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Mr. Chairman, Members of the Subcommittee, my name is Martha Krebs, I am the Deputy Director for Research and Development at the California Energy Commission. It is a pleasure to appear before you and to discuss the experience of the California Energy Commission (CEC) in working with the State's Investor Owned Utilities (IOU) to provide advanced energy efficiency technologies to California's end users.

Overview

In this testimony, I will describe some of the foundational actions that California has taken to establish its leadership in electrical energy efficiency for more than 30 years. Recent actions in efficiency procurement programs as well as climate change policy will assure continuing improvements in electrical energy efficiency, thus reducing demand in the coming years. Finally I will describe the approach that the CEC's Public Interest Energy Research (PIER) program has taken in working with the California IOU's and other State agencies to develop and help bring to market new efficiency technologies. Much of the information in this testimony is based on California Energy Commission documents, in particular, the 2005 Integrated Energy Policy Report and "Energy Efficiency in California and the United States," Chang, Rosenfeld, and McAuliffe, which will appear later this year in Climate Change Science and Policy. The opinions expressed here are my own; while I try to express the policy and accomplishments of California and the CEC, it is not an official document.

California's Energy Efficiency Has Improved Continuously over the last Thirty Years as a Result of Deliberate Policy Action.

There were two critical policy actions taken in the decade after the 1973 OPEC Oil Embargo that has sustained California's leadership in energy efficiency: Appliance and new building efficiency standards and the decoupling of public utility financial returns from the volumes of electricity and natural gas sold.

Standards. California established the state's appliance (Title 20) and new-building (Title 24) standards in 1976 and 1978, respectively. It was the first state in the nation to adopt efficiency standards for appliances. After other states followed, the federal standards were established in the National Appliance Energy Conservation Act of 1987. As administered and developed by the California Energy Commission, these standards are regularly updated and strengthened, repeatedly raising the bar for efficiency gains and

ensuring that California's buildings and appliances will remain the most energy efficient in the nation. California's most recently adopted statewide energy efficiency standards for buildings and appliances (the 2005 updates are expected to save 2,800 MW over the next ten years (about five percent of the 60 GW of in-state capacity). The standards updating process takes place over a three year period that involves open participation by utilities, manufacturers and consumer representatives.

Decoupling. The second critical policy action involved establishing an incentive for utility investments in energy efficiency. Under traditional utility regulation, a utility's recovery of its infrastructure investment costs is tied to how much energy it sells. According to this model, energy efficiency results in lower-than-anticipated sales and thus prevents utilities from fully recovering their fixed costs. As a result, traditional regulation deters utilities from investing in energy efficiency and instead encourages them to increase sales to increase revenues. However, since 1982 (with a brief hiatus in the mid-1990s, when "restructuring" took resource planning responsibilities away from the utilities), California law has required the state's investor-owned utilities to use modest regular adjustments to electric and gas rates to sever the link between the utilities' financial health and the amount of electricity and natural gas they sell. This concept, known as "decoupling," removes significant regulatory and financial barriers to utility investments in cost-effective energy efficiency improvements, and helps align the interests of utilities and customers.

From this period on, California IOUs offered a variety of programs to foster efficiency investments by industry and individual customers. These ranged from direct subsidies to rebate and buy down programs. To support the utilization of advanced technologies in conjunction with the utility programs, the CEC was authorized to establish additional incentive programs for both efficiency and renewable technologies.

Results. With concurrent investments in energy efficiency programs across the state, California has pursued strong energy efficiency programs and policies that have set it apart from the rest of the U.S., **Figure 1** shows that California's historical energy efficiency policies have enabled the state to hold per capita electricity use essentially constant, while in the United States as a whole, per capita electricity use increased by nearly 50 percent since the mid-1970s.

Calculations by Commissioner Arthur Rosenfeld and his colleagues assume that about one-half of the difference between California and the rest of the United States' per capita consumption is due to climate, price, and mix of industries, but the other half is due to the success of state energy efficiency policies, standards and utility programs that promote energy efficient technologies. If California's per capita emissions had grown at the same rate as the rest of the country since 1975, the state would have needed approximately 50 additional medium-sized (500 MW) power plants.

