audience of about 40 persons on "The Energy Efficient Ethernet and its use in Energy Efficient Networks." He gave a summary of the concepts and history behind the development of the IEEE standard 802.3az, which is in final approval stages and is expected to become effective in late 2010.
- April 6 2010
  Russ Neal, Strategic Program Manager, SCE
  Mr. Neal spoke on "Energy Infrastructure: The Smart Grid." His talk was concerned primarily with the issues involved in integrating renewable power sources into current energy grids.
- April 7 2010
  Anthony Eggert, Commissioner, California Energy Commission
  Mr. Eggert spoke to an audience of over 100 persons on "The California Energy Commission and the Future of California." He discussed California's energy problems and future plans, including developments in technology, policy, and efficiency.
- July 13 2010
  David Kirkby, Professor of Physics and Astronomy, UC Irvine
  Dr. Kirkby spoke on the UCI@Home project as part of a summer seminar series. He described the behavioral and engineering studies his team conducted in the faculty housing complex adjacent to UC Irvine.
- August 27, 2010
  Two UCI undergraduates, **Jonathan Chu** and **David Shin**, gave final reports on their summer research projects on approaches to residential energy savings under Dr. Kirkby and Dr. Shivendu, respectively. Their talks were part of a public symposium marking the conclusion of Calit2's summer program for undergraduates.

D Proposed Program Development Activities

D.1 Future Activities for Research, Education, and Outreach

D.1.1 Priorities, Timing and Growth

Considering the limited resources available, the efforts of the Center must be carefully evaluated and systematically allocated. Because of the unique characteristics of various appliances and electronic devices, some steps have been identified for completion before other steps. In addition, a few cases have been identified that will benefit from the accumulation of real-world experience before identifying the best course of action. The Center will need to assist with both standard-setting and demand-side projects, through research, demonstration, and education. Because the Energy Commission is approaching the start of Phase III of its current round of Title 20 rule-making, the initiation of such work soon, preferably including the establishment of a center, would be beneficial. In every case, close cooperation will be required with the utilities, the Energy Commission staff, the Energy Commission-funded centers, environmental organizations, service providers, customer groups, retailers, and manufacturers.

The expertise available in the proposed Center would be helpful to the utilities and the other Energy Commission Centers in the areas of CE, device engineering, and behavioral studies. In turn, their expertise on grid issues, lighting, cooling, demand response, and building standards would prove useful for the proposed Center. The Center could be operational in time to be of value to the Energy Commission in the coming round of Title 20 rulemaking.

The major topics and sequences of action suggested here for a center on plug-load efficiency are shown below in **Table 39**. The first several topics listed, shaded in gray, are the topics the study team regards as highest or first priorities for the Center. The topics are discussed below in the same order as they are shown in the table. The list of work shown is greater than what can realistically be accomplished by a Center in the first few years, but the Irvine team has elected to present all the relevant priority items for now. There are also topics other than electronic devices (e.g., gas appliances) that the Energy Commission may ask the Center to investigate, and those would be given priority. Decisions about more detailed prioritizations will await Energy Commission decisions about funding and support from other parties. The Center should also be able to respond to changing priorities as requested by the Energy Commission or required by changing markets.

Some important appliance or electronic items are not included here or given low priority here, even if next-step tasks seem evident, because there is already a history of regulation and a set of players at work, so participation by another Energy Commission center would be of only marginal value. Thus for example, there is litte discussion about refrigerators (an Energy Commission success story already), plug-in lighting (the CLTC can handle that), food service equipment (PG&E has a good center), motors, or vending machines (SCE knows the field). For these and similar topics a n center on appliances and electronic devices might be able to provide assistance, but that assistance would be defined by the other parties.

For each energy topic area the team has considered four possible thrusts of action for the Center, which will be given different emphases for various topics and time periods. They will of course overlap in the detail of real practice, but it is helpful at this stage to be prompted by the separate kinds of skills and concerns that will be needed at various stages of projects. The four thrusts are:

- *Engineering research* (basic and applied, including the physical sciences). This work would include (for example) developing standards for evaluating plug loads, lab testing of home appliances and office equipment, circuit design, outfitting white-goods appliances with intelligence and remote controllability, computer modeling and simulation, mechanical engineering design, construction of prototypes, and installation of demonstration projects.

- *Behavioral/marketing research* (social sciences, business, economics). The types of research that could be used are outlined in **Table 38** below. Some behavioral issues are specific to a particular device, so researchers and manufacturers will want to conduct studies of those issues, but for the plug load there are also behavioral issues that cross all the device categories – responsiveness to price, attitudes toward new technology, adoption of energy-efficient solutions, and awareness of energy usage. The planning table therefore also recognizes behavioral studies as a separate category. A Center should be capable of conducting any such studies if needed.
- *Education*. This work would include (for example) preparing educational materials for hard-copy or multimedia web distribution, giving presentations to community groups or classrooms, designing and rendering course materials for workforce training, and designing educational games and exhibits. The target audiences might be utility customers, retailers, commercial establishments, or manufacturers.
- *Organizational Coordination* (collaborations needs and mechanisms). This work would involve personnel from one of the other three staff groups, but the emphasis would be on establishing collaborations to achieve common objectives. Some of the negotiations and agreements might be 'bottom up', originating with the field personnel and approved by management; other situations might be 'top down', in which field personnel work out the implementation of decisions made by senior management. This category is defined here to include the drafting of codes and standards, the development of incentives and rebates, and negotiations with manufacturers to achieve more efficient products without establishing formal standards. For new collaborations an initial effort will be required to become familiar with the other party's interests and experience.

In general the conclusions below are consistent with the recommendations in the CPUC's Strategic Plan (CPUC 2008), in Goal #3 of the chapter on the residential sector.

Table 38: Behavioral Research Options for the Center

Research Type	Description	Advantages	Disadvantages
Market Data	Gather data on unit sales, stocks, energy use, and savings potential	Inexpensive, quick way to find important opportunities for gains in efficiency	Data very diverse and often approximate over range of devices
Market Tests	Try alternative presentations by product, geography, or target audience	Valuable insights and perspectives.	Must engage distributors or manufacturers; time-consuming
Laboratory Research on Users	Create test procedures for users in simulated home or commercial settings; measure use patterns and reactions	Reveals unanticipated user challenges; provides opportunity for pre-market improvements in the lab	User interactions with the device may be different in the lab than in natural contexts
Surveys	Ask about perceptions, preferences, reasons, usage patterns. Use phone, mail, or web.	Inexpensive way to assemble comprehensive data set	Self-reported estimates often wrong
Field Audits	Count number of devices, types of use, and operating states in offices or homes	Assess product prevalence & usage patterns; provides the most reliable picture of actual use patterns in real contexts.	Hard to get access during active times; usually restricted to low-use hours; privacy issues
Field Monitoring	Record power use over time in homes & offices, over individual machines or groups of machines. Meter-level data available from utilities.	Gives most complete picture of actual kW and kWh use	Conventional meters provide only gross data; smart meters not yet widely available; appliance-level equipment requires special installation.

Source: Adapted from work by Ecos Consulting (Calwell 2008)

Table 39: Timeline for Development of Center Programs
(Shaded topic titles are suggested as areas of highest priority)

Topic/Project	Year 1 (tentatively 2011-12)	Year 2	Years 3-5
Organizing the Center			
•*Organizational Coordination*			
Establish office operations	====	=====	
Recruit director; hire engineering staff or reassign staff	=================	==	===
Recruit formal memberships	=============	====	==== ===
Build or remodel demonstration/deployment facilities	===========	==	====
Purchase equipment: for energy measurements and performance appraisal	==========		
Meetings of advisory groups and governing board	= = = =	= = = =	= = = =
•*Engineering Research*			
•*Behavioral Research*			
•*Education*			
Begin web site and newsletter	==============	== == == ==	== == == =
Set-Top-Boxes			
•*Engineering Research*			
Develop/confirm test procedures	=========	=====	
Develop better video streaming, better arrangements of components	=====	===========	
Develop and test new STB/HD/DVR/IP combinations in the lab	=	==============	=======
•*Behavioral/Market Research*			
Track and project market trends (interviews, data)	=====	==== ===	== == ==
Study potential incentive programs for commitments to high-efficiency	==============		
•*Organizational Coordination*			
Select primary industry partners with STB experience	==========		
Work with manufacturers to develop or choose more efficient components	======	==============	
Help develop standards by working with manufacturers and service providers		==============	===========
With a cable provider, experiment with different models in real homes	======	==============	
•*Education*			
Explain consumer alternatives	====	==========	

Source: Calit2

Topic/Project	Year 1 (tentatively 2011-12)	Year 2	Years 3-5
Energy Use in Medical Devices			
•*Engineering Research*			
Lab-bench analyses of widely used devices	======	===========	====
Develop 1 or 2 prototype instruments/devices with higher efficiency		==========	==========
Develop or evaluate testing standards for selected medical devices		============	======
Develop statewide estimates of total energy usage, using census and lab results		========	=========
•*Behavioral/Market Research*			
Audits/census of energy consumption in homes	=======	===============	=============
Audits/census of energy consumption in medical practice	=======	===============	=============
•*Education*			
Workshops for medical personnel		======	
•*Organizational Coordination*			
Consult with GE, Welch Allyn, other efficiency pioneers in the industry	=============	==============	
Identify local medical-device industry partners willing to develop prototypes	=========	=====	
Assist utilities and Energy Commission staff on development of the CASE study		===============	=============
Speaker Systems – Home Audio			
•*Engineering Research*			
Evaluate existing test procedures and recommend changes	=====	=============	
Characterize energy usage of a few leading large systems in lab studies		==============	
•*Behavioral/Market Research*			
Perform detailed market assessment	========	=======	
Characterize energy usage in real homes with and without smart power strips		===============	===========
•*Organizational Coordination*			
Help IOUs develop templates and CASE studies		=========	=============
Help IOUS with retail-level programs		===============	==============
Facilitate industry development of communication standards via HDMI	============	========	
•*Education*			
Information on coordinating television off mode with speakers	=======	======	

Topic/Project	Year 1 (tentatively 2011-12)	Year 2	Years 3-5
Small Networks in Homes & Offices (HAN)			
•*Engineering Research*			
Measure energy savings of different HAN approaches in Center labs	==============	============	
Cooperate with NEEP in developing test protocols for the smart power strips	========	==============	
Examine the smart power strip feasibility for utilities incentive program	======	============	
Establish ‘deemed savings’ for categories of power strips	=======	============== =	
•*Behavioral Research*			
Observe usage in Center labs and in the field to determine real energy saving	========	============	
•*Education*			
Recommend possible HAN solutions to consumers	===========	==============	
•*Organizational Coordination*			
Assist utilities with an incentive program for smart power strips		==============	
Coordination with manufacturers and utilities re incentives & standards	============	==========	
Smart Self-Monitoring in Appliances			
•*Engineering Research*			
Design/build prototype self-monitoring systems; measure potential savings	=====	================	
•*Behavioral Research*			
Focus groups to determine usage preferences	============		
User tests in lab setting	=====	================	===
User tests with demo models in real-world settings		==========	===========
•*Organizational Coordination*			
Coordinate with manufacturers re implementation (e.g., workshop)		================	
Coordination with manufacturers and utilities re incentives & standards		==============	
•*Education*			

Topic/Project	Year 1 (tentatively 2011-12)	Year 2	Years 3-5
Computers & Laptops & Game Consoles			
•*Engineering Research*			
Studies of energy usage by types of software – graphics, browsing, office	===	=================	
Develop test protocols for selected form factors	=====	=================	
Research on energy-saving circuit designs	=========	================	===============
•*Behavioral/Market Research*			
Customer gaming preference: performance vs. energy efficiency	================		
•*Education*			
Workshop on energy usage in software and gaming		============	
•*Organizational Coordination*			
Advise ENERGY STAR on gaming software		=================	=============
Work with PG&E (or other utilities) to update technical and market info.	===	===========	
Behavioral Studies of Users			
•*Behavioral Research*			
Small-scale experiments to determine most effective feedback mechanisms	===========	===========	========
Large-sample studies to clarify diverse user profiles		=================	===============
Small-scale studies and focus groups to test alternative motivators	========	================	
Large-sample surveys to ask about most effective motivators		=================	
Audits of energy behaviors in actual offices and homes	======	=================	
Data mining from social networks for identifying efficiency features that attract consumer behavior change	========	=================	
Based on the studies, identify key economic & efficiency targets		=================	=======
•*Education*			
Provide feedback from audits		==============	
•*Organizational Coordination*			
Provide findings to utilities and agencies for fine-tuning rebates and incentives		==============	===========
•*Engineering Research*			
Designing appliances with new functions identified from the consumer behavioral studies		==========	==============

Topic/Project	Year 1 (tentatively 2011-12)	Year 2	Years 3-5
Large Networks in Grids			
•*Engineering Research*			
Study security issues	======	================	=========
•*Behavioral Research*			
Study privacy issues	========	================	==========
•*Education*			
•*Organizational Coordination*			
Coordinate with Smart Grid Center at Sacramento State University	=================	================	==============
Coordinate with EPRI re IP-addressable appliances	===	========	
Make plug-load data and experience available to NIST and utilities	======	================	=============
Server Rooms and Data Centers			
•*Engineering Research*			
Install and test fuel cell and absorption chiller in a server room			============
Research on energy-saving circuit designs	=========	===============	==============
•*Behavioral Research*			
Survey preferences and behavior of IT managers	=========	================	
•*Education*			
•*Organizational Coordination*			
Maintain coordination with utilities, CEE, IEEE	==================	================	==============
Communication Network Systems			
•*Engineering Research*			
Monitor energy savings in sample server rooms that use IEEE 802.3az		================	
Lab research on savings from additional cross-layer coordination	=========	================	============
Test and demonstrate new cross-layer systems		===========	========
•*Behavioral Research*			
Survey preferences and behavior of IT managers	=========	================	
•*Education*			
Short course on technology trade-offs for IT managers		====	
•*Organizational Coordination*			
Maintain coordination with utilities, CEE, IEEE	==================	================	==============

