CALIFORNIA STATEWIDE COMMERCIAL SECTOR ENERGY EFFICIENCY POTENTIAL STUDY

Study ID #SW039A

FINAL REPORT

VOLUME 1 OF 2
Main Report

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EXECUTIVE SUMMARY

California is the nation's most efficient state in terms of per capita electricity consumption. Since 1973, per capita electricity consumption in the United States increased by 50 percent, while, remarkably, per capita use in California was held constant. Much of this is likely the direct result of the state's conscious efforts to fund and promote energy efficiency through programs and state standards. It's estimated that over the past 25 years these programs and policies have resulted in savings of 9,000 megawatts, equivalent to avoiding construction of 18 mid-size power plants.

Yet, significant energy savings potential remains. This study finds that more than $690 million would be spent on programs to promote efficiency in California's commercial sector over the next 10 years if current efficiency program spending levels continue – an investment projected to yield roughly $2.6 billion in savings. Further, the study shows that increasing funds for programs targeting the commercial sector alone would not only reduce consumption, but also net billions of dollars in additional savings. For example, by doubling the amount spent on such programs, the state could save nearly $3.4 billion on electricity costs.

This is the most comprehensive study of commercial energy-efficiency potential conducted in California, the world's fifth biggest economy, and the first such study to be conducted in the state since the mid-1990s. Recently, a number of factors – supply shortages, price volatility, future price uncertainty – have combined to warrant a detailed analysis of energy-efficiency potential. Energy providers and policy makers can use the study's findings to better understand commercial sector energy efficiency as a cost-effective alternative to conventional power.

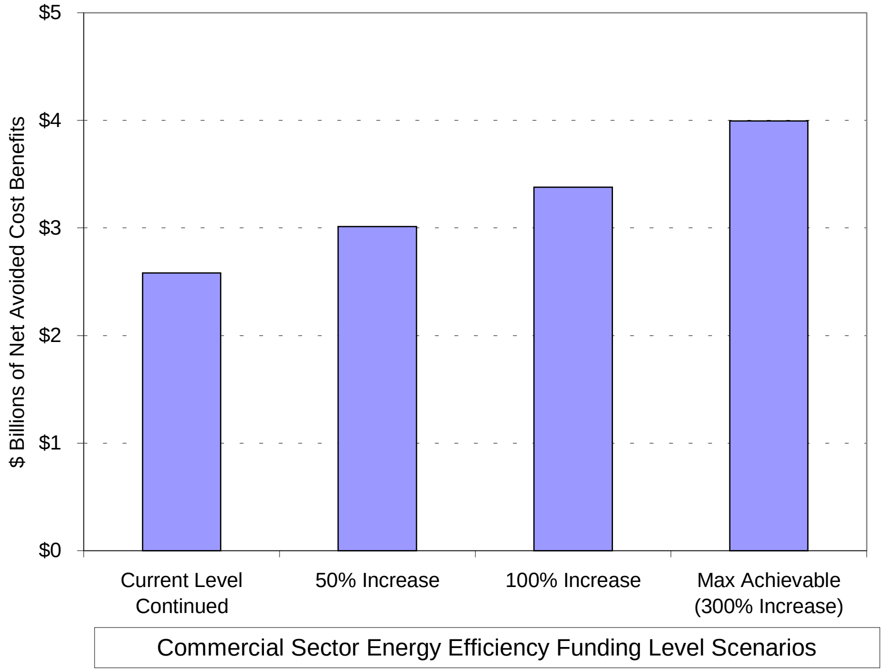
This study assesses electric energy-efficiency potential in existing commercial buildings within the service territories of the three major electric investor-owned utilities (IOUs) in California: Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE), and San Diego Gas and Electric Company (SDG&E). These utilities account for about 80 percent of the state's total electrical consumption and peak demand. The study was managed by PG&E with review and input from the California Measurement Advisory Council (CALMAC) and the Market Assessment and Evaluation Statewide Team of Research Organizations (MAESTRO). It was funded through the public goods charge (PGC) for energy efficiency.

The study is designed to answer a number of research questions important to the planning of future commercial energy-efficiency programs. These include:

- How much near-term commercial sector energy-efficiency potential is there?
- What are the costs associated with this potential and acquiring savings through programs?
- How sensitive are potential estimates to factors such as avoided energy costs and electric rate increases?
- Are the current California commercial energy-efficiency programs generally aligned with the estimated energy-efficiency potential?

Simulating different future funding levels, the study forecasts program energy and peak demand savings under three energy cost scenarios (Base, Low, and High). Under the base energy cost forecast, for example, net program peak savings potential ranges from roughly 785 megawatts (MW) under current funding to 1,650 MW if current funding is tripled. As shown in Figure E-1, net financial savings to the state ranges from $2.6 billion to $4.0 billion, depending on the funding level. All scenarios constructed for the study are cost-effective.

Figure E-1
Net Avoided Cost Benefits of Commercial Electric Efficiency Savings – 2002 to 2011



This report is the first in a planned series examining energy-efficiency potential in the major IOU service territories. Future reports in the series will address energy-efficiency potential in additional sectors and vintages, and will address efficiency potential for natural gas.

E.1 WHY THIS STUDY?

Energy efficiency has been characterized for some time now as an alternative to energy supply options, such as conventional power plants that produce electricity from fossil or nuclear fuels. In the early 1980s, researchers developed and popularized the use of a conservation supply curve paradigm to characterize the potential costs and benefits of energy efficiency. Under this framework, technologies or practices that reduced energy use through efficiency were characterized as “liberating ‘supply’ for other energy demands” and could therefore be thought of as a resource and plotted on an energy supply curve. This energy-efficiency resource paradigm argues simply that the more economic energy efficiency, or “nega-watts” captured, the fewer power plants and less fuel consumption required to power homes and businesses, the lower the associated environmental and human health impacts of energy consumption, the lower the exposure to future energy price volatility, and the lower the total energy bill paid by consumers.

E.2 STUDY SCOPE

This study focuses on assessing electric energy-efficiency potential in the commercial sector *existing construction* market for the major IOUs. This market includes both retrofit and replace-on-burnout measures, and thus it explicitly excludes new construction and major renovation markets. The study assesses achievable potential savings over the mid-term, which we define as the next 10 years, and is restricted to energy-efficiency measures and practices that are presently commercially available. In addition, the scope of this study is focused on measures that could be relatively easily substituted for or applied to existing technologies on a retrofit basis. As a result, measures and savings that might be achieved through integrated redesign of existing energy-using systems, as might be possible during major renovations or remodels, are not included.

E.3 STUDY CONTEXT

E.3.1 California Electricity Use

To understand and estimate the potential for further efficiency improvements in California's electrical energy use, it is important to understand how electricity is used in the state. Energy and peak demand baseline data presented here and throughout this report are based on sector and end use data from 2000, the latest detailed California Energy Commission data available at the time of this study. Thus, these figures do not account for the conservation-based reductions that occurred in 2001. Future updates of this study will incorporate the effects of the conservation and energy-efficiency actions taken in 2001.

Electricity use in California has long been dominated by the residential, commercial, and industrial sectors. The commercial sector, however, makes up the largest share of recent summer peak demand, representing 38 percent of the total state demand (see Figure E-2). The commercial sector of the major IOUs accounts for 30 percent of peak demand in the state. Commercial sector customers within the service territories of the major IOUs accounted for approximately 16,500 MW of the 55,000 MW of peak demand in 2000. For the entire state, the commercial sector accounted for roughly 21,000 MW of summer peak demand**.**

As shown in Figure E-3, the principal end uses that dominate commercial sector peak demand are the air conditioning and lighting of buildings. Air conditioning dominates commercial peak demand in the major IOUs, accounting for 45 percent or roughly 7,300 MW, while lighting accounts for 33 percent or roughly 5,300 MW.

At 100,000 GWh per year, the commercial sector also makes up the largest share of recent electricity consumption, representing 35 percent of the state's usage. The commercial sector of the major IOUs accounts for 28 percent of total electricity consumption (thus, IOU customers account for 80 percent of total commercial consumption in the state). The office sector accounts for the largest share of electricity usage in the IOU territories, at around 28 percent, or roughly 23,000 GWh. The next highest energy consuming segments are food stores, hospital/health facilities, and miscellaneous buildings, with each accounting for about 12 percent of commercial usage in the IOU territories, or about 10,000 GWh each.

Figure E-2
Contribution of Major IOU Commercial Sector to Peak Demand*

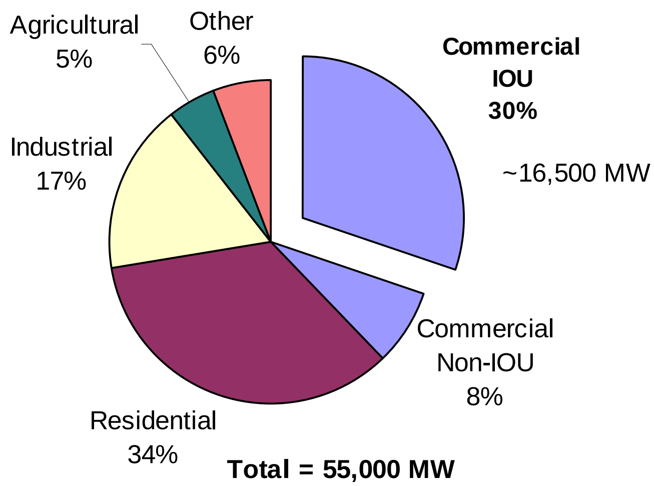
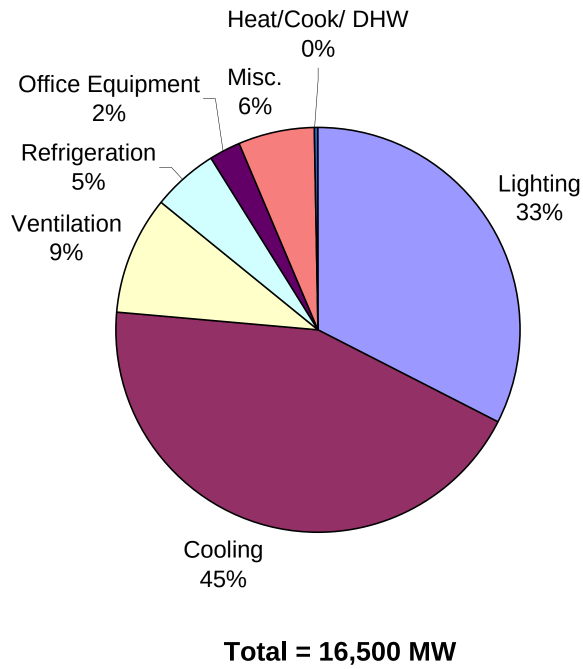


Figure E-3
Breakdown of Commercial IOU Summer Peak Demand by End Use: 2000



XENERGY

E.3.2 Historic Efficiency Programs

California has long been one of the fastest growing states in the United States; nonetheless, it has managed electricity use very efficiently. Since 1973, per capita electricity consumption in the United States increased by 50 percent, while, remarkably, per capita use in California was held constant. As a result, California is the nation's most efficient state in terms of per capita electricity consumption. Much of this is likely a direct result of the state's conscious efforts to fund and promote energy efficiency through programs and state standards.

California has been a consistent leader in developing programs and policies aimed at increasing the efficiency with which electricity is used in the state's economy. Spending on programs, however, has increased and decreased, sometimes dramatically, over time. The cumulative effect of California's efficiency programs and standards over the past 25 years, according to CEC estimates, have resulted in savings of 9,000 MW, equivalent to avoiding construction of 18 five hundred megawatt power plants.

E.4 PROGRAM POTENTIAL RESULTS – 2002 TO 2011

For this study, we constructed four different commercial sector energy-efficiency, funding scenarios. The first scenario is "Continued Current," which is intended to approximate a continuation of the current (2002) program funding level over the next 10 years. The next two scenarios, "50% Increase" and "100% Increase," represent 50-percent and 100-percent increases in total program funding as compared to the "Continued Current" case, over the 10-year period. The last funding scenario is called "Max Achievable." This scenario represents our estimate of maximum achievable potential which could occur if all customers where made fully aware and knowledgeable of efficiency measures and all incremental costs were paid for by the program. Costs under this scenario are roughly 300 percent higher than under the "Continued Current" case.

E.4.1 Program Potentials – Energy and Peak Demand Impacts

We forecasted program energy and peak demand savings under each funding scenario for a 10-year period beginning in 2002. We calibrated our energy-efficiency adoption model to actual program accomplishments over the period 1996 to 2001. Our estimated energy and peak demand program potentials are shown in Figures E-4 and E-5. Net program energy savings potential ranges from roughly 4,000 GWh under "Continued Current" funding to almost 8,000 GWh under "Max Achievable" funding. Program peak demand reductions range from 785 MW to 1,650 MW. "Continued Current" funding is similar to actual funding levels in 1999 and 2000, with incentives set at an average of 33 percent of measure costs. Under the "Continued Current" funding scenario, roughly 38 percent of our estimated economic potential[1] of 10,500 GWh would be captured.

[1] Economic potential is defined in Section 4 and presented in Section 6.

Figure E-4
Program ENERGY Savings Potential by Funding Level

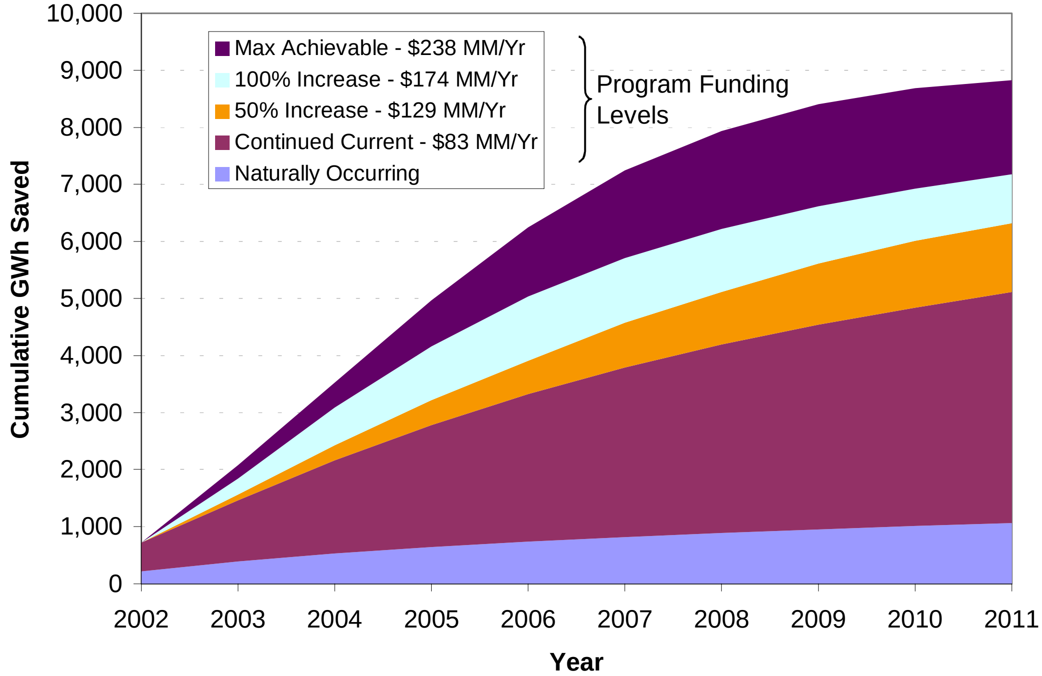
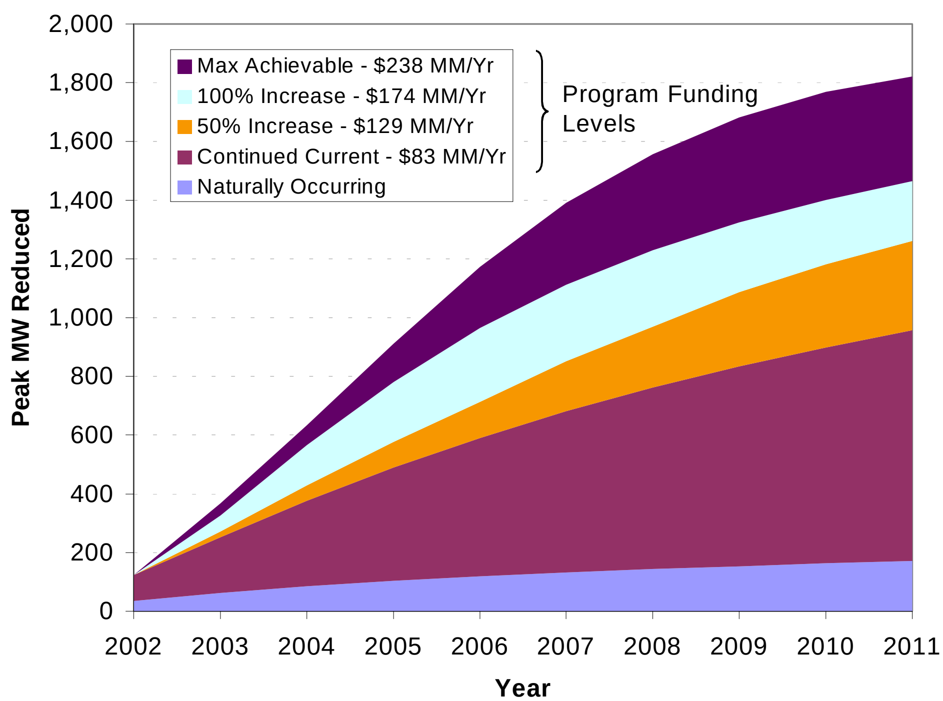


Figure E-5
Program PEAK DEMAND Reduction Potential by Funding Level



Expenditures for "Max Achievable" funding are roughly 200 percent greater than "Continued Current" and provide an estimate of maximum achievable potential in which incentives would cover 100 percent of measure costs and marketing expenditures would make virtually all of the available market aware of efficiency measures. Under the "Max Achievable" scenario, we estimate that 73 percent of the economic potential could be captured.

The "50% Increase" and "100% Increase" are scenarios in which expenditures are 50 percent and 100 percent greater than the "Continued Current" expenditures. Incentive payments as a percent of incremental measure costs average approximately 50 percent and 66 percent under the "50% Increase" and "100% Increase" scenarios, respectively. Estimated energy savings under the "50% Increase" and "100% Increase" scenarios are approximately 5,300 and 6,100 GWh, respectively, and peak demand reductions are 1,100 and 1,300 MW.

E.4.2 Program Potentials – Benefits and Costs

The costs and benefits associated with the commercial efficiency funding scenarios over the 10-year period are shown in Figure E-6. As shown in the figure, total program costs vary from $0.7 billion under the "Continued Current" scenario, to $1.1 billion under "50% Increase," to $1.4 billion under "100% Increase," to $2.0 billion under "Max Achievable." Total avoided cost benefits range from $4 billion under "Continued Current" to $6.8 billion under "Max Achievable." Net avoided cost benefits, which are the difference between total avoided cost benefits and total resource costs (which include participant's costs), range from $2.6 billion to $4.0 billion. All of the funding scenarios are cost-effective based on the total resource cost test, which is the principal test used in California to determine program cost effectiveness:

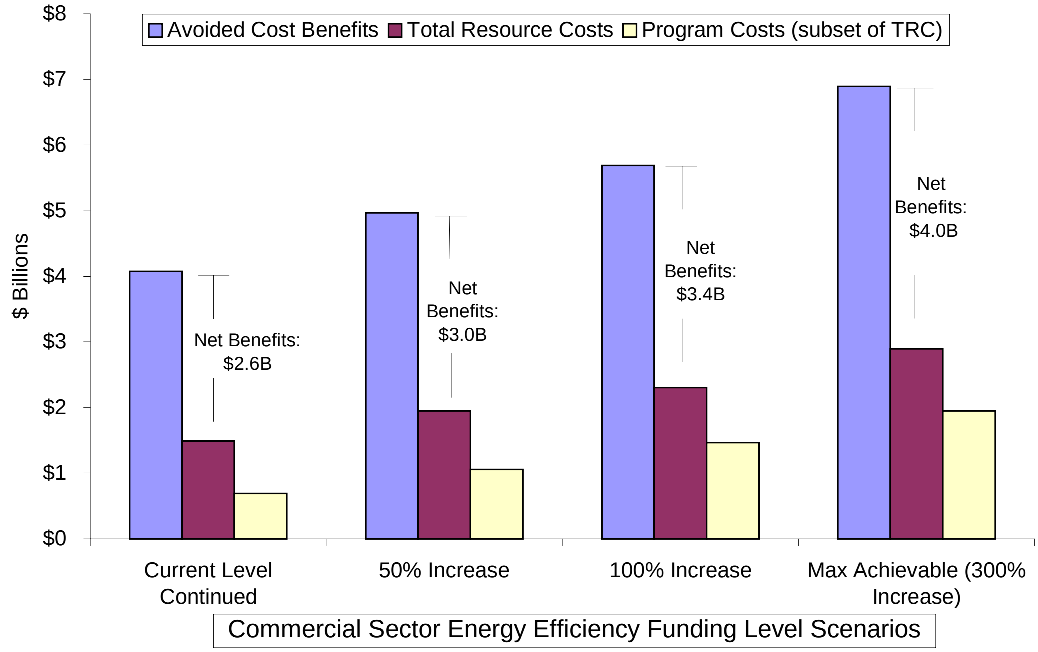
Funding Scenario	Benefit-Cost Ratio
"Continued Current"	2.7
"50% Increase"	2.6
"100% Increase"	2.5
"Max Achievable"	2.4

E.4.3 Program Potentials Under High and Low Energy Costs Scenarios

The preceding results are based on a base case forecast of retail electric rates and avoided costs for energy supply, transmission, and distribution. The assumptions for the base energy cost forecast data are provided in Section 5 of this report. The avoided costs follow those approved by the CPUC for use in the IOUs' 2001 program cost-effectiveness analyses. The base retail rate forecast follows the California Energy Commission's commercial retail rate forecast developed in the fall of 2001. In recognition of the considerable uncertainty in both future retail and wholesale electricity costs, we constructed two alternative energy cost scenarios. One scenario captures a lower cost future and the other a higher cost future.

Estimates of net program potentials under Low energy costs are rough two-thirds of those estimated under the Base energy costs. Program potentials under the High scenario are only about 10 percent higher than under the Base energy costs.

Figure E-6
Costs and Benefits of Commercial Electric Efficiency Savings – 2002 to 2011*



*Note: Participant costs less incentives account for the difference between program costs and total resource costs.

E.5 MOVING FORWARD: A NEW APPROACH TO RESOURCE PLANNING

Although the preceding findings represent a critical first step in the process of understanding the resource potential of energy efficiency in the commercial sector, it is important to remember that they are based on static avoided cost forecasts. Use of static avoided costs does not provide adequate information for determining the optimal mix of all possible resources (e.g., energy efficiency, demand response/load management, distributed generation, conventional supply, renewable energy, etc.). To determine the optimal mix of resources, a broader analytical framework is necessary. Developing such a framework was not a part of the current study; however, efforts to develop such a framework are being considered.

Besides completing additional studies to estimate achievable efficiency potential for other sectors, we believe new analytical methods are necessary to improve upon strategic resource planning processes developed during the period of integrated resource planning in the early 1990s. Research is needed that would explicitly tackle the question of how investments in demand- and supply-side resources should be optimized in California given the events of the past two years. What is needed is an approach that builds off of the lessons learned from both the integrated resource planning period of the late 1980s and early 1990s and the market-based experiments of the last 5 years. Such an approach would require supply-side forecasts and integration analyses that explicitly incorporate price uncertainty, price volatility, and probabilities of future energy “events” such as supply shortages and price spikes.

1 INTRODUCTION

1.1 ABOUT THIS REPORT

This study assesses electric energy-efficiency potential in existing commercial buildings within the service territories of the three major electric investor-owned utilities in California: Pacific Gas and Electric Company (PG&E), Southern California Edison Company (SCE), and San Diego Gas and Electric Company (SDG&E); referred to hereafter as the "major IOUs." The study is managed by PG&E, with review and input from the California Measurement Advisory Council (CALMAC) and the Market Assessment and Evaluation Statewide Team of Research Organizations (MAESTRO). The study was funded through the public goods charge (PGC) for energy efficiency.

This report on electricity savings potential in existing commercial buildings is the first in a planned series of reports on energy-efficiency potential in the major IOU service territories. Future reports in the series will address energy-efficiency potential in additional sectors and vintages, and will address efficiency potential for natural gas.

This report provides both detailed and aggregated estimates of the costs and savings potential of energy-efficiency measures for existing commercial buildings. In addition, forecasts are developed of savings and costs associated with different levels of program funding over a 5-year period. Program savings and cost-effectiveness estimates are also evaluated under several possible future scenarios that take into account uncertainty in electricity rates and wholesale energy costs.

Prior to the current work, no comprehensive study of energy-efficiency potential had been conducted in California since the mid-1990s. Since that time, a number of factors have combined to warrant detailed analysis of energy-efficiency potential in the State.

1.2 WHY AN ENERGY EFFICIENCY POTENTIAL STUDY?

Energy-efficiency potential studies were popular throughout the utility industry from the late 1980s through the mid-1990s. This period coincided with the advent of what was called least-cost or integrated resource planning (IRP). IRP was, and still is in some states, required as a process whereby utilities could consider both supply-side and demand-side resource options to meet future energy needs (EPRI 1991). Energy-efficiency potential studies became one of the primary means of characterizing the resource availability and value of energy efficiency within the overall resource planning process. Like supply-side resources, energy-efficiency resources can be characterized in terms of their costs and availability–on both an hourly basis throughout a typical year and across years into the future.

Although integrated resource planning was abandoned in California with the advent of electric industry restructuring in the State, interest in the resource value of energy efficiency soared when wholesale energy prices spiked out of control in 2000 and 2001. Whether part of formal integrated resource planning or to help policy makers and program planners carry out more effective programs because of energy price shocks, energy-efficiency potential studies help to answer important questions, for example:

- How much near-term energy-efficiency potential is there?
- Is potential running out in some areas or remaining untapped in others?
- What are the costs associated with this potential?
- How much savings can be acquired through programs?
- How sensitive are potential estimates to uncertainty in avoided costs and retail prices?
- How aligned are current programs with estimates of potential?

This report provides both detailed and aggregated estimates of the costs and savings potential of energy-efficiency measures for existing commercial buildings. In addition, forecasts are developed of savings and costs associated with different levels of program funding over a 5-year period. Program savings and cost-effectiveness estimates are also evaluated under several possible future scenarios that take into account uncertainty in electricity rates and wholesale energy costs.

1.3 Study Scope

As noted above, the study focuses on assessing electric energy-efficiency potential in the existing construction market of the commercial sector within the territories of the major IOUs. This market includes both retrofit and replace-on-burnout measures, and thus it explicitly excludes new construction and major renovation markets (new construction will be addressed in subsequent studies). The study is focused on assessing potential savings over the near term, which we define for this report as the next 5 years.

Consistent with this near-term focus, the study is restricted to energy-efficiency measures and practices that are presently commercially available. These are the measures that are of most immediate interest to energy-efficiency program planners. The study data, framework, and models can be easily leveraged in the future to add estimates of potential for emerging technologies. In addition, the scope of this study is focused on measures that could be relatively easily substituted for or applied to existing technologies on a retrofit basis. As a result, measures and savings that might be achieved through integrated redesign of existing energy-using systems, as might be possible during major renovations or remodels, are not included. This is another area in which the current results can be expanded upon.

Finally, note that the analyses for this study were conducted primarily in 2001, a time characterized by unprecedented changes in energy consumption and behavior among consumers and businesses in California in response to the energy crisis. As a result, the estimates of potential presented in this study do not reflect the unusual level of energy conservation that occurred in 2001. As we discuss in Section 2 of this report, the effects of 2001 were not well enough understood to incorporate into the study at the time that the primary analyses were conducted. Future updates of this study may incorporate revised energy consumption baseline information that accounts for any permanent changes in conservation resulting from the recent energy crisis.

1.4 ENERGY EFFICIENCY AS A ENERGY "RESOURCE"

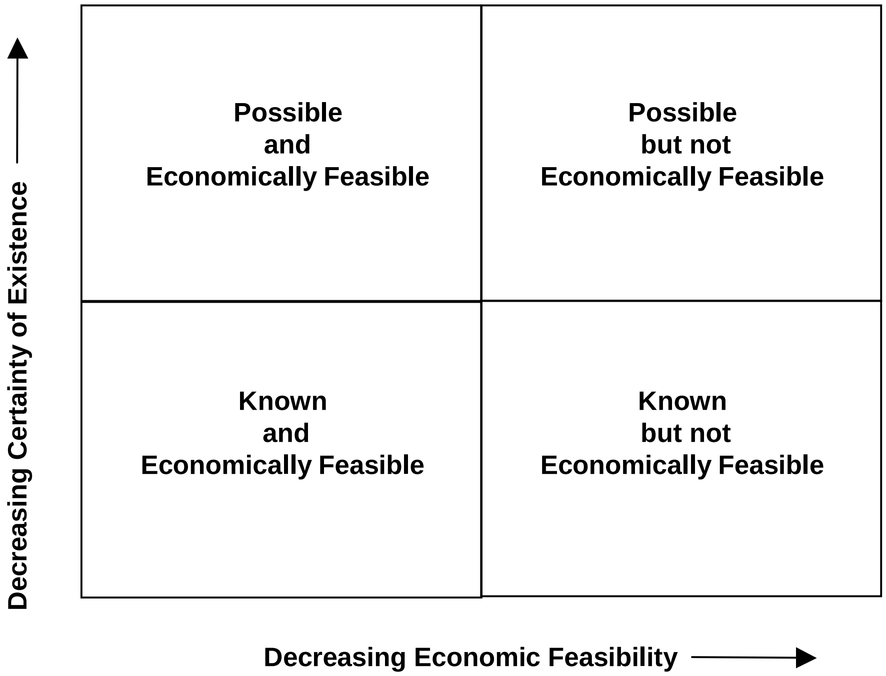
Energy efficiency has been characterized for some time now as an alternative to energy supply options, such as conventional power plants that produce electricity from fossil or nuclear fuels. In the early 1980s, Arthur Rosenfeld,[1] Roger Sant,[2] Amory Lovins (Lovins et al. 1986), and Alan Meier (Meier 1982), among others, conducted much of the initial work in this area by developing and applying conceptual frameworks for understanding and formally characterizing energy efficiency as an energy resource. The term "nega-watt" was coined to emphasize that a kilowatt-hour saved through efficiency was a kilowatt-hour that would not have to be produced and delivered by an existing or new power plant. Meier and Rosenfeld developed and popularized the use of a conservation supply curve paradigm to characterize the potential costs and benefits of energy conservation and efficiency in the early 1980s. Under this framework, technologies or practices that reduced energy use through efficiency were characterized as "liberating 'supply' for other energy demands" and could therefore be thought of as a resource and plotted on an energy supply curve.[3] In short, the energy-efficiency resource paradigm argued simply that the more energy efficiency, or nega-watts produced, the fewer new plants society would need to satisfy consumption.

1.5 TYPES OF POTENTIAL

Like any resource, there are a number of ways in which the energy-efficiency resource can be estimated and characterized. Definitions of energy-efficiency potential are in some ways analogous to definitions of potential developed for finite fossil fuel resources like coal, oil, and natural gas. For example, fossil fuel resources are typically characterized along two primary dimensions: the degree of geologic certainty with which resources may be found and the likelihood that extraction of the resource will be economic. This relationship is shown conceptually in Figure 1-1. As illustrated by the lower left block in the figure, some fossil resources are known with respect to their location and size (usually from drilling samples) and are economically feasible to extract. These are usually referred to as *Proven Reserves*. Other resources are known but not economic to extract. Outside of the known resources are resources that are possible but not well known. Thus, all other quadrants of the figure are *Possible Resources*. However, both the certainty of knowledge about existing resources and their economic viability of extraction can change quickly, for example, in response to wide swings in

[1] Rosenfeld provides an excellent and interesting historical summary of the "early days" of developing estimates of energy-efficiency potential, beginning in the 1970s, in Rosenfeld 1999.
[2] Sant is often credited with coining the terms "least cost energy services" and "cost of conserved energy."
[3] Energy-efficiency supply curves are described in more detail later in this section.

Figure 1-1
Conceptual Framework for Estimates of Fossil Fuel Resources



Source: Healy et al. 1983.

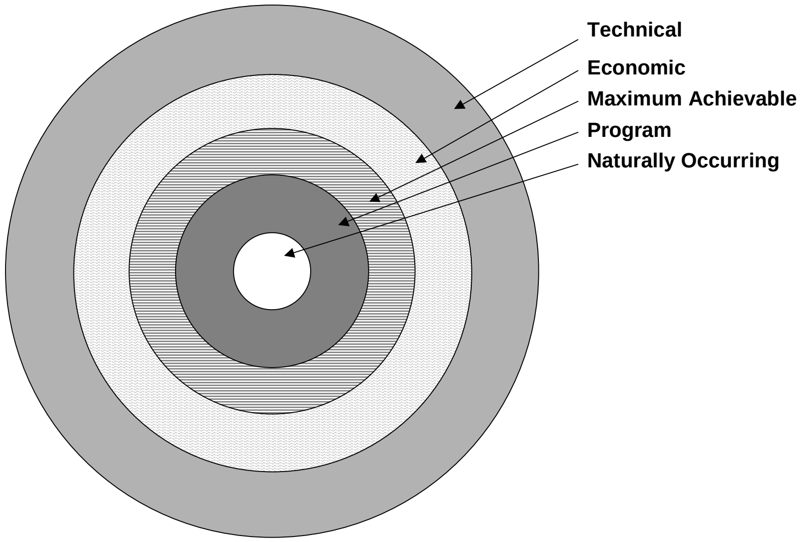
global oil prices. Thus, the conceptual boundaries in the figure have proven to be very amorphous and dynamic over time.

Somewhat analogously, previous energy-efficiency potential studies have defined several different *types* of energy efficiency *potential*. Among the most common of these terms are technical, economic, achievable, program, and naturally occurring potential. These potentials are shown conceptually in Figure 1-2 and described below.

The first set of energy-efficiency potential studies focused primarily on identifying what is often called *technical* potential. **Technical Potential** was usually defined as the *complete* penetration of all measures analyzed in applications where they were deemed *technically* feasible from an *engineering* perspective. These studies sometimes included other efficiency measures that were commercialized and available; however, sometimes studies include emerging technologies that are considered feasible but may not be commercialized. In either case, technical potential is analogous to the *possible resource* definition used for fossil fuels.