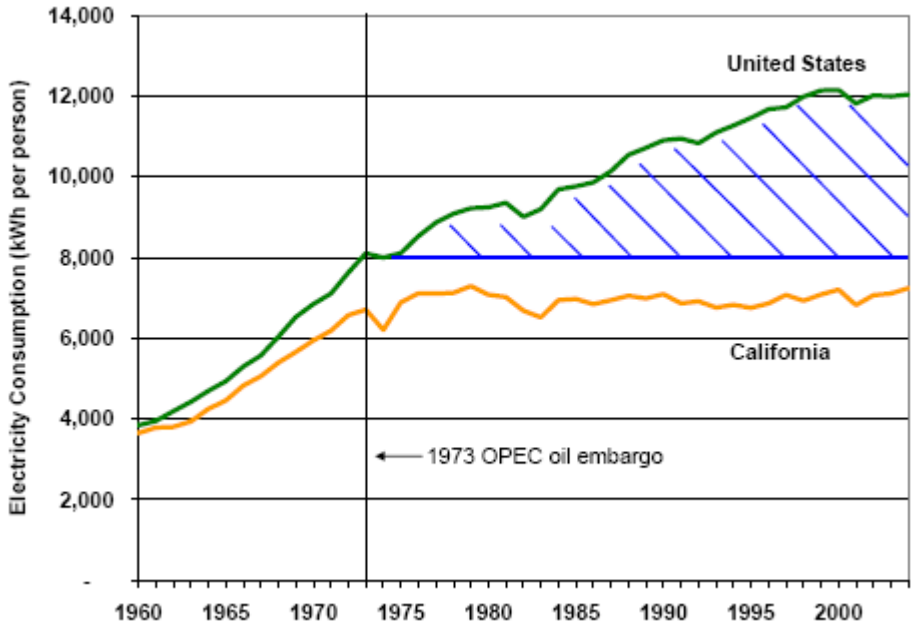

Figure 1: Per Capita Electricity Consumption in California and the U.S.

Figure 2 shows the annual energy savings from California's energy efficiency utility incentive programs and efficiency standards. When summed together, the three decades of energy efficiency programs and standards have resulted in annual efficiency savings today equivalent to approximately 15 percent of California's annual electricity consumption, as shown in Figure 2. From CO2 reduction perspective, these savings

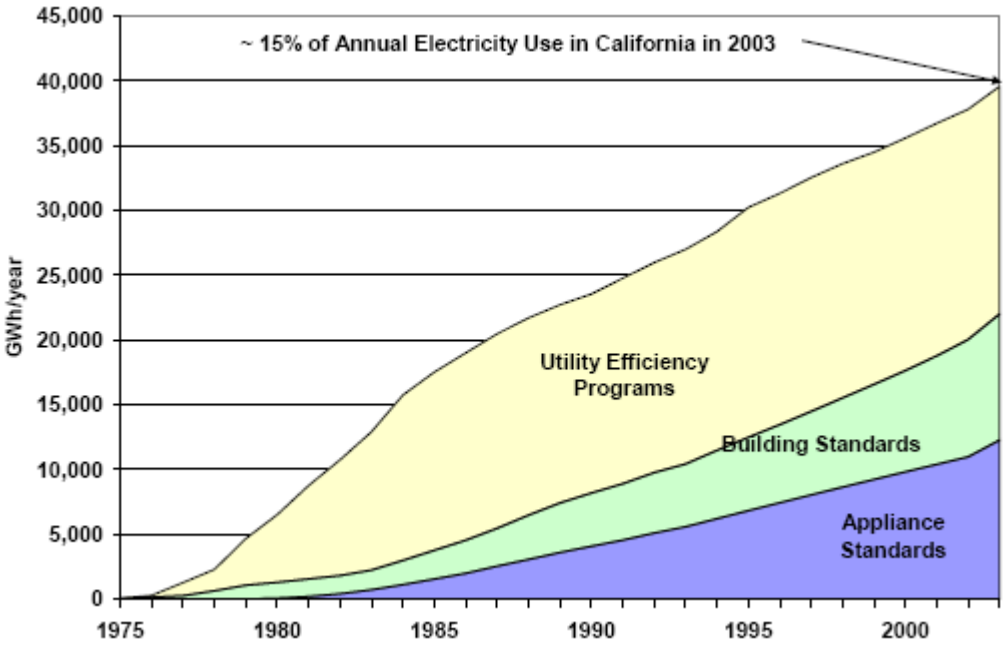

Figure 2: California's Annual Energy Savings from Efficiency Programs and Standards

have reduced CO2 emissions from the electricity generation sector by nearly 20 percent compared to what otherwise might have happened without these programs and standards. This equates to an avoidance of CO2 emissions in the state as a whole of about four percent due to historical energy efficiency programs and standards.