Topic/Project	Year 1 (tentatively 2011-12)	Year 2	Years 3-5
Plug-In Electric Vehicles			
•*Engineering Research*			
•*Behavioral Research*			
•*Education*			
•*Organizational Coordination*			
Provide a forum in which agencies can meet to discuss coordination of transport policies, plug load policies, and GHG policies	=====	================	
Coordinate closely with PHEV Center at UC Davis and with APEP at UCI	==================	================	===============
Workshops for commercial enterprises: employee & customer usage		=========	=======
Distributed Generation			
•*Engineering Research*			
Integration of DC systems into the household or workplace		=============	=============
Develop net zero energy appliances (DC renewable-to-the-appliance)		===	===============
•*Behavioral Research*		================	
Market Accommodation; study payback periods for generation alternatives		===========	=========
•*Education*			
Showcase systems that work		================	
•*Organizational Coordination*			
Workshops for utilities, community associations, manufacturers		==========	========
Public Education			
•*Education*			
Programming & beta testing for online game on energy efficiency		================	======
Installation of game in local science museum			=======
Development of self-audit software and database for households	===	================	
Development of energy efficiency and HAN apps in existing social networks		===============	
Provision of assistance and expertise to extension programs		===========	============
•*Organizational Coordination*			
Annual workshops to coordinate for IOUs, nonprofits, agencies, industry		====	== == ==
Coordination of senior design projects and student environmental groups	==========	===============	===========
•*Engineering Research*			
•*Behavioral Research*			

Topic/Project	Year 1 (tentatively 2011-12)	Year 2	Years 3-5
Televisions			
•*Engineering Research*			
Develop and test alternative sensors for ambient conditions on backlighting	==========	===============	
•*Education*			
Public education materials about backlighting	=========	==========	
•*Organizational Coordination*			
Coordinate adoption of LED technologies with leading manufacturers	=============	======	
Refine incentive programs with utilities for energy efficient televisions	=============		
•*Behavioral/Market Research*			
Surveys of preferences for settings and defaults	=====	================	
USB-Powered Devices			
•*Engineering Research*			
Compile data on power usage of typical devices		============	
•*Education*			
•*Organizational Coordination*			
Behavioral/Market Research			
Compile data on numbers of devices		==============	
Track the emergence of USB 3.0 devices		================	==============

D.1.1.1 Set-Top Boxes (STBs)

STBs are known to be one of the biggest consumers of energy in households, and as features like HD and DVR are added the energy consumption will get worse and the classification problems will become harder. There are over 22 million STBs in California (Rainier 2008). Although there are significant opportunities for improvements in efficiency, the market is unlikely to regulate itself. This topic should be a high priority for the Center; the significance of the problem has been discussed by the IOUs and the Energy Commission for several years (e.g., Wilson 2004). PG&E prepared a proposal information template for set top boxes (Rainier 2008) but no CASE study has been completed. The federal government has not set standards for energy use by STBs, but there are ENERGY STAR specifications, and that program is currently considering revisions; see http://www.energystar.gov/index.cfm?c=revisions.settop_box_spec.

Several parts of the problem will influence the rulemaking.

- Because the customers get very limited equipment choices from the cable company, STBs pose a principal-agent problem, in which the party that chooses the equipment is different than the party that pays the energy bill. However, the Federal Communications Commission has tried and is trying again to establish a retail market for STBs (Harbert 2010).
- Some functions within an STB could be idled without disturbing the programming – for example, the hard drive or the tuner. Idling these separate components could result in substantial savings of energy (May-Ostendorp, undated).
- New-generation set-top box chips with greater efficiency are on the market, but the market is saturated with older models that are less efficient and manufacturers have little incentive to make replacements. Ownership of the boxes typically is with the service providers, who may re-use a box for different customers, so the service providers have huge sunk costs in inventory.
- The functions being offered in STBs are changing rapidly – not just cable connectivity but also HD, satellite and IPTV; the market is in great flux.
- STBs require some minimum connectivity 24 hours a day, to keep up with programming changes and to be ready for instant program access by the user. Service providers fear that requiring customer units to obtain reprogramming instantly from the central source would only lead to customer dissatisfaction.
- The growing market for IPTV means that a new set of providers will be involved in the rulemaking – the telecommunication companies, such as Verizon or AT&T.

In the first two years the Center should join with a few partner organizations to work on the following efforts in parallel: (a) developing and encouraging the use of more efficient internal components (tuner, internal power supply, etc); (b) providing a continual census of the California markets and installed base; (c) gathering input from manufacturers, consumers, and cable companies; (d) studying rebate programs to determine which would be most effective in encouraging the replacement of older inefficient models, (e)determining if current test protocols are adequate evaluations of the efficiency and functionality of STBs, and (f) educating consumers about their alternatives and the energy implications of each. It is anticipated that by the second year an effort will be well under way in the Energy Commission to draft standards for set-top boxes, and by then the Center will be well equipped to assist in that effort, with technical refinements, expert testimony and writing efforts.

D.1.1.2 Medical Devices

The Center could have an immediate impact by addressing the energy usage of medical devices in homes and in medical establishments, because this problem has hardly been investigated in this country, as noted in section 1.c.3. In the medical device industry, the appropriate emphasis on performance and safety, under regulation by the FDA, has not been accompanied by concerns about energy consumption. In case of direct conflict FDA regulations on performance would have to take precedence over regulations for energy efficiency, but in many cases a more efficient use of energy would not compromise effectiveness or safety. Power supplies for medical devices, for example, must meet stringent standards for reliability and performance but have not been extensively reviewed or regulated for energy efficiency (Geist and Keebler 2008).

A few beginning have been made. As noted above, Welch Allyn has joined the ENERGY STAR partnership, and General Electric (GE) is another leader for American industry, in concert with several European firms (GE 2010). Freescale Semiconductor has investigated the low-power requirements of medical devices (Niewolny 2010). The National Institutes of Health has offered funding for research on the topic (see below); a professor at Purdue is doing NIH-funded research on the efficiency of laser-produced plasma instruments for medical purposes (NIH 2010). There have been several studies of energy requirements for wireless body sensor networks, which are constrained to battery power (see for example Otal, Alonso and Kerikoukis 2010). Analog Devices has introduced an efficient instrumentation amplifier for medical devices (Analog 2009). California has a high concentration of biomedical devices, so cooperation with industry on this topic would be convenient as well as productive. An Energy Commission Center could be among the first to provide a census of the typical electrical systems used in medical devices, such as AC/DC converters, battery chargers, and motors, and to establish energy testing of individual devices. For medical devices used in telemedicine, the trips avoided and the outcomes intended are easier to define than they are in business, so the Center could also research the transportation energy saved by the use of devices in telemedicine. The Center should work closely with the few researchers, organizations and manufacturers (e.g. General Electric) that have begun work in this area. The Center should establish close connections with major hospitals and/or medical schools.

D.1.1.3 Audio & Speaker systems

The rapid growth of large screen HDTV consumer market is resulting in a surge of upgrade purchases of peripheral audio devices such as high-power speakers and surround-sound. Mere 'stereo' is now considered inadequate; attention has turned to 'surround sound' in 5.1 and more recently 7.1 versions, and to multi-room speaker systems (e.g., Palenchar 2010). Standard-setting and code development for these consumer electronics are needed; currently only compact audio devices are regulated. The ENERGY STAR program does have a standard for audio-visual devices (including televisions and Blu-Ray players), for both 'on' and 'off' modes, at http://www.energystar.gov/index.cfm?c=audio_dvd.pr_crit_audio_dvd. The Center should also cooperate with the Electric Power Research Institute in Knoxville, Tennessee, which has begun work on this topic with sponsorship from the Energy Commission. *In the first two years the Center should (a) establish baselines by working on testing and evaluation of these larger devices, (b) evaluate the testing standards for speakers and surround-systems, and (c) develop a strategy for curtailing the energy consumption. Master-slave hierarchies within the home entertainment center are an important possible tool for controlling energy consumption, implemented either through smart power strips (see below) or through the data connections between the devices (e.g., using the High Definition Multimedia Interface [HDMI]). While HDMI is widely used, there is currently a lack of consensus among manufacturers in constructing the communication interface board at the devices for facilitating connections between them. Consumer education should be implemented to encourage turning off speaker systems if the television is off.*

D.1.1.4 Small networks in homes & offices

Home-based monitoring and control systems will be important for achieving plug-load efficiency, and the success of these will depend heavily on behavioral factors as well as engineering. The overall aim is to develop an affordable and effective at-home feedback system to simultaneously optimize the many aspects of consumer behavior.

Many organizations are entering this market. Manufacturers are now marketing various kinds of smart strips, dashboards, plug monitors, and related devices; PIER program results were instrumental in pushing this development. Energy Commission support for Ecos Consulting has created a draft report on smart plug strips (Ecos Consulting 2009) and the web site EfficientProducts.org, which includes a page discussing the attributes of various smart plug strips. EPRI has produced reports for its members on the technology, the markets, and the stakeholders (EPRI 2008a, EPRI 2008b, EPRI 2009b). The Northeast Energy Efficiency Partnerships (NEEP) organization is now organizing to develop test protocols for smart power strips. AHAM plans a major exhibit on smart and connected appliances at the forthcoming Consumer Electronics Show. The IPSO Alliance (IP for Smart Objects) is promoting the 'Internet of Things'; see www.ipso-alliance.org. The ACEEE has also published a report on the topic (ACEEE 2007).

Most such devices do save energy; some are expensive or unwieldy; none is optimal for all uses. The sensors, display components and network technologies offered are usually fairly straightforward; the difficulty is in tailoring the software, the sensors, and the circuitry to real-world usage (Grate and Ebert 2010). It is not clear that consumers will be sufficiently motivated by a small percentage change in a small monthly bill. Perhaps the systems will have to be marketed first for other applications, such as power surge protection and home security. Some observers argue that the lessons provided by feedback systems can be learned quickly (which devices and behaviors are most wasteful), which further reduces the value of long-term ownership of such a system. This reference to small networks is somewhat different than the focus in the draft ENERGY STAR specification for Small Network Equipment, which refers primarily to Internet packet-based data networks, routers, and hubs (EPA 2009). The two categories may overlap if the HAN uses Internet protocols and equipment. *The Center's role in the immediate future should be to provide testing in the lab and in simple real-world trials, in coordination with NEEP and the IPSO Alliance, informed by modern social science research methods. The Center should work to help manufacturers, especially small business, and utilities coordinate their actions in the marketing of smart strips and similar devices. The Center should seek to define and establish higher and more useful levels of intelligence in such systems.*

Simple at-home pilot studies, incorporating both quantitative and qualitative methods, can generate useful first-pass results. Such a study might consist of, for example, an experiment in four to ten single-family homes, or qualitative data collection (interviews, focus groups, and usability testing) to explore the psychological factors relevant to our design. Few such studies have been done and more are needed. Previously, feedback has focused on recording consumption at either the household level or the appliance level. Because residents vary and uses vary; alternative ways to picture and control energy use must be provided. These may include controls over groups of related appliances (such as those in an entertainment system or those in a home office), controls of different precision or granularity, and systems with different kinds of audio and visual feedback. The controls or devices may also communicate wirelessly with a central hub in the household or commercial site to provide web-based feedback displays derived from the aggregated data. At the device level, there is room for improved actuators, sensors, software, and local controllers that help to achieve the best overall system performance and adjustment to ambient conditions. *The Center's role in the immediate future is to work with manufacturers in upgrading their small home/office network designs with the most acceptable user interface to meet consumer interest. The Center should provide public education and coordination among manufacturers on these issues.*

D.1.1.5 Self-Monitoring Intelligence in Appliances

It should be possible for appliances to monitor their own usage as well as their power supply, by taking advantage of the low cost and mature microelectronics solutions now available. The Center should work with white goods appliances manufacturers such as General Electric or Whirlpool to develop hardware and software intelligence in major appliances enabling them to learn their actual usage patterns in order to optimize active and standby cycles. Many current appliances do allow for user-determined profiles: computers can be set to hibernate after a period of inactivity, and thermostats can be set for different temperatures in daytime or nighttime. However, these profiles are usually awkward in implementation – a consumer's predicted usage doesn't match actual usage, consumers are put off by complex interfaces and menus, and secondary opportunities for saving energy are overlooked. With the cheap availability of microprocessors and routine artificial intelligence software, it should now be possible to equip appliances to learn the actual usage patterns and control all modes of savings. A PC with a learning program could learn that its user either returns quickly or not at all; a refrigerator with a learning program could learn that the door is not opened at nighttime except on Saturday. Energy-using components could be disabled or idled accordingly by automatic control, and efficiencies too complicated to explain could be invoked also. The additional cost of manufacture would be very small and the initial development time would be very short, so the Center could make a difference quickly. The Pacific Northwest National Laboratory, manufacturers, and other organizations have already begun developing appliances that can respond automatically to signs that the electric grid is overloaded or to changes in time-of-day pricing (Nelson 2007, Gunther 2009, Hammerstrom et al. 2007); this additional intelligence would pertain to the usage pattern of the particular appliance. The Internet Protocol for Smart Objects Alliance (IPSO Alliance) has been working on similar projects; see http://www.ipso-alliance.org/Pages/Front.php. *The Center will work with manufacturers to develop and incorporate prototypes of such hardware and software, first as models for limited in-home trials and later into broader consumer market studies. The Center souls also work with consumers through surveys or focus groups to understand what designs would be effective in practice.*

D.1.1.6 Computers & Laptops & Game consoles

Collectively these devices represent one of the biggest uses of energy among plug loads. There have been many analyses of power consumption in desktops and laptops (e.g., Garrett 2008, Roberson et al. 2004, Peters et al. 2010, Roth and McKenney 2007b). PIER-supported research has already shown how efficient computer hardware can be, and those results have influenced the industry to develop better models. Earlier this year Google made "Focused Research Awards" to several university teams to study possible improvements in efficiency in computing. PG&E has established a program of financial incentives for companies to install specific energy-management software in their computers (Promisec 2010). But there are not yet any energy efficiency standards for computers or game consoles at the federal or state levels.