As more studies began to be employed in utility IRP processes in the mid-1980s and early 1990s, many authors formally added the concept of *economic* potential to their lexicon. **Economic**

Figure 1-2
Relative Relationship of Energy-Efficiency Potential Definitions



Potential was typically used to refer to the *technical potential* of those energy conservation measures that were cost-effective when compared to supply-side alternatives.[4] Economic potential takes into account the fact that many energy-efficiency measures cost more to purchase initially than do their standard-efficiency counterparts. The incremental costs of each efficiency measure are compared to the savings delivered by the measure to produce estimates of energy savings per unit of additional cost. These estimates of energy-efficiency resource costs can then be compared to estimates of other resources such as building and operating new power plants.

In addition to these concepts, some studies, such as this one, include another: *maximum achievable* potential. **Maximum Achievable Potential** is defined as the amount of economic potential that could be achieved over time under the most aggressive program scenario possible.[5] Experience with efficiency programs shows that maximum achievable potential will always be less than economic potential for two key reasons. First, even if 100 percent of the extra costs to customers of purchasing an energy-efficient product are paid for through program financial incentives such as rebates, not all customers will agree to install the efficient product. Second, delivering programs to customers requires additional expenditures for administration and marketing beyond the costs of the measures themselves. These added program costs reduce the amount of potential that it is economic to acquire.

[4] *Economic potential* has been defined differently in different studies. For example, in the traditional IRP framework, economic potential is often defined based on the marginal cost of building and running new power plants. These studies usually take a utility or societal perspective in defining what is economic. Other studies sometimes define economic potential from the consumer's perspective, that is, based solely on the direct costs and benefits to consumers.

[5] Note that this definition only applies to voluntary programs. Mandatory government efficiency standards, such as California's Title 24 and Title 20 standards, can and do achieve savings equal to economic potential for the equipment or consumption levels regulated.

Although the potentials defined above are important and helpful for establishing the amount of the efficiency resource that is theoretically available, utility resource planners and government policymakers are most interested in knowing the amount of savings or resource reduction that could occur in response to a particular set of programs or policies, rather than the maxima possible in theory. As a result, many energy studies began in the 1990s to formally estimate what is sometimes called *program potential.* **Program Potential** usually refers to the amount of savings that would occur in response to one or more specific market interventions. Because program potential will vary significantly as a function of the specific type and degree of intervention applied, it is often developed for multiple scenarios (e.g., “moderate” intervention versus “aggressive” intervention). Savings associated with program potential are savings that are projected beyond those that would occur naturally in the absence of any market intervention.

The final category of potential used in this study is one that we and others refer to as *naturally occurring* potential. **Naturally Occurring Potential** is often used to refer to the amount of savings estimated to occur as a result of normal market forces, that is, in the absence of any utility or governmental intervention.

1.6 Report Organization

The remainder of this report is organized as follows:

- Section 2 presents an overview of current and projected electricity use;
- Section 3 summarizes historic energy-efficiency expenditures and savings;
- Section 4 presents the methodologies used for this study;
- Section 5 describes the scenarios for which estimates of potential are developed;
- Section 6 presents technical and economic potential results;
- Section 7 presents program potential results;
- Section 8 compares estimates of potential with current and recent program activity;
- Section 9 discusses issues associated with the study results and next steps for further research;
- Appendix A – Data Development
- Appendix B – Economic Inputs (avoided costs, rates, discount rates)
- Appendix C – Measure Inputs
- Appendix D – Non-Additive Measure-Level Results
- Appendix E – Floor Space and Time-of-Use Inputs (square footage and load shapes)
- Appendix F – Program Potential Results
- Appendix G – AB970 HVAC Efficiency Standards
- Appendix H – Summary of PY2001 Commercial IOU Programs

- Appendix I – Office Equipment Analysis Detail
- Appendix J – DSM ASSYST Model Documentation

2 STUDY CONTEXT: ELECTRICITY USE IN CALIFORNIA

In this section we provide background data and discussion on electrical use in California. We begin by presenting historical use for the State as a whole, and then focus on characterizing commercial use within the major IOUs. Our analysis of baseline consumption focuses on the year 2000. We use 2000 as our reference year for two reasons. First, the bulk of the analyses presented in this study were conducted during 2001, meaning that 2000 data was the latest complete year consumption data available to them. Second, as most readers are aware, and as we discuss later in this section, 2001 was an unusual year with respect to energy consumption and peak demand because of the massive conservation response to the 2001 energy crisis.

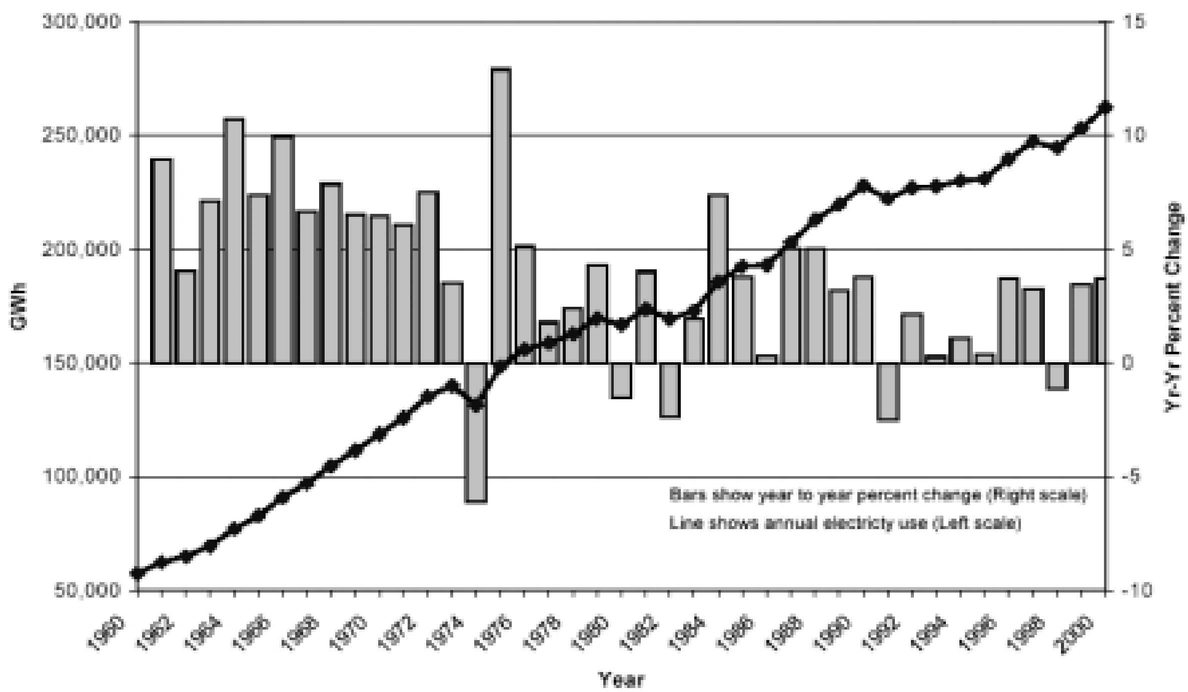
2.1 RECENT OVERALL USE AND PAST TRENDS

California has long been one of the fastest growing states in the United States. Its population has grown from 20 million in 1970 to 34 million in 2000. The State's gross state product increased over the same period from $112 billion[1] to $1,260 billion. Because electricity use is strongly correlated with population and economic growth, the State's energy use has also increased over the past 40 years. The State's energy consumption and percent change in annual electricity use since 1960 are shown in Figure 2-1. In the 13 years preceding the country's first energy crisis in 1973, electricity use in California almost tripled, from 50,000 GWh per year to almost 150,000 GWh per year. The annual rate of electricity growth during these years averaged over 5 percent per year. Over the following quarter century, the average rate of growth of electricity was significantly reduced in California. Electricity growth averaged 3.2 percent per year in the 1980s and only 2.2 percent per year in the 1990s.[2] In fact, while per capita electricity consumption has increased by 50 percent since 1973 in the United States[3] as a whole; remarkably, per capita use in California has been held constant. As a result, California is the nation's most efficient state in terms of per capita electricity consumption. As discussed in Section 3 of this report, much of this is likely a direct result of the State's conscious efforts to fund and promote energy efficiency through programs and state standards.

To understand and estimate the potential for further efficiency improvements in California's electrical energy use, it is important to understand how electricity is used in the State. Two key dimensions of electricity use are sector and end use. Sector refers to the type of customer using electricity (e.g., commercial, residential, etc.), while end use is a term used to refer to service desired by the electricity (e.g., lighting or cooling). Electricity use in California has long been

[1] Source: U.S. Department of Commerce, Bureau of Economic Analysis
[2] Brown, R.E. and Jonathan G. Koomey, 2002. *Electricity Use in California: Past Trends and Present Usage Patterns*, Review Draft, Lawrence Berkeley National Laboratory, LBNL-47992. January.
[3] Note that although per capita use in the US has grown significantly since the 1973 energy crisis, the 1.6 percent rate of growth was well below the 5 percent rate of annual growth in the fifteen years preceding the 1973 crisis.

Figure 2-1
California Electricity Consumption: 1960 – 2000*

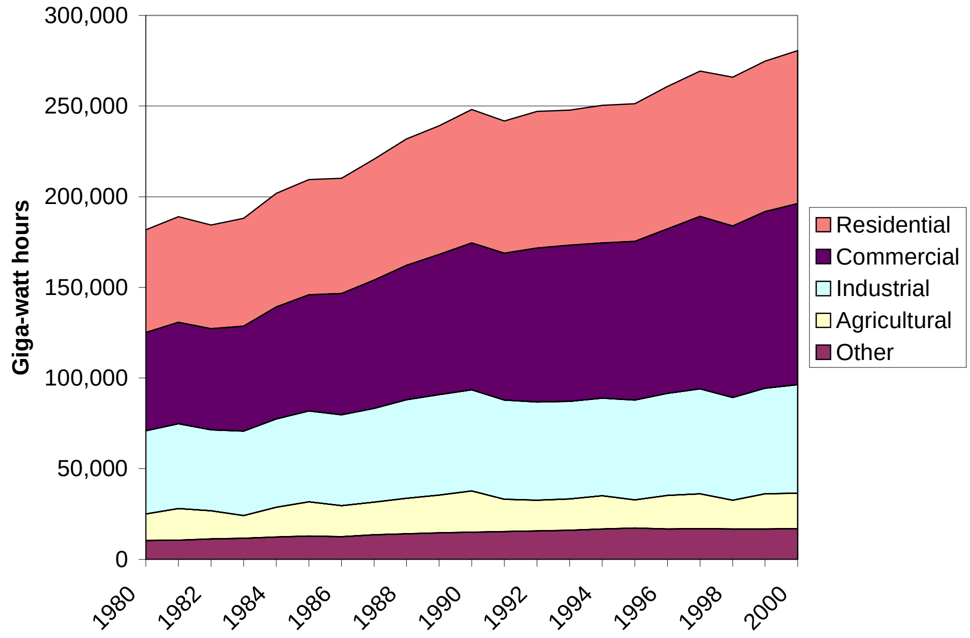


*Excludes line losses.
Source: California Energy Commission (CEC) 2001a. *2002 – 2012 Electricity Outlook*. P700-01-004.

dominated by the residential, commercial, and industrial sectors, as shown in Figures 2-2 and 2-3. The commercial sector makes up the largest share of recent electricity consumption, representing 36 percent of the State's usage, followed by the residential sector at 30 percent, and the industrial sector at 21 percent. The agricultural sector, which dominates the State's water use, makes up 7 percent of its electricity consumption, while other customers, such as transportation and street lighting accounted for the remaining 6 percent. In 1980, the commercial sector represented only 30 percent of total usage. Since 1980, the commercial sector has grown most rapidly, averaging 3 percent per year, while the industrial sector grew most slowly, averaging just 1.3 percent per year. Residential use grew by 2 percent per year over the same period.

When we look at peak electrical demand in the State, shown in Figure 2-4, we see that the commercial and residential sectors are even more significant, accounting for a combined 73 percent of peak load in 2000. Rates of growth for peak demand by sector have been similar to those for electricity consumption over the past 20 years.

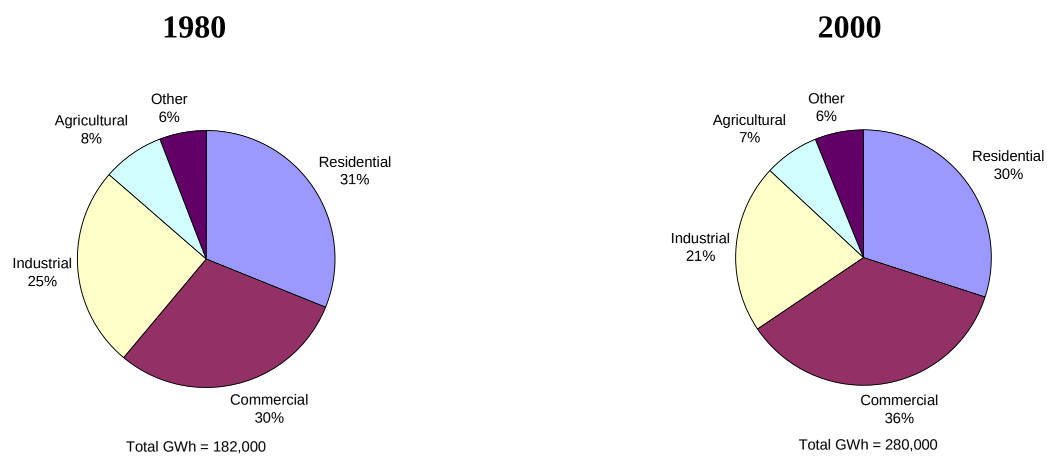
Figure 2-2
California Electricity Consumption by Sector: 1960 – 2000*



*Includes line losses.

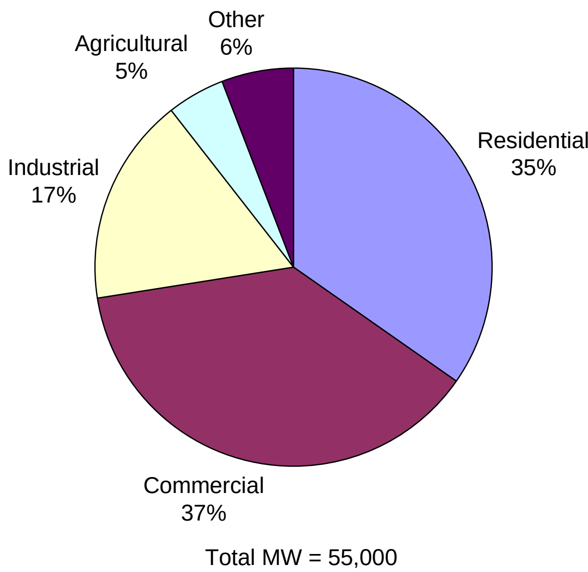
Source: California Energy Commission (CEC) 2000. *California Energy Demand: 2000-2010*. P200-00-002.

Figure 2-3
Breakdown of California Electricity Use by Sector: 1980 and 2000



Source: Brown, R.E. and Jonathan G. Koomey, 2002 and CEC 2000. *California Energy Demand: 2000-2010*.

Figure 2-4
California Peak Electricity Demand by Sector: 2000*

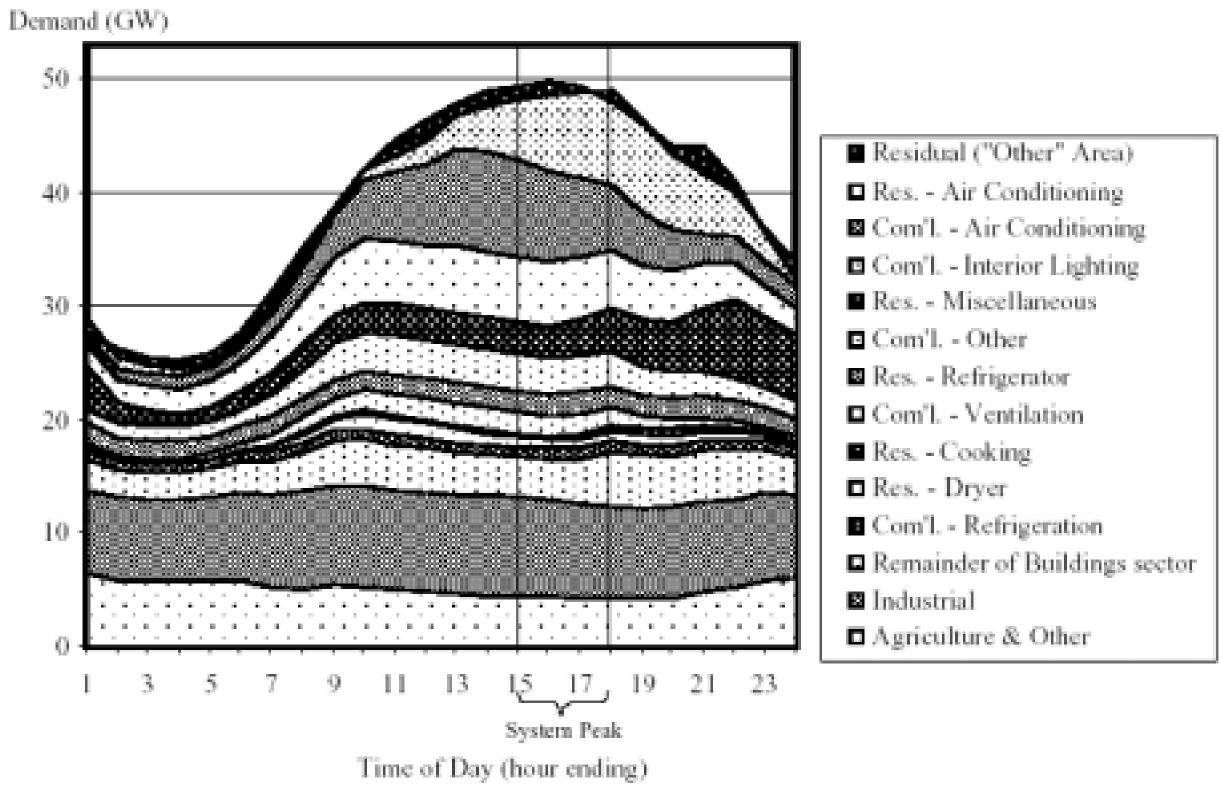


*Includes line losses.
Source: California Energy Commission (CEC) 2001a. *2002 – 2012 Electricity Outlook*. P700-01-004.

Electricity is used within each sector for a wide variety of purposes. For example, in the residential and commercial sectors, building occupants use electricity to obtain lighting, thermal comfort, refrigeration, and other services. In the industrial sector, electricity is used primarily to manufacture products that are used throughout all sectors of the economy. Agricultural electricity use provides for the pumping of water for crops and refrigeration for dairies. Electricity is used to provide street lighting and the movement of electric trains for mass transit systems. Because California is a summer peaking state, that is, the maximum amount of electricity needed occurs during the hottest days of the summer, it should not be surprising that electricity to provide the cooling and ventilation of residential and commercial buildings accounts for the largest share of peak demand, roughly one-third of total, or approximately 16,000 MW of peak demand in 1999. Commercial lighting makes up the next single largest end use share of peak demand at over 5,000 MW. Other key contributors to peak demand include industrial manufacturing (roughly 6,000 MW) and residential lighting and refrigerators (5,000 to 6,000 MW).[4]

[4] Figures cited are from Brown and Koomey's (2002) analysis of CEC and FERC data for 1999.

Figure 2-5
Largest Contributors to California Peak Demand



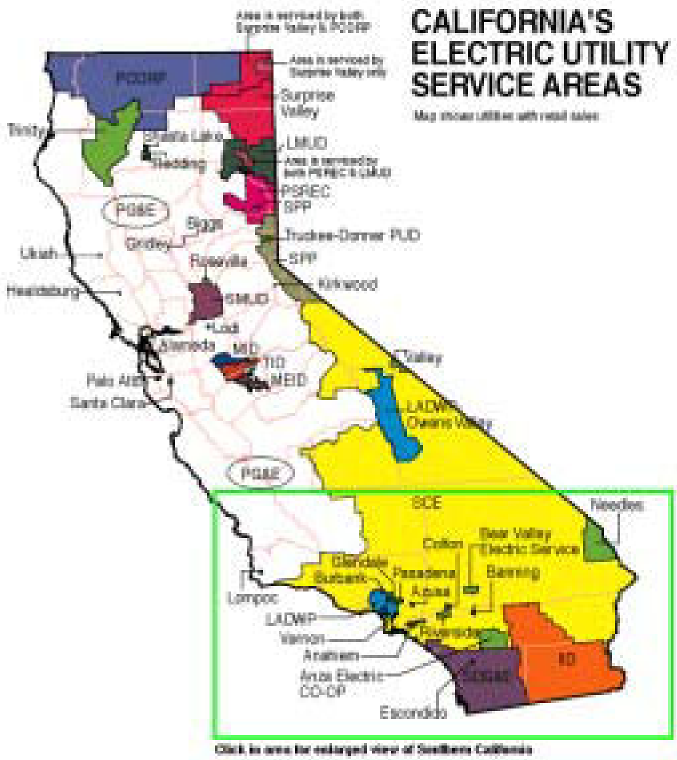
Source: Brown and Koomey 2002.

2.2 IN-SCOPE COMMERCIAL SECTOR ELECTRIC USE FOR THE MAJOR IOUS

The scope of this study includes commercial energy use in the territories of PG&E, SCE, and SDG&E. These territories are shown, along with those of the other utilities in the State, in Figure 2-6. The three major electric IOUs account for about 82 percent of the State's total electrical consumption.

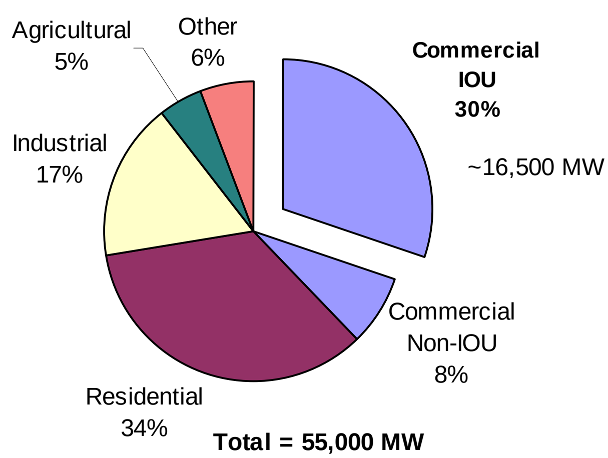
As noted above, the commercial sector is largest contributor to both the State's electrical energy usage and peak demand. Commercial customers within the service territories of the major IOUs accounted for approximately 16,500 MW of peak demand in 2000, which represented roughly 80 percent of the total commercial demand in the State (see Figure 2-7). In 2000, energy consumption for the commercial sector in the major IOU territories was roughly 80,000 GWh (including line losses).

Figure 2-6
California Service Territory Map - 1996



Source: California Energy Commission website: see http://energy.ca.gov/maps/utility_service.html

Figure 2-7
Contribution of Major IOU Commercial Sector to Peak Demand*

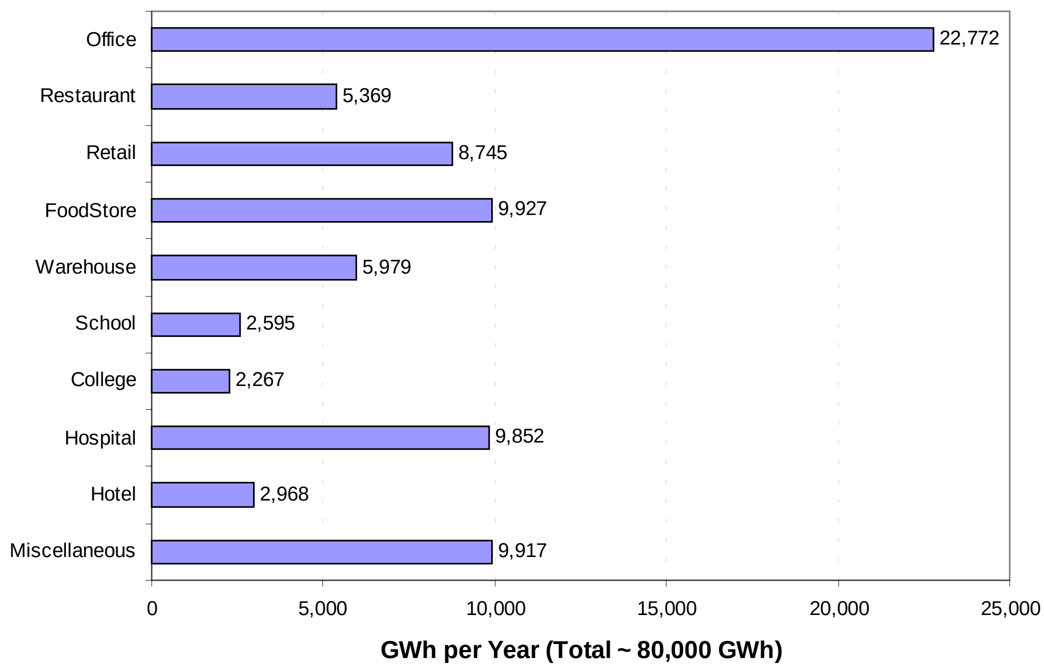


*Includes line losses

Source: Brown, R.E. and Jonathan G. Koomey, 2002 and California Energy Commission (CEC) 2001a. *2002 – 2012 Electricity Outlook*. P700-01-004.

Electricity use within the commercial sector can be analyzed in a variety of ways. In Figures 2-8 through 2-10, we summarize characteristics of commercial electricity usage for customers in the service territories of the major IOUs. Figure 2-8 summarizes commercial energy usage by building type. The office sector accounts for the largest share of electricity usage, around 28 percent, or roughly 23,000 GWh. The next largest energy consuming building types were food stores, hospital/health facilities, and miscellaneous buildings, each account for about 12% of commercial usage or about 10,000 GWh each.

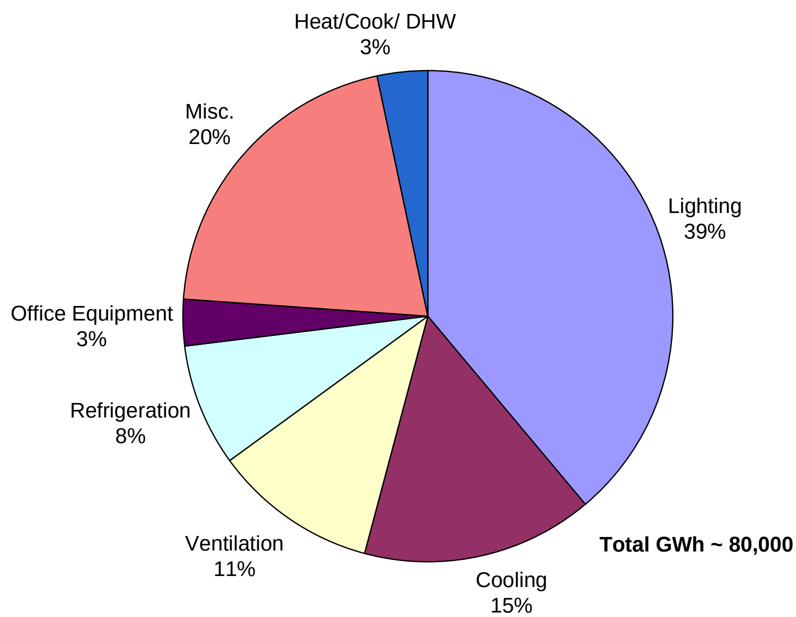
Figure 2-8
Commercial Energy Usage by Building Type within the Major IOU territories*



*Includes line losses. Source: CEC 2000. *California Energy Demand: 2000-2010*.

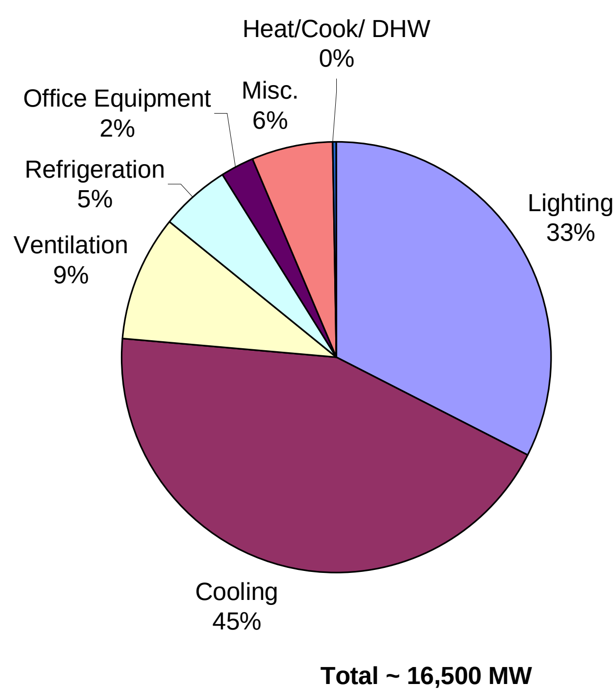
Commercial energy consumption by end use is shown in Figure 2-9. Lighting is by far the largest end use, accounting for 39% of total consumption or about 31,000 GWh. Cooling, ventilation, and refrigeration are the next largest end uses, accounting for about 15 percent, 11 percent, and 8 percent of total consumption respectively. Peak demand is broken down by end use in Figure 2-10. Cooling dominates commercial peak demand, contributing 45percent or roughly 7,300 MW, while lighting accounts for 33 percent and over 5,300 MW.

Figure 2-9
Commercial Energy End Use Breakdown for Major IOUs*



*Includes line losses. Source: CEC 2000. *California Energy Demand: 2000-2010 and XENERGY analysis.*

Figure 2-10
Commercial Peak Demand End Use Breakdown for Major IOUs*



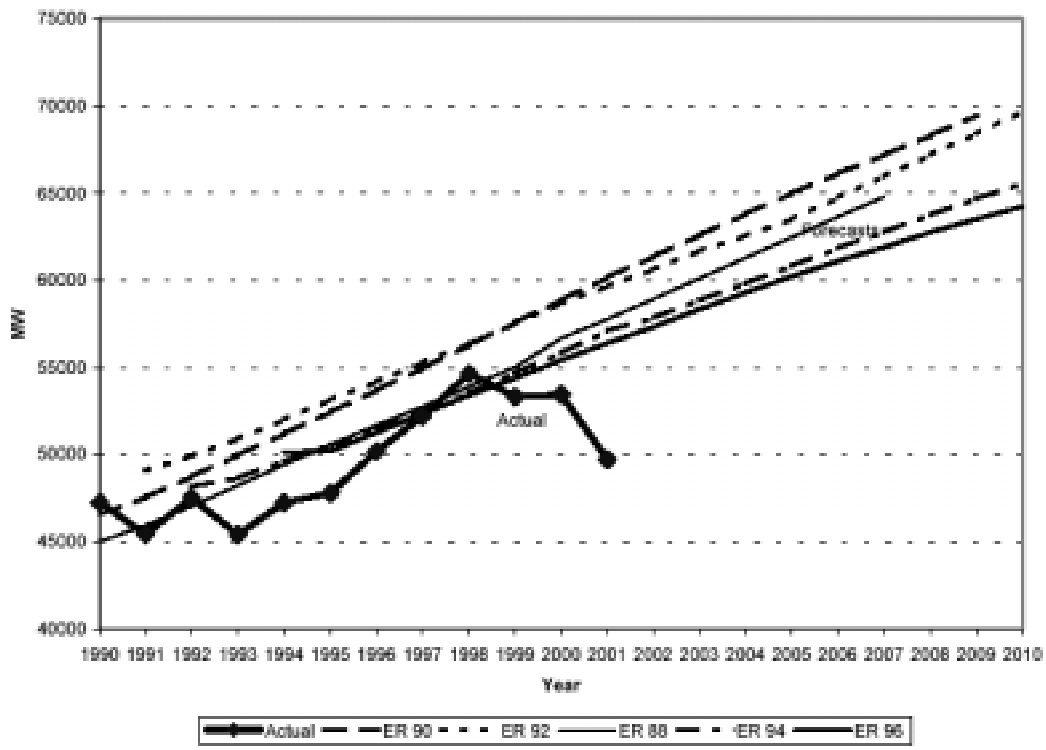
*Includes line losses. Source: RER Inc. and XENERGY Inc. analysis.

2.3 CEC FORECASTS OF FUTURE CONSUMPTION AND PEAK DEMAND

2.3.1 Historic Forecasts

In order to estimate energy efficiency potential over time, it is necessary to benchmark savings to a forecast of electricity consumption. Fortunately, in California there is a consistent statewide process in place for electricity forecasting at the California Energy Commission. The CEC has conducted such forecasts for many years. Throughout much of the 1980s and 1990s, these forecasts were produced as part of biannual Electricity Reports (ER). Examples of forecasts produced for 1988 (ER88) through 1996 (ER96) are shown in Figure 2-11. Note that the historic forecasts assume normal weather and economic conditions. Actual consumption and peak demand in any given year can vary considerably in response to these to conditions.

Figure 2-11
CEC Peak Demand Forecasts Versus Actual

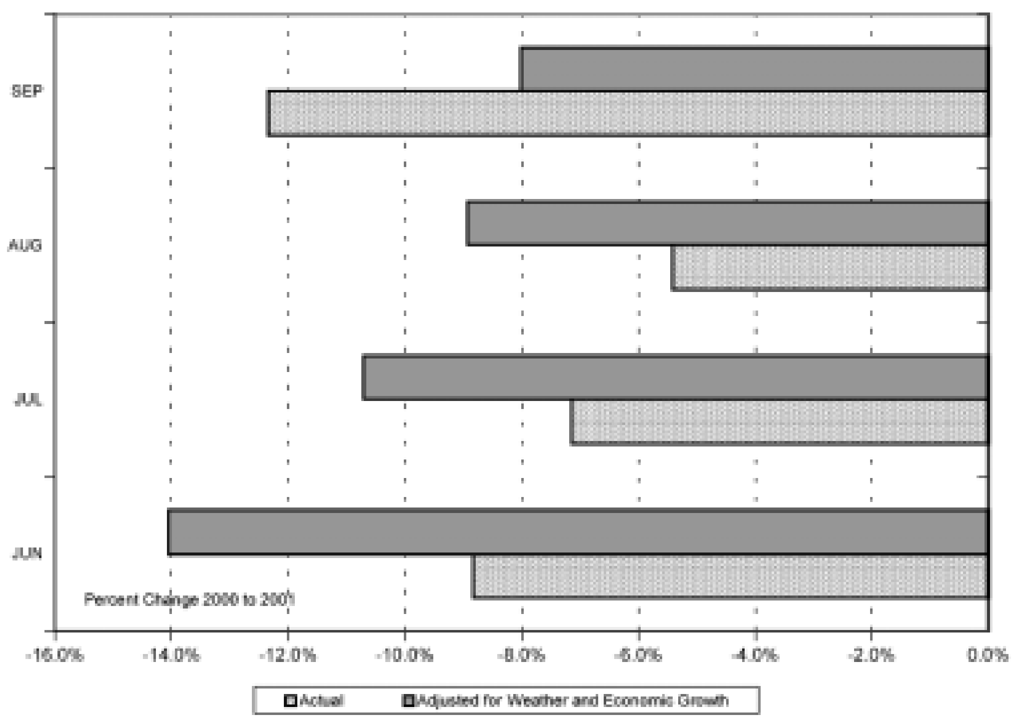


Source: California Energy Commission (CEC) 2001a. *2002 – 2012 Electricity Outlook*. P700-01-004.