These energy savings, and associated reduction in greenhouse gas emissions, have delivered substantial net economic benefits to California. The state's efficiency standards, which are designed to be cost-effective, accelerate energy savings across the state. The cost of utility efficiency programs has averaged two to three cents per kWh saved, from the utility perspective. This is less than half the cost of the avoided baseload generation – the generation type most often displaced by energy efficiency programs – and is about one-sixth of the cost of peak generation. Over the last decade alone, these efficiency programs have provided net benefits of about $5.3 billion to California's customers from foregone electricity purchases. Though California is often maligned for its high electricity retail *rates* compared to the rest of the U.S., the state's energy efficiency policies have reduced overall energy *bills* for its residents and businesses. Since 1973, on a per capita basis, energy bills in California have averaged $100 per year less than U.S. bills.

Energy Efficiency Is a Critical Component of California's Future Energy and Climate Change Response Policies.

The Loading Order and the 2006-08 Efficiency Resource Procurement by the Investor Owned Utilities. Since 2003, energy efficiency programs in California have been guided by a formal state policy that places cost-effective energy efficiency above all other energy resources. The Energy Action Plan, which was adopted by the state's energy agencies, endorsed by Governor Schwarzenegger, and later updated in 2005, establishes a "loading order" of preferred energy resources. The loading order declares that cost-effective energy efficiency and demand response are the state's top priority procurement resources, followed by renewable energy generation, and finally cleaner and more efficient fossil-fueled generation.

After examining the potential for cost-effective achievable energy efficiency improvements in the state, the California Public Utility Commission (CPUC) in 2004 established energy savings targets for the Investor Owned Utilities that are the most aggressive in the nation. These targets will more than double the current level of savings over the next decade. While other states' energy efficiency efforts deliver annual savings ranging from about 0.1 percent to 0.8 percent of their electricity use, the annual California targets will ramp up to one percent by 2008.

Figure 3 illustrates the historical annual energy savings and the targeted savings levels, which significantly surpass historical reductions. In a few years' time, California's per capita electricity consumption should begin to decline. The energy savings targets will avoid nearly 5,000 MW of peak demand in the next 10 years, averting the construction of

a new 500-MW power plant every year. Customers will also obtain some relief from rising natural gas bills through the tripling of annual gas savings by the end of the decade.

In 2005, California regulators adopted a new administrative structure for the delivery of energy efficiency programs that charges the state's regulated utilities with fully integrating energy efficiency into their resource procurement process. Utilities are now required to invest in energy efficiency whenever it is cheaper than building new power plants, and the savings achieved through these energy efficiency programs will be subject to independent verification. This rigorous evaluation of savings will be essential to ensure that the savings have in fact occurred and can be counted upon for resource planning purposes, as well as for the state's greenhouse gas emission reduction goals.