Because there are so many other actors and so long a history of studies, the team recommends the Center focus only on three special topics: the energy consumption of software, the energy consumption of game consoles, and chip design issues.

Recently, the rapidly evolving social networking sites, online games and search engines have driven the production and display of unprecedented volumes of data, resulting in gigawatts of power consumption. Yet there has been very little research to determine which Internet portals, social networking sites, or personal software packages are more energy efficient than others in executing user commands. There are a few studies in the literature, on for example the energy usage of Internet advertising or of popular software packages, debugging techniques for finding energy waste, and analyses of on how different algorithms or structures lead to great different levels of energy usage through frequent repetition (Taylor and Koomey 2008, Amsel and Tomlinson 2010, Saxe 2010, Janbu 2010). The UC Irvine team's preliminary results suggest, for example, that one popular web video program uses many times more energy than another, and that there are noticeable differences in power consumption between the most popular browsers (Amsel and Tomlinson 2010). A more extensive evaluation of software approaches for their energy consumption is needed. Government standards for code structure would probably be impractical for achieving restraint, but standards for overall usage like ENERGY STAR or even simple publication of comparative results could be effective.

The Center should analyze the energy efficiency of popular software packages and later develop better engine performance to render the same user experience. The Center should work with the software industry to develop an evaluation or test procedure for the software packages and later develop a rating system to encourage more energy efficient software productions. The Center could provide public education on the alternatives.

Game consoles are marketed almost exclusively on the basis of power and performance. High-end graphics cards for gaming consume 100W – 200 W in use and 3W-90W in idle mode. Game consoles are not yet regulated by formal standards, but the Energy Star program has developed version 5.1 of its specifications for computers to cover game consoles; that coverage will become effective in 2010. Most of the energy consumption is in the graphics function – for speed, color, and detail. *The Center should test the energy performance of high-end video cards and game consoles in the lab and perform a market census of actual sales of such devices.*

One of the principal difficulties in determining standards for computers and game consoles is determining that there are many form factors, and many of the internal components of desktop PCs come in different versions (e.g., hard drives, graphics cards, RAM). The Energy Commission has issued a Technical Brief on the efficiency of internal power supplies (Ecos Consulting and EPRI Solutions 2008). *The Center could take a lead role in coordinating the development of test procedures for configurations of game consoles.*

Changes in some circuit design issues can make a noticeable difference in energy consumption – such as bus design, error correction procedures, power leakage, the memory interface, and interference (see for example Lattice Semiconductor 2010; Djahromi, Eltawil, and Kurdahi 2007). *The Center should support electrical engineering research on such issues, to the extent that external grant funding can be obtained.*

D.1.1.7 Behavioral Studies

Three main (and related) behavioral issues cut across all categories of white goods and electronic devices. First, what physical forms of feedback about power usage are most effective for residential or commercial users? Second, what is their responsiveness to various motivators, such as price structures or rebates or social approval? Third, what are the most useful variables for understanding the behavioral differences found among groups of consumers – is it socio-economic standing, type of housing, attitude toward technology, or something else? Many different kinds of studies will be necessary.

Initial studies should be small, such as laboratory trials with users, focus groups, and pilot studies in real households. The Center's work will build on the studies that have already been done (e.g., Anderson and White 2009, CEA 2009, Moezzi 2009, Ehrhardt-Martinez 2009, Rode et al. 2004, Blackwell et al. 2009, Linden et al. 2006, EPRI 2010a, EPRI 2009a, Roberts 2009, Sullivan 2009).

Large-scale studies will also be necessary – surveys, quasi-experimental designs, monitoring programs, and data mining. To develop its samples the Center would explore access to the data banks already held by utilities and by the private companies that conduct energy audits of homes and businesses, assuming concerns about privacy and anonymity can be managed. Just as computer users allow for their anonymized data to be used for studying problems and making improvements, energy consumers might also allow use of their meter data, and might be even more willing to do so in return for incentives such as detailed audits or lower fees. New samples could be constructed that are stratified to include homes with and without renewable energy sources of their own, with or without various kinds of meters, and different demographic profiles; samples of several hundred homes are anticipated. A good source on experimental design for energy efficiency studies is the work by Sullivan sponsored by the CPUC and CIEE (Sullivan 2009). The resulting data on consumer profiles, regional variations, and alternative conservation measures would aid both educational efforts and standard-setting. The New York State Energy research and Development Authority has developed a thorough program for audits of office electronic equipment (NYSERDA 2004). Less systematic but potentially valuable data would be available from various web-based sources: comments, searches, and clicking patterns could reveal what features consumers regard as most important. *The Center should provide feedback and recommend solutions for efficiency improvement to users on the basis of the energy usage audits at their home or office. The coordination of utilities' and retailers' incentives program can be dependent on the implementation of such recommendations by customers at home or in a commercial office. Manufacturers and marketers could learn more about consumer behavior in purchasing.*

Social media networks such as Facebook and Twitter provide a new additional opportunity for studying the behaviors in question. Text mining of anonymized entries in those networks could search for specific references to appliances, televisions, brand names, etc., to determine what efficiency features most interest consumers or have most influenced consumers. Although the occurrence of such references is likely rare as a percentage of the total, the numbers are still large enough (thousands at least, perhaps millions) to allow sorting and alternative search procedures, ultimately providing insights into how features are grouped, perceived, and implemented by consumers.

D.1.1.8 Large Networks in Grids

There are many technical and political issues relating to the 'smart grid' that remain to be resolved – customer feedback, distributed generation, intermittent supplies, grid interconnections -- but for the most part these issues are not directly related to the efficiency of devices within the household or commercial establishment.

However, the idea of providing control over individual appliances from the grid does make a difference to device efficiency and to consumer choice. California's SB17 directs that appliances be integrated with the larger grid in order to assure control over demand on the grid, and a few manufacturers like GE have begun marketing appliances that can react to deficiencies in the power supply. EPRI has produced a report for its members on IP-addressable appliances (EPRI 2009c) and has produced a prototype socket connector for grid access that manufacturers could add to their appliances (EPRI 2009d). As noted above, the Pacific Northwest National Laboratory (PNL) and other organizations have also been working on 'grid-friendly appliances'.

Implementing such systems will pose three kinds of issues. First are the many issues of technical coordination – which communication protocols to use, which appliances are easiest to integrate or most important to integrate, whether there is a reduction of energy usage or merely a shifting of demand from one time to another. The second set of issues is about privacy. IP-configured devices would be identifiable directly, and other appliance operations could be inferred from a smart meters, because different devices have different patterns of start-up and operation. So outsiders would know which appliances are used at what times, and perhaps therefore when residents are present or absent (Lisovich et al. 2010, Coney 2008). This issue would not be an appropriate project for starting the Center, but the issue merits inclusion in a longer-term vision for the Center because agencies, utilities and manufacturers will face challenges on the issue and will need assistance in resolving them. Three parts of the privacy problem need to be addressed: (a) an analysis and understanding of the exact vulnerabilities and inference channels that could lead to a breach of privacy, (b) the development of privacy protecting technologies to hide sensitive information while still enabling the smart homes and smart meter technologies to accomplish their energy-conservation purposes, and (c) regulations and policies to ensure that personal information once obtained is not misused. Perhaps these issues of security and privacy can be settled, as they are settled and familiar now for many consumer financial transactions, but in this different setting the exact outcome is not obvious. For a detailed legal analysis of this problem as a fourth-amendment issue, see Lerner and Mulligan (2008). However, the PNL report concludes that neither technical feasibility nor consumer acceptance is the most difficult problem; the report asserts that a third problem is the main one: finding a business model for costs and returns that is mutually acceptable for manufacturers, utilities, and customers (Hammerstrom et al. 2007).

Energy Commission has already funded a center on smart-grid issues, at Sacramento State University. The California Smart Grid Center tests emerging technologies that are not yet ready for commercial use; it has several projects, funded by about $1 million from the Energy Commission. While most of its projects are at the grid level, they do have projects on grid-connected devices in the home. For example, in 2010 the center completed testing of a retrofit thermostat system for Cypress Envirosystems (BusinessWire 2010), and it is a major player in the plans to renovate the Power Inn area of Sacramento with a high-tech community (Wassweman 2010). The center is one of several partners in SMUD's award from the federal government for a large-scale smart-grid demonstration project. "When completed in 2012, SMUD's smart grid will enable informed participation by customers as well as the creation of new products and services. SMUD's smart grid will include more than 600,000 smart meters, 100 electric vehicle charging stations, and 50,000 residential energy control systems including programmable smart thermostats and home energy management networks" (SMUD 2010).

The Center should subordinate its activities on this topic to the work of the many other organizations, concentrating on the three issues just mentioned. Likely partners would be the center at Sacramento State University and the Irvine Smart Grid Demonstration Project, an SCE project with federal and Energy Commission funding, managed under subcontract to the Advanced Power and Energy Program at UC Irvine. The Center would be able to contribute to the discussion about the Smart Grid in two ways. *First, the Center should become the go-to coordination point in Southern California on how plug-load issues relate to the larger grid. Second, the Center should conduct studies of the risks to privacy posed by the development of the Smart Grid.*

D.1.1.9 Server Rooms and Data Centers

In recent years most major companies, agencies, departments, and universities have established server rooms for their own personnel and programs, and the associated consumption of energy is still growing rapidly. Jonathan Koomey has estimated that "Worldwide data center power demand in 2005 was equivalent (in capacity terms) to about seventeen 1000 MW power plants" (Koomey 2008). Server rooms pose three challenges for energy efficiency: the amount of energy used by the circuitry, the amount of energy lost in the form of heat, and the energy used by cooling systems to unload the heat. A recent Intel report estimates the net effect -- that 1W saved in the processor results in 2.84W total savings (Haas 2009). Case studies from the DOE's *Save Energy Now* initiatives suggest there could be substantial energy saving potentials from improvements in cooling and air handling balance and in the lighting system (DOE 2008a, 2008b). However, if other factors remain fixed, an increase in the efficiency of the processors could lead to an apparent decrease in the effectiveness of the overall system because the fraction of energy tagged as 'useful' would decline (Ananchaperumal 2010). The transition to blade servers and to virtualization should also be encouraged. A recent article published by the ACM has a good summary of the issues (Brown and Reams 2010); BC Hydro claimed nearly 3 million kWh in savings for 2007 at BC Hydro and the BC Ministry of Health (Rogers 2008).

The Energy Commission has already been working on various aspects of these issues through supporting virtualization projects, promoting DC distribution in data centers, and research on existing server farms. PG&E and other utilities have offered financial incentives for virtualization efforts by commercial users (Fogarty 2010). The Energy Commission has also been working on the cooling issues through the Western Cooling Efficiency Center at UC Davis and through its own Buildings End-Use Energy Efficiency Program and Industrial/Agricultural/Water research programs. A demonstration project examining data center operation with a DC power configuration shows energy savings of 7 to 28 percent from computation demand and more than 28 percent from cooling demand (CEC 2008). Power quality would remain an issue even for direct DC supply (Rajagopalan et al. 2010). *For institutional and geographic reasons the Energy Commission Center should focus on server rooms rather than massive data centers, although many of the problems and solutions are similar. The Center should cooperate to assist other organizations such as manufacturers and utilities that are at work on the problem. The Center could pursue any of several approaches, such as using DC power directly from fuel cells or renewable sources or using the waste heat to drive an absorption chiller. Research on energy savings in CPU and internal communications would be especially productive because of the multiplier effect just noted. The behaviors and preferences of IT managers control large energy flows; education programs for IT managers would be very useful.*

D.1.1.10 Communication Networks

IP communication devices such as routers, switches, and hubs are increasingly important for energy consumption, both because of their growing number (in homes as well as offices) and because such devices are typically left on for 24 hours a day. The EPA has recently issued a Draft Specification Framework in the ENERGY STAR program for the smaller kinds of network devices (e.g., not rack mounted), to solicit further input on the nature of the problem and possible solutions (EPA 2009). For larger devices used in data centers and server rooms, additional energy savings in circuitry will be possible if the new IEEE standard 802.3az is implemented (as of this writing in August adoption seems likely). The standard achieves significant reductions in network energy consumption by aggregating data in transmission and powering down routers and switches when not in use. In communications as well as in computing, energy can also be saved if duplicative or unnecessary error-correction mechanisms could be skipped (Djahromi, Eltawil and Kurdahi 2007). *The Center could pursue any of several approaches: (a) assisting the implementation of the new IEEE standard 802.3az on Ethernet communications in server rooms as well as major data centers, (b) testing and developing algorithms intended to relax voltage requirements and error-checking when error tolerances can be high, or (c) researching ways to save energy by avoiding duplication of error correction. The Center should also educate server room managers in these matters to understand the tradeoffs enabled by the new communications techniques and to determine their typical or preferred modes of setting operation levels.*

D.1.1.11 Plug-In Electric Vehicles

Electric cars will become part of the household plug load, even if they also get charged at commercial stations (or get replacement batteries there). Plug-in and hybrid vehicles (PEV or PHEV) certainly will have a major impact on some homes and some grid circuits very soon and a major impact on the grid in the longer run, although predictions about adoption and deployment vary (Carson 2010b). The batteries in the PEVs are also expected to serve as a mode of energy storage -- vehicle batteries charged off-peak could contribute supplying power during peak-load periods, and batteries with degraded power capability will still be useful for energy storage in non-automotive applications. Although most press attention is being given to the vehicles, work is also being done on the necessary infrastructure, especially through the EV Project (Rahim 2010, ECOtality 2009), which includes a forthcoming major deployment in San Diego. At least two companies have already announced they are developing public charging stations. A good summary of the issues was published in 2008 in an article by Smith in the Wall Street Journal (Smith 2008).