2.3.2 2001: An Extraordinary Year

On average, the CEC's forecasts have proven fairly accurate over time; however, like virtually all forecasts, the CEC's methods are not intended to predict extraordinary changes in usage associated with unexpected events like the energy crisis experienced in the second half of 2000 and most of 2001. As has been documented extensively elsewhere, energy consumption and peak demand decreased dramatically in 2001. This reduction can be seen in Figure 2-11 and is shown on a monthly basis, normalized for changes in weather and economic conditions, in Figure 2-12. This reduction occurred as the result of a combination of voluntary demand response from consumers and installation of energy-efficient equipment spurred both by the crisis itself and increased energy-efficiency program efforts.[5,6] The fraction of the reduction in 2001 attributable to voluntary conservation efforts versus installation of major energy-efficient equipment[7] is not currently known with certainty. However, it is likely that the majority of the reduction was due to voluntary conservation efforts.[8]

Figure 2-12
Summer 2001 Peak Demand Reductions



Source: California Energy Commission (CEC) 2001a. *2002 – 2012 Electricity Outlook*. P700-01-004.

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[5] For an analysis of the 2001 Summer demand reduction, see *The Summer 2001 Conservation Report*, published by the California State and Consumer Services Agency, produced by the California Energy Commission under the direction of the Governor's Conservation Team, February 2002.

[6] According to CEC 2001a, key factors driving both voluntary and hardware changes included demand reduction programs, electricity price increases, the 20/20 rebate program, winter rolling outages, and media exposure of the energy crisis and its potential costs to the State and consumers.

[7] *Conservation* refers here to behavioral changes in energy use, such as turning up thermostat settings during cooling periods; *efficiency* refers to permanent changes in equipment that result in increased energy service per unit of energy consumed, e.g., the installation of a more efficient air conditioner.

[8] Some survey results are available from customers interviewed regarding their conservation and efficiency actions in the summer of 2001. For the residential sector, see the *Summer 2001 Conservation Report*; for the commercial sector, see *Statewide Small/Medium Nonresidential Needs and Wants Study*, prepared by Quantum Consulting Inc. and XENERGY Inc. for Pacific Gas and Electric Company, December, 2001.

2.3.3 Current Forecast Scenarios

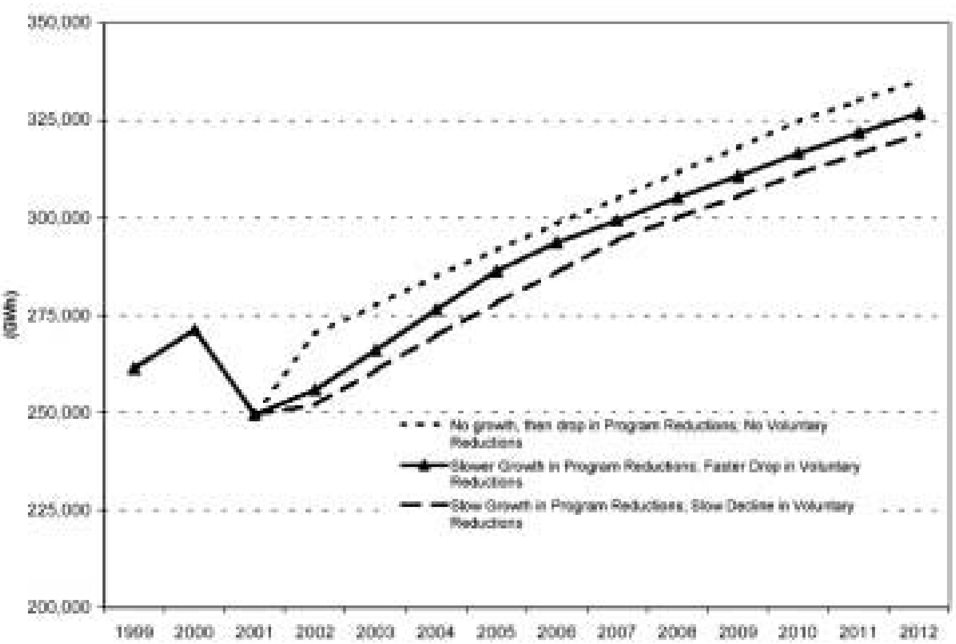
In response to the extraordinary reduction in peak demand and consumption that occurred in 2001, the CEC's latest forecast deviates from its previous forecasting approach, in that it focuses on scenarios rather than single point estimates over time. According to the CEC (2001a):

> The uncertainty about what caused the demand reduction in the summer of 2001, in particular, the uncertainty about how much was due to temporary, behavioral changes and how much was due to permanent, equipment changes, contributes to increased uncertainty about future electricity use trends. To capture this uncertainty about future electricity use, three scenarios were developed. These scenarios combine different levels of temporary and permanent reductions to capture a reasonable range of possible electricity futures.

The CEC developed several possible patterns of future trends in summer 2001 demand reductions. These patterns were based on alternative assumptions about the level and persistence of voluntary impacts and permanent, program impacts. (Note that *program* impacts, as used in the CEC's forecast scenarios, refer to the emergency program efforts initiated in response to the State's energy crisis, i.e., programs funded under SB 5X, AB 970, and AB 29X, not the public goods charge-based efficiency programs administered primarily by the State's major IOUs.) The CEC developed three scenarios, one of which was selected as the most likely case, while the other two scenarios represent higher and lower cases. Figures 2-13 and 2-14 show these energy and peak demand forecast scenarios.

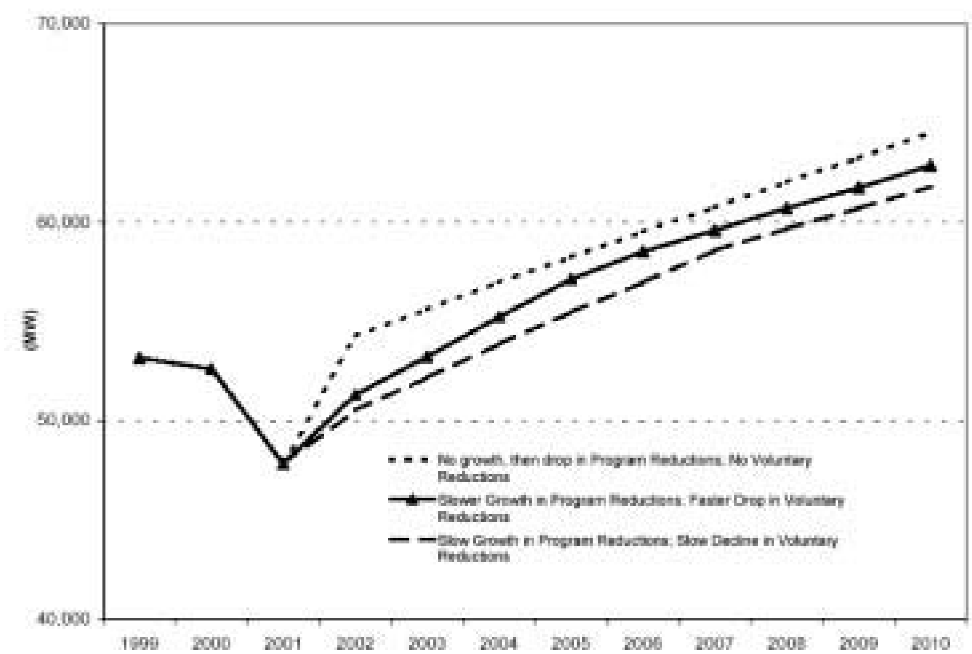
The electricity demand forecast scenario the CEC believes is the most likely scenario, is labeled "Slower Growth in Program Reductions; Faster Drop in Voluntary Reductions" and assumes that program impacts increase in 2002 but stay constant after that, while voluntary impacts decrease more rapidly. Under this scenario, 50 percent of the peak load reductions that occurred in 2001 persist for several years. The lower demand forecast scenario, labeled "Slow Growth in Program Reductions; Slow Decline in Voluntary Reductions", assumes that program impacts grow from 2001 to 2006 while impacts of voluntary reductions drop slowly over the period after an initial drop of 1,000 MW in 2002. Under the lower scenario, roughly 75 percent of 2001 reductions persist. The higher scenario, labeled, "No growth, then drop in Program Reductions; No Voluntary Reductions," assumes that there are no impacts from voluntary actions in 2002 and after, while impacts of programs stay constant until 2005 and then start declining. Under the higher scenario, only about 13 percent of the 2001 reductions persist.

Figure 2-13
CA Energy Commission Energy Consumption Forecasts



Source: California Energy Commission (CEC) 2001a. *2002 – 2012 Electricity Outlook*. P700-01-004.

Figure 2-14
CA Energy Commission Peak Demand Forecasts



Source: California Energy Commission (CEC) 2001a. *2002 – 2012 Electricity Outlook*. P700-01-004.

2.4 USE OF 2000 FOR BASE ENERGY AND PEAK DEMAND FOR THIS STUDY

Note that for the current study we are only estimating energy-efficiency potential for the commercial sector for existing buildings. In addition, the majority of the data development conducted for our study began in early 2001 and used data from the CEC's previous energy forecast (CEC 2000), which predated the unprecedented drop in peak demand and energy use that occurred in response to the energy crisis. As a result, our estimates of efficiency potential presented in this report are exclusive of voluntary, behavioral reductions and efficiency improvements that occurred in 2001.

3 ELECTRIC EFFICIENCY PROGRAMS

In this section we present information on California's electric energy-efficiency programs. We provide historic information on all programs but focus primarily on the commercial sector programs of the major IOUs. Like the information presented in Section 2 of this report, information on past efficiency programs provides an important context for the estimates of energy-efficiency potential developed for this study.

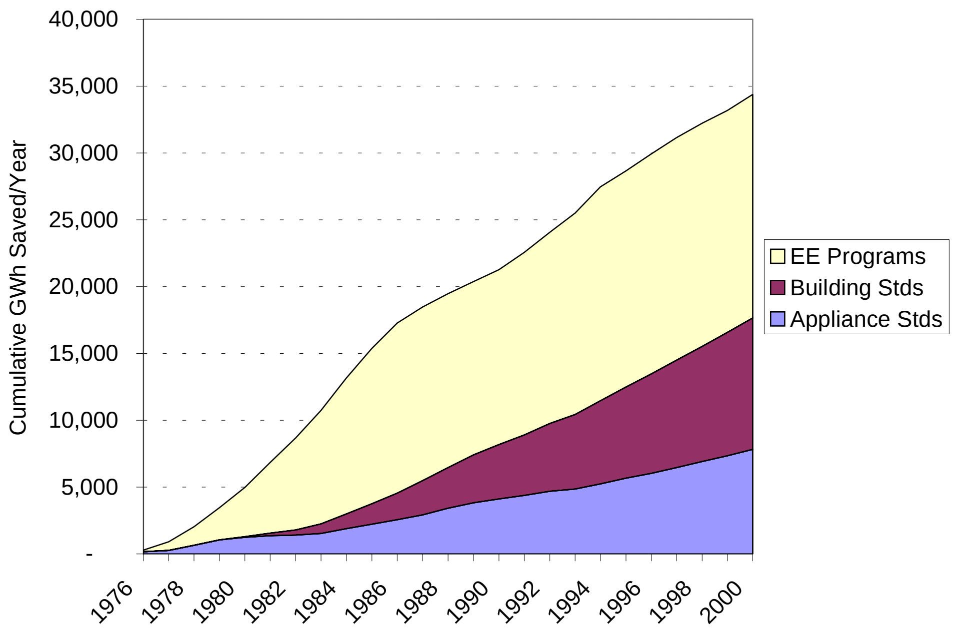
3.1 CALIFORNIA ENERGY-EFFICIENCY PROGRAM IMPACTS

California has long been both a national and international leader in developing programs and policies aimed at increasing the efficiency with which electricity is used in the State's economy. Spending on programs, however, has increased and decreased, sometimes dramatically, over time. Some of the key milestones and trends in the 25-year history of efficiency programs in the State include the following:

- In the mid-1970s, the State, through the California Energy Commission, developed comprehensive energy codes to require that new residential and commercial buildings and appliances meet minimum energy-efficiency standards. The CEC subsequently worked on 3-year cycles to continuously review and upgrade building standards. In 2001, the CEC adopted a set of emergency standards in response to the energy crisis.
- In the late 1970s and 1980s, energy regulators and utilities developed and implemented the first utility-based energy savings programs for the State's major IOUs. These programs focused on squeezing out unnecessary energy waste and installing first-generation efficient equipment. Spending on these programs grew rapidly in the early 1980s but then plummeted in the late 80s as wholesale energy prices decreased.
- In the early 1990s, a group of government, utility, and public interest groups worked together to develop a process for reinvigorating investment in energy efficiency. The California Collaborative, as the group was known, developed an incentive mechanism that rewarded utilities for effective investments in energy-efficiency programs. The work of the Collaborative led to a new surge in efficiency investments that lasted until 1996, when the process of electric restructuring led to another dramatic drop in efficiency program spending.
- In the late 1990s, recognizing their long-term value to the State, California held programs and funding in place during restructuring, at a time when other states completely eliminated programs and funding. Nonetheless, programs in the late 1990s faced several challenges: funding levels were lower than during the earlier part of the decade, policy objectives shifted from resource acquisition to market transformation, and the nexus of program oversight shifted temporarily to the California Board for Energy Efficiency.

Savings from the State's appliance and building standards occur every year directly as a function of construction of new buildings and purchases of new appliances covered by the standards. Because standards require minimum efficiency levels, these savings are immediate and permanent and tend to follow building construction activity levels. Savings from efficiency programs, run primarily by utilities, vary over time primarily as a function of program expenditure levels. As shown in Figures 3-1 and 3-2, cumulative energy and peak demand savings from programs and standards were approximately 34,000 GWh per year and 9,000 MW, respectively, through the year 2000. Savings from energy-efficiency programs accounted for roughly half of the impacts.

Figure 3-1
Energy Savings Impacts of Energy-Efficiency Programs and Standards

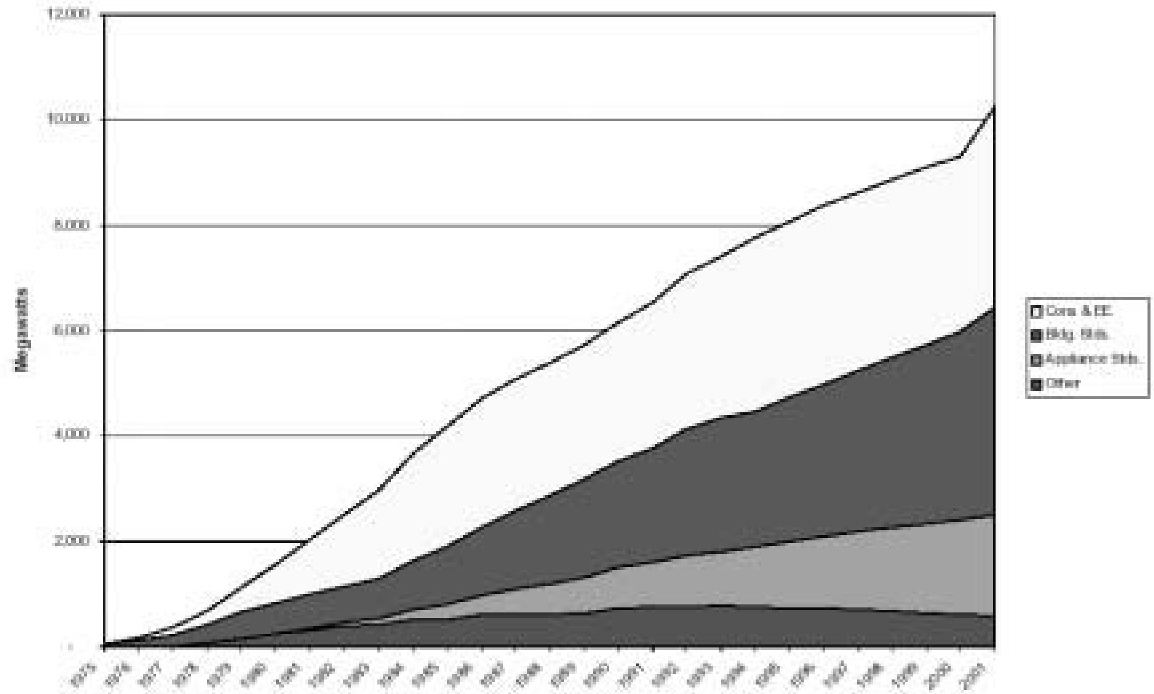


Source: Historic data compiled by CEC staff. Smith 2002.

Savings from energy-efficiency programs have varied widely throughout the past 25 years as a function of changes in annual funding levels. As shown in Figure 3-3, spending levels have peaked twice, once in 1984 and once in 1993, while expenditure downturns and valleys occurred in the latter half of both the 1980s and the 1990s. These dramatic funding swings have reflected changes in policy makers' perceptions about energy prices and the need for new power plants, as well as philosophical shifts in the State's political and regulatory orientation. Expenditures increased in 2000 primarily because of the use of carryover funds that were not expended in previous years and a surge in program demand driven by the increase in wholesale and retail[1] electricity prices that occurred in the second half of the year.

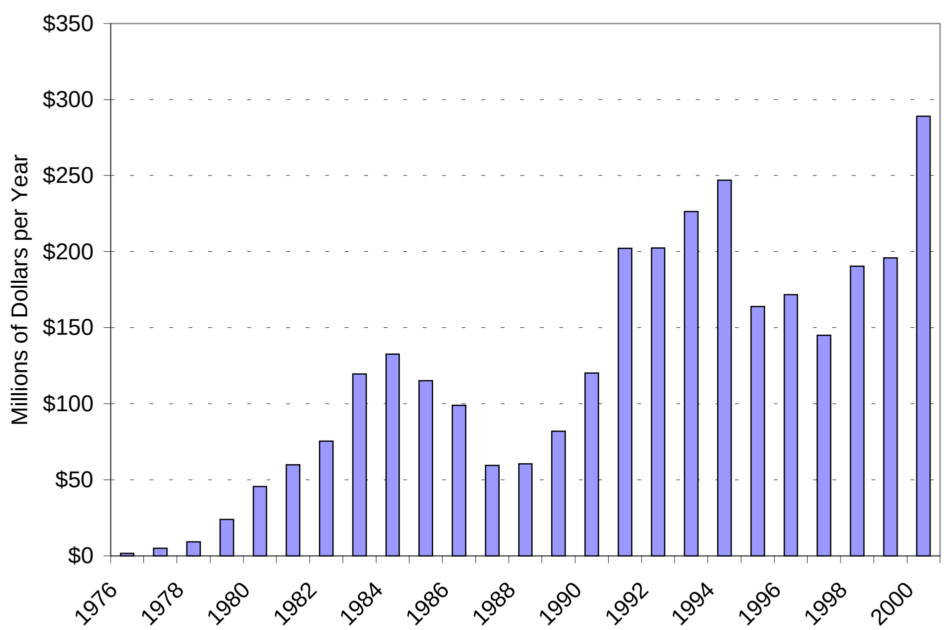
[1] Only customers in the SDG&E service territory were exposed to increased retail prices in the Summer of 2000.

Figure 3-2
Peak Demand Impacts of Energy-Efficiency Programs and Standards



Source: California State and Consumer Services Agency 2002

Figure 3-3
Annual Electric Energy-Efficiency Program Expenditures for Major IOUs (in nominal dollars)



Source: Historic data compiled by CEC staff. Smith 2002.

Annual program impacts for major IOU electric efficiency programs are shown in Figures 3-4 and 3-5. The pattern of energy savings over time generally follows expenditure levels. First-year energy savings of 1,800 GWh have been achieved during spending peaks, but first-year savings have tended to average around 1,000 GWh. Peak demand savings have averaged around 200 MW but reached a peak of over 400 MW in 1994. Nonresidential program savings have accounted for an average of 80 percent of energy savings historically, but represented closer to 70 percent of savings in recent years.

The cumulative effect of California's efficiency programs and standards is shown in relation to actual energy consumption over the past 25 years in Figure 3-6. According to CEC estimates, these programs and policies have resulted in savings of 9,000 MW, equivalent to avoiding construction of 18 500-MW power plants.

Figure 3-4
First-Year Electric Energy Savings for Major IOUs' Efficiency Programs

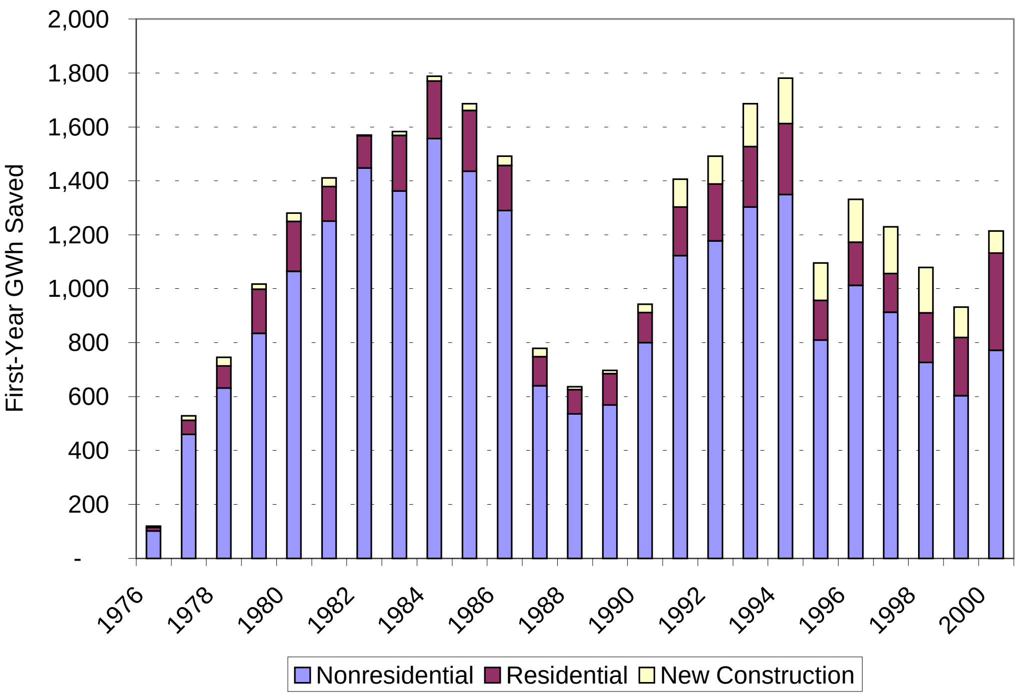


Figure 3-5
First-Year Peak Demand Savings for Major IOUs' Efficiency Programs

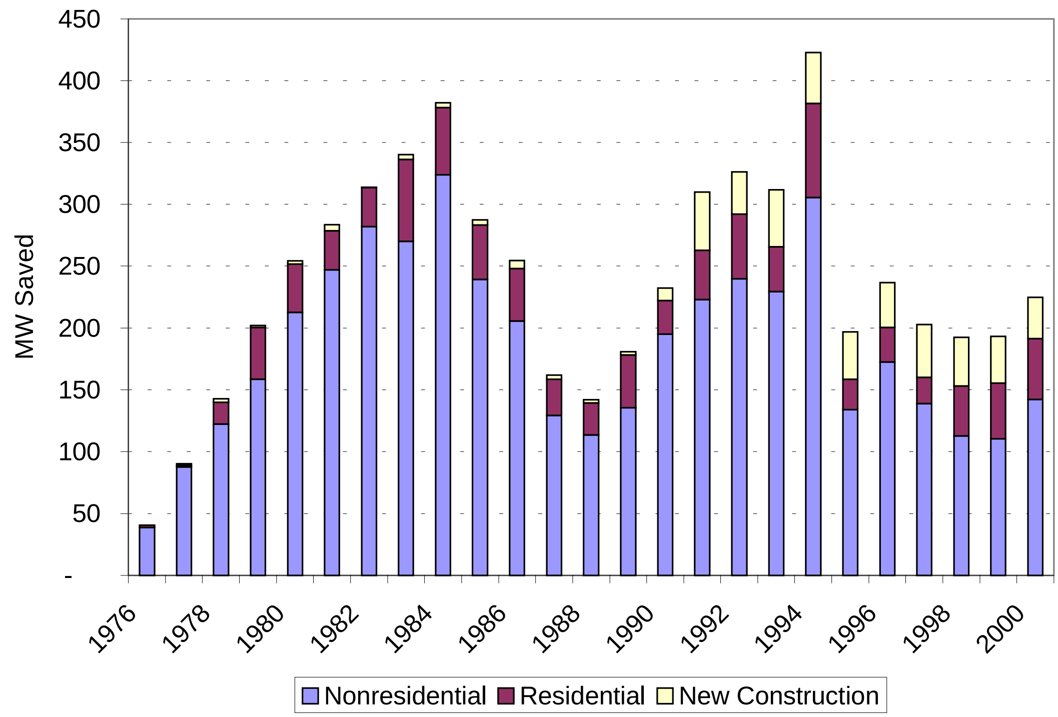
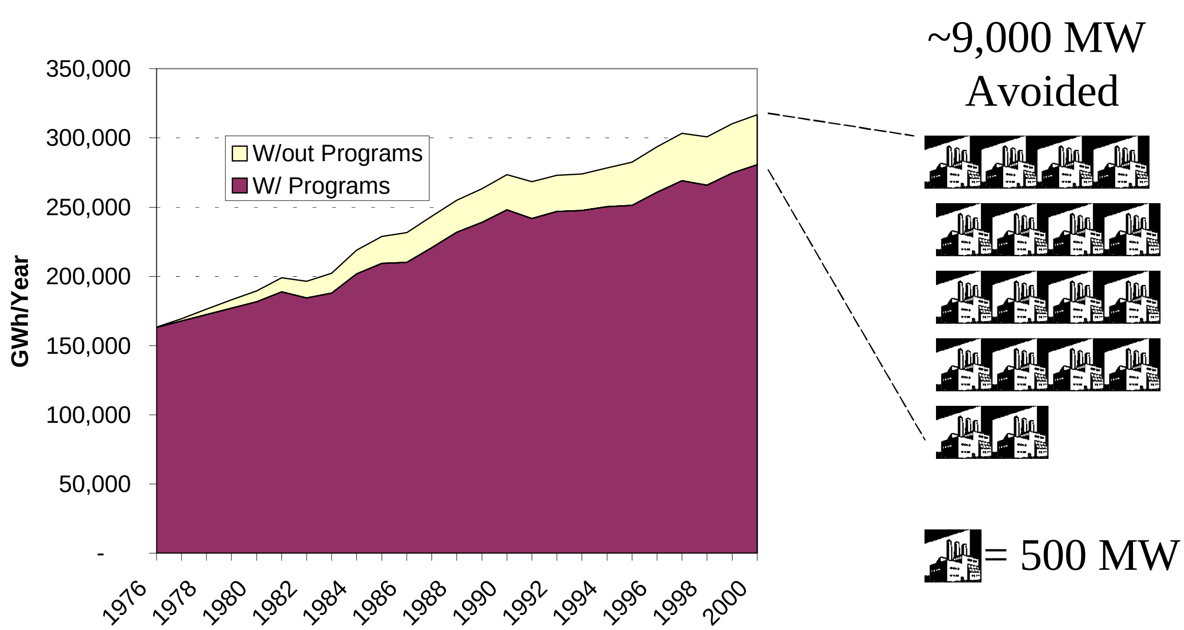


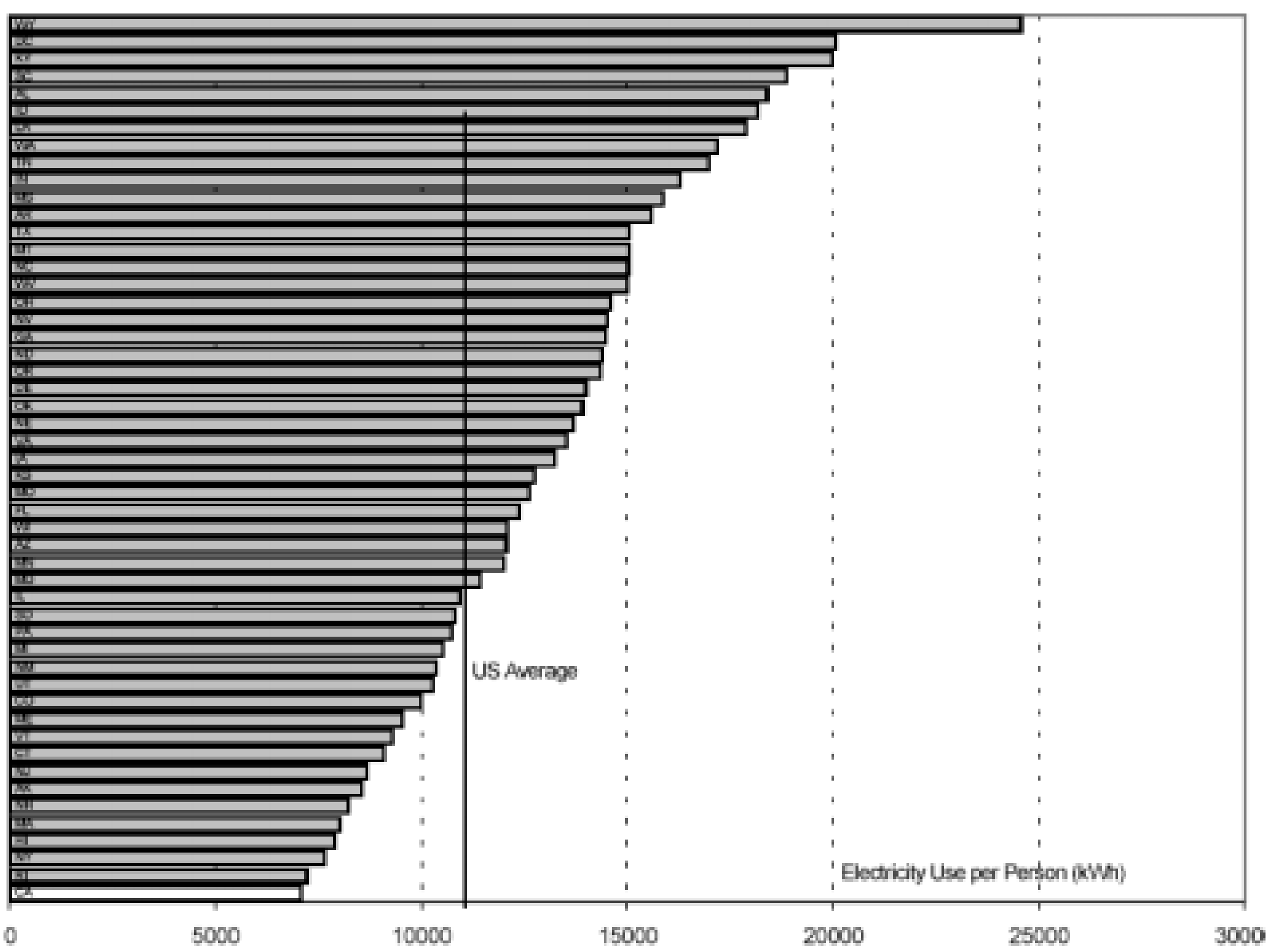
Figure 3-6
Cumulative Impact of California Efficiency Programs and Standards



3.2 EFFICIENCY OF CALIFORNIA ELECTRICAL USE COMPARED TO REST OF U.S.

Partly as a result of the State's assertive energy programs and policies, California is the nation's most efficient state in terms of per capita electricity consumption, as shown in Figure 3-7. Electricity use in California and the rest of the U.S. is a function of many factors. Generally, electricity use increases during times of increased economic activity and population growth and decreases or remains flat during periods of weak economic activity or net decreases in population growth. Electricity use changes as a result of another key factor: *efficiency*. Efficiency measures the amount of work or useful services that are obtained from a unit of energy consumed. The more efficient an energy using system, the more work or useful service, such as light or heat, that is obtained per unit of energy consumed. Note that *efficiency* is not the same as *conservation*. Conservation involves using less of a resource, usually through behavioral changes, such as raising a thermostat setting from 75 to 78 ^{o}F for air conditioning on a hot day. As a result of the availability of gains from efficiency and conservation, the relationship between economic growth and electricity use is far from constant.

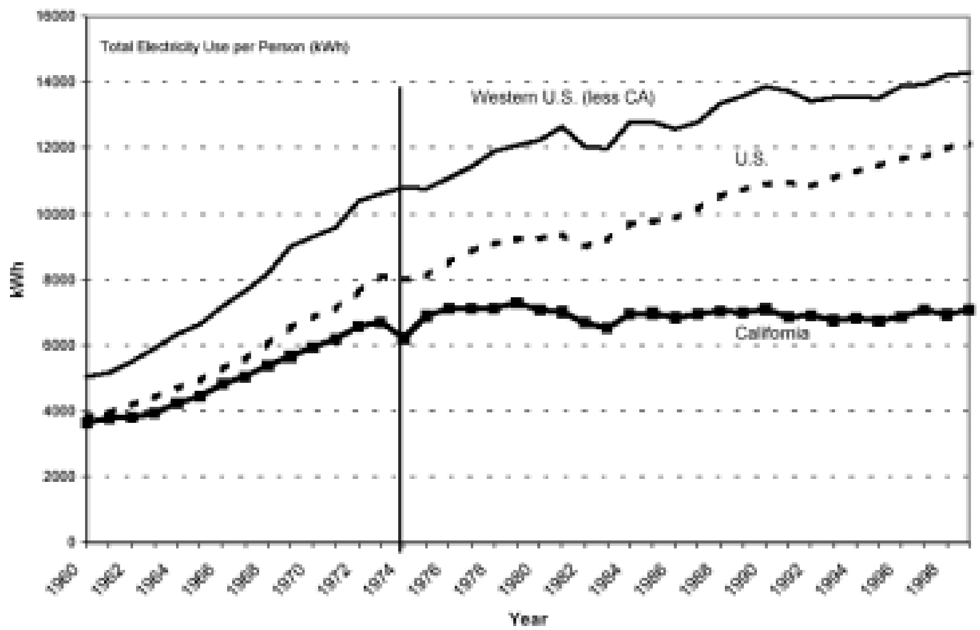
Figure 3-7
California is Most Efficient: per Capita Electricity Consumption by State



Source: California Energy Commission (CEC) 2001a. *2002 – 2012 Electricity Outlook*. P700-01-004.