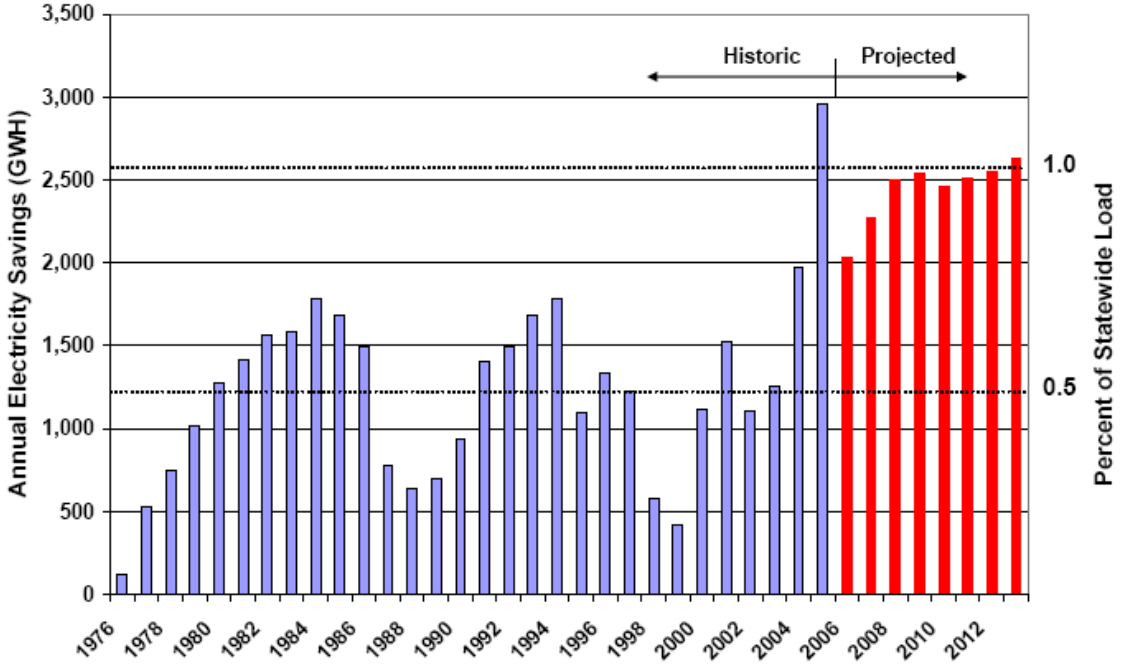

Figure 3: Historical and Projected Electricity Reductions in California

In 2006, California utilities began launching aggressive programs to execute their energy savings goals. The utilities have budgeted $2 billion to deliver their energy efficiency programs during the three-year cycle from 2006 through 2008. This three-year investment will return nearly $3 billion in *net* benefits to California's economy through reduced energy bills and the avoided construction of new power plants. Moreover, by 2008, these programs will reduce the state's annual greenhouse gas emissions by over three million metric tons of CO2, which is equivalent to removing about 650,000 cars from the roads.

In looking forward to the next procurement order beyond 2008 as well as climate change response requirements, the CPUC is holding workshops this summer to explore the technical and financial basis for even larger efficiency savings in the future.

California Climate Action Policy Specifics. In June 2005, Governor Schwarzenegger signed Executive Order S-3-04, which established aggressive greenhouse gas reduction targets for California: reduce greenhouse gas emissions to 2000 levels by 2010; to 1990 levels by 2020; and to 80 percent below 1990 levels by 2050.33 The 2020 emissions reduction goal was subsequently codified by **Assembly Bill (AB) 32**, California's Global Warming Solutions Act of 2006, which was signed into law by the governor in September 2006.

Energy efficiency strategies figure prominently in the state's plan for meeting the 2010 and 2020 GHG reduction goals. While per capita emissions in the utility sector are slowly declining, the state's absolute GHG emissions have risen since the mid-1970s due to continuing population growth of 1.8 percent per year. Some of the strategies identified in this sector involve efficiency efforts already underway as discussed above. For example, currently funded programs and existing efficiency standards in the electricity and natural gas sectors are expected to save 15.8 MmtCO2 in 2020 (about nine percent of what will be needed to meet the state's goal). Other efficiency strategies will require additional action. Existing and expanded efficiency improvements in the buildings and industry sectors are expected to contribute 17 percent of the total greenhouse gas reductions needed to meet the state's 2020 goal.

These contributions to California's emissions reduction goals could be even greater, as the greenhouse gas reductions resulting from future improvements to the state's building and appliance energy efficiency codes and standards have yet to be determined. While transportation is the largest source of GHG emissions (41 percent), electricity consumed by buildings and industry (including electricity imported from out-of-state) is the second largest source of California's GHG emissions, totaling 108 million metric tons of carbon dioxide equivalent (MmtCO2) and accounting for 22 percent (of the state's total GHG emissions. Natural gas use in buildings and industry contribute another 14 percent of California's GHG emissions.

California's Energy Technology Research and Development Programs Have Emphasized Energy Efficiency.

From its initial establishment in 1975, the California Energy Commission has developed and administered incentive programs that support the development, demonstration and deployment of advanced energy technologies across the spectrum of energy generation and end use. The scale of this effort was substantially increased when the Public Interest Energy Research Program was created in 1996.

In 1996 as part of AB 1890 (Chapter 854, Statutes of 1996), California's utility restructuring legislation, the legislature required that $62.5 million be collected annually from the three investor-owned electric utilities and deposited in the Public Interest Energy Research and Development Account, to be invested by the California Energy Commission for energy-related research, development and demonstration (RD&D) efforts that serve the greater public interest. Thus, administration of public interest

RD&D was shifted from California's investor-owned utilities to state government, a major change intended to ensure an appropriate role for public interest energy research in a newly competitive energy marketplace.