Although in most cases the nation and the state want to encourage reductions in electricity use, national policies that target the oil and CO2 crises and transportation issues will encourage more PEV usage rather than less. Energy agencies and utilities will thus be in the awkward position of encouraging conservation while helping to promote a major use. Many observers have suggested that the oil/CO2 policies will eventually take precedence and that the utilities will have to develop separate metering and accounting procedures for PEVs.

In addition to the ECOtality project, many other organizations are doing research on aspects of this development. KEMA and its partners recently released a major report on electric vehicles

(KEMA 2010). The Air Resources Board has funded work at the UCI Advanced Power and Energy Program (APEP) to review the test procedures for determining emissions and fuel economy and to assess the electric grid impacts (Allgood et al., 2010; Jansen et al., 2010). PIER has funded a research center on electric vehicles at UC Davis (CEC 2007b), which has drafted a 15-year PHEV research roadmap (http://phev.ucdavis.edu/research/PHEV_Timeline%288-13%29.pdf) and is already engaged in studying actual PEV usage patterns, alternative charging systems, and life-cycle emissions and costs. SCE secured a DOE award, with UCI as a partner, for the Irvine Smart Grid Demonstration Project, which will among other things study the integration of electric vehicles with households on a major smart-grid circuit. SDG&E is cooperating as a part of The EV Project, managed by ECOtality under DOE sponsorship, and the CPUC has given SDG&E clearance to try different rate structures for PEVs (ECOtality 2009; ECOtality 2010; CPUC 2010d). At UC Irvine the ZEV•NET initiative conducted by the UCI APEP (www.zevnet.org) is studying the coordination of rail transportation with short-range shared vehicles, a role appropriate for electric vehicles.
Considering the factors just mentioned, there seems to be only a secondary role for the Center in the deployment of plug-in electric vehicles. *The plug-load Center would facilitate and supplement the Vehicle-to-Home (V2H) efforts at UCI APEP and the UC Davis center. The center should address the integration of PEV charging loads into the smart management of the building -- for example, could or should the charging systems respond to changes in the building load or to DR signals like other smart appliances, and how could or should separate metering systems develop? The Center would also be a useful meeting ground for the coordination of transport policies, energy policies, and air pollution policies.*

D.1.1.12 Distributed Generation

Among the positive attributes of distributed generation is the potential efficiency gain for using the direct current (DC) produced by many of the distributed power sources (e.g., fuel cells, solar photovoltaic, wind, microturbines). It is conventional to convert the Direct Current (DC) power to Alternating Current (AC) for the building, but this step is taken at a cost of efficiency. Because most electronic devices operate on DC, a second inversion back to DC occurs, either in an external power supply or within the device itself, resulting in another loss even before power reaches the appliance operation. The integration of DC within buildings could therefore present a 10 percent to 20 percent increase in the efficiency of plug-loads (see for example Nordman, Brown, and Marnay 2007; Darnell Group 2010; Fortenbery 2010; and Wiles 2007). Another gain from distributed generation would be the opportunity to harvest the exhaust heat energy from the generator at the site of end use and thereby dramatically increase the overall efficiency of the generator. This gain has long been achieved with district heating (see section A.2.2) and is now increasingly done at smaller sites.

The possibility of local generation at residences and commercial sites has long been recognized, but the actual implementation has been slow. The coming wave of smart meters that can measure the flow of power in two directions will help, but challenges remain: awkward rate structures in utilities, uncertainties about payback periods, and even community architectural standards that restrict solar or wind structures. There are many success stories but also many failure stories and even more reluctance stories. The National Renewable Energy Laboratory in Colorado does research on electric infrastructure issues. The UCI Advanced Power and Energy Program (APEP) has been engaged in distributed generation research with a variety of stakeholders including Southern California Edison for over fifteen years, with emphasis on the integration into the built environment, control and command, and the distribution and use of DC within buildings (e.g., for computers). *The Center should coordinate efforts with APEP and Energy Commission staff to explore the distribution and utilization of DC in the built environment with a focus on processors, communication networks, and server farms. The Center should explore installing a separate DC system at its own facility, using a renewable energy source. The Center should also assist* *with public education. However, there are already many organizations working on t his topic, so this topic is not a high priority for the Center.*

D.1.1.13 Public education and outreach

Education about energy efficiency is essential – for the public, for agency officials, for procurement managers. However, there are many organizations working in the area already, including other Energy Commission-sponsored centers, so this area is not an immediate priority for the Center. As noted in section C.3, *the Center might be able to help by promoting information about plug-load devices in coordination with the many extant education programs. The Center could help, for example, by convening workshops to review the evidence on 'what works', to design better projects, and to help educational projects to cooperate (Drakos 2007).*

If the Center is to take on a separate initiative, two possibilities seem most productive. (1) The Center could develop one or more computer games on energy efficiency, as a way of reaching younger audiences and illustrating the consequences of alternative actions. These could be implemented on-line and/or installed in science museums in California. For example, UC Irvine faculty members have installed a web-based game about dinosaurs in the Discovery Science Museum in Santa Ana, California. (2) Assuming the Center is affiliated with an educational institution (like most other Energy Commission Centers), *the Center could assist with workforce education.* The Center could not be a leader in actually preparing large numbers of technical workers, but with relatively small resources it could assist by *sponsoring undergraduate participation in the Center's research projects, assisting campus student groups promoting sustainable energy, sponsoring projects for senior design classes, or providing technical expertise to existing training programs.* A review of programs in the California Community College programs is in an article in Affinity Online (Evans 2010).

D.1.1.14 Televisions

The Energy Commission led the way with the nation's first standards for energy efficiency in televisions in both active and standby modes (Docket #09-AAER-1C), setting IEC 62087 version 2 as the test protocol. Additional improvements are possible outside the standards-setting process. For example, UCI Calit2 is working with PG&E and TV manufacturers for evaluating the manufacturing cost of LED lighting, PDP, CCLT, etc. for various sizes of televisions (Most of the energy consumption by televisions is for the backlighting, and the switch from fluorescent systems to LED systems has begun.) A precise determination of the percentage of manufacturing cost attributable to lighting components will allow appropriate and accurate design of an incentive program that can faithfully mirror the energy efficiency improvement of each type. In another example, the use of low cost microelectronics and light sensors to monitor usage patterns and control display settings without user intervention could also be an attractive engineering solution. TV energy usage can be unnecessarily high as a result of default brightness settings intended for retail display or as a result of the consumer's setting the brightness level for daytime usage or for 3D glasses. A smart TV could determine the ambient light condition to adjust its back lighting intensity accordingly within a profile set by the consumer. *The Center should work on developing and testing context sensors for televisions and documenting consumer preferences.*

Television sets are usually the lead or center item in a constellation that includes a set-top box, speakers, a DVR, a DVD player, and more – which are typically not being used if the television is not being used. This relationship has attracted interest as a potential area for controlling the energy consumption of several devices at once.

Among television models there is no one display technology that emerges as consistently the most efficient – for all technologies the efficiency varies with size. LCD TVs, for example, are the most efficient in small sizes but not in large sizes. More recently, LED-backlit televisions have come on the market in much greater numbers; they are more efficient than fluorescent-backlit models. (LED systems are also more expensive, but it is expected that they will be less expensive in larger volume.)

The Center should accelerate the process by coordinating as an honest broker with manufacturers and retailers to determine the best incentives for encouraging environmentally preferable inventories.

Another possible next step being considered by the Energy Commission would be to apply regulation to the larger screen sizes exempted from the 2009 regulations. Those large televisions are fewer in number, but the market is growing and the energy consumption per unit is substantial. Coming on the heels of the 2009 regulations, this idea may be too difficult to handle politically. The *recommended Center may be able to help with engineering analyses.*

D.1.1.15 USB-powered devices

An additional category of appliances also deserves attention – those powered from other appliances via USB. Most typically, they are accessories such as speakers, scanners, and webcams attached to a computer. Their widespread use may mean that estimates of the active-mode power use of the other appliances are too small. Furthermore, the rated power consumption of the USB-powered devices would be an underestimate unless it factors in the AC/DC loss already incurred by the supplying appliance. A USB 2.0 device can draw up to 500mA (less in practice) and up to 2.5W (typically 0.1W to 1.5W). The advent of USB 3.0, now arriving on the market, allows even greater power draws. USB 3.0 is much faster than USB 2.0 so it will do well on the consumer market. It appears that no separate standards have been promulgated for such devices. Like other plug-load devices, their power draw is small but their number (billions) means they add up (Chin 2010, Thon 2005, Petersen undated). *The Center should implement a census of the installed base and of the energy consumption by individual devices, with particular emphasis on the emergence of USB 3.0*

D.2 Facility Needs and Plans

A facility for the Center should have the following characteristics.

- Several demonstration and deployment rooms, adequate for testing and providing demonstrations to visitors. There should be at least a mock kitchen, a mock living room, and a mock office because the requirements and configurations for each are quite different. Variations on these would be helpful. Each space should have a variety of wall plugs, power strips, switches, plug meter, fluorescent or CFL or incandescent lighting, and motion sensors. Some of the rooms could be built to older standards of construction to allow simulation of problems with retrofit. Some of the rooms should have ample natural lighting to model typical houses or offices. In each space, alternative interface devices for information feedback to users will be tested. In addition, a server room will be a focus research space for examining various next generation communications networks for data server solutions such as the new Ethernet cross layer solution, fuel cells as direct DC power source, absorption chiller, etc. The telepresence conference room is also included in the facility, illustrating the use of consumer electronics for high fidelity real time video conferencing, which reduces energy usage associated with travel.
- Local utility metering, applied to the facility and each demonstration room, in addition to the larger building as a whole, for testing smart-grid and home-network arrangements. Each of the three facilities will have a dashboard of meters to show current and cumulative power consumption.
- Appropriate space for meetings, breaks, and visitors
- Standard building services to code – exits, restrooms, stairways, etc.

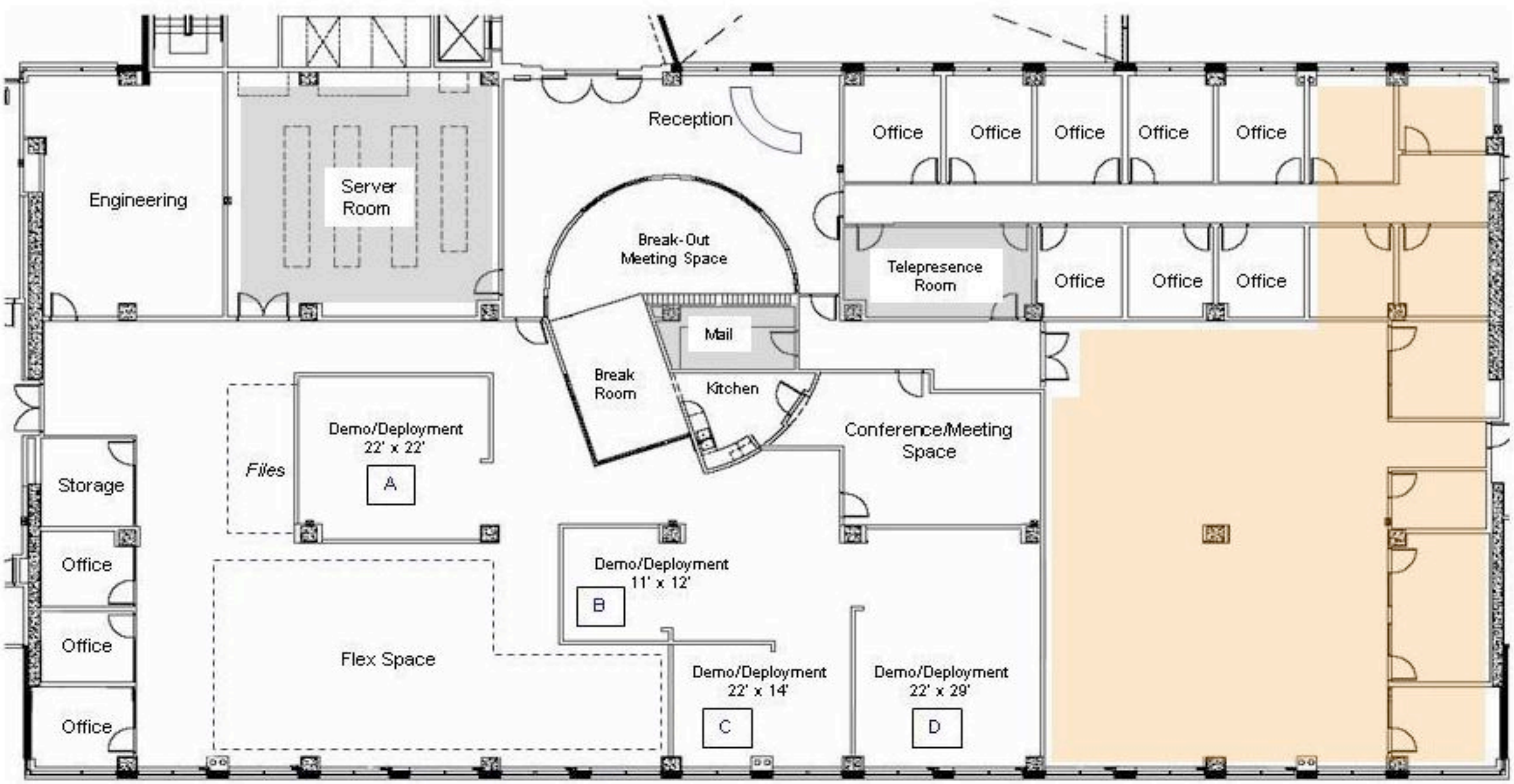
- Diverse and adequate instrumentation for testing the performance of appliances and CE devices in different patterns of energy consumption – e.g., the brightness of televisions and monitors, the sound quality of speakers, or the speed of game consoles. The needs will often be determined by existing government or industry standards, but in some cases the Center will be the organization that develops the standard employing different instrumentation.
- The shared spaces – kitchen, meeting rooms, telepresence conference room, and hallways – should be equipped with or accessible for 'living lab' tests of plug-load devices (e.g., coffee pots, printers, speakers, monitors, dashboards).
- Wireless controls, wired controls, and/or powerline controls throughout
- The possibility of access to DC power from renewable sources
- Sufficient vertical clearance for overhead utilities and major equipment
- An emergency generator, a truck dock, and (if not on ground floor) a freight elevator
- Easy access to, or inclusion of, electronics lab space and machine shop space
- Easy access for out-of-town visitors –road access, airport access, convenient parking
- Office or cubicle space for several staff and students