As shown in Figure 3-8, since 1974 electricity use per person in the U.S. has grown at an annual rate of 1.7 percent. Over the same time period, however, per capita electricity use in California has remained almost constant, growing at only 0.1 percent per year; while per capita use in the rest of the western U.S. grew at 1.2 percent. Because of its focus on continuously improving its energy standards and efficiency programs, California has become the nation's most efficient state in terms of per capita electricity use. Had California's per capita electricity use increased at the same rate as did the rest of the country's over the last quarter century, peak demand in the State would have been 15,000 MW higher than it was in 2000. This would have required the construction and siting of roughly 30 additional major power plants throughout the State.

Figure 3-8
Electricity Consumption per Capita: 1960 - 2000



Source: California Energy Commission (CEC) 2001a. *2002 – 2012 Electricity Outlook*. P700-01-004.

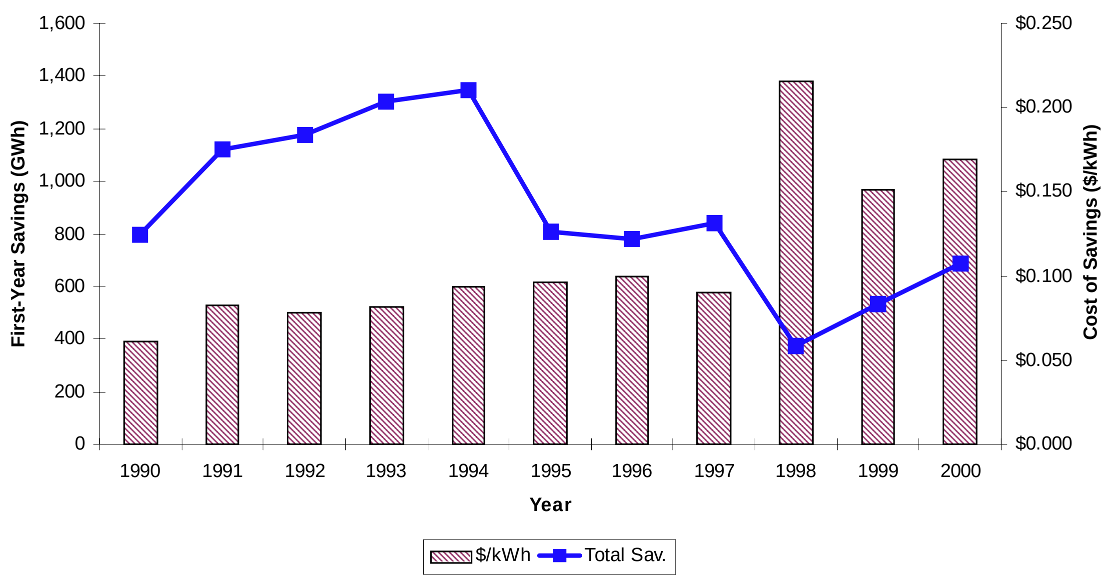
3.3 MAJOR IOUS' NONRESIDENTIAL PROGRAM IMPACTS: 1990 - 2000

Because the focus of this report is on energy-efficiency potential in the commercial sector of the major IOUs, in this subsection we present summary data on the impacts of the major IOUs' nonresidential energy-efficiency programs over the period 1990 to 2000. The following two figures illustrate the combined long-term electric energy-efficiency program activity among the major IOUs. Figure 3-9 shows the total net kWh savings as well as the administrative expenditures per unit of savings from 1990 through 2000. Figure 3-10 is the same as Figure 3-9 with the exception that it excludes nonresidential information and upstream program savings and expenditures. Please note that the data shown for the years 1990 through 1995 may include costs and savings associated with information and upstream program and industrial programs.

In general, the statewide trend from the early1990s for nonresidential energy-efficiency programs was toward increasing annual savings, with a peak of over 1,300 GWh saved in 1994. For the period 1995 through 1997, annual savings fell but remained relatively flat. In 1998, total net savings statewide experienced another decrease but began to climb back up during 1999 and 2000. Savings in the commercial sector made up the majority of savings throughout out the period. Industrial sector savings likely accounted for 20 to 30 percent of the impacts.

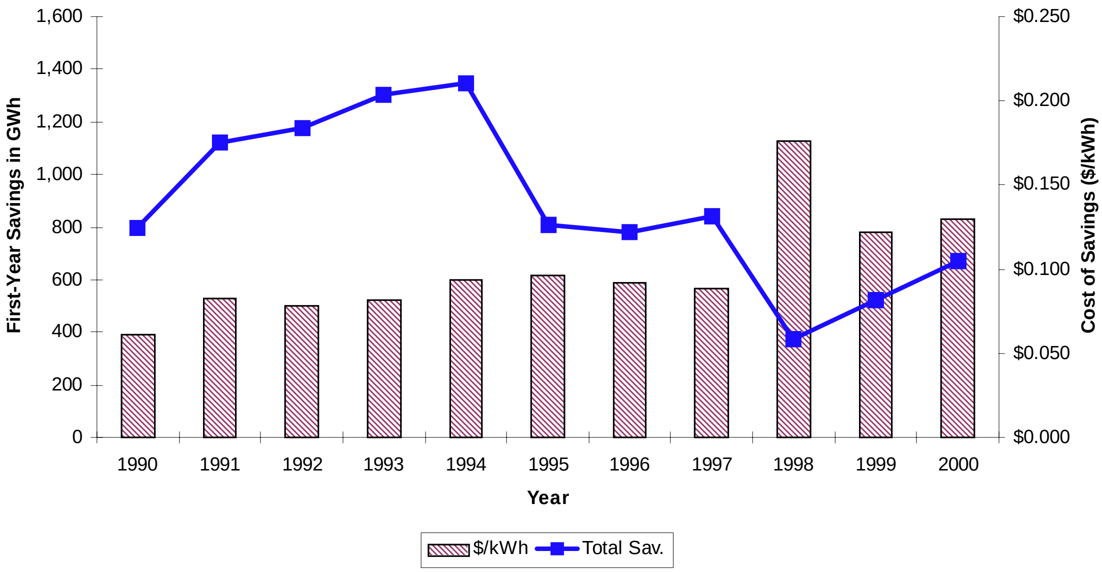
The average program cost[2] per unit of savings was climbing slightly over the period of 1990 through 1997. In 1998, the average cost per unit savings showed a significant increase. Even excluding information and upstream programs, the increase was nearly double. Readers should note, however, that regulatory reporting requirements were changing during this period as the California Board for Energy Efficiency (CBEE) began requiring new reporting formats. In addition, many programs were changed in response to orders from the CBEE and CPUC to shift programs away from resource acquisition and toward market transformation strategies. In the 2 years following this increase, the cost per unit of savings dropped but remained significantly higher than prior to 1998.

Figure 3-9
Electric Utility Energy-Efficiency Savings and Expenditures
Includes Informational and Upstream Programs



[2] Note that "program" costs include all utility expenditures on the programs including incentives for purchasing efficient equipment paid out to customers. Program costs do not include the additional costs to program participants of purchasing the energy-efficient equipment that are not covered by incentives.

Figure 3-10
Electric Utility Energy-Efficiency Savings and Expenditures
Excludes Informational and Upstream Programs



3.4 SUMMARY OF PY2000 AND PY2001 PROGRAMS

This subsection briefly summarizes recent nonresidential program activities administered by the major IOUs.[3] A more complete summary of recent program activity is provided in Appendix H.

Common Programs Across IOUs

Nonresidential programs common to all utilities in 2001 included the following (approximate original budgets for 2001 are provided in parentheses):

- Standard Performance Contract – SPC – ($25 million) provides financial incentives for installation of energy-efficient equipment;
- Express Efficiency ($41 million) provides standardized rebates for installation of specific energy-efficiency measures and is targeted to small and medium sized customers;
- Energy Audit Programs (2 to 6 percent of nonresidential program budgets) provide customers with site-specific energy-efficiency information, mostly targeted to commercial customers;
- Upstream HVAC Programs ($3.3 million) offer financial incentives to HVAC market actors to encourage the installation of efficiency HVAC equipment;

[3] Nonresidential energy-efficiency program information was developed through a review of utility filings, PY2001 1st Quarterly Reports, and program manager interviews.

- Upstream Motor Programs ($1.5 million) offer incentives to motor distributors to encourage premium efficiency motor stocking and sales; and
- Process Overhaul Programs ($5.4 million) are designed to promote energy-efficient process overhauls by providing specialized, technical consulting services to study opportunities related to customer process loads.

As noted, most of the programs and associated funding involves payment of incentives to promote installation of energy efficient equipment. Important exceptions are the Audit and Process Overhaul programs.

Information, Outreach, and Technical Support

The major IOUs also provided various types of energy-efficiency support activities such as:

- Business Energy Guides – designed to help small nonresidential customers better manage their energy costs through energy efficiency;
- Energy Centers – designed to educate customers about energy-efficient business solutions;
- Emerging Technologies activities that focus on demonstrating energy-efficiency options not widely adopted by various market actors; and
- Renovation and Remodeling programs that encourage high-performance nonresidential building design and construction practices.

Much of the noted support activities target the commercial sector. However, the Emerging Technologies and Renovation and Remodeling areas also support energy efficient related to the industrial sector.

Other Support and Programs

Each of the major IOUs also offered a number of programs that are designed to support the financial incentives programs (e.g., Express Efficiency, SPC). These programs include such activities as providing special services to upstream market actors such as technical assistance, incentives, etc., targeting more complex applications such as chillers or compressed air systems, and/or providing marketing and outreach support to target market segments such as hard-to-reach. The commercial sector is the primary focus for most of these programs.

The utilities also contract for a number of Third Party Initiative and Summer Initiative programs. For the most part, these programs also target the commercial sector. (Appendix H provides a list of these third-party programs for 2001).

4 METHODS

4.1 OVERVIEW

In this section, we describe the methods used to conduct this study. We explain the specific steps and methods employed at each stage of the analytical process necessary to produce the results presented in Sections 6 and 7 of this report.

4.2 SUMMARY OF ANALYTICAL STEPS USED IN THIS STUDY

The crux of this study involves carrying out a number of basic analytical steps to produce estimates of the energy-efficiency potentials introduced above. The basic analytical steps for this study are shown in relation to one another in Figure 4-1. The bulk of the analytical process for this study was carried out in a model developed by XENERGY for conducting energy-efficiency potential studies. Details on the steps employed and analyses conducted are described in Section 4.3. The model used, DSM ASSYST™, is an MS-Excel-based model that integrates technology-specific engineering and customer behavior data with utility market saturation data, load shapes, rate projections, and marginal costs into an easily updated data management system. The model itself is described in Appendix J.

The steps implemented in this study are listed below, each of which is described in the remainder of this section:

Step 1: Develop Initial Input Data

- Develop list of energy-efficiency measure opportunities to include in scope
- Gather and develop technical data (costs and savings) on efficient measure opportunities
- Gather, analyze, and develop information on building characteristics, including total square footage, electricity consumption and intensity by end use, end-use consumption load patterns by time of day and year (i.e., load shapes), market shares of key electric consuming equipment, and market shares of energy-efficiency technologies and practices.

Step 2: Estimate Technical Potential and Develop Supply Curves

- Match and integrate data on efficient measures to data on existing building characteristics to produce estimates of technical potential and energy-efficiency supply curves.

Step 3: Estimate Economic Potential

- Gather economic input data such as current and forecasted retail electric prices, and current and forecasted costs of electricity generation, along with estimates of other potential benefits of reducing supply such as the value of reducing environmental impacts associated with electricity production

- Match and integrate measure and building data with economic assumptions to produce indicators of costs from different viewpoints (e.g., societal and consumer)
- Estimate total economic potential

Step 4: Estimate Maximum Achievable, Program, and Naturally Occurring Potentials

- Gather and develop estimates of program costs (e.g., for administration and marketing) and historic program savings
- Develop estimates of customer adoption of energy-efficiency measures as a function of the economic attractiveness of the measures, barriers to their adoption, and the effects of program intervention
- Estimate maximum achievable, program, and naturally occurring potentials
- Develop alternative economic estimates associated with alternative future scenarios

Step 5: Scenario Analyses

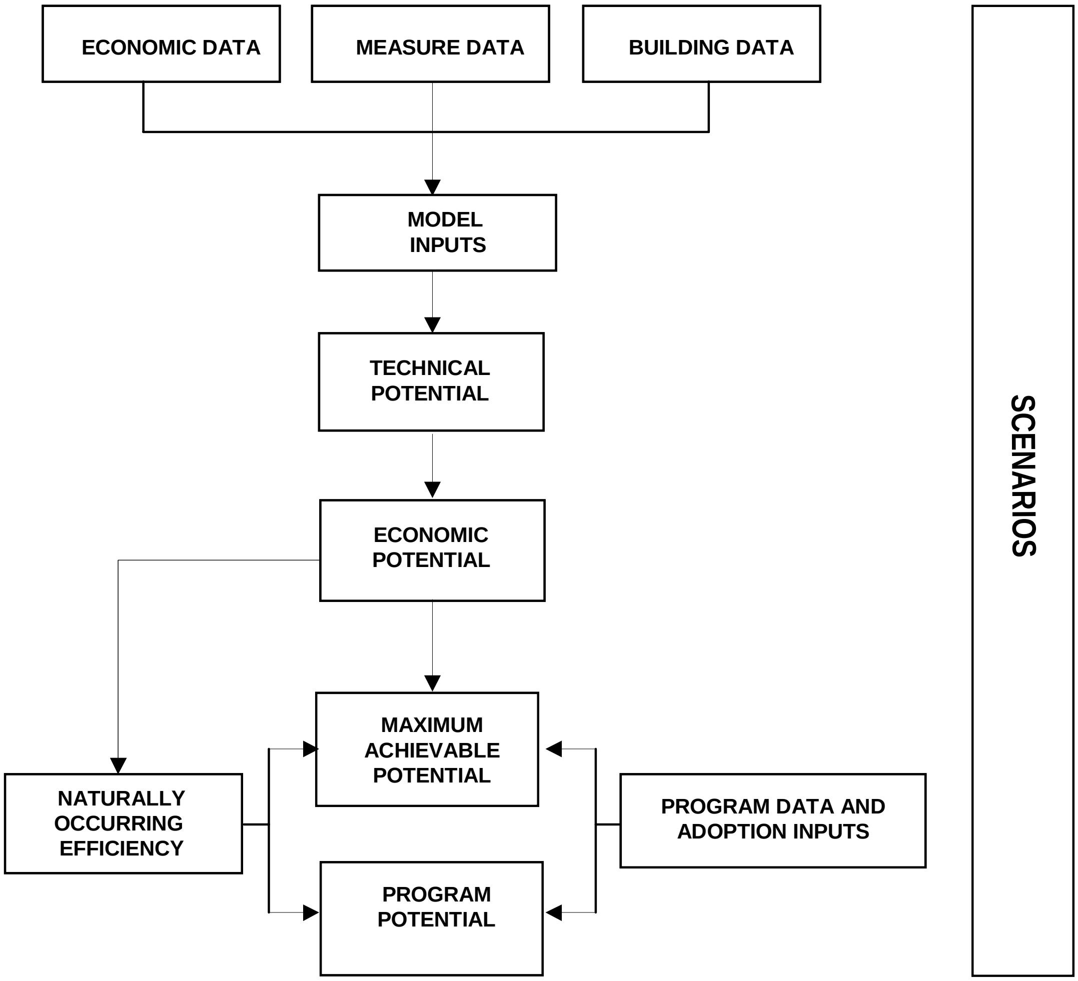
- Recalculate potentials under alternate economic scenarios

4.3 Step 1: Develop Initial Input Data

4.3.1 Development of Measure List

This subsection briefly discusses how we developed the list of energy-efficiency measures included in the study. Additional information is provided in Appendix A. The set of measures included in this potential study is shown in Table 4-1. The study scope was restricted to energy-efficiency measures and practices that are presently commercially available. These are measures that are of most immediate interest to energy-efficiency program planners. The study data, framework, and models can be easily changed, however, to include estimates of potential for emerging technologies. In addition, the scope of this study was focused on measures that could be relatively easily substituted for or applied to existing technologies on a retrofit basis. As a result, measures and savings that might be achieved through integrated redesign of existing energy-using systems, as might be possible during major renovations or remodels, are not included. This is another area in which the current results can be expanded upon.

Figure 4-1
Conceptual Overview of Study Process



The list of measures was developed by starting with the list of measures included in the *DEER 2001 Update Study* (XENERGY 2001b), with some aggregation to prototypical applications. The measure list for the DEER Update study was developed in consultation with a CALMAC stakeholder group that included the major IOUs, California Energy Commission, and California Public Utilities Commission. We then reviewed the 2001 program application filings of the major IOUs to the CPUC and added measures that might have significant potential but were not on the *DEER 2001 Update Study* list.

Table 4-1
Measures Included in Scope of this Study

End Use	Energy-Efficiency Measures
Lighting	T8 lamps with electronic ballasts, reflectors, occupancy sensors, perimeter dimming, compact fluorescent lamps, high-intensity discharge lamps, and outdoor lighting controls.
Cooling	High-efficiency chillers and packaged air conditions, energy management controls, window treatment, improved maintenance and diagnostics, cool (reflective) rooftops, and variable-speed drives.
Ventilation	Premium-efficiency motors and variable-speed drives.
Refrigeration	High-efficiency fan motors, strip curtains for walk-ins, night covers for display cases, evaporator fan controller for MT walk-ins, efficient compressor motor retrofit, compressor VSD retrofit, floating head pressure controls, refrigeration commissioning, demand hot gas defrost, demand defrost electric, and anti-sweat (humidistat) controls
Office Equipment	Power management enabling, network power management enabling, external hardware control, nighttime shutdown, and LCD monitor for PC

4.3.2 Technical Data on Efficient Measure Opportunities

Estimating the potential for energy-efficiency improvements requires a comparison of the costs and savings of energy-efficiency measures as compared to standard equipment and practices. Standard equipment and practices are often referred to in energy-efficiency analyses as *base cases*. Most of the measure cost data for this study was obtained from the *DEER 2001 Update Study*.[1] Additional measure cost information was obtained from the work papers associated with the energy-efficiency program applications of the major IOUs for 2001, as well as other secondary sources and interviews with utility program managers and other industry experts.

Estimates of measure savings as a percentage of base equipment usage were developed from a variety of sources, including:

- Industry-standard engineering calculations,
- Results from building energy simulation model analyses conducted for the California Conservation Inventory Group's *Technology Energy Savings Study* (NEOS 1994),
- A comprehensive refrigeration study conducted by Lawrence Berkeley National Laboratory (LBNL 1995),
- Energy-efficiency program applications to the CPUC, and
- Secondary sources.

[1] The *DEER Update 2001 Study* involved analysis of thousands of cost observations collected for residential and commercial measures.

All measure cost and percentage savings estimates used in this study are shown in Appendix C.

4.3.3 Technical Data on Building Characteristics

As noted above, estimating the potential for energy-efficiency improvements involves comparison of the energy impacts of existing, standard-efficiency technologies with those of alternative high-efficiency equipment. This, in turn, dictates a relatively detailed understanding of the statewide energy characteristics of the existing marketplace. As described further in Section 4.3, a variety of data are needed to estimate the average and total savings potential for individual measures across the entire existing commercial building population. The key data needed for our representation of the population of existing buildings included:

- Total floor space of the in-scope commercial buildings;
- Annual energy consumption for each end use studied (both in terms of total consumption in GWh and normalized for intensity on per-square-foot basis, i.e., kWh/ft2);
- End-use load shapes (that describe the amount of energy used or power demand over certain times of the day and days of the year);
- The saturation of electric end uses (for example, the fraction of total commercial floor space with electric air conditioning);
- The market share of each base equipment type (for example, the fraction of total commercial floor space served by four-foot fluorescent lighting fixtures); and
- Market share for each energy-efficiency measure in scope (for example, the fraction of total commercial floor space already served by compact fluorescent lamps).

Most of the data elements listed above were required at the utility service area and building type level for this study. These key data elements are discussed briefly in the following subsections. More detailed documentation is provided in Appendices A through E.

Floor Space and End-Use Energy Consumption

The primary source of floor space and end-use energy consumption data was the CEC commercial end-use forecasting database. In the end-use forecasting approach, end-use energy consumption is expressed as the product of building floor space (in square feet), the fraction of floor space associated with a given end use (the end-use saturation), and the EUI (the energy use intensity of an end use expressed in kWh per square foot). These three data elements have been collected and estimated from various sources over time and form the foundation upon which the CEC energy demand forecasts are developed. The base energy consumption estimates are shown in Section 2 of this report. Square footage by building type is shown in Appendix E. Saturation and EUI data by base equipment type are documented in Appendix C.

Load Shapes, Energy and Peak Factors

Load shape data was used to develop energy and peak factors. Energy and peak factors are used to allocate annual energy usage into utility costing periods and to provide estimates of peak demand based on cost period energy usage. The factors were developed by California IOU service area, end-use, and building type and were used to allocate measure impacts to utility costing periods. This is necessary because avoided-cost benefits (which are described later in this section) vary significantly by time of day, type of day, and month of year.

In the case of the electric energy factors, these factors are computed based on predefined costing periods (e.g., season, day of the week, and hours of the day) divided by annual energy use. The end result is a series of values for each period such that the sum of the periods is equal to 1. PG&E, SCE, and SDG&E typically use costing definitions that differ very slightly from each other. To maintain consistency of our study's results across the utilities, we choose one utility's costing periods to use for our analyses. The costing period definitions used for this study are shown in Table 4-2.

Table 4-2
Costing Period Definitions Used for Electric Energy Factors

	Summer	Winter
	May 1 - Oct 31	All Other Months
Peak	1 PM to 6 PM Weekdays	(none)
Partial-Peak	9 AM – 12 PM Weekdays	9 AM – 9 PM Weekdays
	7 PM – 9 PM Weekdays	
Off-Peak	10 PM – 8 AM Weekdays	10 PM to 8 AM Weekdays
	All Weekends and Holidays	All Weekends and Holidays

The peak factors are based on the same predefined periods as the energy factors. In this case, the peak demand within a cost period is divided by the average demand within that same period; that is, the peak factor is the ratio of peak to average demand in a period. This is done for both noncoincident demands as well as for coincident demands. In the case of coincident demands, the time of coincidence was set to be the time at which the California electric system typically peaked within each marginal costing period. The most important of these periods, from a cost and reliability perspective is the Summer Peak Period. Our analysis indicated that 4pm corresponded to the maximum system peak as registered by the California Independent System Operator in 2000. Our estimates of peak demand by end use were developed to correspond to a 4pm system peak.

Further documentation on the sources used to develop these factors is provided in Appendix A. The factors developed and used in the study are shown in Appendix E.

Base Technology Shares (Applicability Factors)

The technology or equipment mix within an end use determines the applicability of energy-efficiency measures for that end use. For example, high-efficiency DX air conditioning measures are only applicable to the portion of the space cooling end use that is served by DX air conditioning (as opposed to other air conditioning equipment such as central plant chillers). Data on base technology shares were developed from several sources, as summarized in Table 4-3. A brief discussion of sources and development of technology share data follows. The primary sources are commercial end-use surveys (often referred to as CEUS studies) conducted by the major IOUs at various points in the 1990s. These surveys typically involve very in-depth collection of building equipment and characteristics data through surveys conducted on site at representative samples of commercial buildings.

Table 4-3
Data Sources for Technology Shares

End Use	Data Source
Indoor Lighting	PG&E CEUS, SCE CEUS, SDG&E CEUS
Outdoor Lighting	PG&E CEUS, SCE CEUS, SDG&E CEUS
Space Cooling	PG&E CEUS, SCE CEUS, SDG&E CEUS
Ventilation	PG&E CEUS applied to all three utilities
Refrigeration	LBNL Commercial Refrigeration Report (LBL-37397)
Office Equipment	LBNL Office Equipment Study (LBNL-45917)

The data sources listed in Table 4-3 are summarized below:

- The PG&E Commercial End Use Survey (CEUS). Data from this survey were collected by PG&E during calendar years 1996 and 1997 via on-site surveys. A total of 983 buildings were included in the sample. XENERGY analyzed the CEUS data directly to estimate technology shares for this study.
- The SCE CEUS. Data from this survey were collected by SCE via on-site surveys in two waves, based on building type. Data for offices, retail stores, food stores, restaurants, and warehouses were collected in 1992. Data for schools, colleges, hospitals/health facilities, lodging, and miscellaneous buildings were collected in 1995. A total of 700 surveys were conducted in 1992, and 500 surveys were conducted in 1995. ADM Associates provided additional analysis of SCE CEUS data for this study.
- SDG&E CEUS. This was a survey of 350 commercial buildings in the SDG&E service territory. Data were collected via on-site surveys during 1998. Extensive technology detail on lighting and HVAC systems was available. RER Inc. analyzed the data to provide technology share inputs for this study.
- LBNL commercial refrigeration study. This study provides detailed specification of commercial refrigeration systems as well as methods for estimating savings for efficient refrigeration measures. Refrigeration modeling procedures and methods used in this study rely, where possible, on the inputs and assumptions contained in the LBL report. Quantum Consulting Inc. analyzed the refrigeration sources and developed inputs for this study.

- LBNL office equipment study. In this study Lawrence Berkeley National Laboratories utilized secondary source data to estimate office equipment electricity consumption by sector (residential, commercial, and industrial) and equipment type. Estimates were made for calendar year 1999. Energy Solutions Inc. developed office equipment analyses using this and other sources as described in Appendix I.

Additional documentation of the base technology shares developed for this study is provided in Appendixes A and C.

Existing Energy-Efficient Measure Saturations

In order to assess the amount of energy-efficiency savings available, estimates of the current saturation of energy efficient measures are necessary. The primary source of data used for the measure saturation estimates were the utility CEUS studies. In some cases, judgmental adjustments to these saturation estimates were required to bring them up to date because the available sources were several years old. In these cases, we examined program tracking data to estimate increases in measure saturation that were likely to have occurred between the time each CEUS was conducted and the present. Development of measure saturation data is discussed in more detail in Appendix A.

4.4 STEP 2: ESTIMATE TECHNICAL POTENTIAL AND DEVELOP ENERGY EFFICIENCY SUPPLY CURVES

As defined previously, **Technical Potential** refers to the amount of energy savings or peak demand reduction that would occur with the *complete* penetration of all measures analyzed in applications where they were deemed *technically* feasible from an *engineering* perspective. Total technical potential is developed from estimates of the technical potential of individual measures as they are applied to discrete market segments. Market segments in this study are the building types used in the CEC's demand forecasting models (e.g., offices, retail, etc.).

4.4.1 Core Equation

The core equation used to calculate the energy technical potential for each individual efficiency measure, by market segment, is shown below:

$$\begin{array}{c} \text{Technical} \\ \text{Potential of} \\ \text{Efficient} \\ \text{Measure} \end{array} = \begin{array}{c} \text{Total} \\ \text{Square} \\ \text{Feet} \end{array} \times \begin{array}{c} \text{Base Case} \\ \text{Equipment} \\ \text{EUI (kWh/ft}^2\text{)} \end{array} \times \begin{array}{c} \text{Applicability} \\ \text{Factor} \end{array} \times \begin{array}{c} \text{Not} \\ \text{Complete} \\ \text{Factor} \end{array} \times \begin{array}{c} \text{Feasibility} \\ \text{Factor} \end{array} \times \begin{array}{c} \text{Savings} \\ \text{Factor} \end{array}$$

where:

- **Square Feet** is the total floor space for all buildings in the market segment.
- **Base Case Equipment EUI** is the energy used per square foot by each base case technology in each market segment. This is the consumption of the energy-using equipment that the efficient technology replaces or affects. For example, if the efficient

measure were a compact fluorescent lamp, the base EUI would be the annual kWh per square foot of an equivalent incandescent lamp.

- **Applicability Factor** is the fraction of the floor space that is applicable for the efficient technology in a given market segment, for the example above, the percentage of floor space lit by incandescent bulbs.
- **Not Complete Factor** is the fraction of applicable floor space that has not yet been converted to the efficient measure; that is, (one minus the fraction of floor space that already has the energy-efficiency measure installed).
- **Feasibility Factor** is the fraction of the applicable floor space that is technically feasible for conversion to the efficient technology from an *engineering* perspective.
- **Savings Factor** is the reduction in energy consumption resulting from application of the efficient technology.

Technical potential for peak demand reduction is calculated analogously.

An example of the core equation is shown in Table 4-4 for the case of a prototypical 75-Watt incandescent lamp, which is replaced by an 18-Watt compact fluorescent in the office segment of the SCE service territory.

Table 4-4
Example of Technical Potential Calculation – Replace 75 W Incandescent with 18 W CFL in the Office Segment of the SCE service territory

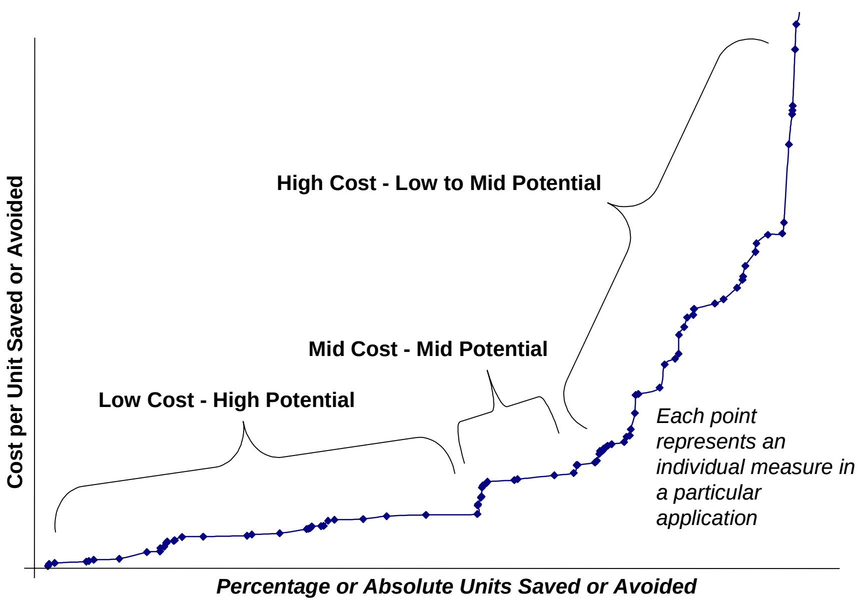
Technical Potential of Efficient Measure =	Total Square Feet	Base Case x Equipment EUI (kWh/ft^2)	× Applicability Factor	× Not Complete Factor	× Feasibility Factor	× Savings Factor
7.7 million kWh	471 million	11.4	0.011	0.20	0.90	0.72

Technical energy-efficiency potential is calculated in two steps. In the first step, all measures are treated *independently*; that is, the savings of each measure are not marginalized or otherwise adjusted for overlap between competing or synergistic measures. By treating measures independently, their relative economics are analyzed without making assumptions about the order or combinations in which they might be implemented in customer buildings. However, the total technical potential across measures cannot be estimated by summing the individual measure potentials directly. The cumulative savings cannot be estimated by adding the savings from the individual savings estimates because some savings would be double-counted. For example, the savings from a measure that reduces heat gain into a building, such as window film, are partially dependent on other measures that affect the efficiency of the system being used to cool the building, such as a high-efficiency chiller; the more efficient the chiller, the less energy saved from the application of the window film.

4.4.2 Use of Supply Curves

In the second step cumulative technical potential is estimated using an energy-efficiency supply curve approach.[2] This method eliminates the double-counting problem. In Figure 4-2, we present a generic example of a supply curve. As shown in the figure, a supply curve typically consists of two axes—one that captures the cost per unit of saving a resource or mitigating an impact (e.g., $/kWh saved or $/ton of carbon avoided) and the other that shows the amount of savings or mitigation that could be achieved at each level of cost. The curve is typically built up across individual measures that are applied to specific base case practices or technologies by market segment. Savings or mitigation measures are sorted on a least-cost basis and total savings or impacts mitigated are calculated incrementally with respect to measures that precede them. Supply curves typically, but not always, end up reflecting diminishing returns, i.e., as costs increase rapidly and savings decrease significantly at the end of the curve.

Figure 4-2
Generic Illustration of Energy-Efficiency Supply Curve



As noted above, the cost dimension of most energy-efficiency supply curves is usually represented in dollars per unit of energy savings. Costs are usually annualized (often referred to as "levelized") in supply curves. For example, energy-efficiency supply curves usually present

[2] This section describes conservation supply curves as they have been defined and implemented in numerous studies. Readers should note that Stoft 1995 describes several technical errors in the definition and implementation of conservation supply curves in the original and subsequent conservation supply curve studies. Stoft concludes that conservation supply curves are not "true" supply curves in the standard economic sense but can still be useful (albeit with his recommended improvements) for their intended purpose (demonstration of cost-effective conservation opportunities).

levelized costs per kWh or kW saved by multiplying the initial investment in an efficient technology or program by the "capital recovery rate" (CRR):

$$\text{CRR} = \frac{d}{1-(1+d)^{-n}}$$

where *d* is the real discount rate and *n* is the number of years over which the investment is written off (i.e., amortized).

Thus,

Levelized Cost per kWh Saved = Initial Cost x CRR/Annual Energy Savings

Levelized Cost per kW Saved = Initial Cost x CRR/Peak Demand Savings

Table 4-5 shows a simplified numeric example of a supply curve calculation for several energy-efficiency measures applied to commercial lighting for a hypothetical population of buildings. What is important to note is that in an energy-efficiency supply curve, the measures are sorted by relative cost: from least to most expensive. In addition, the energy consumption of the system being affected by the efficiency measures goes down as each measure is applied. As a result, the savings attributable to each subsequent measure decrease if the measures are interactive. For example, the occupancy sensor measure shown in Table 4-5 would save more at less cost per unit saved if it were applied to the base case consumption before the T8 lamp and electronic ballast combination. Because the T8 electronic ballast combination is more cost-effective, however, it is applied first, reducing the energy savings potential for the occupancy sensor. Thus, in a typical energy-efficiency supply curve, the base case end-use consumption is reduced with each unit of energy-efficiency that is acquired. Notice in Table 4-5 that the total end-use GWh consumption is recalculated after each measure is implemented, thus reducing the base energy available to be saved by the next measure.