By 2002 the Federal natural gas public research surcharge administered by the Gas Technology Institute was being zeroed out by the FERC, California acted to maintain RD&D for its gas utilities. In 2003, the legislature authorized and the CPUC created the Public Interest Natural Gas Research Fund that is administered by the CEC in conjunction with its electric PIER funds. This fund is collected from California's investor owned natural gas utilities; in FY 2007-08, it will provide $18 million for RD&D. Thus the CEC has about $80 million annually to support RD&D to advance new energy technologies, the largest such research funds among the 50 states.

The legislature explicitly defined what energy RD&D "in the public interest" means following three principles; they have guided PIER's investments over its first decade of existence:

- Provide environmentally sound, safe, reliable and affordable energy services and products;
- Support RD&D not adequately provided by competitive *or* regulated energy markets
- Advance energy science and technology to the benefit of all California's citizens.

PIER is reauthorized every five years. Its 2006 reauthorization took place in an atmosphere of high concern and determination to address the impacts of climate change. The legislature rearticulated PIER's goals with an emphasis on reducing greenhouse gases and having market impacts. They also added a new mandate for transportation research relevant to both vehicles and fuels that reflects the concern about transportation as a major source of greenhouse gases. The remaining three goals reflect the continuing importance of the Loading Order discussed above. The goals are:

"Develop and help bring to market, energy technologies that provide increased environmental benefits, greater system reliability, and lower system costs"

- "Advanced transportation technologies that reduce air pollution and greenhouse gas emissions beyond applicable standards, and that benefit electricity and natural gas ratepayers.
- "Increased energy efficiency in buildings, appliances, lighting, and other applications beyond applicable standards, and that benefit electric utility customers.
- "Advanced electricity generation technologies that exceed applicable standards to increase reductions in greenhouse gas emissions from electricity generation, and that benefit electric utility customers.
- "Advanced electricity technologies that reduce or eliminate consumption of water or other finite resources, increase use of renewable energy resources, or improve transmission or distribution of electricity generated from renewable energy resources."

PIER's funding priorities have reflected these goals. Figure 4 represents the cumulative PIER investment from 2001- 2005. The transportation RD&D effort began in FY 2005-06 and is not reflected in this figure. The figure indicates the importance that CEC has placed on efficiency and demand response as a priority target for Energy RD&D in California.

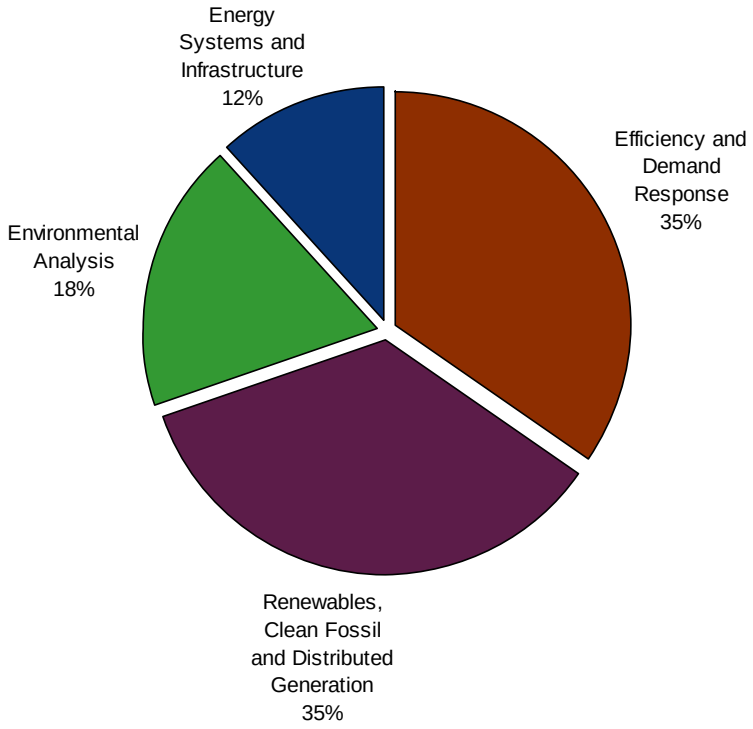

Figure 4: Proportion of PIER Funding by Research Areas for 2001-2005

The CEC RD&D Approach to Efficiency Research. To support the state in accomplishing these policies and goals, as well as anticipate future needs, the PIER program has defined five strategic objectives that will provide California with affordable, comfortable and energy-smart choices for daily life and a strong state economy:

1. ***Reduce energy cost and improve performance of efficiency end-use systems (residential, commercial, industrial, agricultural).*** This objective is directly tied to helping the state meet the aggressive efficiency goals, as well as supports the implementation of efficiency as the first option in the loading order.
2. ***Develop energy-efficient technologies for unique California conditions and industries.*** This objective will also help the state meet the aggressive efficiency goals and it will help address issues related to population and economic growth in hot inland areas.
3. ***Reduce water use and improve efficiency of alternative water sources, treatment, and delivery.*** In addition to supporting the efficiency goals, this objective supports the policy to reduce electricity demand related to the water supply.