A possible plan, using the fourth floor of the Calit2 building for illustration, is shown as **Figure 12**. The example indicates approximately 6,000 sq.ft. assigned to the Center in a university building. Four demonstration/deployment spaces are shown, of different sizes, with and without natural light.

In this suggested case the reception desk would be shared with another organization; a separate engineering room is dedicated to the Center for the electrical work; break rooms and meeting facilities are near the offices and demonstration rooms. The Calit2 building has a light machine shop on another floor shared by all building users; in another building that would have to be included in the floor plan.

Figure 12: Illustrative floor plan for the Center.

This plan uses an existing floor in UCI's Calit2 building for illustration purposes.



Source: Calit2

Requirements for an emergency generator, utilities, a truck dock, and a freight elevator would be applicable to any large building and are met by the Calit2 building, but they are not included in this illustration; nor are standard facilities like stairways and restrooms.

D.3 Federal, State, and Private Additional Funding Support

The Center should have sources of long-term base funding in addition to the Energy Commission support. Fortunately, there are many organizations with financial interests in energy efficiency and many sources of other research funding for topics that relate to energy efficiency. The possible sources fall into three general categories: a program of paid memberships for organizations; contract projects for interested parties for research, service, or training; and grant assistance for basic or applied research.

D.3.1 Corporate and Other Memberships

The Center should have annual memberships for organizations, at two or three different funding levels. The details will have to be worked out, but the model used by the CLTC and WCEC seems appropriate –there should be a few categories of membership, each with a different membership fee and different privileges and responsibilities. The relationships should spell out the rights for public credit as a sponsor, for pre-assured time for work or consultation, for use of display and demonstration areas, for intellectual property, for visiting researchers, and for proprietary information. Subject to discussion with the host institution, it would be attractive for the membership fees to incur a reduced overhead rate. For example, there might be two levels of industry membership, a level for non-profit organizations and universities, and a general membership level open to any person or organization. In the prototype budget shown below in Section D.4, membership levels of $50,000 and $20,000 are shown, for illustrative purposes only. This source of funding should become a long-term base of support for the center, in addition to continuing support from the Energy Commission.

D.3.2 Grant or Contract Research Assistance

Commercial establishments and offices may want the Center to conduct audits, consultations, or experiments in their settings. PIER or other government agencies may contract with the Center for special studies. For tests done at the sponsor's site, any on-site expenses and responsibility for renovation would usually be borne by the sponsor. For tests in the Center's facilities, the Center's usual contract arrangements and indirect cost would apply. In addition to targeted contracts with deliverables for particular sponsors, the Center should be able to win awards for projects in basic or applied research.

If the Center is part of a larger organization, the Center would be subject to that organization's policies for sponsored projects and would receive grants management assistance from that organization.

The Center would be able to apply to funding sources like the following. Other sources exist as well.

- *The U.S. Department of Energy (DOE)* sponsors several grant programs related to energy efficiency. In January it announced grant awards totaling over $40 million, including two awards to universities, for projects on improving efficiency in major IT centers. In recent months opportunities for DOE funding have included early-career research grants, an SBIR program, and major funding for smart grid research. It also offers grants for energy conservation and retrofit projects to local governments; some of that funding could be available to the Center for subcontract projects. For example, two major awards have been awarded that could be associated with the proposed center. First, the DOE has awarded a major smart grid contract to Southern California Edison with UCI as a partner. Secondly, the DOE has awarded a large grant to UCI with Siemens Research Center as a partner for the development of next generation building energy controls.

- The *Public Interest Energy Research (PIER)* program within the Energy Commission provides grants specifically for California-related energy research. PIER has a funding program on energy efficiency as well as related topics such as smart grids and some federal funds available under ARRA. The *Energy Innovations Small Grant Program* offers grants of up to $95,000 (hardware projects) or $50,000 (software/modeling projects), and academic institutions are eligible. (At the time of this writing the PIER program is up for reauthorization by the legislature.) Sample projects at UCI or elsewhere include the installation and integration of a high-temperature fuel cell with an absorption chiller into a major market centric building, including smart coupling to building and plug loads, a major energy building controls contract, and a community sustainable design control with a focus on building and plug-load performance.
- *UC Discovery Grants* fund industry-university partnerships for applied research in many areas of science and engineering, for UC faculty only, in amounts from $50,000 to more than $1 million. Applications are limited to projects conducted with California firms. Topics such as power consumption in mobile devices, efficiency in combustion, new insulation materials, and embedded control systems would be quite suitable for Discovery Grants.
- For the *U.S. Department of Defense* the power consumption of military mobile devices is critical, so they offer funding for advances in the energy efficiency of such items. The research results can then be applied to consumer products. For example, DARPA-BAA-09-44 seeks proposals on "Active Cooling Modules" and Army BAA W911NF-07-R-0001-04 supports this topic on Power Electronics: "the design of low peak power, highly efficient circuits and protocols for communications." DOD is also letting contracts on various aspects of a zero-net-energy infrastructure.
- The *National Science Foundation (NSF)* offers funding for academic research; many of the topics are relevant for the recommended Center, such as circuit design, combustion research, networking, energy-consumption behavior, or mechanical systems. For example, the recent solicitation on "Computer and Network Systems" (NSF 09-556) invited proposals on energy efficiency in computing; the solicitation on "Cyber-Physical Systems" (NSF 10-515) invited proposals on zero-net-energy buildings; and the NSF small-business program recently funded a project on "Improving Energy Efficiency by Using Nanofluids in Vapor Compression Systems." NSF awards usually range from a few hundred thousand dollars to a few million dollars.
- The *National Institute of Standards and Technology (NIST)* offers financial assistance for research in fields that are important to plug-load energy efficiency: electronics and electrical engineering, manufacturing engineering, chemical science and technology, physics, materials science and engineering, and information technology. See for example the NIST Advanced Technology Program at www.atp.nist.gov.
- Programs to assist small businesses can be of help to the Center if it is performing research with a small business (for example, a university startup). The *Small Business Administration (SBA)* provides funding for programs that assist small businesses with energy audits and energy efficiency. The most recent announcement was OSBDC-2010-06, which had a closing date in late 2009. Many federal agencies sponsor projects in the *Small Business Innovation Research (SBIR)* program and the *Small Business Technology Transfer Research (STTR)* program, through which a small business can partner with a research institution.

- The *National Institutes of Health (NIH)* offers grants on energy efficiency in medical devices. Its program on Energy Efficiency and Renewable Energy System Technology Research and Development (Program Announcements PA-09-100 and PA-09-101) offer support under their small-business program for the development of "Technologies to optimize battery usage and/or energy consumption by medical devices (e.g., hearing aids, dental hand-pieces, chairs, lights), imaging technology (e.g., dental X-ray technology, magnetic resonance imaging systems), radiation therapy equipment (e.g., accelerators for proton radiotherapy), or chair/bed-side information technology (computers and displays)." The program also covers topics such as "Alternative energy efficient separation techniques" and "Patient monitoring technology that decreases transportation to medical facilities". Initial awards for concept development can be up to $100,000 and 'Phase II" awards for up to $750,000.
- The *Semiconductor Research Corporation*, a joint venture established by several semiconductor firms, has funded several power-conservation research projects, including one at UCI on preventing power leakage from micro and nano circuit components.
- *Resources for the Future* offers the Gilbert F. White Postdoctoral Fellowships for one year of study in areas related to energy, environment, and natural resources.
- The *American Public Power Association* offers grants to students who work with public power agencies on energy efficiency projects.
- *The South Coast Air Quality Management District* offers some funding opportunities that might prove relevant, such as incentives for telecommuting centers to reduce transportation and incentives for low-emission appliances. AQMD funding might help with some projects but would not likely be a major source of funding for the Center.

In Appendix C there are letters of support for the idea of such a center. While the organizations expressing support cannot be expected make specific tangible commitments without further information and discussion, these letters do indicate a general agreement on the need for such a Center and the willingness of many parties to consider providing assistance.

D.4 Organizational Development and Growth Plans

D.4.1 Organizational Development

The organization of the center should resemble that shown in **Figure 13** below.

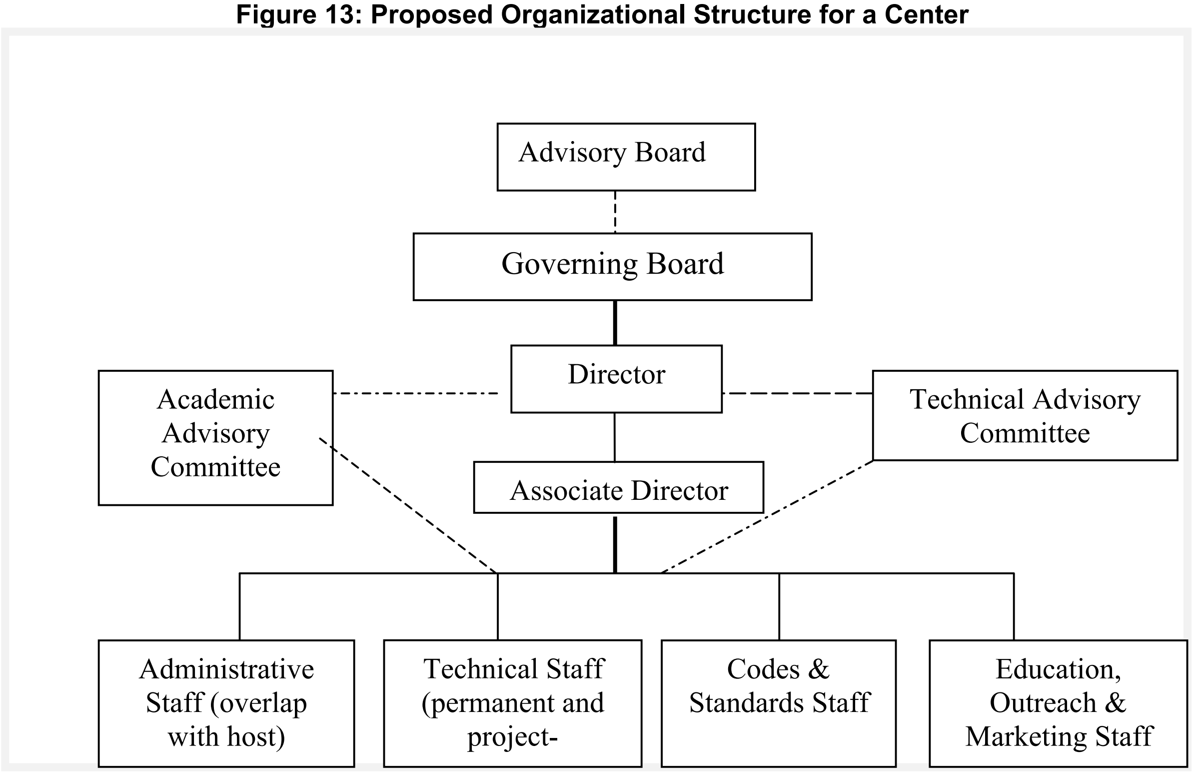
Thus the organization should include these important elements:

- *Director.* The director would be responsible for the overall operation of the center. He/she should have substantial experience in the energy community, including familiarity with the standard-setting process, preferably in California. The director should also have substantial research credentials but need not come from an academic institution. He/she should have a direct reporting relationship to the administration of the host organization, although for internal reasons the Center may nominally be part of some larger unit within the host organization. The director will also have to be accomplished at fund-raising. This is the pattern followed in some of the existing Energy Commission centers. Recruiting a suitable director would be an important first task for the Center's host organization and may take several months; an interim director may be necessary from within the host organization.