Table 4-5 shows an example that would represent measures for one base case technology in one market segment. These calculations are performed for all of the base case technologies, market segments, and measure combinations in the scope of the study. The results are then ordered by levelized cost and the individual measure savings summed to produce the energy-efficiency potential for the entire sector (as presented in Section 6 of this report).

In the next subsection, we discuss how economic potential is estimated as a subset of the technical potential.

Table 4-5
Sample Technical Potential Supply Curve Calculation for Commercial Lighting
(*Note: Data are illustrative only*)

Measure	Total End Use Consumption of Population (GWh)	Applicable, Not Complete and Feasible Sq.Feet (000s)	Average kWh/ft^2 of population	Savings %	GWh Savings	Levelized Cost ($/kWh saved)
Base Case: T12 lamps with Magnetic Ballast	425	100,000	4.3	N/A	N/A	N/A
1. T8 w. Elec. Ballast	425	100,000	4.3	21%	89	$0.04
2. Occupancy Sensors	336	40,000	3.4	10%	13	$0.11
3. Perimeter Dimming	322	10,000	3.2	45%	14	$0.25
With all measures	309		3.1	27%	116	

4.5 STEP 3: ESTIMATE ECONOMIC POTENTIAL

As introduced earlier in this section, **Economic Potential** is typically used to refer to the *technical potential* of those energy conservation measures that are cost effective when compared to either supply-side alternatives or the price of energy. Economic potential takes into account the fact that many energy-efficiency measures cost more to purchase initially than do their standard-efficiency counterparts. The incremental costs of each efficiency measure are compared to the savings delivered by the measure to produce estimates of energy savings per unit of additional cost. These estimates of energy-efficiency resource costs can then be compared to estimates of other resources such as building and operating new power plants.

4.5.1 Cost Effectiveness Tests

In order to estimate economic potential, it is necessary to develop a measure of by which it can be determined that a measure or program is *economic*. There is a large body of literature in which the merits of different approaches to calculating whether a public purpose investment in energy efficiency is cost effective are debated (Chamberlin and Herman 1993, RER 2000, Ruff 1988, Stoft 1995, and Sutherland 2000). In this report, we adopt the cost-effectiveness criteria used by the California Public Utilities Commission (CPUC) in its decisions regarding the cost-effectiveness of energy-efficiency programs funded under the State's public goods charge. The CPUC uses the total resource cost (TRC) test, as defined in the California Standard Practice Manual (CASPM 2001), to assess cost effectiveness. The TRC is a form of societal benefit-cost test. Other tests that have been used in analyses of program cost-effectiveness by energy-efficiency analysts include the Utility Cost, Ratepayer Impact Measure (RIM), and Participant tests. These tests are discussed in detail the CASPM.

Before discussing the TRC test and how it is used in this study, we present below a brief introduction to the basic tests as described in the CASPM:[3]

- **Total Resource Cost Test** - The Total Resource Cost Test measures the net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs. The test is applicable to conservation, load management, and fuel substitution programs. For fuel substitution programs, the test measures the net effect of the impacts from the fuel not chosen versus the impacts from the fuel that is chosen as a result of the program. TRC test results for fuel substitution programs should be viewed as a measure of the economic efficiency implications of the total energy supply system (gas and electric). A variant on the TRC test is the Societal Test. The Societal Test differs from the TRC test in that it includes the effects of externalities (e.g. environmental, national security), excludes tax credit benefits, and uses a different (societal) discount rate.
- **Participant Test** - The Participants Test is the measure of the quantifiable benefits and costs to the customer due to participation in a program. Since many customers do not base their decision to participate in a program entirely on quantifiable variables, this test cannot be a complete measure of the benefits and costs of a program to a customer.
- **Utility (Program Administrator) Test** - The Program Administrator Cost Test measures the net costs of a demand-side management program as a resource option based on the costs incurred by the program administrator (including incentive costs) and excluding any net costs incurred by the participant. The benefits are similar to the TRC benefits. Costs are defined more narrowly.
- **Ratepayer Impact Measure Test** - The Ratepayer Impact Measure (RIM) test measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program. Rates will go down if the change in revenues from the program is greater than the change in utility costs. Conversely, rates or bills will go up if revenues collected after program implementation are less than the total costs incurred by the utility in implementing the program. This test indicates the direction and magnitude of the expected change in customer bills or rate levels.

The key benefits and costs of the various cost-effectiveness tests are summarized in Table 4-6.

[3] These definitions are direct excerpts from the California Standard Practice Manual, October 2001.

Table 4-6
Summary of Benefits and Costs of California Standard Practice Manual Tests

Test	Benefits	Costs
Total Resource Cost Test	Generation, transmission and distribution savings Participants avoided equipment costs (fuel switching only)	Generation costs Program costs paid by the administrator Participant measure costs
Participant Test	Bill reductions Incentives Participants avoided equipment costs (fuel switching only)	Bill increases Participant measure costs
Utility (Program Administrator) Test	Generation, transmission and distribution savings	Generation costs Program costs paid by the administrator Incentives
Ratepayer Impact Measure Test	Generation, transmission and distribution savings Revenue gain	Generation costs Revenue loss Program costs paid by the administrator Incentives

Generation, transmission and distribution savings (hereafter, energy benefits) are defined as the economic value of the energy and demand savings stimulated by the interventions being assessed. These benefits are typically measured as induced changes in energy consumption, valued using some mix of avoided costs. Statewide values of avoided costs are prescribed for use in implementing the test. Electricity benefits are valued using three types of avoided electricity costs: avoided distribution costs, avoided transmission costs, and avoided electricity generation costs.

Participant costs are comprised primarily of incremental measure costs. Incremental measure costs are essentially the costs of obtaining energy efficiency. In the case of an add-on device (say, an ASD or ceiling insulation), the incremental cost is simply the installed cost of the measure itself. In the case of equipment that is available in various levels of efficiency (e.g., a central air conditioner), the incremental cost is the excess of the cost of the high-efficiency unit over the cost of the base (reference) unit.

Administrative costs encompass the real resource costs of program administration, including the costs of administrative personnel, program promotions, overhead, measurement and evaluation, and shareholder incentives. In this context, administrative costs are not defined to include the costs of various incentives (e.g., customer rebates and salesperson incentives) that may be offered to encourage certain types of behavior. The exclusion of these incentive costs reflects the fact that they are essentially transfer payments. That is, from a societal perspective they involve offsetting costs (to the program administrator) and benefits (to the recipient).

4.5.2 Use of the Total Resource Cost to Estimate Economic Potential

We use the TRC test in two ways in this study. First, we develop an estimate of economic potential by calculating the TRC of individual measures and applying the methodology described below. Second, we develop estimates of whether different program scenarios are cost effective as described in Section 4.6.

Economic potential can be defined either inclusively or exclusively of the costs of programs that are designed to increase the adoption rate of energy-efficiency measures. *In this study, we define economic potential to exclude program costs*. We do so primarily because program costs are dependent on a number of factors that vary significantly as a function of program delivery strategy. There is no single estimate of program costs that would accurately represent such costs across the wide range of program types and funding levels possible. Once an assumption is made about program costs, one must also link those assumptions to expectations about market response to the types of interventions assumed. Because of this, we believe it is more appropriate to factor program costs into our analysis of *maximum achievable* and *program potential* (as will be described in Section 4.6). Thus, our definition of *economic potential* is that portion of the technical potential that passes our economic screening test (described below) exclusive of program costs. Economic potential, like technical potential, is a theoretical quantity that will exceed the amount of potential we estimate to be achievable through current or more aggressive program activities.

As implied in Table 4-6 and defined in the CASPM 2001, the TRC focuses on resource savings and counts benefits as utility avoided supply costs and costs as participant costs and utility program costs. It ignores any impact on rates. It also treats financial incentives and rebates as transfer payments; i.e., the TRC is not affected by incentives. The somewhat simplified benefit and cost formulas for the TRC are presented in Equations 4-1 and 4-2 below.

$$\text{Benefits} = \sum_{t=1}^{N} \frac{\text{Avoided Costs of Supply}_{p,t}}{(1+d)^{t-1}} \qquad \textbf{Eqn. 4-1}$$

$$\text{Costs} = \sum_{t=1}^{N} \frac{\text{Program Cost}_t + \text{Participant Cost}_t}{(1+d)^{t-1}} \qquad \textbf{Eqn. 4-2}$$

where

d= the discount rate
p= the costing period (see Table 4-2)
t= time (in years)
n= 20 years

The discount rate used is 8 percent, as required by the CPUC for program filings by major IOUs in 2001.[4] We use a *normalized* measure life of 20 years in order to capture the benefit of long-lived measures. Measures with measure lives shorter than 20 years are "re-installed" in our analysis as many times as necessary to reach the normalized 20-year life of the analysis.

The avoided costs of supply are calculated by multiplying measure energy savings and peak demand impacts by per-unit avoided costs by costing period.[5] Energy savings are allocated to costing periods and peak impacts estimated using the load shape factors discussed in Section 4.3.3 and shown in Appendix A.

As noted previously, in the *measure-level* TRC calculation used to estimate economic potential, program costs are excluded from Equation 4-2. Using the supply curve methodology discussed previously, measures are ordered by TRC (highest to lowest) and then the *economic* potential is calculated by summing the energy savings for all of the technologies for which the marginal total resource cost (TRC) test is greater than 1.0. In the example in Table 4-7, the economic potential would include the savings for Measures 1 and 2, but exclude saving for Measure 3 because the TRC is less than 1.0 for Measure 3. The supply curve methodology when combined with estimates of the TRC for individual measures produces estimates of the economic potential of efficiency improvements. By definition and intent, this estimate of economic potential is a theoretical quantity that will exceed the amount of potential we estimate to be achievable through program activities in the final steps of our analyses.

In this study we calculate economic potential for three scenarios, which capture different assumptions about future avoided supply costs and commercial rates. These scenarios and their associated avoided cost and rate forecasts are described in Section 5 of this report.

[4] We recognize that the 8 percent discount is much lower than the implicit discount rates at which customers are observed to adopt efficiency improvements. This is by intent since we seek at this stage of the analysis to estimate the potential that is cost-effective from primarily a societal perspective. The effect of implicit discount rates is incorporated into our estimates of program and naturally occurring potential.

[5] The per-unit avoided cost values used in this study are shown in Section 5 and Appendix B.

Table 4-7
Sample Use of Supply Curve Framework to Estimate Economic Potential
(*Note: Data are illustrative only*)

Measure	Total End Use Consumption of Population (GWh)	Applicable, Not Complete and Feasible Sq.Feet (000s)	Average kWh/ft^2 of population	Savings %	GWh Savings	Total Resource Cost Test	Savings Included in Economic Potential?
Base Case: T12 lamps with Magnetic Ballast	425	100,000	4.3	N/A	N/A	N/A	N/A
1. T8 w. Elec. Ballast	425	100,000	4.3	21%	89	2.5	Yes
2. Occupancy Sensors	336	40,000	3.4	10%	13	1.3	Yes
3. Perimeter Dimming	322	10,000	3.2	45%	14	0.8	No
Technical Potential w. all measures				27%	116		
Economic Potential w. measures for which TRC > 1.0				24%	102		

4.6 STEP 4: ESTIMATE MAXIMUM ACHIEVABLE, PROGRAM, AND NATURALLY OCCURRING POTENTIALS

In this section we present the method we employ to estimate the fraction of the market that adopts each energy-efficiency measure in the presence and absence of energy efficiency programs. In Section 1 of this report we introduced the concepts of *maximum achievable*, program, and naturally occurring potentials. We defined:

- **Maximum Achievable Potential** as the amount of economic potential that could be achieved over time under the most aggressive program scenario possible.
- **Program Potential** as the amount of savings that would occur in response to one or more specific market interventions.
- **Naturally Occurring Potential** as the amount of savings estimated to occur as a result of normal market forces, that is, in the absence of any utility or governmental intervention.

Our estimates of program potential are the most important results of this study. Estimating technical, economic, and maximum achievable potentials are necessary steps in the process from which important information can be obtained, however, the end goal of the process is better understanding how much of the remaining potential can be captured in programs, whether it would be cost-effective to increase program spending, and how program costs may be expected to change in response to measure adoption over time.

According to our definitions and the method described in this section, maximum achievable potential is really a type of program potential that defines the upper limit of savings from market interventions. Therefore, in the remainder of this section, we will often discuss our general method using the term "program potential" to represent both program and maximum achievable potential. The assumptions and data inputs used for the specific program scenarios and maximum achievable potential scenarios developed for this study are described in Section 5 of this report.

4.6.1 Adoption Method Overview

We use a method of estimating adoption of energy-efficiency measures that applies equally to be our program and naturally occurring analyses. Whether as a result of natural market forces or aided by a program intervention, the rate at which measures are adopted is modeled in our method as a function of the following factors:

- The availability of the adoption opportunity as a function of capital equipment turnover rates and changes in building stock over time;
- Customer awareness of the efficiency measure;
- The cost-effectiveness of the efficiency measure; and
- Market barriers associated with the efficiency measure.

The method we employ is executed in the measure penetration module of XENERGY’s DSM ASSYST model.

In this study, only measures that pass the measure-level total resource cost test discussed under Section 4.5 are put into the penetration module for estimation of customer adoption.

Availability

A crucial part of the model is a stock accounting algorithm that handles capital turnover and stock decay over a period of up to 20 years. In the first step of our achievable potential method, we first calculate the number of customers for whom each measure will apply. The input to this calculation is the total floor space available for the measure from the technical potential analysis described in Section 4.4, i.e., the total floor space multiplied by the Applicability, Not Complete, and Feasibility factors described previously. We call this the *eligible* stock. The stock algorithm keeps track of the amount of floor space available for each efficiency measure in each year based on the total eligible stock and whether the application is new construction, retrofit or replace-on-burnout.[6]

[6] Replace-on-burnout measures are defined as the efficiency opportunities that are available only when the base equipment turns over at the end of its service life. For example, a high-efficiency chiller measure is usually only considered at the end of the life of an existing chiller. By contrast, retrofit measures are defined to be constantly available. For example, application of a window film to existing glazing.

Retrofit measures are available for implementation by the entire eligible stock. The eligible stock is reduced over time as a function of adoptions[7] and building decay.[8] Replace-on-burnout measures are available only on an annual basis, approximated as equal to the inverse of the service life.[9] The annual portion of the eligible market that does not accept the replace-on-burnout measure does not have an opportunity again until the end of the service life.

New construction applications are available for implementation in the first year. Those customers that do not accept the measure are given subsequent opportunities corresponding to whether the measure is a replacement or retrofit-type measure.

Awareness

In our modeling framework, customers cannot adopt an efficient measure merely because there is stock available for conversion. Before they can make the adoption choice, they must be aware and informed about the efficiency measure. Thus, in the second stage of the process, the model calculates the portion of the available market that is *informed*. An initial user-specified parameter sets the initial level of awareness for all measures. Incremental awareness occurs in the model as a function of the amount of money spent on awareness/information building and how well those information-building resources are directed to target markets. User-defined program characteristics determine how well information-building money is targeted. Well-targeted programs are those for which most of the money is spent informing only those customers that are in a position to implement a particular group of measures. Untargeted programs are those in which advertising cannot be well focused on the portion of the market that is available to implement particular measures. The penetration module in DSM ASSYST has a Target Effectiveness parameter that is used to adjust for differences in program advertising efficiency associated with alternative program types.

The model also controls for information retention. An information decay parameter in the model is used to control for the percentage of customers that will retain program information from one year to the next. Information retention is based on the characteristics of the target audience and the temporal effectiveness of the marketing techniques employed.

Adoption

The portion of the total market this is available and informed can now face the choice of whether or not to adopt a particular measure. Only those customers for whom a measure is available for

[7] That is, each square foot that adopts the retrofit measure is removed from the eligible stock for retrofit in the subsequent year.

[8] Buildings do not last forever. An input to the model is the rate of decay of the existing floor space. Floor space typically decays at a very slow rate.

[9] For example, a base case technology with a service life of 15 years is only available for replacement to a high-efficiency alternative each year at the rate of 1/15 times the total eligible stock. For example, the fraction of the market that does not adopt the high-efficiency measure in year X will not be available to adopt the efficient alternative again until year X + 15.

implementation (Stage 1) and, of those customers, only those who have been informed about the program/measure (Stage 2), are in a position to make the implementation decision.

In the third stage of our penetration process, the model calculates the fraction of the market that adopts each efficiency measure as a function of the Participant test. The Participant test is a benefit-cost ratio that is calculated in this study as follows:

$$\text{Benefits} = \sum_{t=1}^{N} \frac{\text{Customer Bill Savings (\$)}_t}{(1+d)^{t-1}} \qquad \textbf{Eqn. 4-3}$$

$$\text{Costs} = \sum_{t=1}^{N} \frac{\text{Participant Costs (\$)}_t}{(1+d)^{t-1}} \qquad \textbf{Eqn. 4-4}$$

where

d= the discount rate
t= time (in years)
n= 20 years

We use a *normalized* measure life of 20 years in order to capture the benefits associated with long-lived measures. Measures with lives shorter than 20 years are “re-installed” in our analysis as many times as necessary to reach the normalized 20-year life of the analysis.

The bill reductions are calculated by multiplying measure energy savings and customer peak demand impacts by retail energy and demand rates.[10]

The model uses measure implementation curves to estimate the percentage of the informed market that will accept each measure based on the participant’s benefit-cost ratio. The model provides enough flexibility so that each measure in each market segment can have a separate implementation rate curve. The functional form used for the implementation curves is:

$$y = \frac{a}{\left(1 + e^{-\ln\frac{x}{4}}\right) \times \left(1 + e^{-c\ln(bx)}\right)}$$

where:

y = the fraction of the market that installs a measure in a given year from the pool of informed applicable customers;

x = the customer’s benefit-cost ratio for the measure;

[10] The retail rate values used in this study are shown in Section 5 and Appendix B.

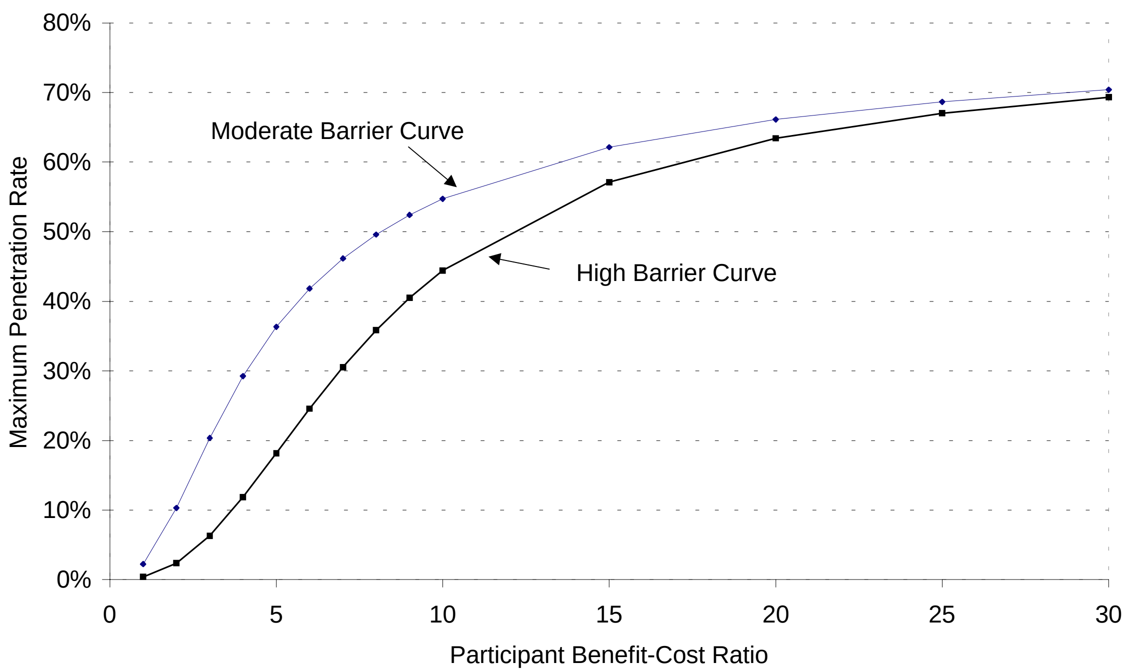
a = the maximum annual acceptance rate for the technology;

b = the inflection point of the curve. It is generally one over the benefit-cost ratio that will give a value of 1/2 the maximum value; and

c = the parameter that determines the general shape (slope) of the curve.

The primary curves utilized in this study are shown in Figure 4-3. These curves produce base year program results that are calibrated to actual measure implementation results associated with major IOU commercial efficiency programs over the past several years.

Figure 4-3
Primary Measure Implementation Curves Used in Adoption Model

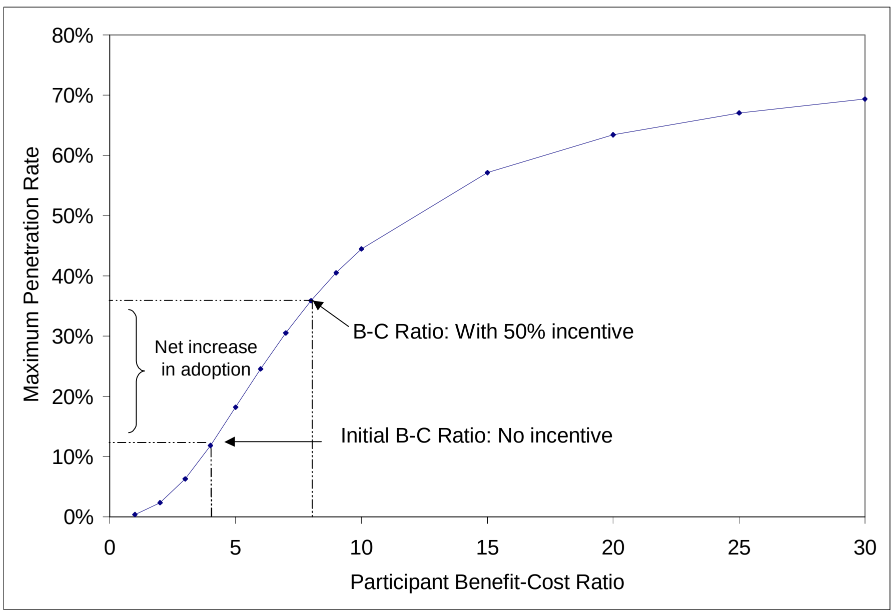


Note that for both the moderate and high barrier curves, the participant benefit-cost ratios have to be very high before significant adoption occurs. This is because the participant benefit-cost ratios are based on a 15-percent discount rate. This discount rate reflects likely adoption if there were no market barriers or market failures. Experience has shown, however, that actual adoption behavior correlates with implicit discount rates several times those that would be expected in a perfect market.[11]

[11] For some, it is easier to consider adoption as a function of simple payback. However, the relationship between payback and the participant benefit-cost ratio varies depending on measure life and discount rate. For a long-lived measure of 15 years with a 15-percent discount rate, the equivalent payback at which half of the market would adopt a measure is roughly 6 months, based on the high barrier curve in Figure 4-3. At a 1-year payback, one-quarter of the market would adopt the measure. Adoption reaches near its maximum at a 3-month payback. The curves reflect the real-world observation that implicit discount rates can average up to 100 percent.

The model estimates adoption under both naturally occurring and program intervention situations. There are only two differences between the naturally occurring and program analyses. First, in any program intervention case in which measure incentives are provided, the Participant benefit-cost ratios are adjusted based on the incentives. Thus, if an incentive that pays 50 percent of the incremental measure cost is applied in the program analysis, the Participant benefit-cost ratio for that measure will double (since the costs have been halved). The effect on the amount of adoption estimated will depend on where the pre- and post-incentive benefit-cost ratios fall on the curve. This effect is illustrated in Figure 4-4.

Figure 4-4
Illustration of Effect of Incentives on Adoption Level as Characterized in Implementation Curves



In this study, as discussed in Section 5, achievable potential energy-efficiency forecasts were developed for several scenarios ranging from base levels of program intervention, through moderate levels, up to an aggressive energy-efficiency acquisition scenario. Uncertainty in rates and avoided costs were also characterized in alternate scenarios. The final results produced are annual streams of achievable program impacts (energy and demand by time-of-use period) and all societal and participant costs (program costs plus end-user costs). Model results and outputs are shown in Section 7 and Appendix F.

5 DEVELOPMENT OF SCENARIOS

5.1 INTRODUCTION

In this chapter we describe scenarios for which we estimate energy-efficiency potential. Scenario analysis is a tool commonly used to address uncertainty, which is inherent to forecasts. By constructing alternative scenarios, one can examine the sensitivity or robustness of one's predictions to changes in key underlying assumptions.

In this study, we construct scenarios of energy-efficiency potential for two key reasons. First, our estimates of potential are forecasts of future adoptions of energy-efficiency measures that are a function of data inputs and assumptions that are themselves forecasts. For example, as described in Section 4, our estimates of potential depend on estimates of measure availability, measure costs, measure savings, measure saturation levels, electricity rates, and avoided costs. Each of the inputs to our analysis is subject to some uncertainty, though the amount of uncertainty varies among the inputs. The second key reason that we construct scenarios is that the final quantity with which we are most interested in this study, achievable potential, is by definition extremely mutable. Achievable potential is dependent on the level of resources and types of strategies employed to increase the level of measure adoption that would otherwise occur. In California, the level of resources and types of strategies are determined by policies and objectives of the institutions charged with enabling, governing, and administering public purpose energy efficiency programs.[1] As illustrated in Section 3, funding levels for energy efficiency have changed dramatically over time.

Thus, we chose to develop scenarios to address uncertainty in factors over which one has limited direct control (e.g., future avoided costs and rates) as well as those that are controllable by definition (e.g., efficiency program funding levels).

5.2 SCENARIO ELEMENTS

As noted above, there is uncertainty associated with virtually all of the inputs to our estimates of energy-efficiency potential. However, the level of uncertainty varies among inputs and not all inputs are equally important to the final results. In addition, the number of scenarios and amount of uncertainty analysis that can or should be conducted is partly limited by the resources

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[1] The minimum funding level for efficiency programs is determined by the public goods charge (PGC) authorized in Senate Bill (SB) 1194 and signed into law by Governor Gray Davis in 2000. Under SB 1194, the major investor-owned utilities (IOUs) in California are required to collect the PGC through a surcharge on customer bills. The California Public Utilities Commission (CPUC) has regulatory authority over how the IOUs administer the energy-efficiency funds.

available for this study.[2] We determined that the greatest uncertainty in our estimates of economic and achievable potential (which are considered of more policy importance than estimates of technical potential) is that associated with future wholesale and retail electricity prices and future program funding levels. As a result, we limited the current scenario analyses for the current study to these two dimensions. Each dimension, energy cost and funding level, is referred to as a scenario *element*. As discussed below, we develop three energy cost elements (Base, Low, and High) and four program funding level elements. These elements are then combined into 12 achievable potential scenarios.

5.2.1 Energy Cost Elements

This study was conducted throughout 2001, a period that coincided with the recent California energy crisis. The advent of the energy crisis created considerable uncertainty in industry estimates of wholesale electricity prices and rates for the three electric investor-owned utilities. As a result, we created three future energy cost scenario elements: Base, Low, and High.

Base Energy Cost Element

The base avoided costs are summarized shown in Figures 5-1 and 5-2. Avoided energy costs are shown in Figure 5-1, while Figure 5-2 presents avoided distribution costs. The base avoided cost values also are provided in Appendix B. The energy avoided costs shown were required and approved by the CPUC for 2001 programs.[3] The utilities derived their 2001 energy avoided cost forecasts by applying CPUC-required on-peak multipliers to an avoided-cost forecast developed by the California Energy Commission just prior to the California energy crisis.[4] These multipliers were ordered by the CPUC in Fall 2000 to account for the skyrocketing market clearing prices observed in Summer 2000.[5] The basis for the multipliers was a study conducted by JBS Energy Inc. in September 2000.[6] Continued use of these multipliers has been required as part of the CPUC's energy-efficiency policy rules for PY2002.[7] As can be seen from Figure 5-1,

[2] Recall that the primary objective of this study is to update estimates of potential that had not been estimated in over 5 years. Scenario analysis was an important but initially secondary objective. We expect that additional scenario and uncertainty analyses may be conducted in the near future on related subsequent studies.

[3] As discussed in Section 4, for consistency across utilities, we used PG&E's time-of-use costing periods and avoided costs. For 2001, avoided costs were similar across utilities and costing periods differed only slightly.

[4] The initial, pre-energy crisis, avoided cost forecasts of both the utilities and California Energy Commission produced estimates of wholesale energy prices that were closely related to the estimated marginal costs of energy from new combined cycle gas units. At the time of the PY2001 CPUC program approval process (Fall 2000), however, these costs were several-fold below observed market prices. The multipliers were required for the first 2 years of the forecast period (2001 and 2002).

[5] *Ruling on Cost-Effectiveness Issues*, Administrative Law Judge Linda R. Bytof, October 25, 2000, A.99-09-049.

[6] *Analysis of PG&E's Electric Distribution Marginal Cost, Revenue Allocation and Rate Design, Appendix A: Cost Curve Analysis of the California Power Markets*, prepared testimony of William B. Marcus, JBS Energy Inc., on behalf of the Utility Reform Network, CPUC App. 99-03-014, September 29, 2000.

[7] *Interim Opinion Adopting Energy Efficiency Policy Rules*, Decision 01-11-066, Rulemaking 01-08-028, November 29, 2001. *Attachment 1: Energy Efficiency Policy Manual*, Version 1, prepared by the CPUC Energy Division, October 2001.

the primary effect of the multipliers was to significantly increase the summer period prices for the first 2 years of the forecasts. On-peak avoided costs are at 60 cents per kWh for 2001 and 2002 before dropping to roughly 26 cents in 2003.

Figure 5-1
Base Avoided Energy Costs

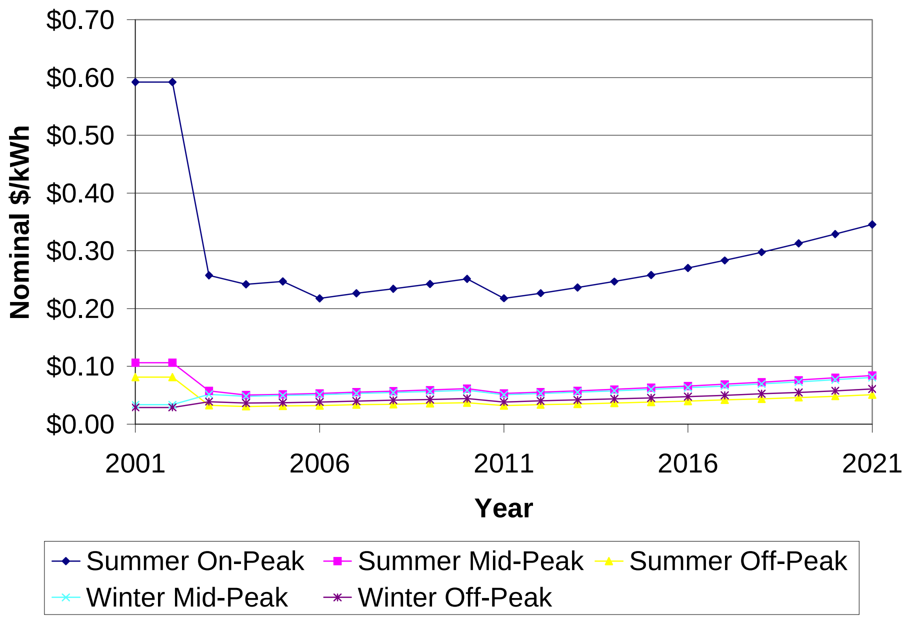
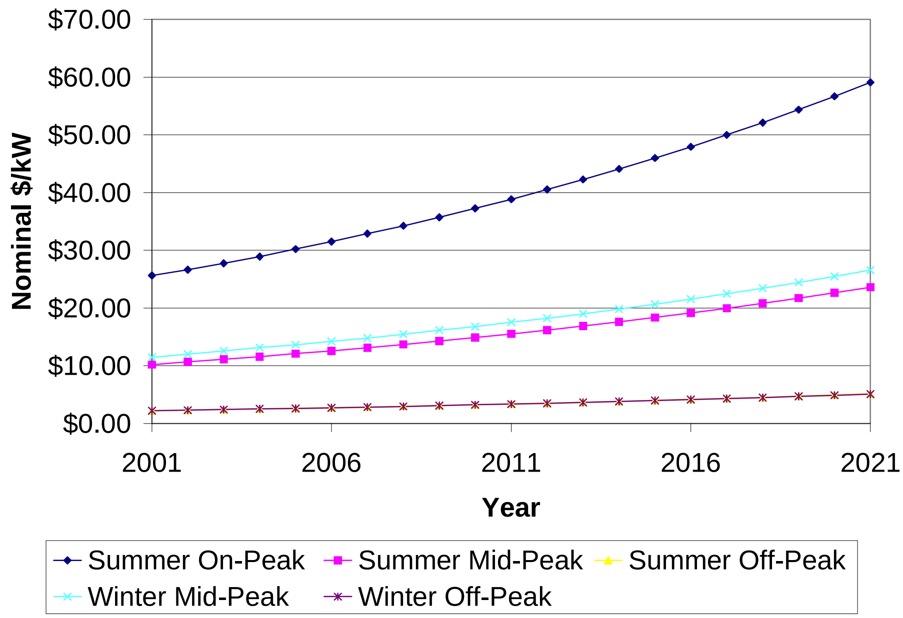


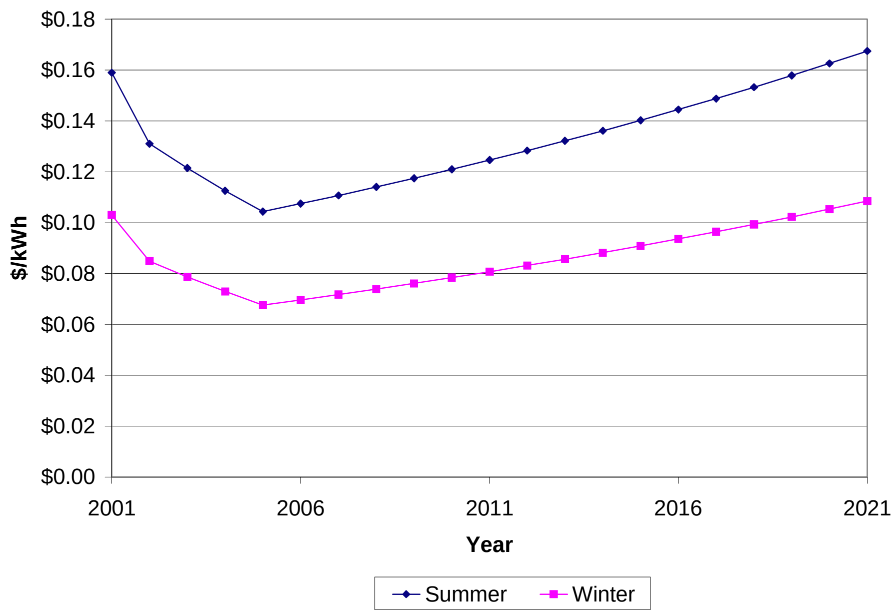
Figure 5-2
Base Avoided Transmission and Distribution Costs



The base avoided cost values, which average around 7 to 11 cents per kWh saved per year over the 20-year forecast period, are higher than those used in energy-efficiency cost-effectiveness analyses conducted prior to 2001.[8] However, these base avoided costs are not far off from the average price of the long-term power contracts purchased by the California Department of Water Resources (DWR) during the height of the energy crisis, although they are lower than the wholesale market prices seen in Summer 2001.