4. ***Develop end-use cost-effective load management and demand response technologies.*** This objective supports the aggressive peak demand reduction goals and help mitigate the impact of increased peak demand spikes due to the growth in hot inland areas.
5. ***Develop knowledge base for future decision-making and informed end-use policy relative to electricity.*** This objective will address the trends, technology gaps, and emerging energy issues to provide policymakers with the knowledge required to develop effective future policy in this area.

Buildings Efficiency RD&D Approach. The Buildings RD&D effort area includes new and existing buildings in both the residential and the non-residential sectors. The program seeks to decrease building energy use through research that will develop or improve energy efficient technologies, strategies, tools, and building performance evaluation methods.

A number of specific issues and technologies have been addressed. Customers do not have affordable and effective tools, technologies, controls, and strategies to respond to future time dependent price structures for electricity. Because affordability is the primary driver for building equipment purchase decisions, development of lower first-cost options for energy efficient products, as well as lower operational costs for energy consuming systems, are essential for increasing the adoption of energy efficiency measures in California.

Decisions regarding building components, systems, and operations are generally made based on non-energy considerations, but understanding and addressing the substantial energy impacts of key non-energy considerations such as health, safety and productivity are critical to improving energy efficiency in California's buildings. The existing building sector is so large that efficient replacement products, improved operational strategies, and appropriate intervention tactics that can reach the existing building market are critical.

Systems and equipment frequently perform less efficiently than predicted due to sub-optimal integration of subsystems and components, improper installation, poor maintenance, and user's inability to detect and diagnose equipment performance degradation, thereby reducing the equipment life and increasing energy costs. Technologies, products, strategies and business models developed for national markets do not adequately address California's unique building energy needs, and do not take advantage of state organizations, programs, and initiatives which can help facilitate improved building energy efficiency. The digital revolution has opened up new, more affordable opportunities for energy savings and peak demand management in buildings, but the proliferation of entertainment and information systems has also significantly increased plug loads.

The Buildings research effort has paid off in numerous technology introductions in the last three years:

- Nine new lighting technologies for home, office, and institutional environments using both compact fluorescents and LED technologies.
- Eight commercial Heating, Ventilation and Air Conditioning Technologies
- Fourteen Code Changes for the 2008 Efficiency Standards Process
- The UC-CSU Campus Technology Demonstration Program – 11 technologies on 13 campuses

Industry RD&D Approach. The industrial, agriculture and water sectors in California use 30 percent of all the electricity consumed annually in the state. These sectors - vital to California's economy - rely on an affordable, reliable and sustained supply of energy. Through Research, Development and Demonstration (RD&D), the program seeks to improve the energy efficiency of industrial processes, agricultural operations, and water and wastewater treatment plants. These sectors are also sensitive to the cost, reliability and quality of electric power. Therefore, besides improving energy efficiency, the program also strives to research, develop, and demonstrate technologies that help these sectors deal with cost, power quality and power supply reliability issues. The following priorities guide RD&D in this area:

- Industry - California has a substantial industrial base. The energy reliability of these industries is critical not only for California's economy but for the national economy as well. The major industries - such as food processing, electronics and e-commerce, petroleum refining and production - all depend on continued low cost and reliable energy.
- Agriculture - Agriculture forms a large segment of California's economy worth $27.2 billion dollars in cash receipts in 2000. Agriculture is highly dependent upon electrical energy for irrigation and post-harvest processing. Electrical costs and power reliability are critical for a successful and sustainable agricultural operation. The PIER IAW develops techniques and technologies for advanced irrigation and other load management practices that will help this sector cope better in the current electric market
- Water - The availability of low-cost clean water is essential to California's economy and continued prosperity. The state transports and treats large volumes of water across the state. Both of these activities rely heavily on electric power. RD&D pursues energy efficiency improvements for processing water for urban, industrial and agricultural consumption and energy-efficient wastewater recovery.