• *Governing Board*. The director would report to this group, composed of a few persons at the top level of the host organization, including a vice president for research, and/or a dean of engineering, for example. This group will have formal meetings quarterly and ad hoc meetings as needed. Assigning the members of this group should be completed by the host organization, with advice from the Energy Commission, upon formation of the Center.

• *Advisory Board*. These persons would be senior executives in industry, energy agencies, and other interested organizations. For example, there could be one to three members each from utilities, IT or CE manufacturers, appliance manufacturers, professional associations, small business, environmental advocacy groups, and agencies, including the Energy Commission. Presumably some or all of the higher-level Member organizations (see above) would have representation on this board. This board would meet a few times a year to advise the center on general directions and priorities. However, the director would not formally report to this board. Filling positions should be the responsibility of the director, with advice from the Energy Commission and the Governing Board. A basic representation of most sectors could be completed within the first few months of the Center's existence; filling out more positions could be accomplished in the first year or so.

Figure 13: Proposed Organizational Structure for a Center



Source: Calit2

• *Technical Advisory Committee*. These would be persons at a 'middle manager' level or technical level, mostly from outside organizations but perhaps there would also be researchers from the parent organization. They would include not only engineers but also social scientists and experts in business or marketing. These people should be knowledgeable about (and probably involved in) specific projects at the Center. The interactions between the director and the Technical Advisory Committee would be frequent – making operational and administrative decisions in tangible interactions with industry and utilities. These people may also work directly with technical staff on specific projects. The number of members may vary; there could be permanent members as well as members serving while certain projects or programs are active. These appointments would probably be defined by the life of the relevant projects.

- *Academic Advisory Committee*. The Center would benefit from academic input representing relevant disciplines in engineering, science, business, and social sciences. This group would meet formally 2-3 times a year; they would be appointed for overlapping terms of 2-4 years. Some of these persons might well be PIs for funded projects in the Center, directing staff on those projects, and/or supervising senior design projects. Five to ten persons would be sufficient, representing different disciplines. Securing these appointments should be completed in the first few months of the Center's existence; the appointments would be made by the director.
- *Associate Director*. This person would be the COO of the Center, overseeing the daily operation of the projects, the financial systems, and the personnel operations, under general guidance from the director. She/he should have managerial experience and a substantial background in energy-related projects. Recruiting an associate director would be an important first task for the Center's director and may take several months; an interim associate director may be necessary from within the host organization.
- *Researchers*. For each of the Center's research projects, especially ones that are externally funded, the Center will formally designate a Principal Investigator, typically a technical professional person, employed under the Center to conduct the project. These may be full-time employees of the Center, but they may also be persons on part-time assignments to the Center (e.g. faculty during summer months). It is expected that only a few such persons would be employed at any one time, in addition to the Director and Associate Director. The director or associate director may serve as Principal Investigator on some of the projects, depending on the topic and on the requirements of the project sponsor. At the Director's discretion, researchers and technical staff not employed by the Center may also use the Center's facilities.
- *Technical staff*. The technical staff would be comprised of engineers, computer scientists, social scientists, and technicians who would set up demonstrations, calibrate instruments, carry out statistical analyses, design circuits, design room-scale installations, build machinery, conduct surveys, and interview users. This category of personnel (probably including various levels) will be the most likely to grow significantly as the center's operations expand. These people would have to remain current with the standards and test procedures developed by ANSI, NIST, the IEC, ASHRAE, and many other organizations. Judging from the experience of other PIER Centers, it appears that the Center should have 3-4 such persons at its founding; the eventual number could be a dozen or so, depending on the growth of funded projects. Such persons could be hired more quickly than the director or associate director, but temporary assignments from the parent organization may be necessary.
- *Codes and Standards Staff*. These persons would be the ones who make useful translations between technical specifications and legal or policy documents, conduct market assessments, and/or estimate energy savings, as needed in various proceedings. They should have significant skills in both science or engineering and writing or law; they will assist the utilities, manufacturers, and/or the Energy Commission staff in preparing CASE assessments, draft regulations, test protocol manuals, and similar documents at various steps in the rulemaking process and in the EM&V process. At full size the Center would require several such persons, and a leader of the group would report to the Associate Director. Such persons could to be hired more quickly than the director or

associate director, but temporary assignments from the parent organization may be necessary.

- *Education and Outreach Staff*. These persons would have experience in science education programs, in marketing with multimedia, and/or in K-12 school systems. They would design and implement educational programs, in coordination with the IOUs and other organizations; conduct formal evaluations of the education programs conducted by the Center or other organizations; keep track of rapidly changing CE markets; and present the Center's programs at national or statewide conferences. These persons would coordinate public relations efforts with the larger host organization. At full size, the Center would probably have 2-3 such persons. Such persons could be hired more quickly than the director or associate director, but temporary assignments from the parent organization may be necessary.
- *Students*. Students and postdocs should be afforded an opportunity to take part in the Center's research work or outreach work – these experiences might be dissertation projects, senior design projects, summer internships, or other experiences. Students would not ordinarily be significant participants in the administrative work or the development of codes and standards. In a research university graduate tuition and fees is usually included in the budget as a benefit cost.
- *Administrative Staff*. These persons would manage the center's finances, manage the director's schedule, manage arrangements for meetings and seminars, assist with pre-award and post-award grants management, and provide publicity in the form of a newsletter and web site for the Center (e.g., www.cltc.ucdavis.edu and www.wcec.ucdavis.edu). These persons might be serving similar functions for the host organization, working part-time for the energy efficiency appliance center for part of their salary. These separate positions, filled full-time or part-time, will be necessary: receptionist, administrative assistant to the director, grants manager, communications and public relations coordinator, and finance manager.

In many respects the technical and administrative staff would function as a matrix organization; each person would be in a group with related skill sets, and each person would work on different projects at different times, typically assigned by the associate director in conjunction with the project principal investigator.

D.4.2 Budget and Growth

Establishing a Center, as opposed to funding individual projects, would be financially advantageous to California because it would enable better coordination of energy efficiency projects by taking a holistic approach, and it would provide a more favorable cost-sharing by private parties – partners and cosponsors would contribute more if assured of continuity and integration. **Table 40** is an estimated budget for the Center's early year -- assuming $1.25 million annually from the Energy Commission, an arbitrary figure but one roughly comparable to the support for other Centers. These amounts are not sufficient to accomplish all the tasks outlined in **Table 39** above; further selection and prioritization will be needed if a Center is established. Another limitation of these estimates should be noted: for this preliminary general summary no attempt is made to correlate individual funding sources with specific items of expenditure that they sources would be willing to support. However, the estimates will serve as a reference starting point for discussions on how the center could or should budget to fulfill its mission.

Table 40: Projected Budget Estimates for Plug-Load Energy Efficiency Center ($)

	Year 1	Year 2	Year 3 +
INCOME			
California Energy Commission	$1,250,000	$1,250,000	$1,250,000
Formal Memberships @ ~$50,000	200,000	300,000	400,000
Formal Memberships @ ~$25,000	80,000	120,000	160,000
Parent Organization Start-Up Funds	600,000	150,000	0
Research Grants $20K-$100K	400,000	500,000	750,000
Research Grants > $100K	300,000	850,000	1,200,000
Testing & Service Contracts	200,000	300,000	400,000
Total	**3,030,000**	**3,470,000**	**4,160,000**
EXPENSE			
Salaries & Benefits Director, Assoc. Director	150,000	250,000	260,000
Researchers full-time	0	150,000	200,000
Researchers part-time	70,000	230,000	500,000
Staff ~$80K/yr	400,000	650,000	750,000
Staff ~$40K/yr	120,000	200,000	300,000
Grad Students (salary & tuition)	150,000	200,000	250,000
Undergraduates – Summer interns, class projects	70,000	70,000	70,000
In-State Travel: projects, conferences	15,000	20,000	20,000
Out-of-State Travel: projects, conferences	35,000	60,000	60,000
Renovation, Mockups	700,000	300,000	300,000
Equipment	300,000	200,000	200,000
Supplies	130,000	100,000	60,000
Workshops and conferences on site	100,000	150,000	150,000
Technical reports & annual report	20,000	20,000	40,000
Other Communications: Web design, newsletter, educational materials, brochures	70,000	70,000	80,000
Indirect Costs @ ~25% MTDC* (off-campus or other special rate) Indirect Costs @ ~50% MTDC (typical regular rate)	450,000 250,000	500,000 300,000	520,000 400,000
Total	**3,030,000**	**3,470,000**	**4,160,000**

\+ Defined as items over $5,000. Other items are considered supplies.

* MTDC is Modified Total Direct Cost, as defined in federal regulations. Source: Calit2

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APPENDICES

Appendix A	ANNOTATED BIBLIOGRAPHY ON BEHAVIORAL RESEARCH CONCERNING ENERGY USE IN APPLIANCES
Appendix B	LIST OF ATTENDEES AT UCI WORKSHOP ON APRIL 1, 2010
Appendix C	GLOSSARY OF ACRONYMS AND ABBREVIATIONS

APPENDIX A

ANNOTATED BIBLIOGRAPHY ON BEHAVIORAL RESEARCH CONCERNING ENERGY USE IN APPLIANCES

W. Abrahamse, L. Steg, C. Vlek, & T. Rothengatter,"A review of intervention studies aimed at household energy conservation". *Journal of Environmental Psychology, 25 (2005):* 273-291.
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Goes beyond the typical approaches of financial incentives, attitude changes, and marketing to deeper analyses of how to change behavior. Draws on experience from public health (e.g. smoking cessation) to look at multiple levels: policy, physical, socio-cultural, interpersonal, and individual. Also draws on design literature, diffusion theory.

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Alan Fogarty and John Lane, "How individual behavior is a critical ingredient of any energy reduction plan," *FMLink*, February 7, 2008, http://www.fmlink.com/ProfResources/Magazines/article.cgi?FM%20World:fmworld021108.html. Emphasizes the importance of using meters or other devices to let people see how much energy they are using.
Andy Frank, "Residential Energy Efficiency: It's the Behavior, Stupid," *Energy Central*, May 11, 2009, http://www.energycentral.com/intelligentutility/demandresponseandhan/articles/2036/Residential-Energy-Efficiency-It-s-the-Behavior-Stupid/. Discusses why behavior must be the framework for any successful energy efficiency program. Argues that personalized information, general and specific commitments, social pressure, and constant feedback are all elements of a successful energy efficiency behavior campaign.
Andy Frank, "Residential Energy Efficiency: This is How We Do It (Part 2)," *Energy Central - Energy Pulse*, June 9, 2009, http://www.energypulse.net/centers/article/article_display.cfm?a_id=2064. Suggests the benefits and challenges for utility companies to engage residential consumers in efficiency programs.
Jon Froehlich, "Promoting Energy Efficient Behaviors in the Home through Feedback: The Role of Human-Computer Interaction," (presented at the HCIC 2009 Workshop, University of

Washington, Seattle, WA), http://www.cs.washington.edu/homes/jfroehli/publications/HCIC09_RoleOfFeedback.pdf.
Outlines common misconceptions of energy usage in the home, establishes the potential of feedback to change energy consumption behavior, and introduces ten design dimensions of feedback technology.

W. David Gardner, "Mobile Device Sales Still Booming," *Information Week*, December 21, 2009, http://www.informationweek.com/news/mobility/business/showArticle.jhtml?articleID=222002858.
Predicts that the total number of mobile devices shipped, including cellular handsets, mobile Internet devices, netbooks, mobile consumer electronics products, and cellular modems, will reach 2.25 billion in 2014.

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Kirsten Gram-Hanssen and Erik Gudbjerg, "Reducing Standby Consumption in Households: By Means of Communication or Technology?," in (presented at the ACEEE Summer Study on Energy Efficiency in Buildings, Danish Building Research Institute, 2006), http://www.eceee.org/conference_proceedings/ACEEE_buildings/2006/Panel_7/p7_7/.

Jeffrey Harris et al., "Don't Supersize Me! Toward a Policy of Consumption-Based Energy Efficiency," (in ACEEE Summer Study on Energy Efficiency in Buildings , 2006), http://www.eceee.org/conference_proceedings/ACEEE_buildings/2006/Panel_7/p7_9/.

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Steven C. Hayes and John D. Cone, "Reducing residential electrical energy use: Payments, information, and feedback, *Journal of Applied Behavior Analysis* 10, no.1 (Fall 1977): 425-435.
Daily feedback provided for residents lead to a 15-21% reduction in energy use from baseline. Cash payments for a reduction in energy use also decreased energy consumption regardless of the magnitude of the payment, but solely providing information on ways to conserve energy did not have significant effects.

T. A. Heberlein & G.K. Warriner (1982). The influence of price and attitude on shifting residential electricity consumption from on to off-peak periods. *Journal of Economic Psychology* 4:107-130.

Martin Holladay, "Tackling the Plug Load Problem," June 18, 2009, http://www.greenbuildingadvisor.com/blogs/dept/musings/tackling-plug-load-problem.
Urges energy-conscious consumers to tackle the plug-load problem by making an inventory of personal plug loads, eliminating unnecessary appliances, putting gadgets on power strips, acquiring fewer electrical gadgets, and getting children on board with energy efficiency.

Se Joon Hong et al., "Understanding the Behavior of Mobile Data Services Consumers," *Information Systems Frontiers* 10, no. 4 (September 2008): 431-445.
Notes the widespread usage of many kinds of mobile electronic devices; reports on a survey of over 800 persons to determine what factors are most important in influencing adoption and usage – e.g., perceived ease of use, media coverage, age, gender, and other factors.