The Base commercial rate forecast used in this study is shown in Figure 5-3. We used an average rate for commercial customers. Current commercial rates are roughly 70 percent higher in the summer and 40 percent higher in the winter than frozen tariffs in place between 1998 and the first half of 2001. Our Base scenario rate forecast starts out at current levels and then declines to values that would be equivalent to levels that the pre-energy-crisis rates would have achieved by 2006 if they had increased by inflation. This rate forecast was based on and is fairly similar to that included in the CEC's October draft of their California Energy Outlook 2002-2012 report.[9]

Figure 5-3
Base Run Commercial Rate Forecast



[8] The value of avoided cost savings range as a function of the load shape of the end use from which savings are achieved. Because the avoided-cost data are much higher for the summer peak period than any other period, the cooling end use typically has the highest average avoided cost, while refrigeration, which has a relatively flat annual load shape, has a lower average value.

[9] California Energy Commission 2001b, Attachment A to Notice of October 12, 2001 Workshop on Staff Proposed *California Energy Demand 2002-2012 Forecast.*

The base energy cost element is summarized in Table 5-1.

Table 5-1
Summary of Base Energy Cost Element

Cost Type	Description	Source
Avoided Costs	Annual avoided cost averages roughly 7 to 11 cents per kWh depending on the end use affected. See Figures 5-1 and 5-2 and Appendix B for specific values.	CPUC authorized avoided costs for major IOU's 2001 cost-effectiveness analyses (CPUC 2000)
Commercial Rates	Estimates of current average commercial IOU rates that decline over time to 1998 levels. Initial average commercial rates decrease to return to nominally normal levels by 2006.	CEC 2001b. CEC's Draft (October) California Energy Outlook 2002-2012.

Low and High Energy Cost Elements

The purpose of developing the Low and High energy cost elements of our scenarios is to bound the Base energy costs by two moderately extreme cases. Although many different combinations of alternative future avoided costs and rates are possible, we choose to create two simple cases.

Because of the tremendous uncertainty around estimates of future wholesale and retail energy costs in California, we developed both Low and High energy cost scenario elements as alternatives to the Base energy cost scenario element. The Low avoided energy costs are simply half of the Base scenario avoided costs throughout the forecast period. The High avoided costs were set at 25 percent above the Base avoided costs throughout the forecast period. The Low commercial rates were set at 1998 frozen levels and then increased from 2001 by inflation. (Thus, on the rate side, this is a hypothetical case only since current rates are significantly above 1998 levels.) In the High element, current commercial rates continue to rise by inflation throughout the forecast period and do not return to pre-crisis levels; that is, the energy-crisis related rate increases of 2001 are permanent in the High element. The actual avoided cost and retail rate values for the Low and High elements are proved in Appendix A. A summary of these elements is provided in Table 5-2.

Table 5-2
Summary of Low and High Energy Cost Elements

	Energy Costs Element	
Cost Type	**Low**	**High**
Avoided Costs	50 percent lower than Base avoided costs.	25 percent higher than Base avoided costs.
Commercial Rates	1998 frozen rates escalated by inflation.	Current actual rates that persist throughout forecast period.

The avoided-cost component of the Low energy cost element is fairly similar to the level of avoided costs that were in use prior to the energy crisis and, hence, are certainly a plausible bound on the low side. The rate component of the Low energy cost element is hypothetical by definition in that the rates are set at 1998 frozen values, putting them below what customers are actually experiencing. Nonetheless, the faster rates return to pre-crisis levels relative to our Base rate forecast, the more applicable the Low element would become.

The High element was developed when the energy crisis was still in full force, that is, before wholesale electricity prices had stabilized and fallen. It was designed to capture the possibility that premium market prices (and by implication, supply shortages) were exacerbated and continued into the future. From today's vantage point, the High element seems unlikely, however, there are a number of high impact, low probability events that could occur in an energy future reflected by the High element.

5.2.2 Program Funding Elements

In this study, we construct four different future funding level elements for the major IOUs' electric energy-efficiency programs for the commercial existing construction market. In combination with the energy cost elements, the program funding elements are used to model achievable potential. Across all energy cost scenarios, the funding level elements are labeled simply *Level 1, Level 2, Level 3,* and *Level 4*. Total program funding expenditures increase sequentially from Level 1 to Level 4. Level 1, the lowest expenditure level, generally approximates spending levels in recent years. Level 4, the highest expenditure element, is used to generate our estimates of maximum achievable potential. As will be clarified further below, *under the Base energy avoided costs*, the funding levels are benchmarked to actual funding levels today so that Level 1 represents "Continued Current" levels of funding, Level 2 represents a "50% Increase" above Level 1, Level 3 represents a "100% Increase" over Level 1, and Level 4 represents the "Maximum Achievable" potential, which equates to a 300 percent increase over Level 1 funding. These qualitative funding level scenario labels apply only under the Base energy costs; otherwise (under the Low and High avoided costs) the funding levels are described only with the Level 1 through Level 4 labels.

Components

The components of program funding that vary under each of the program funding levels are:

- Total marketing expenditures;
- The amount of incremental measure costs paid through incentives; and
- Total administration expenditures.

As described in Section 4.5, customers must be aware of efficiency measures and associated benefits in order to adopt those measures. In our model, program marketing expenditures are converted to increases in awareness. Thus, under higher levels of marketing expenditures, higher levels of awareness are achieved. We also describe in Section 4.6 how program-provided measure incentives lead to increased adoptions through increases in participants' benefit-cost ratios. The higher the percentage of measure costs paid by the program, the higher the participant benefit-cost ratio and number of measure adoptions. Purely administrative costs, though necessary and important to the program process, do not directly lead to adoptions; however, they must be included in the program funding level elements because they are an input to program benefit-cost tests.

Level 1 Funding

For the Base energy cost scenario, our Level 1 funding was constructed to reflect the level of expenditures for the major IOUs commercial programs at different points in time over the past five years. To develop our Base Level 1 expenditure estimates, we reviewed actual expenditures reported in utility CPUC filings for nonresidential programs (excluding new construction).[10] Information on these expenditures is provided in Section 3.3. As shown in Table 5-3, over the period 1996 to 2000, reported expenditures for nonresidential programs for the three utilities averaged roughly $97 million.[11] In 2000, however, reported expenditures for nonresidential programs were roughly $123 million. We estimate that 80 percent of the nonresidential program expenditures were associated with the commercial sector, based on comparisons of program impacts by sector over the past 3 years. Thus, we estimate expenditures associated with the commercial sector were of the order of $77 million for the 1996 to 2000 period and roughly $99 million for PY2000.

Table 5-3
Major IOU Nonresidential Expenditures and Savings, 1996 to 2000
(Expenditures in 2002 $ millions, Savings in GWh)

Sector	Type	1996	1997	1998	1999	2000	Average
Total	Expenditures	$93	$88	$91	$88	$123	$97
	Savings	781	839	376	531	685	642
Commercial (@80%)	*Expenditures*	$74	$70	$73	$70	$99	$77
	Savings	625	671	301	425	548	514
Industrial (@20%)	Expenditures	$19	$18	$18	$18	$25	$19
	Savings	156	168	75	106	137	128

We reviewed the same sources identified above to estimate program administration and marketing costs. Precise estimates of these costs were difficult to make from the sources available at the time. We estimated that program expenditures made up slightly less than half of

[10] These data were generally obtained from the major IOUs Annual Earnings Assessment Proceeding Reports for the years 1996 through 2000. We also reviewed longer-term data compiled by the CPUC's Office of Ratepayer Advocates and the California Energy Commission, as well as a detailed file of forecast program expenditures by program type for PG&E for PY2001.

[11] Note that this figure includes all information programs (including energy centers), as well as all other program marketing, incentive, and administrative costs. Expenditures reported in 2002 dollars.

the total program costs, with financial incentives making up the rest. As shown in Table 5-4, for our Level 1 funding, we set the initial-year program marketing and administration[12] expenditures at $28 million and split this amount fairly evenly between marketing and administration (i.e., $13 million for administration and $15 million for marketing).

The total incentives dollars are estimated directly in our model as a function of predicted adoptions. What we specify in the model is the percent of incremental measure cost paid by the program. The total incentives and average percent of incremental cost paid are shown in Table 5-4. The percent of incremental costs paid by measure is shown in Appendix F. We attempted to set these percentages as closely as possible to the utility incentive levels in recent years. Aligning our percentages with the actual per-unit amounts paid for by the programs is difficult for several reasons. First, incentives in the nonresidential SPC program are set as a function of savings by end use (i.e., dollars per kWh saved). Second, even where prescriptive incentives exist, namely the Express Efficiency program, the amount paid has varied somewhat over the past few years because of "extras" provided to stimulate participation, especially among smaller customers (e.g., summer and vendor bonuses). Notwithstanding the caveats above, we believe that the percent of measure costs paid in our Level 1 funding element, which average about one-third of measure costs, reasonably approximates actual program incentive levels over the past few years.

In the Level 1 funding element, total marketing costs increase by inflation over the 10-year analysis period. We set administration costs to vary slightly over time as a function of program activity levels.[13] The percent of incremental measure costs paid over time is held constant.

Level 2 and Level 3 Funding

Level 2 and Level 3 represent increases in funding from Level 1. Funding levels were increased primarily by increasing both total marketing expenditures and per-unit incentive levels. Administration levels increase as noted above as a function of increases in program activity. As noted above, we set the increases in marketing and incentive levels for Level 2 and Level 3 to result in 50-percent and 100-percent increases in total program expenditures when modeled with the Base energy costs. As shown in Table 5-5, marketing costs average $20 million per year for Level 2 and $22 million per year for Level 3. The average fraction of incremental costs paid for by incentives increases from roughly one-third in Level 1 to approximately half in Level 2 and two-thirds in Level 3.

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[12] Note that "administration", as used here, includes all non-incentive, non-marketing or awareness-building activities.

[13] We set changes in administration costs from year to year as a function of yearly changes in program savings. The function relates future year administration costs (AC_t) to the first-year administration cost (AC_1) as a function of future year program savings (kWh_x) and first-year program savings (kWh_1) as follows: $AC_t = 0.75 \times kWh_t/kWh_1$, with adjustments for inflation. Thus, we set 75 percent of future administration costs to be proportional to first-year program savings, the remaining 25 percent is considered a fixed administrative cost that would be required even with very small programs.

Level 4 Funding (Maximum Achievable)

The Level 4 funding level is used to estimate maximum achievable potential. The key characteristic of this funding level is that 100 percent of incremental measure costs is paid for by the program. In addition, marketing costs increase to an average of $25 million per year.

5.2.3 Combining the Energy Cost and Funding Level Elements into Scenarios

Combining the energy cost and program funding elements produces the 12 scenarios under which we estimate achievable potential in this study. Table 5-5 shows the combinations.

As will seen when we present the actual expenditures for each scenario, the energy cost and program funding elements are interactive in two important respects:

1. Only measures that are economic, as defined in Section 4.5, enter into the achievable potential analyses; and
2. Adoption levels for individual measures will vary across energy cost elements because of differences in commercial rates.

Whether a measure is economic depends on whether its Total Resource Cost test is greater than 1.0. Measure-level TRC ratios vary under the different energy cost elements because of differences in avoided costs between the Low, Base, and High elements. As a result, scenarios associated with the Low energy cost element have the fewest number of measures included in the achievable potential analyses, while scenarios associated with the High energy cost element have the greatest number of measures included in the achievable potential analyses.

With respect to the second point above, adoption levels for individual measures (both naturally occurring and program-induced) will vary across energy cost elements even when measure-level incentives are identical because the differences in commercial rates will result in different participant benefit-cost ratios (because adoption levels are a direct function of participant benefit-cost as discussed in Section 4.6).

Both of the interactions identified above are intuitively correct and reflect what we have seen throughout the history of efficiency programs in California. When avoided costs are low, incentives are available for fewer measures than when avoided costs are high. Similarly, customer adoption of measures is lower when rates are low than when they are high.

As a result of these interactions, total program funding levels will vary across energy cost elements even when the amount of total market expenditures and the percent of individual measure costs paid for by incentives are the same.

5.2.4 Summary of Program Expenditures by Scenario

With the background discussion above, we can now summarize the actual funding levels that are both input and estimated for each scenario. These values are shown in Table 5-4 and discussed further in the program potential results section of this report (Section 7). Year-by-year funding levels are shown in Appendix F.

Table 5-4
Summary of Program Expenditures by Scenario
(Average Expenditures Over the 10-Year Analysis Period in Millions of $ per Year)

	Cost Components				
Scenario ***Energy Cost – Funding Level***	**Marketing**	**Administration**	**Incentives**	**Total**	**Average % of Measure Cost Paid***
Base – "Continued Current" (L1)	$15	$13	$55	$83	33%
Base – "50% Increase" (L2)	$20	$15	$94	$129	50%
Base – "100% Increase" (L3)	$22	$18	$135	$175	66%
Base – "Max Achievable" (L4)	$25	$20	$193	$238	100%
Low – L1	$15	$9	$27	$51	33%
Low – L2	$20	$11	$38	$69	50%
Low – L3	$22	$12	$53	$87	66%
Low – L4	$25	$14	$72	$111	100%
High – L1	$15	$14	$72	$101	33%
High – L2	$20	$16	$110	$146	50%
High – L3	$22	$18	$155	$195	66%
High – L4	$25	$19	$195	$239	100%

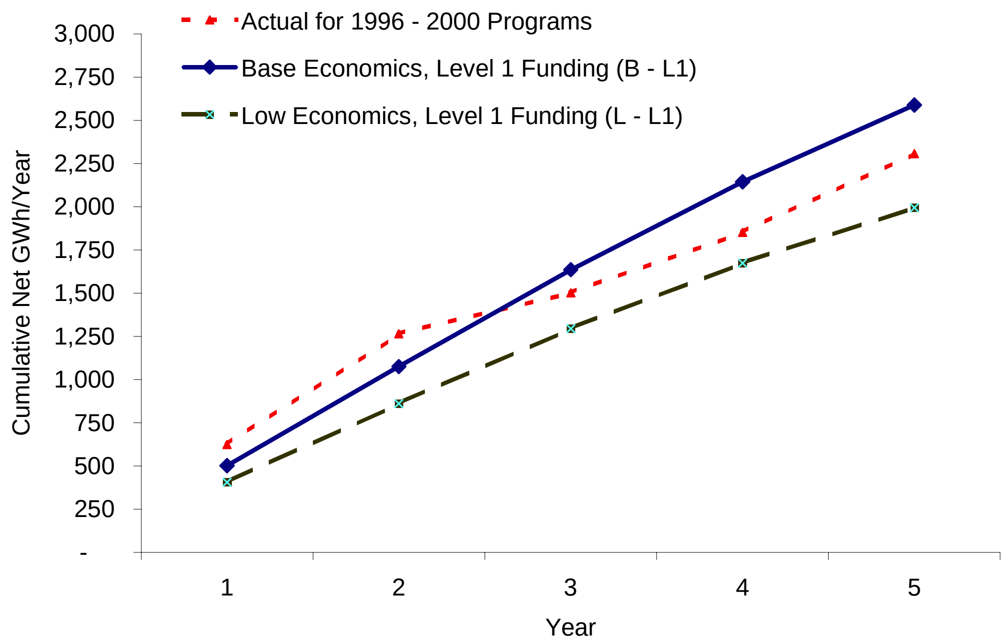
*Over the first several years of the forecast period, the percent of measure cost paid under funding Levels 2 through 4 are ramped up from the 33 percent of measure costs paid under Level 1 funding.

5.3 ACHIEVABLE POTENTIAL SCENARIO CALIBRATION

We used the major IOUs' reported commercial sector energy savings accomplishments from 1996 to 2000 as the base for our calibration of our achievable potential estimates. We compared the 1996 to 2000 actual program savings to the first 5 years of our forecasted savings. As shown in Table 5-3, commercial sector savings ranges from 300 to 625 GWh per year over this period and averaged roughly 500 GWh. Average annual commercial sector funding over this period was $77 million.

The two scenarios that are closest to the market and program funding conditions of the 1996 to 2000 period are scenarios *Base – "Continued Current" (Level 1)* and *Low – Level 1*. Average annual funding for these scenarios for the first 5 years of our analysis is $99 and $69 million, respectively. We picked these two scenarios for model calibration because the economic conditions for the 1996 to 1999 period were similar to those incorporated in the Low economic scenarios, while the economic conditions in 2000 were closer to the assumed economic conditions in the Base scenarios. Given this and the concomitant funding levels, one would expect the *Base – Level 1* and *Low – Level 1* scenario energy savings to also bound the actual energy savings during the 1996 to 2000 period. As shown in Figure 5-4, our results bound the actual as expected.

Figure 5-4
Achievable Potential Estimates versus Actual



6 TECHNICAL AND ECONOMIC POTENTIAL RESULTS

6.1 INTRODUCTION

In this section we provided our estimates of technical and economic energy-efficiency potential for the existing construction portion of the commercial sector of the major IOU service territories. The methodologies used to develop these estimates are described in Section 4. The energy cost scenarios for which estimates are presented are described in Section 5.

A total of 69 commercial measures were used in the analyses. The complete set of measures considered was pre-screened to only include those measures that are presently commercially available. Thus, few emerging technologies were included in the analysis. The measure analysis was segmented into 10 commercial building types for each of the 3 electric IOU service territories. As a result, our analyses were conduct for roughly 2,000 measure-market segment applications.

The technical and economic potential results are presented in several formats:

- In aggregate for each utility;
- By end-use and measure; and
- In the form of energy and demand supply curves.

We provide estimates of savings in both absolute and percentage terms. We express percent savings in two ways: 1) percent of *total* commercial energy or demand; and 2) percent of energy or demand *addressed*. In both cases, we use the California Energy Commission's (CEC's) end-use forecast data for the year 2000.[1] *Total* base energy is the CEC's estimate of the amount of energy consumed for all end uses and building types in the commercial sector for the three utilities in 2000. This figure is roughly 80,000 GWh. We estimate that the peak demand associated with *total* commercial energy for the three utilities is 16,500 MW. Energy-efficiency measures are analyzed for the most important end uses but not all end uses. In particular, we have not included measures for electric heating, cooking, domestic hot water, and miscellaneous end uses. As shown in Section 2, CEC data indicate that the miscellaneous end use comprises about 14 percent of commercial energy use, while electric heating, cooking and water heating make up only 1 percent. As a result, the end uses for which we do apply efficiency measures account for about 76 percent of energy use, or 61,187 GWh. Our corresponding estimate of peak demand for these end uses is 15,475 MW, which makes up 94 percent of peak demand for the commercial sector. We refer to these estimates as the base energy use and peak demand *addressed*.

[1] California Energy Demand, 2000 – 2010, California Energy Commission, P200-00-02, June. The CEC provided data on square footage, end use saturation, and end use intensity (kWh per square foot) to support this study.

6.2 TECHNICAL AND ECONOMIC POTENTIAL UNDER BASE ENERGY COSTS

This section presents technical and economic potential estimates under the base energy costs described in Section 5. Economic potential under the alternative Low and High energy costs is presented in Section 6.3.

6.2.1 Aggregate Technical and Economic Savings Potential by Utility

In Figure 6-1 we present our estimates of total technical and economic potential for energy and peak demand. In Figures 6-2 and 6-3 we show technical and economic potential by utility. Overall, technical energy savings potential is estimated to be 14,721 GWh, about 18 percent of total commercial energy usage (i.e., 14,721 GWh Savings/80,000 GWh of base consumption) and 24 percent of the base energy addressed (i.e., 14,721/61,187). Economic potential is estimated to be 10,627 GWh, about 13 percent total base usage and 17 percent of the base energy addressed. Technical demand savings potential is estimated to be 3,673 MW, about 22 percent of total peak demand (just below 24 percent of the base peak demand addressed). Economic potential is estimated to be 2,373 MW, about 14 percent of total base demand (15 percent of base demand addressed). SCE is estimated to have the largest share of technical and economic energy savings potential at about 49 percent of the total, followed by PG&E at 40 percent and SDG&E at 11 percent. Although the absolute amount of savings potential varies by utility, there is little difference in savings potential on a percentage basis. Estimates of demand savings potential for PG&E and SCE are similar.

Figure 6-1
Estimated Technical and Economic Potential
(Commercial Sector Existing Construction, PG&E/SCE/SDG&E)

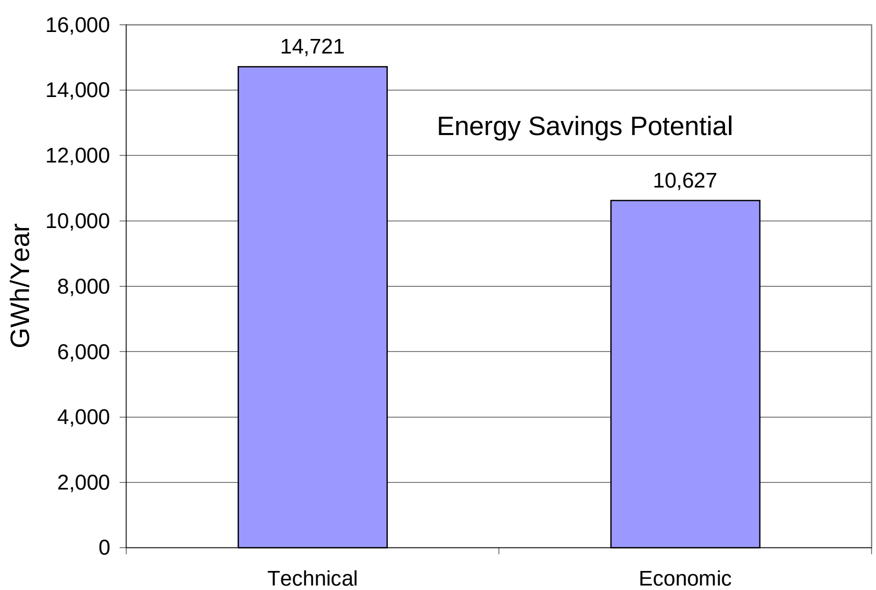


Figure 2-4 (Continued)

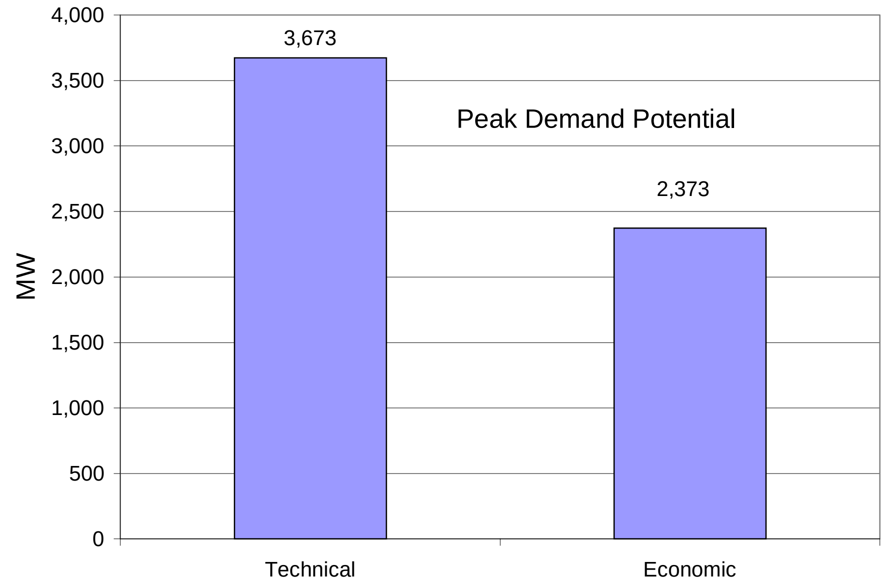


Figure 6-2
Commercial Energy Savings Potential by Utility

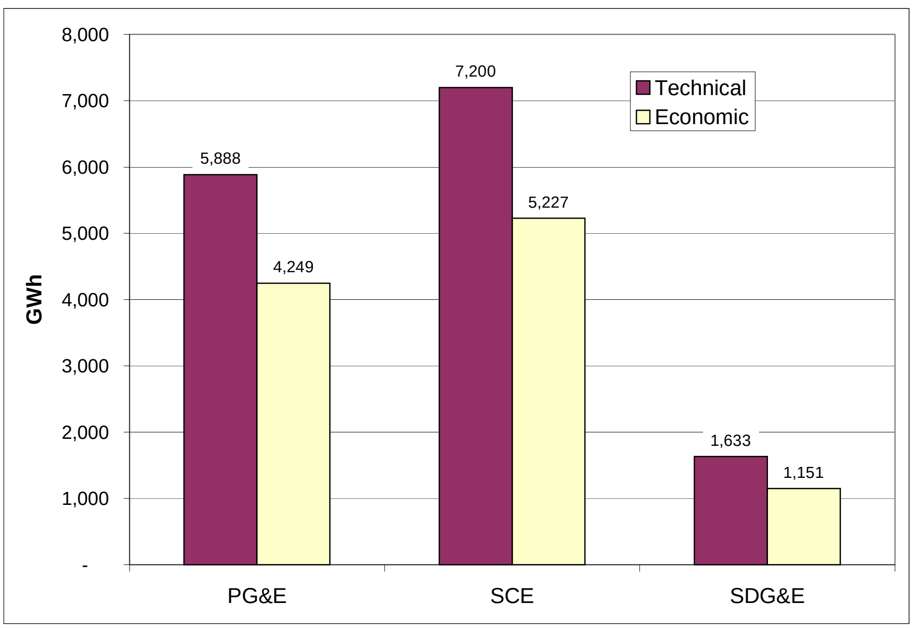
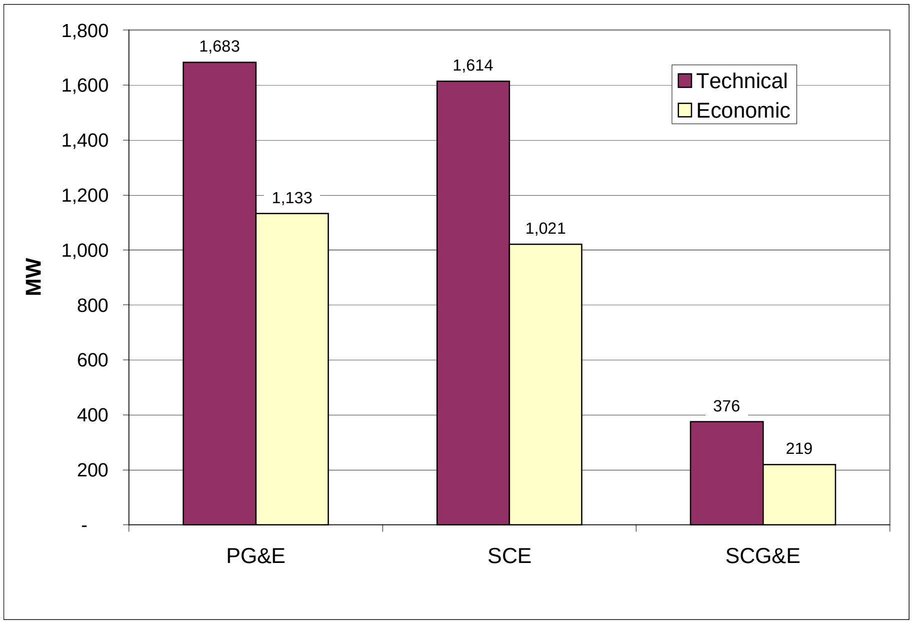


Figure 6-3
Commercial Demand Savings Potential by Utility



6.2.2 Technical and Economic Savings Potential by End Use and Measure

Estimates of energy and peak demand savings potential are provided by end use in Figures 6-4 through 6-7. The first of the figures provides savings in absolute terms; the second, in terms of the percentage of base case end-use energy or peak demand. Despite the significant adoption of high-efficiency lighting throughout the 1990s, interior lighting still represents the largest end-use savings potential in absolute terms for both energy and peak demand. As expected, cooling potential represents a significant portion of the total peak demand savings potential. Refrigeration energy savings potential is roughly equal to that of cooling but is significantly less important in terms of peak demand potential. Economic savings potential values are summarized by end use and utility in Table 6-1.

In Figures 6-8 and 6-9, we present estimates of technical potential by measure in terms of energy and peak demand, respectively. In terms of energy savings, the T8 lamp/electronic ballast (T8/EB) combination continues to hold the position it held at the outset of the 1990s as the measure with the largest potential, this despite the fact that we estimate that current saturation levels are significant (see Appendix A and Appendix C for specific estimates). If applications where reflectors may also be appropriate are included, then the potential for efficient *fluorescent* lighting systems represents about 25 percent of total potential energy savings. Automated perimeter dimming represents a significant savings opportunity as well, though at a cost that generally puts it above the economic threshold. Refrigeration compressor and motor upgrades, occupancy sensors for lighting, office equipment power management, and compact fluorescent lamps round out the measures that represent roughly 5 percent or more of total energy savings potential. The remaining measures represent 37 percent of energy potential.

With respect to peak demand savings, the relative order of measures shifts somewhat. Perimeter dimming represents the largest demand savings opportunity, followed by the T8/EB combination. Cooling measures become more significant in terms of peak impacts with high-efficiency chillers and packaged units, as well as chiller tune-ups making up a large share of total potential demand savings. Occupancy sensors and T8/EB plus reflectors also capture at least 5 percent of the total demand savings potential, as they did with respect to energy savings. These measures, when combined, represent 68 percent of demand reduction potential.

In Table 6-2, we provide a summary of issues and observations associated with these results.