PIER Industry Efficiency RD&D has focused advanced technologies for refrigeration and cooling, waste heat recovery, low emission combustion technology in the industrial setting, water treatment and recovery technologies, process heat production, and efficient data centers/server farms.

Demand Response RD&D Approach. Electricity demand in California increases most dramatically in the summer, driven by high air conditioning loads. The generation system must be able to accommodate these high summer peaks, in addition to the demand swings caused by weather variability and the economy. Though peak demand periods typically occur only between 50-100 hours a year, they impose huge burdens on the

electric system. One measure of the "peakiness" of the electric system is load factor, which measures the relationship between annual peak in MW and annual consumption in MWh. If peak demand grows faster than annual average consumption, the load factor decreases. In California in recent years, weather-adjusted load factors have decreased as air conditioner loads have increased.

One problem with meeting peak demand is that most new gas-fired power plants are combined cycle designed to run at high load factors where they are most efficient and can generate enough revenue to recoup investments. Combined-cycle plants also have less capability to ramp up and down to meet peak demand than the older steam boiler units, which make up the majority of California's fleet of power plants. While some utilities have invested in simple-cycle peaking plants that run just a few hours each year, most of the state's new power plants are combined-cycle and are not well matched with swings in system demand.

Demand response programs help reduce peak demand in two ways. First, price-sensitive programs provide customers with the financial incentives and metering technology to reduce electric loads when prices and electricity demand are high. Second, reliability programs provide customers with a non-price signal that clearly shows when system resources are strained and demand reduction would be most beneficial. Reducing system load before it reaches capacity constraints increases the reliability of California's electricity grid. By reducing the need for additional system infrastructure or peaking generation, demand response also lowers consumer electricity costs over the long term.

Price-sensitive and reliability programs are both key components of demand response. The state has historically relied on reliability programs in times of constrained supply, most recently during the summer of 2005 in Southern California. Advances in metering and communications technologies allow significant improvements to price-responsive and signal-responsive programs. New metering technology will be the primary platform for the state's future demand response policies. Both types of programs are being designed to allow customer control—a key feature expected to increase participation by providing customers with greater choice over impacts on their homes and businesses.

PIER Demand Response RD&D includes research on automated demand response technology (AutoDR) for both buildings and selected industrial processes. These technologies focus generally on two-way communication technologies integrated with energy and process controls to permit customers to optimize their work and manufacturing environments while responding to the external energy supply and pricing signals from the utilities. PIER also supports research that examines alternative pricing approaches and mechanisms that can elicit effective demand response from electricity consumers. California electricity utilities are critical participants in this research.

Results from four years of PIER R&D on AutoDR involving over 40 different facilities revealed average demand reductions of about 10-15% during three- to six-hour long peak demand response events. Representatives from firms as diverse as Albertson's, Target, and Cisco report that they believe automating demand response by price signals can

institutionalize these savings, thereby providing California with reliable demand response savings. PG&E plans to install AutoDR technologies in 200 large commercial facilities in 2007 to reduce peak demand by 15 MW.

PIER Efficiency RD&D Programs Focus on Market Success from the Beginning of Individual Projects; California Utilities are Key Players.

In addressing these issues, maintaining a strong market connection is a key goal of the PIER Buildings Program. The PIER Buildings Program strives to maintain a strong market connection in various ways including:

- Identification of research that is responsive to known market needs
- Inclusion of market partners on research teams
- Identification and implementation of market linkages including linkages to the building community, industry, equipment manufacturers, utilities, codes and standards groups, and other implementers of building efficiency market actions.

A major focus of planning and conducting PIER efficiency research is on implementing the research results - we seek market connections early in a research project to encourage industry players who will adopt the results and achieve market impact. Such connections take on many forms, including advisory groups, coordinating groups, and industry organizations. Projects are developed with a view towards progression from technical verification leading to ultimate demonstration in the user's environment. User input is sought from the beginning. This approach is represented in Figure 5 below.