Jane Hummer, "Using Social Marketing to Promote Energy Efficiency and Conservation," *Environmental LEADER: Energy & Environmental News for Business*, March 22, 2010, http://www.environmentalleader.com/2010/03/22/using-social-marketing-to-promote-energy-efficiency-and-conservation/.

Advocates social incentives rather than financial ones as a way to influence consumer behavior and purchases regarding energy efficiency.

International Energy Agency, *Gadgets and Gigawatts: Policies for Energy Efficient Electronics (Executive Summary)*, Executive Summary, 2009, http://www.iea.org/Textbase/npsum/Gigawatts2009SUM.pdf.
Discusses why the current government approach on energy efficiency will not be able to conquer the threat of the exponential increase in electricity consumption from ICT and CE products that is predicted to occur over the next few decades. Offers policy recommendations and objectives.

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Assembles case studies and research that examine energy-related behavior in detail and sheds light on how people perceive and use energy.

Steve Koenig, "Green Technology Growing on Consumers," *Vision*, February 2010.
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Reports on a survey of 600 Swedish households and a number of interviews where questions about residential energy behavior and possible policy instruments for change were raised. Several policy instruments for change are identified in the study and they include combinations of information, economic measures, and administrative measures and more user friendly technology as well as equipment with sufficient esthetic quality.

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Loren Lutzenhiser (1993). Social and behavioral aspects of energy use. Annual Review of Energy and the Environment, 18(1), 247-289.

Loren Lutsenhiser et al., *Behavioral Assumptions Underlying California Residential Sector Energy Efficiency Programs*, Working Papers on Behavior (Oakland, CA: California Institute for Energy and Environment, April 2009), http://uc-ciee.org/energyeff/documents/ba_ee_res_wp.pdf.
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.

Mark S. Martinez (2006). Residential demand response technologies: A Consumer's guide. Presentation at national town meeting and symposium on demand response. Http://Tinyurl.com/6cw8cu

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Bradford Mills and Joachim Schleich, "What's Driving Energy Efficient Appliance Label Awareness and Purchase Propensity?" *Energy Policy* 38, no. 2 (February 2010): 814-825.

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Considers the behavioral assumptions in energy efficiency potential studies, options for modifying and supplementing these assumptions, and how the question of energy efficiency potential could be expanded to meet the new policy challenges that call for aggressive absolute reductions in energy consumption and carbon emissions.

Momentum Market Intelligence, *Residential Segmentation Research: Detailed Findings*, Contract Report (Bonneville Power Administration, March 2009), http://www.bpa.gov/energy/N/segmentation/BPA_Detailed_Findings_3-11-09.pdf.
Reports on a survey of Bonneville customers, covering demographics and attitudes on energy. Provides a segmentation of the market into groups such as "green idealists", "affluent conservers", and "following the crowd".

I. Matsukawa and N. Ito, "Household Ownership of Electric Room Air Conditioners," *Energy Economics* 20, no. 4 (September 1998): 375-387.

Steven J. Moss, M. Cubed, and Kerry Fleisher, *Market Segmentation and Energy Efficiency Program Design*, CIEE White Paper (California Institute for Energy and Environment, November 2008), http://uc-ciee.org/energyeff/documents/MarketSegementationWhitePaper.pdf.
Discusses how market segmentation can be applied to the electric utility sector.

B.. Neenan and J. Robinson, *Residential Electricity Use Feedback: A Research Synthesis and Economic Framework* (Knoxville, TN: Electric Power Research Institute, February 2009), http://my.epri.com/portal/server.pt?space=CommunityPage&cached=true&parentname=ObjMgr&parentid=2&control=SetCommunity&CommunityID=405.

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Danny Parker, D. Hoak, D., Alan Meier, & Richard Brown (2006). How much energy are we using? Potential of residential energy demand feedback devices. Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings. Http://Www.Fsec.Ucf.Edu/En/Publications/Pdf/Fsec-Cr-1665-06.Pdf.

Jane S. Peters and Marjorie McRae, *Process Evaluation Insights on Program Implementation*, Working Papers on Behavior (Oakland, CA: California Institute for Energy and Environment, February 2009), http://uc-ciee.org/energyeff/documents/proc_eval_whtppr.pdf.
Draws lessons learned from the past 30 years of energy efficiency program evaluation in order to facilitate improved program design and implementation going forward.

Judy Roberson et al., *After-hours Power Status of Office Equipment and Inventory of Miscellaneous Plug-Load Equipment* (Berkeley, CA: Lawrence Berkeley National Laboratory, May 2004), http://enduse.lbl.gov/Info/LBNL-53729.pdf.
Reports steady and continual growth in the market for electronic office equipment, particularly personal computers and monitors, but also printers and multi-function devices.

John Marshall Roberts, *Cracking the Green Code: Using a Values-Based Model to Improve Customer Communications and Marketing*, Project Energy Code (Distributed Energy Financial Group, LLC, February 2009), http://www.defgllc.com/Assets/downloads/project-energy-code-03-apr2009.pdf. Outlines a highly actionable framework that can be easily applied to a variety of marketing and communication contexts, helping environmentally-minded professionals create messages that strategically overcome mental resistance and inspire sustainable behavior change.

Simon Roberts and William Baker (2003). Towards effective energy information: Improving consumer feedback on energy consumption. Centre for Sustainable Energy. (no. Con/spec/2003/16).

Jennifer A. Rode, Eleanor F. Toye, and Alan F. Blackwell, "The fuzzy felt ethnography—understanding the programming patterns of domestic appliances," *Personal and Ubiquitous Computing* 8, no. 3-4 (July 2004): 161-176.
Reports on a detailed ethnographic study of nine professional households and how they program appliances – which ones are programmed ahead of time for special operations (e.g. ovens), which devices are easy to program for repeated operations (e.g. car radios), which operations are perceived to be simple or hard. Explores gender differences in detail.

Christof Roduner et al., "Operating Appliances With Mobile Phones - Strengths and Limits of a Universal Interaction Device," in *Pervasive Computing*, vol. 4480, Lecture Notes in Computer Science, 2007, 198-215.
Demonstrates that mobile devices can greatly simplify appliance operation in exceptional situations, but that the idea of a universal interaction device is less suited for general, everyday appliance control.

Spencer Sator, *Managing Office Plug Loads*, Newsletter, Energy Manager's Quarterly (E-Source, 2008), http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=15887.
"Before installing efficient lighting and HVAC upgrades—and long before purchasing carbon offsets—companies can enjoy the economic, social, and competitive advantages of simply turning off office appliances when not in use and shopping for the most efficient models when it comes time to replace old equipment."

L. Schipper, S. Bartlett, D. Hawk, & E. Vine (1989). Linking life-styles and energy use: A matter of time? *Annual Review of Energy*, 14(1), 273-320.

P. Wesley Schultz, "The Constructive, Destructive, and Reconstructive Power of Social Norms" (PowerPoint presented at the Behavior, Energy, and Climate Change 2008, Stanford, CA, November 17, 2008), http://piee.stanford.edu/cgi-bin/docs/behavior/becc/2008/presentations/17-1C-01-The_Constructive_Destructive_and_Reconstructive_Power_of_Social_Norms.pdf.
Argues that normative campaigns (reporting the behavior of others) can be very effective; discusses positive and negative effects of such campaigns.

R.J. Sexton, N.B. Johnson, & A. Konakayama (1987). Consumer response to continuous-display electricity-use monitors in a time- of-use pricing experiment. *The Journal of Consumer Research*, 14(1), 55-62.

F.W. Siero, A.B. Bakker, G.B. Dekker, and M.T.C. Van Den Burg (1996) Changing organizational energy consumption behavior through comparative feedback. *Journal of Environmental Psychology*, 16(3), 235-246.

Stanford Report, "Researchers awarded $6.27 million to study energy efficiency, human behavior," *Stanford University News*, October 27, 2009, http://news.stanford.edu/news/2009/october26/energy-efficiency-funds-102709.html.
News article reporting the establishment of the center and its intent to include behavioral studies related to energy efficiency.

Michael J. Sullivan, *Using Experiments to Foster Innovation and Improve the Effectiveness of Energy Efficiency Programs*, Working Papers on Behavior (Oakland, CA: California Institute for Energy and Environment, March 2009), http://uc-ciee.org/energyeff/documents/exp_design_wp.pdf.
Looks at the statewide machinery for R&D on energy efficient behavior. Must include

innovation and experimentation. Who is responsible for the R&D – government, utilities, universities? Argues that California has not planned the process well; in particular that it has not provided enough for experimentation. Discusses alternative experimental designs.

Michael J. Sullivan, *Behavioral Assumptions Underlying Energy Efficiency Programs for Businesses*, Working Papers on Behavior (Oakland, CA: California Institute for Energy and Environment, January 2009), http://uc-ciee.org/energyeff/documents/ba_ee_prog_bus_wp.pdf.
Argues that utility programs aimed at businesses for purposes of increasing energy efficiency have been dominated by 'rational decision-making' assumptions – price, efficiency, payback periods, etc.
Argues that behavioral factors, market barriers, and related sources of energy consumption must also be considered.

Greg Tarr, "Study: Energy Star Brand Gains Awareness As 'Functional' Tool," *TWICE*, March 17, 2010, http://www.twice.com/article/450388-Study_Energy_Star_Brand_Gains_Awareness_As_Functional_Tool.php.
Reports that the 7th EcoPinion study, which was conducted by EcoAlign, found strong awareness of the ENERGY STAR label, especially among older consumers. Warns that the emergence of similar rating programs, e.g. Home Star, may just dilute the strength of the concept.

Pippa Chenevix Trench, *Visibility, Ambivalence, and Trust: Cultural Stumbling Blocks to Greater Household Energy Efficiency*, Project Energy Code (Distributed Energy Financial Group, LLC, October 2008), http://www.defgllc.com/Assets/downloads/project%20energy%20code%2001%20oct2008%20vf.pdf
Addresses the non-economic factors that affect conservation messages. Argues that to be effective messages must show that others are already taking efficiency measures, must not trigger 'green guilt' backlash, and must come from trusted sources.

Ueno, T., Inada, R., Saeki, O., & Tsuji, K. (2005). Effectiveness of displaying energy consumption data in residential houses. Analysis on how the residents respond. Proceedings, European Council for An Energy-Efficient Economy, Paper, 6.

Alladi Venkatesh, "Digital Home Technologies and Transformation of Households," *Information Systems Frontiers* 10, no. 4 (September 2008): 391-395.
Analyzes more generally the effect of IT on the home, with respect to improving or transforming the diverse social and informational functions of a household.

Matthew Wiggins, Kurtis McKenney, and James Brodrick, "Residential Energy Monitoring," *ASHRAE Journal* (June 2009): 88-89.
Argues the importance of residential energy monitoring systems; acknowledges problems of complexity, cost, and retrofit; projects 10% market penetration within a decade.

Iain S. Walker, *Residential Thermostats: Comfort Controls in California Homes* (Berkeley, CA: Lawrence Berkeley National Laboratory, May 2004), http://drrc.lbl.gov/pubs/lbnl-938e.pdf
Reviews the history and literature on residential thermostats, including programmable thermostats.

Whirlpool Corporation, "Whirlpool Corporation survey taps into today's eco-conscious consumer," December 2008, http://www.whirlpoolcorp.com/features/ecosurvey/.
News report on a survey of over 2000 consumers, commissioned by Whirlpool. Confirms that consumers are aware of the importance of energy efficiency; married people are more aware than singles; men would replace the refrigerator but women would replace the washing machine; etc.

Wood, G., & Newborough, M. (2007). Energy-Use information transfer for intelligent homes: Enabling energy conservation with central and local displays. *Energy & Buildings*, 39(4), 495-503.

Alan Wolf, “Friends’ Opinions Matter in CE Purchases,” www.twice.com, December 7, 2009, http://www.twice.com/article/438842-Friends_Opinions_Matter_In_CE_Purchases.php. A poll fielded by BIGresearch on behalf of the Retail Advertising and Marketing Association (RAMA) finds that 43% were influenced by word-of-mouth, 33% by articles. Coupons are effective too.