Figure 6-4
Commercial Energy Savings Potential by End Use

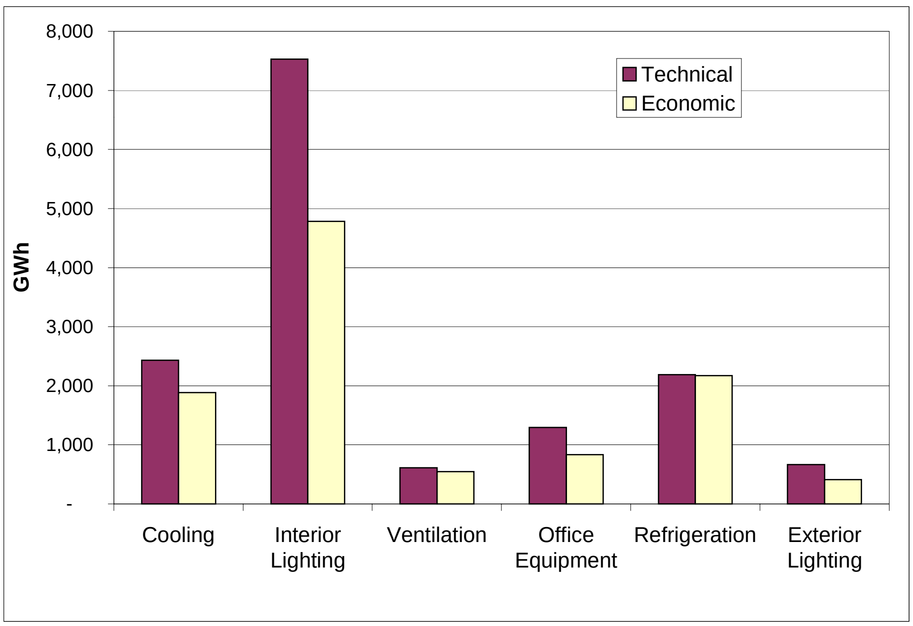


Figure 6-5
Commercial Energy Savings Potential as Percent of Base End-Use Consumption

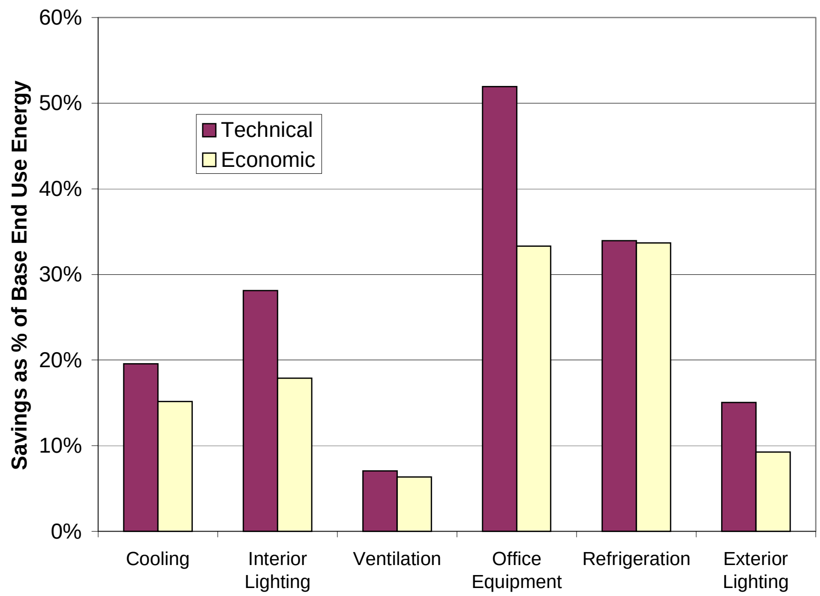


Figure 6-6
Commercial Demand Savings Potential by End Use

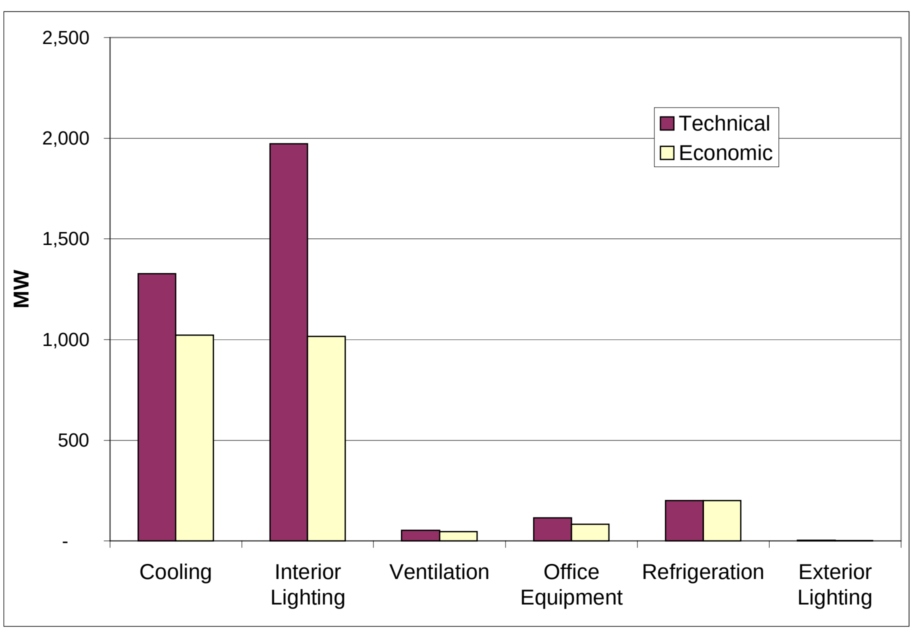


Figure 6-7
Commercial Energy Savings Potential as Percent of Base End-Use Peak Demand

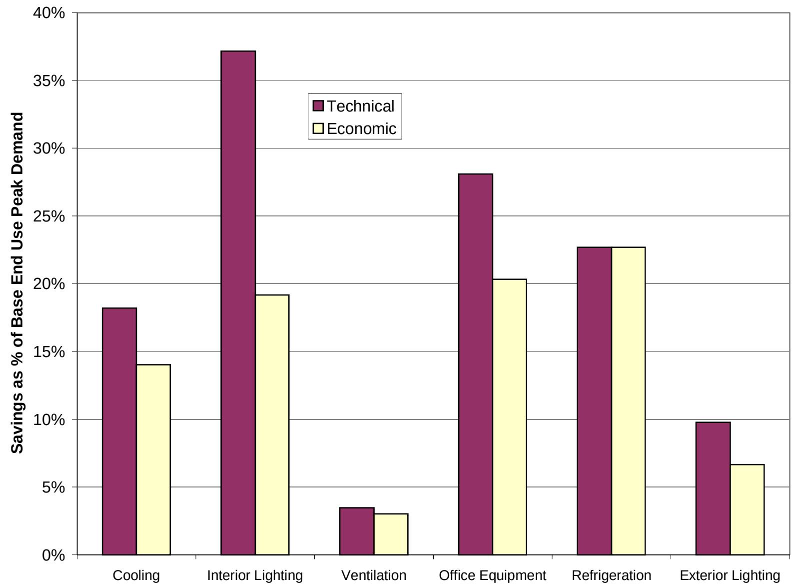


Table 6-1
Economic Savings Potential by End Use and Utility

	PG&E		SCE		SDG&E		Total	
End Use	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**	**GWh**	**MW**
Cooling	804	578	929	370	152	74	1,885	1,022
Interior Lighting	1,870	415	2,396	496	519	106	4,785	1,017
Ventilation	148	12	315	26	84	9	547	47
Office Equipment	355	34	377	38	99	10	831	82
Refrigeration	958	92	996	89	215	19	2,169	200
Exterior Lighting	113	1	214	1	82	0.4	409	2
Total	4,248	1,132	5,227	1,020	1,151	218	10,626	2,370

Figure 6-8
Commercial Energy Savings Potential by Measure

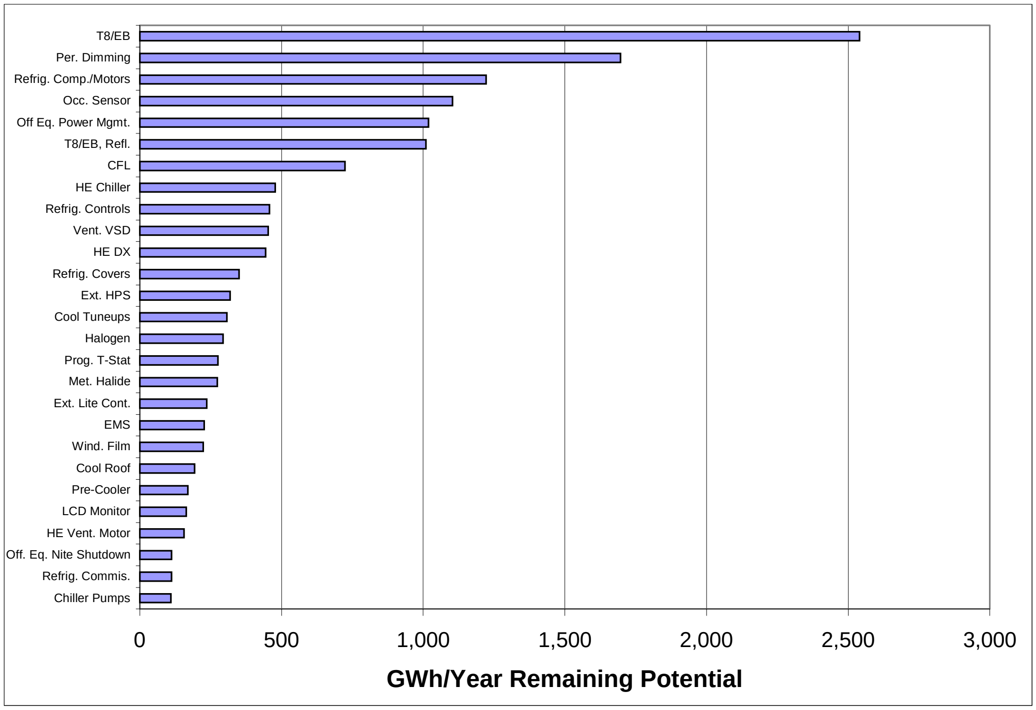


Figure 6-9
Commercial Demand Savings Potential by Measure

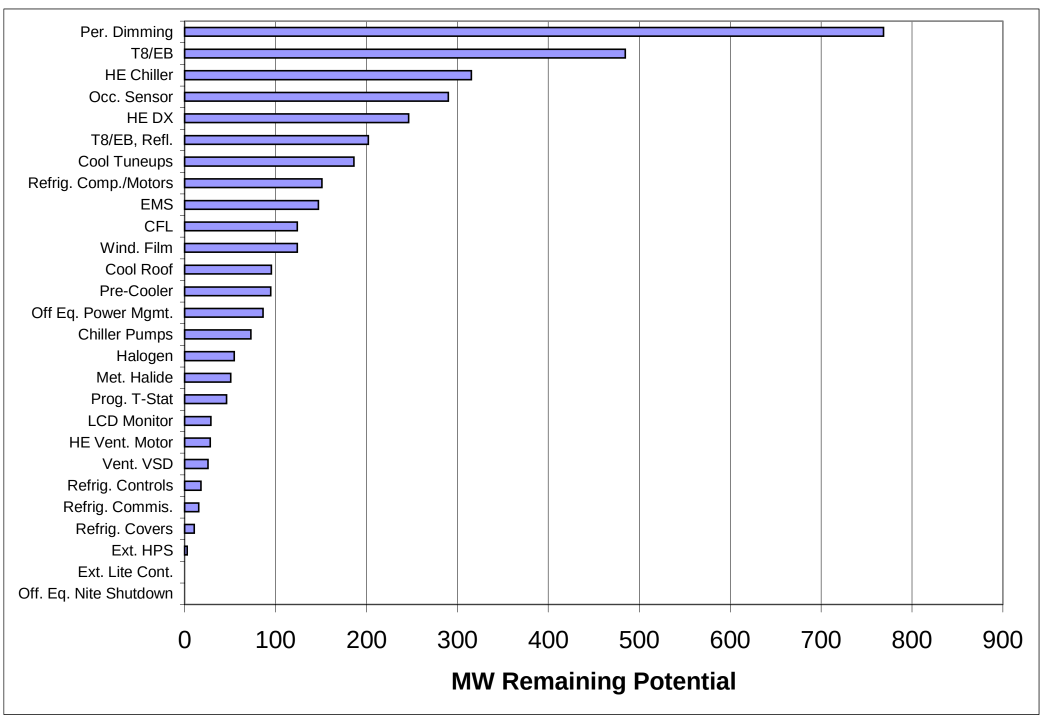


Table 6-2
Considerations for Interpreting Results

End Use	Key Considerations
Cooling	1) ***New standards***. Note that the CEC's 2001 standards require significant increases in the efficiency of packaged air conditioners and chillers. Because our ultimate goal in this study is to estimate program savings potential, these improvements have been netted out of our base case energy and demand and are not included in our potential estimates. We estimate that these new commercial cooling equipment standards will result in roughly 1,000 GWh of savings over the next 20 years. Including these savings in our potential estimates would have increased our technical potential as a percentage of base cooling energy by 8 percent to 28 percent. 2) ***Niche measures, cost/savings uncertainty, and aggregation bias***. Although we generally excluded emerging technologies and measures from this study, there were several in the cooling area that might be considered in the gray zone. These include cool roofs, chiller and DX tune-ups, and evaporative pre-coolers. At this time, costs and savings estimates are fairly uncertain for all of these measures. In particular, we found very little empirical data upon which to base estimates of costs and savings for cool roofs. As a result we used building simulation results from a CEC study conducted in 1994 that used 14 building types to represent the entire population of commercial buildings. The limited number of prototypes and the fact that the prototypes were not developed to be indicative of the subpopulation of buildings applicable for a cool roof may result in an underestimation of cool roof potential. Further research on cool roofs is currently in progress as part of CEC SB5 1x program efforts. When available, new empirical results for these measures should be incorporated into an update of this study.
Interior Lighting	1) ***Existing measure saturation***. As discussed in Appendix A, current saturation levels for T8 lamp/electronic ballast and compact fluorescent lamps are high but are uncertain. Lighting potential results are very sensitive to estimates of current saturation. This uncertainty will be reduced when the new statewide commercial end use study is completed. Nonetheless, we caution that capturing the remaining lighting savings should be expected to be more costly than was capturing this market in the 1990s. This is because the market segments that have not yet adopted are likely to be those that are more costly to reach because they are small and capital constrained. 2) ***Costs and approach to dimming***. Dimming represents a significant savings opportunity in commercial lighting systems; however, automated dimming systems remain fairly expensive and complex. There are less expensive, simpler approaches such as stepped or manual dimming. In this study, we modeled the automated dimming approach, for which savings were found to be generally uneconomic. A refinement to this study would be to include a lower cost stepped dimming option. 3) ***T5 lamps***. T5 lamps are included in our screening results but not in our supply curves. Because this study focused on simple equipment substitutions and measure applications in existing buildings, T5 potential was not modeled. Cost-effective T5 savings in existing commercial buildings generally requires redesign of the existing

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End Use	Key Considerations
	lighting system. Incorporation of this opportunity into future updates of this study should also be considered.
Refrigeration	1) ***Complexity of the end use and measure saturation uncertainty***. Refrigeration is the most complex of the commercial end uses addressed. Throughout the 1990s, a number of studies were conducted aimed at identifying energy-saving refrigeration measures. These studies identified numerous such measures and began the process of estimating the costs and savings associated with them. This study draws on these previous studies and finds that there appears to be a significant potential for savings in this end use. However, there are few sources of reliable measure saturation data available. In addition, despite the identified potential, refrigeration savings actually achieved in the 1990s in utility efficiency programs have been fairly modest. This may reflect market barriers to achievement of the identified potential or errors the estimates of potential themselves. Further research on this end use is recommended. 2) ***Level of economic savings***. Almost all of the technical potential identified in this study is estimated to be economic. This may be correct or may be a result of underestimated measure costs or inconsistencies between cost and savings estimates. Further analysis of the cost of savings for this end use is needed.
Ventilation	1) ***Level of economic savings.*** Economic potential generally varies as a function of the size distribution of motors within a business type. 2) ***Uncertainty.*** There is some uncertainty around VSD feasibility factors, in addition, it is difficult to identify the fraction of motors in the population for which VSD retrofit is feasible from existing data sets.
Office Equipment	1) ***Level of economic savings.*** Most of the potential is associated with measures that require some behavioral change, principally in network enabling of power management and manual shutdown actions 2) ***Uncertainty.*** The percent of the market currently using power management features is uncertain.
Exterior Lighting	1) ***Level of economic savings.*** Existing saturation of measures is already very high.

6.2.3 Energy-Efficiency Supply Curves

Our commercial sector energy-efficiency supply curves are shown in Figures 6-10 and 6-11 for energy and peak demand savings potential, respectively. The curves are shown in terms of savings as a percentage of total commercial sector energy consumption and peak demand for the three utilities in scope. Note that our economic potential figures presented previously are based on the Total Resource Cost test as described in Section 4. Also note that our avoided-cost values include both energy and demand benefits. Thus, our economic potential integrates the value of the savings potentials shown in both the energy and demand supply curve figures. In Table 6-3 we show aggregated energy supply curve values by measure. These results are aggregated across market segments and utilities. Individual segment results can vary significantly from the aggregated average values shown. Detailed economic results for individual measures by market segment are provided in Appendix D, though the results in this appendix are not additive.

Figure 6-10
Commercial Energy-Efficiency Supply Curve - Energy

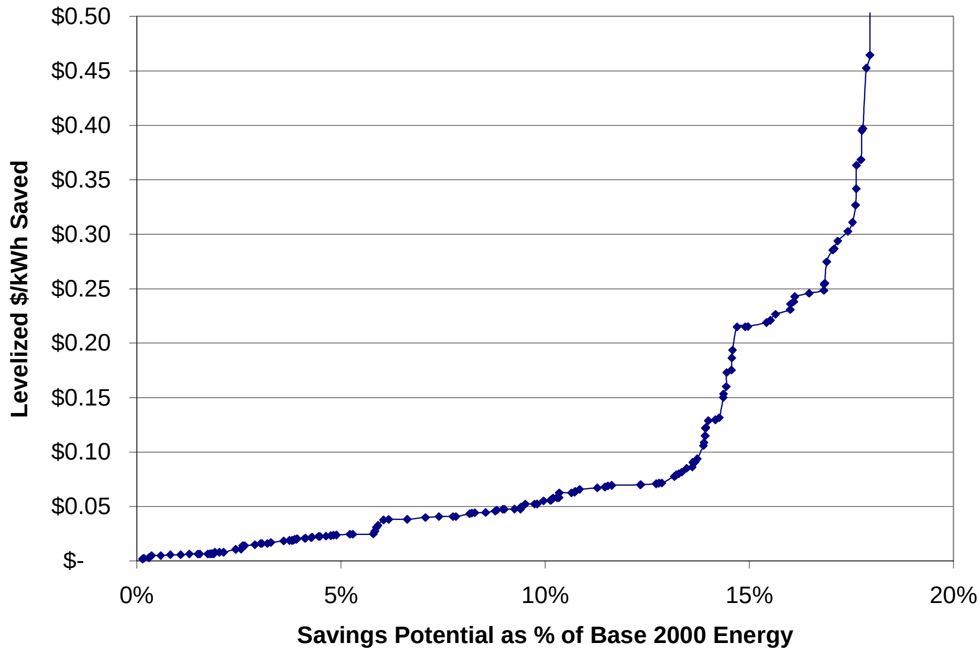

Figure 6-11
Commercial Energy-Efficiency Supply Curve - Demand

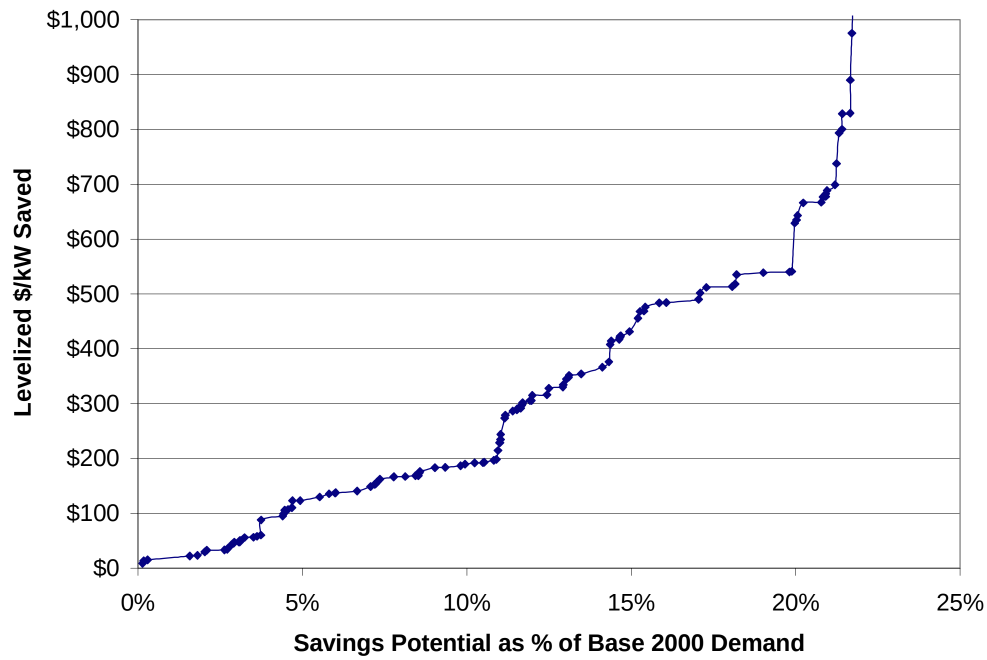

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Table 6-3
Aggregated Measure Values for Energy-Efficiency Supply Curves

Measures	GWH Savings	Cumulative GWH Savings	Levelized Energy Cost $/KWH	Percent Savings
T8/EB, Refl.	1,010	1,010	$0.007	1%
Refrig. Misc.	45	1,054	$0.007	1%
Refrig. Controls	458	1,512	$0.017	2%
HE Chiller	478	1,990	$0.017	2%
Refrig. Covers	350	2,340	$0.021	3%
Prog. T-Stat	277	2,616	$0.022	3%
CFL	724	3,340	$0.025	4%
Ext. Lite Cont.	236	3,576	$0.026	4%
Refrig. Comp./Motors	1,222	4,798	$0.032	6%
Vent. VSD	453	5,251	$0.034	7%
Occ. Sensor	1,104	6,355	$0.048	8%
Ext. HPS	319	6,674	$0.052	8%
T8/EB	2,539	9,213	$0.059	11%
HE DX	445	9,658	$0.066	12%
HE Vent. Motor	156	9,814	$0.071	12%
Refrig. Commis.	112	9,927	$0.071	12%
Off Eq. Power Mgmt.	1,019	10,945	$0.090	14%
EMS	227	11,173	$0.097	14%
Wind. Film	224	11,397	$0.110	14%
Halogen	295	11,692	$0.136	15%
Chiller Pumps	110	11,802	$0.148	15%
Cool Tuneups	308	12,110	$0.225	15%
Cool Roof	193	12,304	$0.238	15%
Per. Dimming	1,696	14,000	$0.250	17%
Met. Halide	273	14,273	$0.265	18%
Pre-Cooler	170	14,444	$0.326	18%
Off. Eq. Nite Shutdown	113	14,556	$2.031	18%
LCD Monitor	165	14,721	$5.976	18%

Measures	MW Savings	Cumulative MW Savings	Levelized Demand Cost $/kW	Percent Savings
HE Chiller	315	315	$26	2%
T8/EB, Refl.	202	517	$33	3%
Refrig. Misc.	6	523	$49	3%
HE DX	246	769	$120	4%
Prog. T-Stat	46	815	$135	4%
CFL	124	939	$144	5%
EMS	147	1,086	$150	6%
Occ. Sensor	290	1,376	$184	8%
Wind. Film	124	1,500	$199	8%
Chiller Pumps	73	1,572	$224	9%
Refrig. Comp./Motors	151	1,723	$259	9%
T8/EB	485	2,208	$312	12%
Cool Tuneups	186	2,394	$372	13%
HE Vent. Motor	28	2,422	$397	13%
Cool Roof	95	2,517	$483	14%
Refrig. Commis.	15	2,533	$520	14%
Per. Dimming	769	3,301	$553	18%
Pre-Cooler	95	3,396	$587	19%
Vent. VSD	26	3,422	$596	19%
Halogen	55	3,476	$732	19%
Met. Halide	51	3,527	$1,427	19%
Ext. HPS	3	3,530	$6,151	19%
LCD Monitor	29	3,558	$34,229	19%
Refrig. Covers	10	3,569	N/A	19%
Refrig. Controls	18	3,587	N/A	20%
Off Eq. Power Mgmt.	86	3,673	N/A	20%
Off.Eq Nite Shutdown	-	3,673	N/A	20%
Ext. Lite Cont.	-	3,673	N/A	20%

6.3 Economic Potential Under Low and High Energy Costs

In this subsection we present estimates of economic potential under both the Low and High economic scenarios defined in Section 5. Note that technical potential is not presented for the Low and High energy cost scenarios because only economic potential changes in response to the changes in assumptions associated with avoided costs. Technical potential is estimated, as described in Section 4, independent of measure economics. Thus, this subsection focuses on presenting differences in economic potential among the three scenarios. The overall economic potential for each energy cost scenario is shown in Figures 6-12 and 6-13 on an absolute and a percent of total sector load basis, respectively. Economic potential is fairly sensitive to the decrease in avoided costs in the Low energy costs scenario, dropping by 25 percent for energy savings as compared to the Base scenario. Economic potential under the High energy costs scenario is 14 percent above that of the Base scenario. The asymmetry of these results generally follows the asymmetry assumed for the Low and High energy costs – i.e., avoided costs are 50 percent lower than Base in the Low scenario but only 25 percent higher than Base in the High scenario. The spread of economic potential under uncertain avoided costs is quite large, ranging from roughly 8,000 GWh to 12,000 GWh. The difference in demand potential is under the full range of avoided costs is 1,000 MW. Results by end use are compared in Figure 6-14.

Figure 6-12
Economic Potential By Energy Cost Scenario

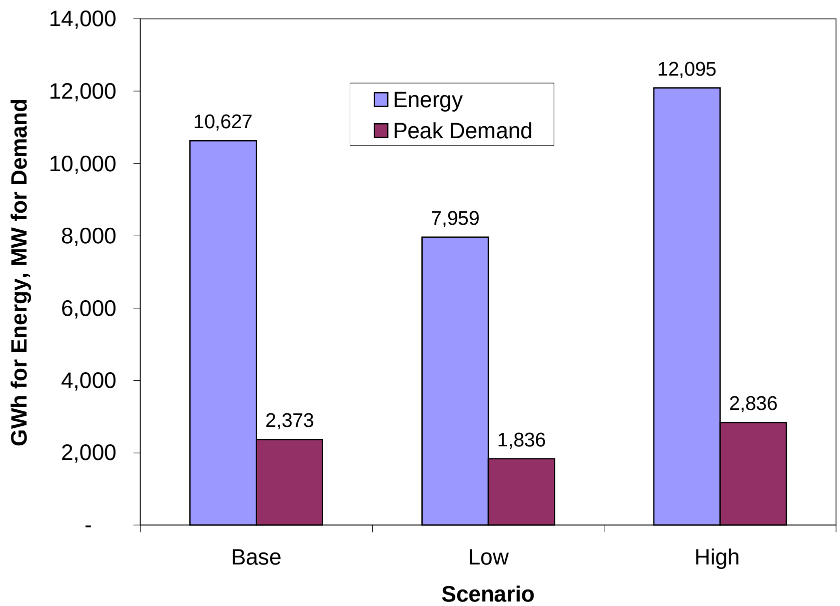


Figure 6-13
Economic Potential as Percent of Base Consumption and Peak Demand
By Energy Cost Scenario

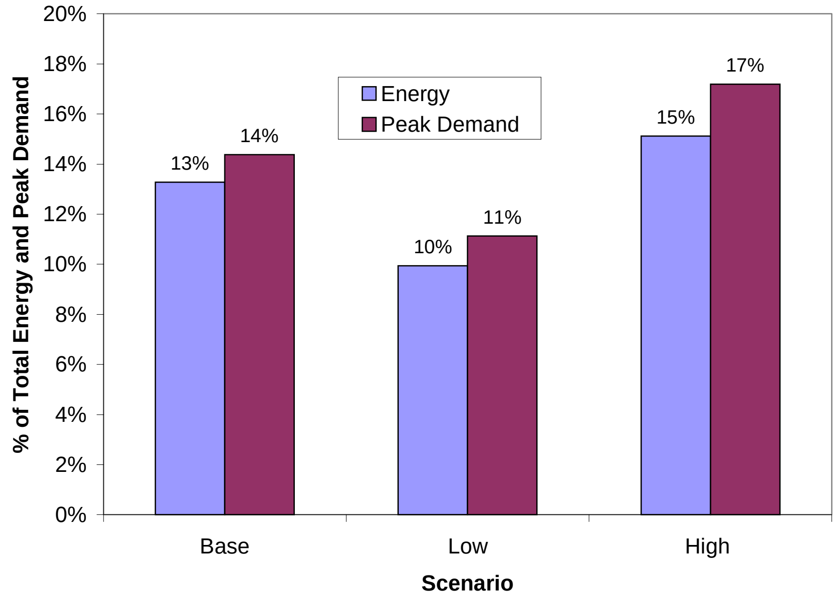
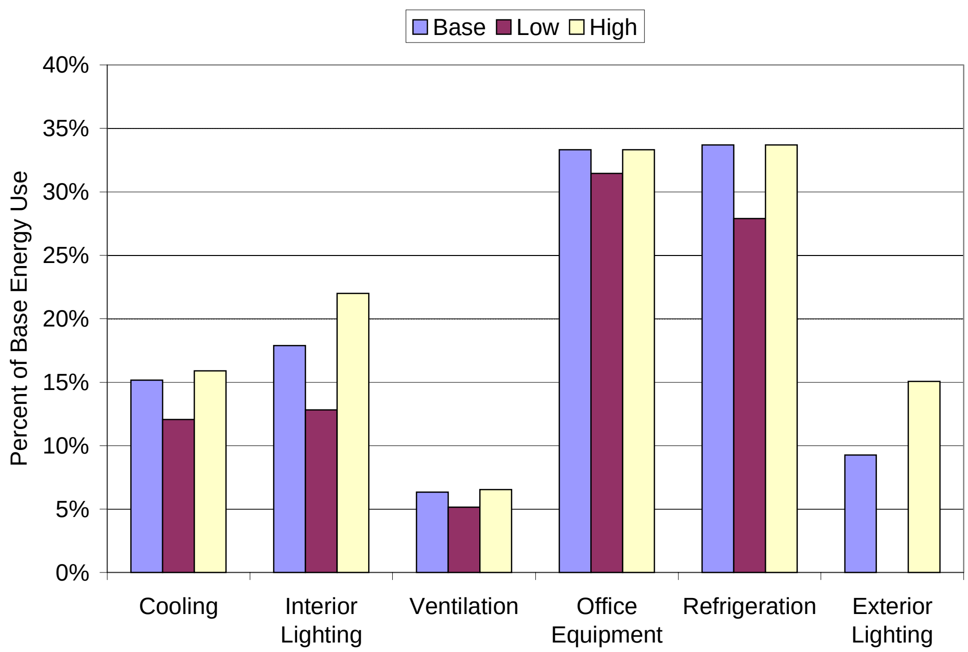


Figure 6-14
Economic Potential as Percent of Base End-Use Consumption
by Energy Cost Scenario



From these estimates of economic potential, we proceed to estimate achievable program potentials as presented in Section 7.

7 PROGRAM POTENTIAL RESULTS

In this section we present the results of our achievable program potential estimates for commercial buildings in the major IOUs service territories. Our definition of and method of estimating achievable program potential are provided in Section 4 of this report. Program potential is estimated under several scenarios that reflect a range of possible alternative futures.

7.1 REVIEW OF SCENARIOS UNDER WHICH ACHIEVABLE PROGRAM POTENTIALS ARE ESTIMATED

In Section 5, we discussed the fact that there is some uncertainty associated with virtually all of the inputs to our estimates of energy-efficiency potential. However, the level of uncertainty varies among inputs and not all inputs are equally important to the final results. We determined that the greatest uncertainty in our estimates of economic and program potential is that associated with future wholesale and retail electricity prices and future program funding levels. As a result, we limited our scenario analysis for the current study to these two dimensions. Each dimension, energy cost and funding level, is referred to as a scenario *element*. In Section 5 we described three energy cost elements (Base, Low, and High) and four program funding level elements. These elements are combined into 12 program potential scenarios.

The energy cost scenarios are summarized in Table 7-1 and discussed further in Section 5.

Table 7-1
Summary of Energy Cost Scenario Elements

	Energy Cost Scenario Elements		
Cost Type	**Low**	**Base**	**High**
Avoided Costs	50 percent lower than Base avoided costs.	Avoided cost averages roughly 7 to 11 cents per kWh depending on end use affected.	25 percent higher than Base avoided costs.
Commercial Rates	1998 frozen rates escalated by inflation.	Current average commercial IOU rates decrease and return to nominally normal levels by 2006.	Current actual rates that persist throughout forecast period.

For each energy cost scenario element, we construct four different future funding levels. In combination with the energy cost elements, the program funding elements are used to model program potential. Across all energy cost scenarios, the funding level elements are labeled simply *Level 1*, *Level 2*, *Level 3*, and *Level 4*. Total program funding expenditures increase sequentially from Level 1 to Level 4. Level 1, the lowest expenditure level, generally approximates spending levels in recent years. Level 4, the highest expenditure element, is used to generate our estimates of maximum achievable potential.

As discussed in Section 5, *under the Base energy avoided costs*, the funding levels are benchmarked to actual funding levels today so that Level 1 represents "Continued Current" levels of funding, Level 2 represents a "50% Increase" above Level 1, Level 3 represents a "100% Increase" over Level 1, and Level 4 represents the "Maximum Achievable" potential, which equates to a 300-percent increase over Level 1 funding. These qualitative funding level scenario labels apply only under the Base energy costs; otherwise (under the Low and High avoided costs) the funding levels are described only with the Level 1 through Level 4 labels. Funding levels are described in detail Section 5 and are summarized with program potential results at the end of this section.

7.2 NATURALLY OCCURRING EFFICIENCY RESULTS

Before presenting the net program potential results, we first present our estimates of naturally occurring efficiency savings under our three economic scenario elements. This is because total or gross program potential includes naturally occurring savings. Net program savings exclude naturally occurring savings. It is also useful to examine the estimates of naturally occurring savings under the different economic assumptions because these results are essentially equivalent to bottom-up estimates of the efficiency component of electricity price elasticity.[1]

Before examining the naturally occurring estimates, readers may want to review our discussion of how customer adoption of efficiency measures is modeled in Section 4. In the method employed, a customer perspective benefit-cost test is calculated for each measure and market segment. The benefit-cost test uses the forecast of rates for each scenario element over the period 2001 to 2021. The rate forecasts are shown in Section 5 and Appendix B for each scenario. Note that the start year for each analysis is static, i.e., it is always 2001.[2] In addition, by definition the customer adoption behavior is modeled assuming that that the customer bases their decision on the forecasted data as if it were known. For example, in the Base run, the customer "believes" that rates come down fairly sharply over the next few years and return to pre-crisis levels (nominally). Under the High scenario, the customer decision is modeled as if the customer "believes" that rates will stay at their current levels (nominally) indefinitely.

Naturally occurring energy and peak demand savings are shown for the three economic scenario elements in Figures 7-1 and 7-2.

Naturally occurring energy savings under all of the scenarios decrease at an increasing rate over the ten-year analysis period. This is principally because, in the absence of further program

[1] That is, elasticity exclusive of conservation (behavioral changes) and fuel switching.

[2] In the modeling process, measures with service lives less than 20 years are assumed to be reinstalled as many times as necessary to equate to a twenty year stream of benefits. Costs of the future year installations are included in the present value calculations. That is, measure costs and benefits are normalized over a twenty year forecast period.

activity, customer awareness and knowledge of efficiency opportunities is assumed to decline. Naturally occurring energy savings under the Base economic cost assumptions start off at roughly 200 GWh per year but average only 100 GWh over the 10-year period (the corresponding peak demand figures are 36 and 17 MW, respectively).

In the Low scenario naturally occurring savings are only marginally below those in the Base scenario. This is not surprising because over the 20-year period for which the customer benefit-cost ratios are calculated, the effect of the temporary rate increase is perceived to be relatively small. Given that the short-term rate increase will dramatically reduce payback periods for measures, it is likely the present value approach to modeling customer decisions underestimates naturally occurring adoption somewhat in the Base scenario. In the case of the High scenario, naturally occurring savings increase dramatically, roughly doubling. In 2001, actual customer behavior may have been closer to the High scenario than the Base scenario. If perceptions of the permanence of the rate increase change more toward an expectation that rates will return soon to normal, the Base and Low scenarios are likely to become more reflective of actual decision-making.

Note that in the short-term, the estimates of naturally occurring savings from installation of efficiency measures are small compared with the amount of savings from 2001 conservation behavior (i.e., voluntary reductions in energy use independent of hardware changes). The CEC estimates total statewide demand savings from all activities in 2001 (i.e., conservation behavior *and* equipment changes) of roughly 4,000 to 5,000 MW, or approximately 8 percent of normal expected demand.[3] Applying an eight percent demand reduction to our estimates of base demand for the commercial sector of the major IOU territories results in an estimate of 1,300 MW of commercial sector demand reduction for 2001. Our estimate of measure-based naturally occurring demand under the High rate scenario is roughly 5 percent of this figure. Adding our estimate of achieved potential from major IOU programs in 2000 (as a proxy for 2001)[4] results in an estimate that about 12 percent of the total demand reduction in 2001 was associated with hardware/measure-related savings, excluding non-IOU programs.[5]

[3] California Energy Commission 2001a, *California Electricity Outlook 2002-2012*, P700-01-004, November.