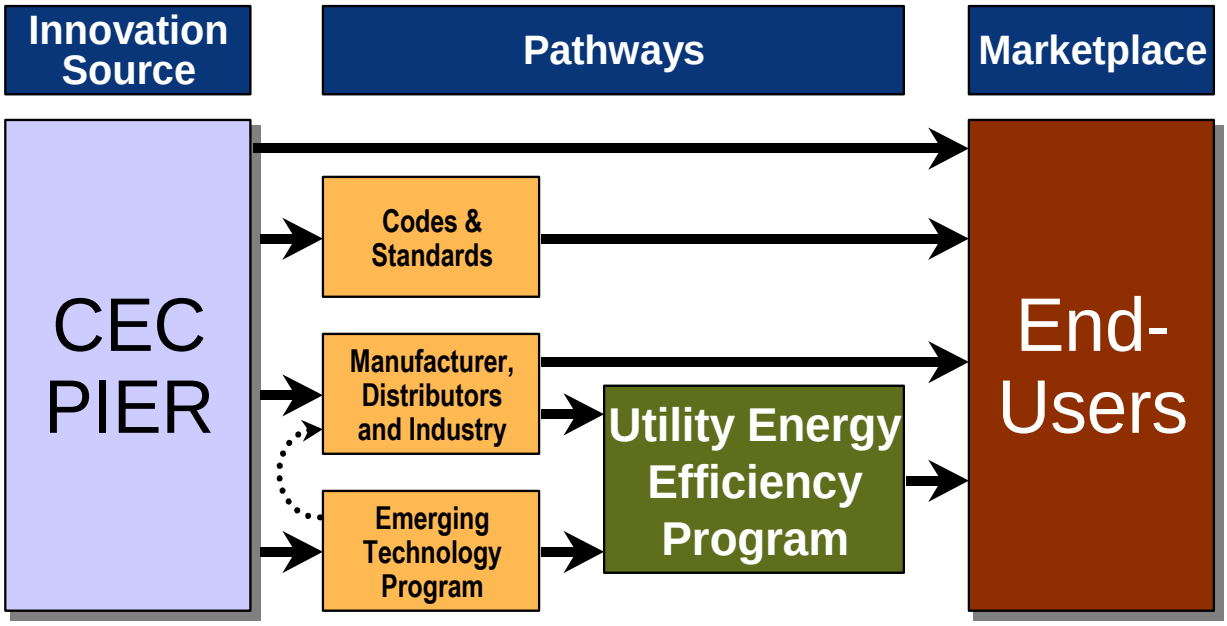

Figure 5: Efficiency Research Program Delivery Mechanism to Market

Many Efficiency RD&D projects enlist the support and guidance of an Advisory Committee and some larger research programs/projects have a Technical Advisory Group (TAG). These advisors are industry representatives from a wide range of disciplines, including building operation/management, insurance, city building codes, energy research, product manufacturing and distribution, and the electric/gas utilities. These advisory bodies provide input on market needs; help refine project scopes; suggest market adopters; and review research results

PIER efficiency research also connects with the market through California's Emerging Technology Coordinating Council. The council is a collaboration of public agencies involved with administrating California utility-ratepayer funded programs for energy related research and energy-efficient emerging technologies. The group includes representatives from the California Energy Commission, Pacific Gas & Electric, Southern California Edison, Southern California Gas, and San Diego Gas & Electric.

The utilities' emerging technology programs as well as their incentives and efficiency procurement programs are critical elements of the market development and commercialization efforts of the CECs Efficiency RD&D program. All of these programs are the result of California's progressive commitment to efficiency and its recognition that technological advance can change the way we produce and use energy. I am pleased to be able to present this information to you.

This completes my prepared testimony. Thank you.

Short Biography for
The Hon. Martha Krebs, Ph.D.

Dr. Krebs is Deputy Director, California Energy Commission for Research&Development, responsible for about $80 million program in applied energy R&D.

She was former Associate Vice Chancellor for Research at UCLA and founding Director of the California NanoSystems Institute at UCLA and UC Santa Barbara. Former

She was the Assistant Secretary of Energy and Director of the Office of Science, 1993-2000, where she was responsible for the $3.5 billion basic research program that underlay the Department's energy, environmental and national security missions.

She was the Associate Director for Planning and Development at the DOE's Lawrence Berkeley National Laboratory (1983-1993), where she was responsible for strategic planning for research and facilities, Laboratory technology transfer, and science education and outreach.

On the House Committee on Science (1977-1983) she served first as a Professional Staff Member and then as Subcommittee Staff Director.

She serves on the Board of Trustees for Institute for Defense Analyses and is a member of the National Research Council's Board on Energy and Environmental Systems and the Borad on Chemical Science and Technology. She is a member of Phi Beta Kappa, a Fellow of the American Physical Society, a Fellow of the American Association for the Advancement of Science, and a Fellow of the Association of Women in Science. Bachelor's degree and Ph.D. in Physics from the Catholic University of America.