APPENDIX B

LIST OF ATTENDEES AT UCI WORKSHOP ON APRIL 1, 2010

Last Name	First Name	Company
Abear	Teren	Southern California Edison
Ahmed	Syed	Southern California Edison
Ahmed	Nadia	Engineering - UCI
Ahmed	Abdullah	SCG/SDG&E
Ander	Gregg	Southern California Edison
Arnon	Bob	Verde
Bagherzadeh	Nader	UCI
Bailey	Doug	Power Integrations
Baldi	Pierre	Biology - UCI
Bartholet	Tom	Navigator Strategies
Begalli	Domingos	Physical Sciences -UCI
Behbahani	Alireza	Engineering - UCI
Beigi	Sam	Advanced Solar Integration Technologies
Bell-Wheelans	Andrea	Calit2 - UCI
Benavides	Alfredo	Electrum Engineering
Bonneville	Charlotte	HMG
Brase	Wendell	Administrative Services - UCI
Brouwer	Jacob (Jack)	National Fuel Cell Research Center
Brown	Rich	Lawrence Berkeley National Laboratory
Brownstone	David	Economics - UCI
Buckingham	Mike	Smartlabs, Inc
Capolino	Filippo	Engineering - UCI
Chaubey	Ramesh	U.S. AIR FORCE
Chu	Narisa	CWLab International, Ltd.
Close	Brett	Southern California Edison

Cohen	Linda	Economics - UCI
Corcoran	Gary	LED Era, Inc.
Couch	Patrick	TIAX LLC
Delforge	Pierre	NRDC
Deo	Sumit	Business- UCI
Do	Hong Hoa	Engineering - UCI
Dutt	Nikil	Computer Science - UCI
Edwards	Keith	Aeneas Group, Inc.
Engel	Daniel	Freeman, Sullivan & Company
Everett	Michael	Maxwell Technologies Inc.
Fassler	Richard	Power Integrations
Foksheneanu	Liana	Nextep Consultants LLC
Gallardo	Gregory	Calit2 - UCI
Gamble	Kristen	Social Ecology- UCI
Gomez	Marc	Facilities Management - UCI
Haba	Chaz	I Cel Systems
Hagerty	Brian	Topgallant Energy
Harenburg	Richard	Synergistic Systems
Harrington	Chris	Toshiba America Information Systems
Hasson	Miko	Nextep Consultants LLC
Higa	Randall	SCE
Hinokuma	Ryohei	JETRO
Hornquist	edwin	SCE
Hsieh	Jeffry	SilverPlus
Hundhausen	Allan	FutureDash
Ilyadis	Nick	Broadcom
Jafarkhani	Hamid	Engineering - UCI
Jaffee	Valerie	Jaffee & Associates
Jang	Jae	Aeneas Group, Inc.
Johnson	Jan	Green Tech Communications

Johnson	Douglas	Consumer Electronics Association (CEA)
Kamel Karlin	Michel Beth	MelRoK Corporation Social Ecology - UCI
Khalifeh	Ala'	Engineering - UCI
Kim	Thomas	DKO - HiSAVER
Kim	Jaeyong	LS Cable
Kim	Dy	LS Cable
Kimura	Ken	JETRO
Kirkby	David	Physics and Astronomy - UCI
Koch	Sharon	self-employed
Krishnasamy	Kumaran	Broadcom Corp.
Kurdahi	Fadi	Engineering - UCI
Kwan	Dennis	SilverPlus
Laddey	Virginia	Interested Citizen
Lanzisera	Steven	Lawrence Berkeley National Laboratory
Le	Crystal	Calit2 - UCI
Lew	Virginia	California Energy Commission
Li	G.P.	Calit2 - UCI
Lin	Kwei-Jay	Engineering - UCI
Lou	Wang-He	Mitsubishi
Lowe	Ken	Vizio
Lu	Yarran	Broadcom
Ly	Vireak	Southern California Edison
Mafie	Farhad	Savant Company Inc.
Marcus	Wayne	Seniorresource.com
Matijasevic	Goran	Engineering - UCI
Meacham	Jim	Advanced Energy Services
Meister	Brad	California Energy Commission
Mitchell	Scott	Southern California Edison
Mueller	Fabian	APEP - UCI

Myong	Hanmi	LS Cable
Nazarenus	Shellie	Calit2 - UCI
O'Keefe	Brian	Southern California Edison
Osman	Ayat	CPUC
Palm	Stephen	Broadcom
Parmar	Rajiv	Talus Networks
Resar	Timothy	IVT, Inc.
Ross	Stuart	Calit2 - UCI
Samuelsen	Scott	UCI APEP
Sanchez	Samuel	ACE Computers
Sarem	Sam	Improved Petroleum Recovery Consultants
Schmidt	Edward	NEEP
Scruton	Chris	California Energy Commission
Segal	Jacob	IRG
Shivendu	Shivendu	Business - UCI
Shokair	Said	UROP - UCI
Silverman	Dennis	Physics and Astronomy - UCI
Siminovitch	Michael	CLTC - UC Davis
Slingsby Ph.D.	Steve	GreenTech Fund / MF-CH, Inc
Smedley	Keyue	Engineering - UCI
Strong	Kevin	FutureDash Corp.
Venkatesh	Alladi	Business - UCI
Wong	Teresa	Clinical Data Consultants
Wood	Aeon	At Box Technology
Yamaguchi	Janet	Discovery Science Center
Yeung	Peter	Silver Spring Networks
Zabalegui	Tanya	UCI Extension - OCTANe@UCI
Zaidi	Maha	Sunaira Energy Solutions
Zechmeister	Jerry	Automated Power
Zechory	Avi	Nextep Consultants LLC

APPENDIX C

GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ACM	Association for Computing Machinery
AHAM	Association of Home Appliance Manufacturers
APE	Advanced Power and Energy Program, at UC Irvine
ASAP	Appliance Standards Awareness Project
Btu	British thermal unit
Calit2	California Institute for Telecommunications and Information Technology, at UC Irvine
CE	consumer electronics
CEA	Consumer Electronics Association
CEC	California Energy Commission
CIEE	California Institute for Energy and Environment
CLTC	California Lighting Technology Center, at UC Davis
CPUC	California Public Utilities Commission
CRT	cathode ray tube
DOE	U.S. Department of Energy
DRRC	Demand Response Research Center, at LBL
DVR	digital video recorder
eceee	European Council for an Energy-Efficient Economy
EF	Energy Factor – a measure of useful energy as part of input energy
EIA	Energy Information Administration, a part of DOE
EISA	Energy Independence and Security Act , 2007
EPA	U.S. Environmental Protection Agency
EPACT	Energy Policy Act of 2005
EPCS	Energy Policy and Conservation Act (1975)
EPRI	Electric Power Research Institute
EPS	Eexternal power source, external power supply
GWh	GigaWatt hours
HAN	home area network(s)
HVAC	heating, ventilation, and air conditioning
kW	kilowatts
kWh	kilowatt hours
MWh	megawatt hours
IOU	investor-owned utility
LADWP	Los Angeles Department of Water and Power
LCD	liquid crystal display

LED	light-emitting diode
NAECA	National Appliance Energy Conservation Act, 1987
NEMA	National Electrical Equipment Manufacturers Association
NRDC	Natural Resources Defense Council
PEV	plug-in electric vehicle
PG&E	Pacific Gas and Electric Company
PHEV	plug-in hybrid electric vehicle
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric Company
SMUD	Sacramento Municipal Utility District
STB	set-top box
UCI or UC Irvine	University of California, Irvine
WCEC	Western Cooling Efficiency Center (at UC Davis)
ZNE	Zero Net Energy

ATTACHMENT I

LETTERS OF SUPPORT

Dr. G.P. Li
Director, UCI Division, Calit2
4100 Calit2 Building
University of California, Irvine
Irvine, CA 92697-2800

Dear G.P.,

It was a pleasure to meet you and Stuart when you were in the Bay Area, and I'm glad you had time to also visit our labs in San Ramon. I am happy to write in support of the plans for a center for research and education on appliances and consumer electronics. As a leader among governments in attaining energy efficiency, California should have such a center because appliances and electronic devices are now a major use of energy in residences, offices, and commercial establishments. Based on our own experience and my review of your drafts, I agree that a broad approach is needed to manage the plug load problem. A center that can combine engineering, economics, and social science will be very valuable. Serving as a trusted coordinating point is a needed service in bringing together industry, government, and the utility programs, and I appreciate your recent assistance in contacting electronics manufacturers.

As one of the major investor-owned utilities in California, PG&E has a substantial interest in promoting energy efficiency and conducts trials and demonstrations through our emerging technologies program. PG&E has benefitted from working with the other CEC centers, and I believe a center on appliances and electronics will be a useful addition to the group.

As further plans for the center develop, we look forward to discussing the particulars of how we can work together.

Sincerely,

Lee C. Cooper

Lee Cooper

Manager, Business and Consumer Electronics

Demand Side Management Products

Pacific Gas and Electric Company

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EECR&D Chron #10-033
June 9, 2010

Dr. G.P. Li
Director, UCI Calit2
4100 Calit2 Building
UC Irvine
Irvine, CA 92697-2800

Dear G.P.:

The Sacramento Municipal Utility District supports your plans for a Plug-Load Energy Efficiency Center at UC Irvine. California needs the Center because consumer electronics and plug loads constitute a major use of energy in residences, offices, data centers, and commercial establishments. In fact, consumer electronics are the fastest growing electrical loads in California homes. Based on our conversations and my review of your drafts, I am convinced that an energy efficiency center that focuses specifically on plug loads is needed to grapple with this growing problem. A center could bring together the combinations of engineering, economics, and social science that will be needed, and could provide testing, demonstration and education as well. I believe the Center would play a key role in helping industry, utilities and consumers achieve greater energy efficiency.

At SMUD we have actively promoted energy efficiency for well over 30 years. We have very aggressive energy efficiency goals totaling 15% of electricity sales over a ten-year period. SMUD has an active emerging technology program that works to move emerging technologies into the mainstream. Sample projects include net zero energy homes, deep energy efficiency retrofits and demonstration projects of various lighting, air conditioning, industrial and other energy using processes. We offer energy efficiency classes; provide rebates and tips to our customers; and are actively installing smart meters and other smart grid measures. We are always looking for innovative ways to reduce energy use and save money for our customers. Since consumer electronics represent such a large and growing portion of energy demand throughout the state, we are hoping to leverage the work of the Center in our programs.

I would welcome close coordination with the kind of center you propose. As you and the CEC develop further plans, we will be able to discuss the particulars of how SMUD can help develop the Center.

Sincerely,

James Parks

Jim Parks
Program Manager
Energy Research & Development

CUSTOMER SERVICE CENTER • *6301 S Street, Sacramento CA 95817-1899*

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June 9, 2010

Professor G.P. Li, Director
California Institute of Telecommunications and Information Technology (Calit2)
University of California
Irvine, CA 92697-2800

Dear Professor Li:

We are pleased to write in support of establishing the Plug-Load Energy Efficiency Center at the University of California, Irvine (UCI). CTG Energetics (CTG) is actively involved in the design, construction, and operations of high performance buildings, is an active member of the U.S. Green Building Council, and is a major driver of the evolution of the LEED rating systems. Based on our significant project experience, including multiple zero net energy projects and communities, we find that plug-loads are a critical target for significantly reducing the energy intensity of buildings and achieving the bold energy goals of the state of California. Given the decision of UCI to incorporate Smart HVAC systems, plug-in vehicles, and the demands of server loads into the proposed Plug-in Load Center, we find the opportunity remarkably timely and compelling.

The proposed Center is fortunate to benefit from the reputation and record of UCI in energy technologies, transportation technologies, and building technologies. The campus is widely recognized for its leadership in the advancement of energy efficient systems. The Advanced Power and Energy Program (APEP) and the National Fuel Cell Research Center (NFCRC) are examples of UCI programs with whom CTG has interacted over the years, and the collaboration with the California Institute of Telecommunications and Information Technology (Calit2) offers a unique interface of smart management, smart sensors, and smart appliances.

CTG has been happy to provide support and guidance to the planning process for the Center. Please know that CTG strongly supports the creation of the Center, appreciates the great need for the Center (particularly in southern California), and commends the Commission for establishing the resource on behalf of California.

Sincerely,

CTG Energetics, Inc.

Dr. Malcolm Lewis, P.E. LEED AP
Chairman and CEO

South Coast
Air Quality Management District
21865 Copley Drive, Diamond Bar, CA 91765-4178
(909) 396-2000 · www.aqmd.gov

June 9, 2010

Professor G.P. Li
Director
California Institute of Telecommunications and Information Technology (Calit2)
University of California
Irvine, CA 92697-2800

Dear Professor Li:

The South Coast Air Quality Management District (SCAQMD) staff is pleased to write in support of establishing the Plug-Load Energy Efficiency Center (Center) at the University of California, Irvine (UCI). The goals and activities of the Center, to investigate and implement efficiency strategies and technologies for residential and commercial consumption, appear directly aligned with the SCAQMD goals of ensuring air quality is not sacrificed with the implementation of energy efficient and greenhouse gas reducing technologies. As a large energy load in the basin, building operations represent a major opportunity to reduce the regional emission load, and we look forward to the Center's vision of integrating zero-emission technologies, such as stationary fuel cell distributed generation, into the portfolio of building operations.

This will become increasingly important as "plug-load" appliances transition to vehicles, such as plug-in hybrid electric and battery electric vehicles being introduced at the end of this year. We strongly support the partnership of Calit2 with the Advanced Power and Energy Program (APEP) in order to assure that the full set of building operation technologies and the management of vehicle infrastructure are addressed.

We wish you luck with your efforts and look forward to working with the Center. Should anyone have questions regarding our support, please contact me or Dr. Matt Miyasato at (909) 396-3249 or mmiyasato@aqmd.gov.

Sincerely,

Chung Liu

Chung Liu, D. Env.
Deputy Executive Officer
Science & Technology Advancement

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May 27, 2010

Dr. G.P. Li
Director, UCI Calit2
4100 Calit2 Building
UC Irvine
Irvine, CA 92697-2800

Dear G.P.,

This letter is in support of your plans for a Plug Load Energy Efficiency Center at UC Irvine. California needs such a center as plug load is currently one of the fastest growing energy end uses. Based on our conversations, the workshop you organized in April, and my review of your draft plans, I am confident that Calit2 and UC Irvine will do an excellent job in providing a holistic approach to plug load research and all of the varying facets associated with such an endeavor. You and your faculty and staff have already made good progress in conceptualizing the many aspects of plug load issues. I believe the center will help California develop effective codes and standards, enabling demand response strategies, and identify emerging technology opportunities that will benefit rate payers.

SCE has three well-established Technology Test Centers that include: process refrigeration, heating, ventilating and air conditioning, and lighting systems. We are now developing a center that will examine zero net energy for the residential sector. As a partner with the Lighting Center at UC Davis and the Demand Response Research Center at UC Berkeley, it is easy to foresee similar levels of coordination with the plug load center you are proposing.

As you continue to develop your plans, we remain enthusiastic about this opportunity to advance plug load issues and partner closely with UC Irvine.

Sincerely,

6042 N. Irwindale Ave.
Suite B
Irwindale, CA 91702