[4] 2001 major IOU commercial program savings were not available at the time that our analysis took place.

[5] Including CEC and other State-sponsored emergency programs for 2001 would increase this figure significantly.

Figure 7-1
Naturally Occurring Efficiency Energy Savings by Economic Scenario

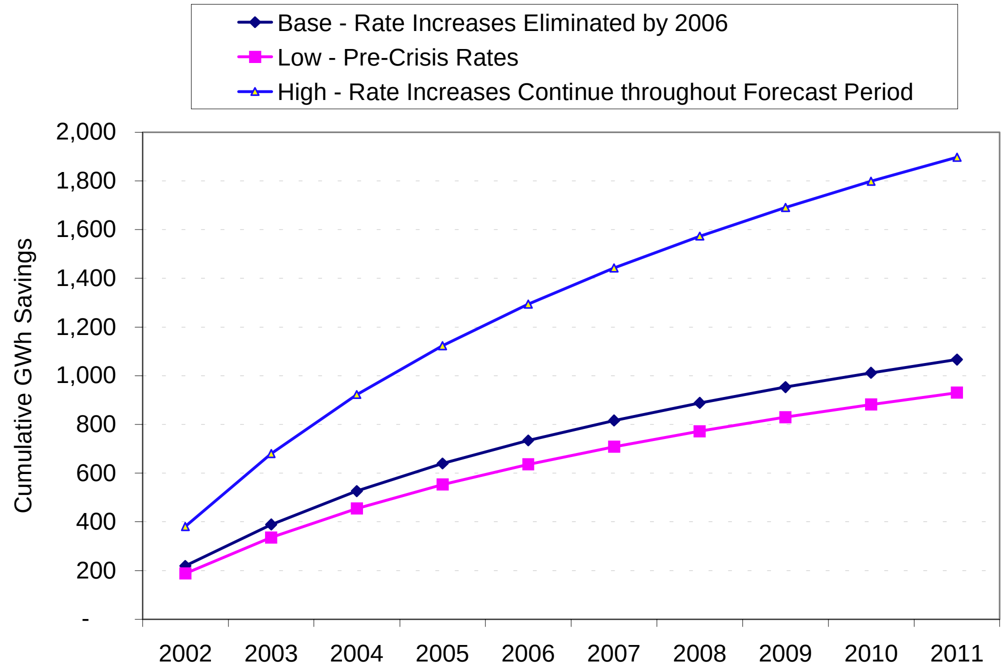
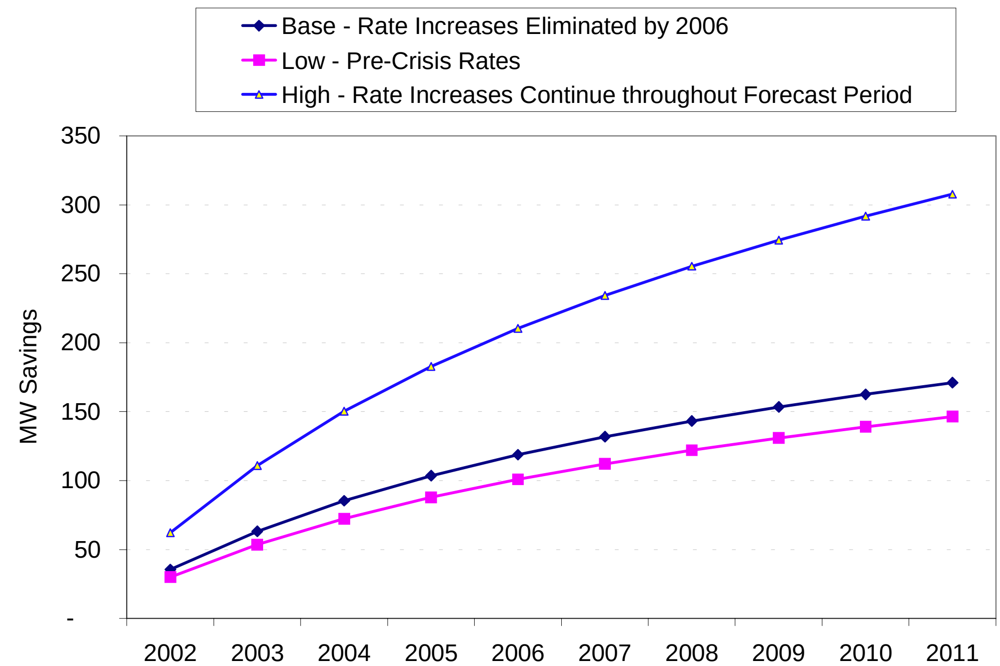


Figure 7-2
Naturally Occurring Efficiency Peak Demand Savings by Economic Scenario



7.3 PROGRAM POTENTIAL RESULTS BY SCENARIO

In this subsection we present the results from our estimates of program potential under all 12 of the scenarios summarized at the outset of this chapter and defined in Section 5. We forecasted program energy and peak demand savings under each scenario for a 10-year period beginning in 2002. We calibrated our energy-efficiency adoption model, described in Section 4, to actual program accomplishments. A comparison of our estimated energy savings with actual program savings from 1996 to 2000 is presented at the end of Section 5.

Our estimated energy and peak demand potentials are shown under each energy cost scenario in Figures 7-3 through 7-8. In Table 7-2 (shown at the end of this section), we show the total resource cost (TRC) test results for each scenario, along with total program costs and total impacts in year 10.

7.3.1 Program Potential Under Base Energy Costs

As shown in Figure 7-3 and Table 7-2, under the Base energy costs scenarios, net program energy savings potential ranges from roughly 4,000 GWh under "Continued Current" (Level 1) funding to almost 8,000 GWh under "Max Achievable" (Level 4) funding. Program peak demand reductions range from 785 MW to 1,650 MW.

"Continued Current" funding under Base energy costs is similar to funding levels in 1999 and 2000, with incentives set at an average of 33 percent of measure costs. Under the "Continued Current" funding with Base energy costs scenario, we estimate that roughly 38 percent of the economic potential of 10,627 GWh (see Section 6) would be captured.

"Max Achievable" funding is 200 percent greater than Level 1 and is an estimate of maximum achievable potential in which incentives eventually cover 100 percent of measure costs and marketing expenditures would make virtually all of the available market aware. Incentive levels are ramped up quickly over time. Under the "Max Achievable" scenario, we estimate that 73 percent of the economic potential could be captured.

Level 2 and Level 3 are scenarios in which expenditures are 50 percent and 100 percent greater than the Level 1 expenditures under the Base energy cost assumptions. Incentives eventually average approximately 50 percent under the "50% Increase" scenario and 66 percent under the "100% Increase" scenario as a percentage of measure costs. Again, incentive levels are ramped up quickly over time. Estimated energy savings under the "50% Increase" and "100% Increase" scenarios are approximately 5,300 and 6,100 GWh, respectively, and peak demand reductions are 1,100 and 1,300 MW, respectively.

7.3.2 Program Potential Under High and Low Energy Costs

Estimates of program potential under the Low energy costs scenarios are shown in Figures 7-5 and 7-6. As one would expect, under Low energy costs, net program energy savings potentials are significantly smaller than under Base energy costs, ranging from roughly 3,000 GWh under

Level 1 funding to almost 4,700 GWh under Level 4 funding. The Low scenario potentials decrease relative to the Base potentials as funding levels increase, from 72 percent of the Base potential under Level 1 funding down to 60 percent of Base under Level 4. This is because the economic potential and the resulting pool of measures to fund are smaller under the Low scenarios than the Base scenarios (recall from Section 4 that only measures that pass the total resource cost test are included in the program potential analysis). Program peak demand reductions for the Low scenarios range from roughly 570 MW to 1,000 MW. Energy savings under Low energy costs for Levels 2 and 3 are approximately 3,600 and 4,000 GWh, respectively, and peak demand reductions are 730 and 830 MW, respectively.

Estimates of program potential under High energy costs are shown in Figures 7-7 and 7-8. Program energy savings potentials under the High scenarios are only slightly higher than under Base energy costs, ranging from roughly 4,700 GWh under Level 1 funding to almost 7,400 GWh under Level 4 funding. Program peak demand reductions for the High scenarios range from roughly 924 MW to 1,600 MW. Energy savings under High energy costs for Levels 2 and 3 are approximately 5,800 and 6,500 GWh, respectively, and peak demand reductions 1,200 and 1,400 MW, respectively.

Program potentials under the High scenario are almost 20 percent higher for Level 1 funding than under Base energy costs, but are actually slightly lower for Level 4 funding. This is because naturally occurring efficiency savings are almost twice as high under the High energy costs scenario as they are under the Base case. Thus, the gross savings (i.e., including naturally occurring) are higher under the High case than under the Base energy costs, as can be seen by comparing Figures 7-3 and 7-7. (Note that cumulative gross savings under the High energy costs are just over 9,000 GWh; while under the Base energy costs cumulative gross savings are just under 9,000 GWh.) Thus, even though the gross savings are slightly higher under the High case than under the Base energy costs, net savings are slightly lower because of the difference in naturally occurring.

Figure 7-3
Program ENERGY Savings Potential by Funding Level - BASE Energy Costs

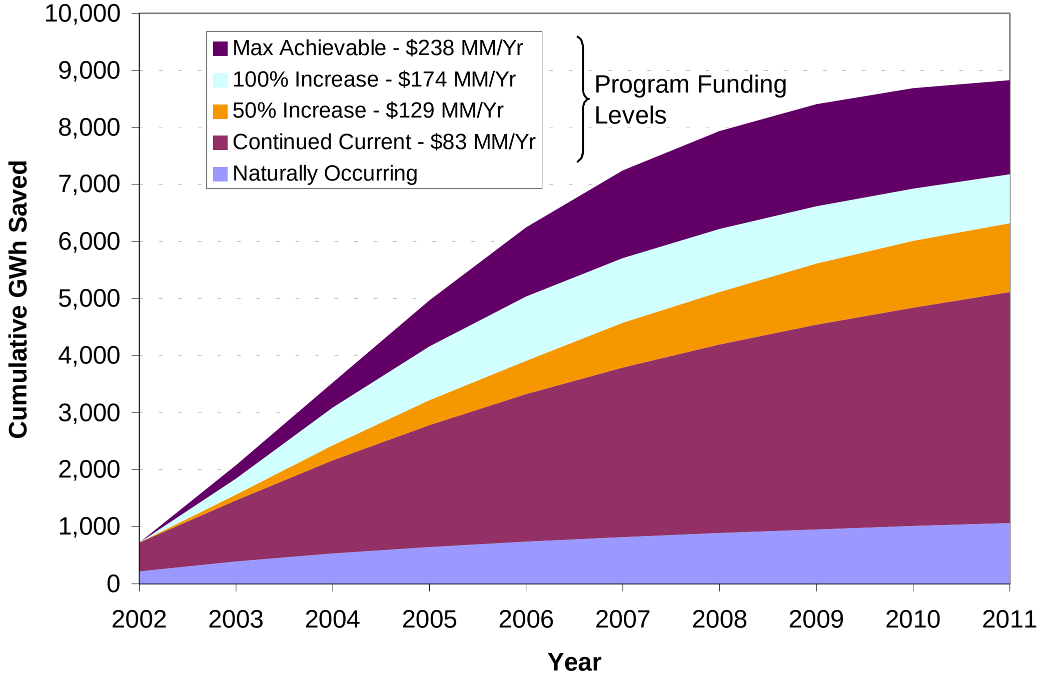


Figure 7-4
Program PEAK DEMAND Reduction Potential by Funding Level - BASE Energy Costs

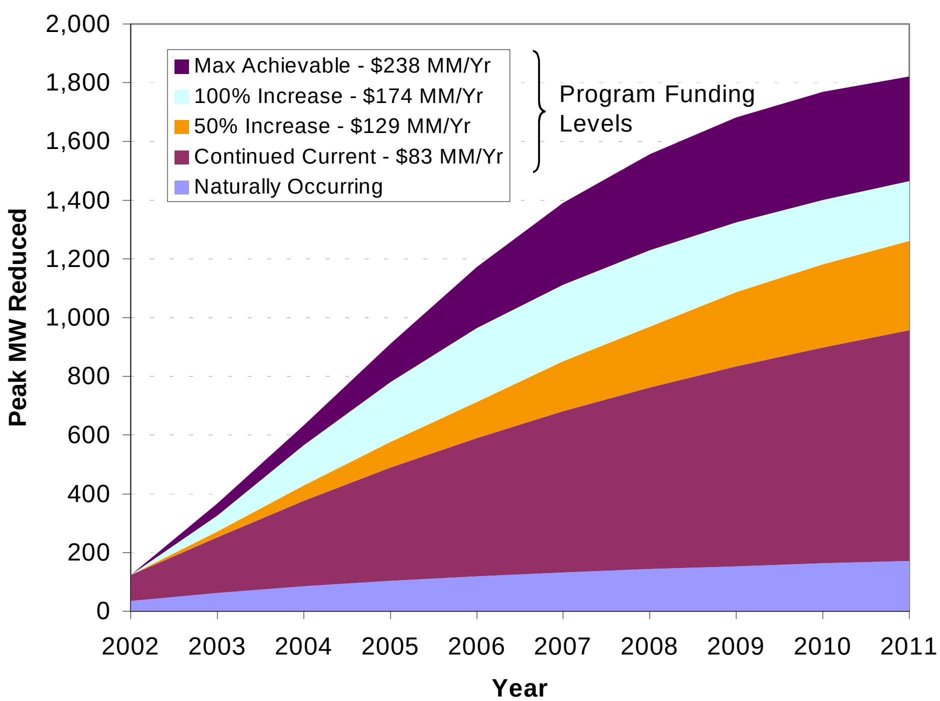


Figure 7-5
Program ENERGY Savings Potential by Funding Level - LOW Energy Costs

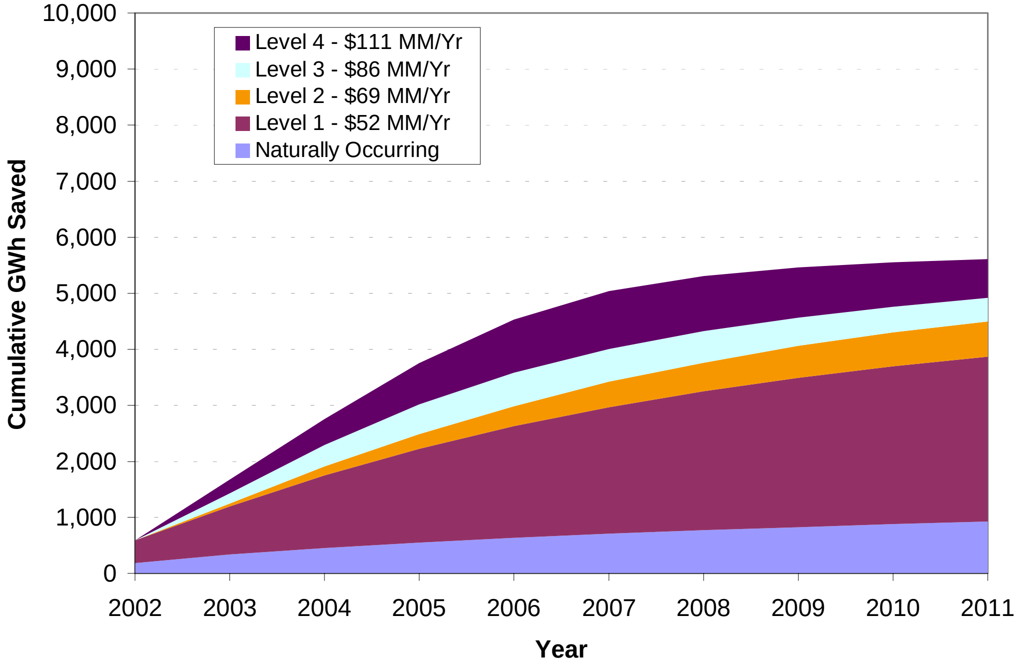


Figure 7-6
Program PEAK DEMAND Reduction Potential by Funding Level - LOW Energy Costs

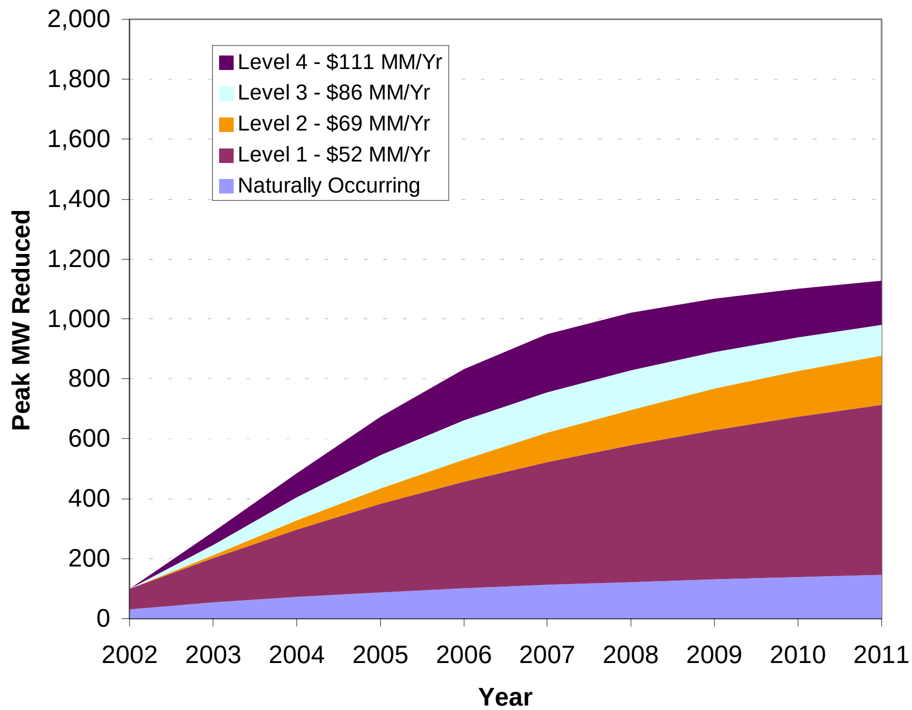


Figure 7-7
Program ENERGY Savings Potential by Funding Level - HIGH Energy Costs

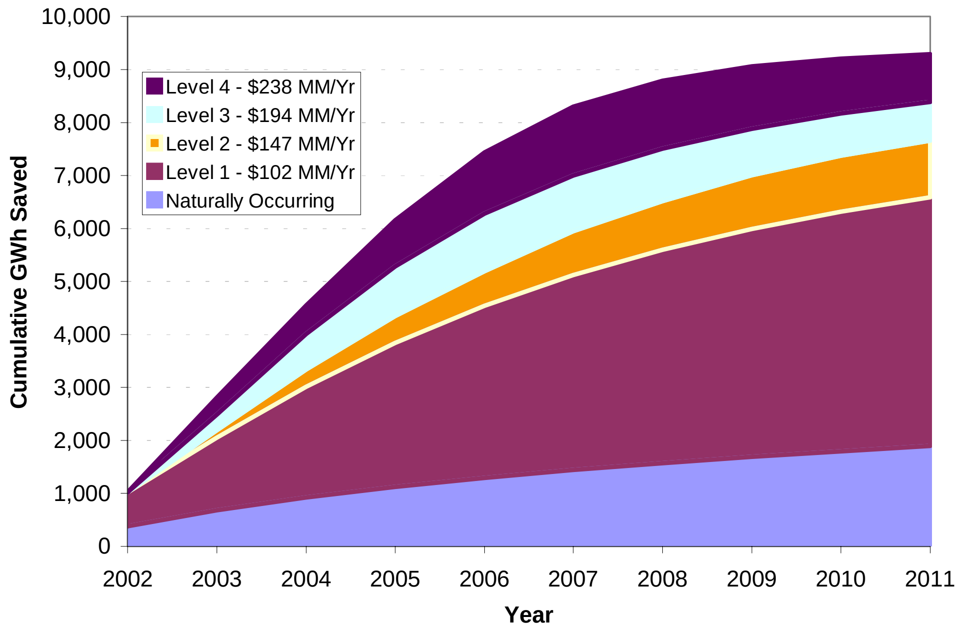
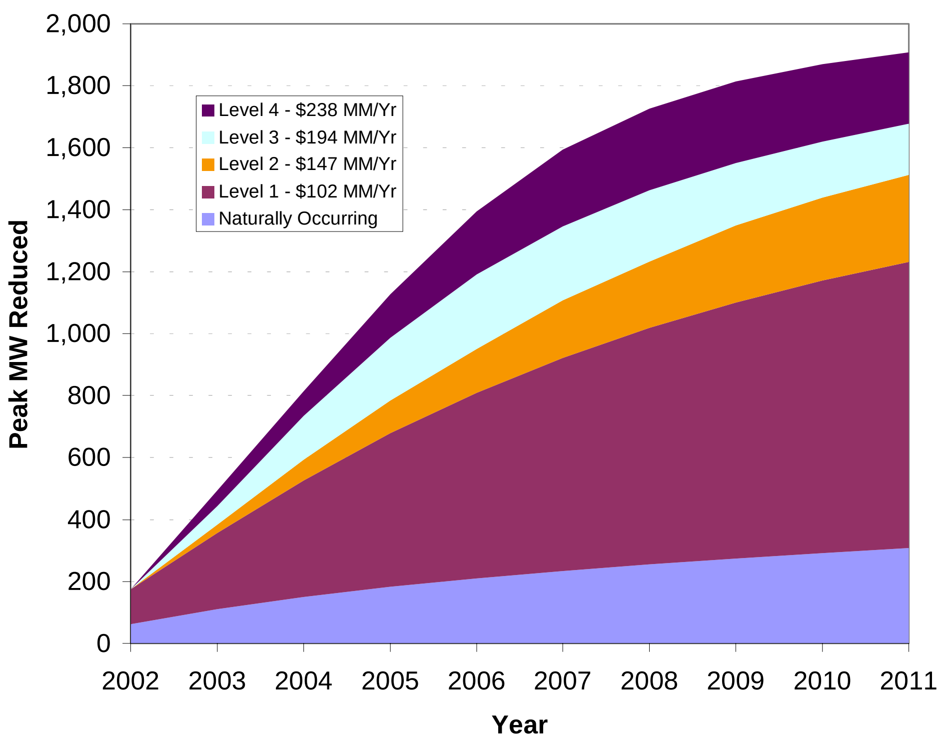


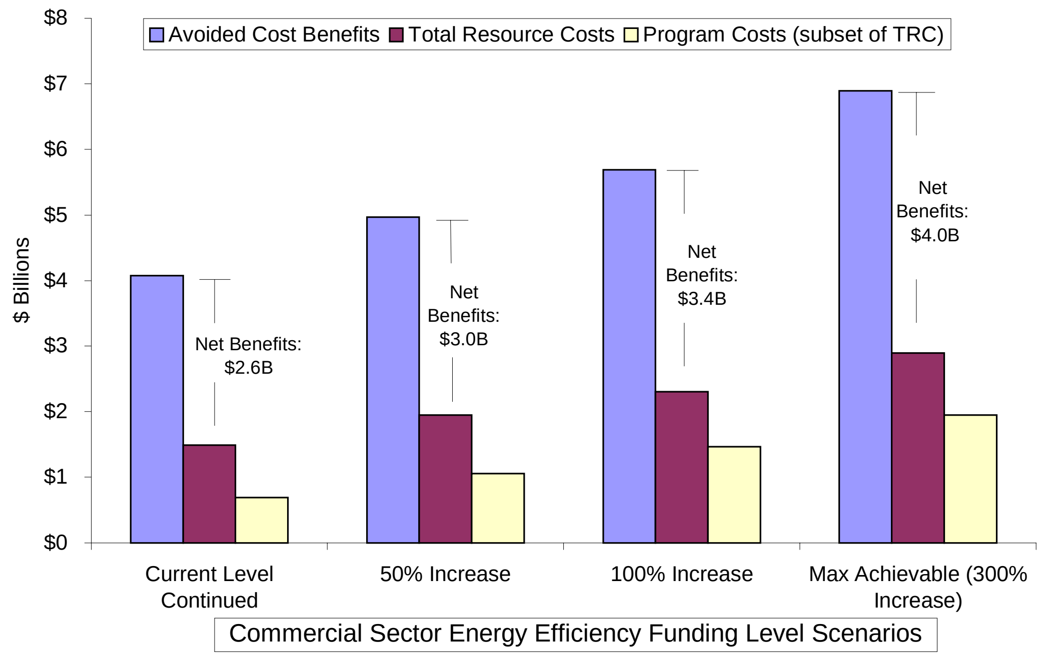
Figure 7-8
Program PEAK DEMAND Reduction Potential by Funding Level - HIGH Energy Costs



7.3.3 Cost and Benefit Results

The costs and benefits associated with the commercial efficiency funding scenarios under Base energy costs over the 10-year period are shown in Figure 7-9. As shown in the figure, total program costs vary from $0.7 billion under the "Continued Current" scenario, to $1.1 billion under "50% Increase," to $1.4 billion under "100% Increase," to $2.0 billion under "Max Achievable." Total avoided cost benefits range from $4 billion under "Continued Current" to $6.8 billion under "Max Achievable." Net avoided cost benefits, which are the difference between total avoided cost benefits and total resource costs (which include participant's costs), range from $2.6 billion to $4.0 billion. All of the funding scenarios are cost effective based on the total resource cost test, which is the principal test used in California to determine program cost effectiveness.

Figure 7-9
Costs and Benefits of Commercial Electric Efficiency Savings – 2002 to 2011
(under Base Energy Costs Scenario)



*Note: Participant costs minus incentives account for the difference between program costs and total resource costs.

TRC test and other results are shown in Table 7-2 for all scenario runs. The results shown indicate that all the scenarios are cost effective based on the TRC. TRC values range from a high of 3.2 under the High energy costs with Level 1 funding scenarios to a low of 1.85 under the Low energy costs with funding Level 4 scenario. TRC values under the Base energy costs range from 2.7 for Level 1 funding to 2.4 for Level 4. The results show that TRC values are much more sensitive to energy cost assumptions than they are to funding levels.

The TRC values decrease somewhat as funding levels increase because savings are acquired from measures that are of decreasing cost effectiveness. That is, under the higher funding levels, energy efficiency opportunities are being purchased from higher and higher on the energy-efficiency supply curve. Countering this trend somewhat is the fact that the proportion of net savings increases under the more aggressive scenarios. This is because naturally occurring savings are static across funding levels (since they are by definition unaffected by market interventions) while gross program savings increase substantially; thus the ratio of net to gross savings increases across the more aggressive funding levels.

Perhaps somewhat surprisingly to some readers, even the Level 4 maximum achievable funding scenarios, in which marketing costs increase from $15 to $25 million per year and incentives increase from 33 to 100 percent of measure costs ($94 to $193 million per year), are still cost effective under all of the energy cost assumptions. This is partly because incentives are treated as a societal transfer payment in the TRC test and do not affect it directly (see Section 4 for TRC definition). In addition, only those measures that pass the measure-level TRC test are included in the program forecasts.

While it is useful to know that all of the program potential forecasts were cost effective under all of our energy cost scenarios, cost-effectiveness screening does not answer the larger resource-planning question of how much energy efficiency is optimal from a societal or utility perspective. In order to determine the optimal mix of resources, a broader analytical framework is necessary, as we discuss in Section 9.

Table 7-2
Summary of 10-Year *Net* Program Potential Results*

Scenario	Result	Level 1	Level 2	Level 3	Level 4
Base	Program Costs:	$693 MM	$1,058 MM	$1,462 MM	$1,952 MM
	Participant Costs:	$799 MM	$892 MM	$844 MM	$944 MM
	Benefits:	$4,075 MM	$4,962 MM	$5,685 MM	$6,891 MM
	Net GWh Savings:	4,042	5,256	6,112	7,758
	Net MW Savings:	785	1,090	1,294	1,650
	Program TRC:	2.73	2.55	2.47	2.38
Low	Program Costs:	$439 MM	$577 MM	$731 MM	$934 MM
	Participant Costs:	$465 MM	$503 MM	$465 MM	$466 MM
	Benefits:	$1,774 MM	$2,044 MM	$2,253 MM	$2,591 MM
	Net GWh Savings:	2,941	3,566	3,988	4,685
	Net MW Savings:	566	730	833	981
	Program TRC:	1.96	1.89	1.88	1.85
High	Program Costs:	$862 MM	$1,222 MM	$1,649 MM	$2,006 MM
	Participant Costs:	$1,169 MM	$1,245 MM	$1,141 MM	$1,203 MM
	Benefits:	$6,403 MM	$7,359 MM	$8,109 MM	$9,050 MM
	Net GWh Savings:	4,698	5,763	6,490	7,393
	Net MW Savings:	924	1,204	1,370	1,599
	Program TRC:	3.15	2.98	2.91	2.82

*Program costs are average per year in 2002 dollars. Energy and demand savings are cumulative amounts in year 10. Program TRC is for the entire 10-year period. The total resource cost (TRC) test is described in Section 4.

8 PROGRAM-POTENTIAL COMPARISON

In this section we compare our estimates of potential with recent commercial sector program activities and accomplishments.

8.1 OVERVIEW

As shown in Figure 8-1, significant commercial program savings were achieved over the period 1990 to 2000. The dominant portion of these savings was in lighting. In particular, by the later 1990s, utility programs had proved extremely successful in transforming the market for T8 lamps and electronic ballasts for many customer groups and trade allies. In Figure 8-2, we present a comparison of remaining economic potential and major program accomplishments for PY2000, the most recent year for which complete tracking data for the LNSPC and Express programs were available. The chart also includes a bar labeled “max achievable.” In the figure, this amount is set for simple comparison purposes at 80 percent of the economic potential.[1] We then annualized the estimated maximum achievable potential figures for the three major end uses, using 5 years for lighting and 10 years for HVAC and refrigeration.

Based on these estimates, it appears that close to half of the annualized potential for lighting and roughly one-third of the annualized potential for HVAC and refrigeration were captured. The combination of the Express Efficiency prescriptive rebate program and the Large Nonresidential Standard Performance Contracting program is reaching a reasonable share of the available energy efficiency potential. Although market penetration among smaller customers increased in PY2000, most of the impacts achieved throughout the 1990s tended to be among larger customers. A recent report[2] provides a specific analysis of the hard-to-reach market segments in which the CPUC has expressed recent interest.

The remainder of this section compares our estimates of potential with recent program accomplishments by end use.

[1] We do not mean to imply by this that only 80 percent of economic potential can ever be achieved. We merely wish to indicate that, in the absence of legally required efficiency standards, few measures ever achieve 100-percent market penetration; without standards, reaching an entire market with any efficiency measure is extremely difficult in practice.

[2] Quantum Consulting Inc. 2001, *Statewide Nonresidential Hard-to-Reach Study*, prepared for Pacific Gas and Electric Company, draft, December.

Figure 8-1
Overall Comparison of Potential and Program Savings

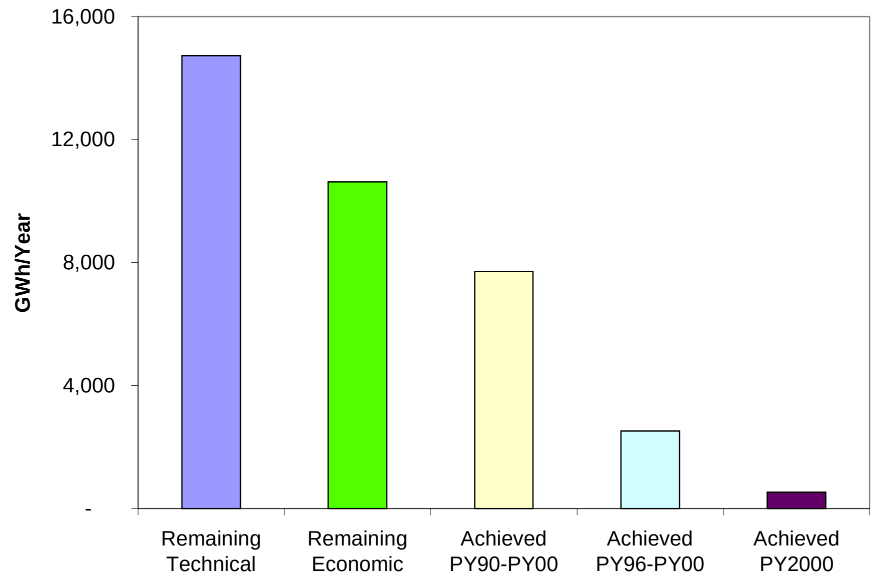
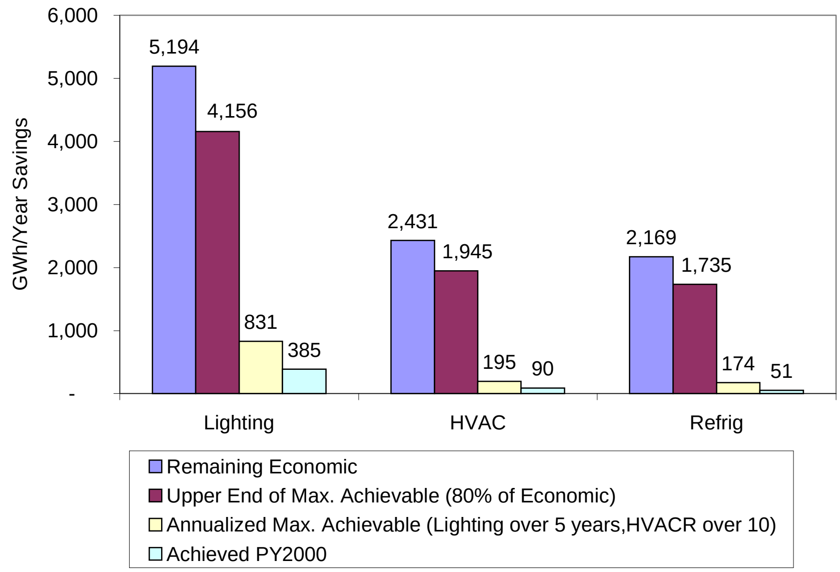


Figure 8-2
Potential Versus PY2000 Program* Savings by End Use



*LNSPC and Express Efficiency only, does not include third-party or information programs.

8.2 POTENTIAL-PROGRAM COMPARISON – LIGHTING

8.2.1 T8/EB and CFL Measures

Based on data from the 1997 PG&E Commercial Building Survey and our analysis of program tracking data since that time, we estimate the saturation of T8/EB lighting systems to be roughly 55 percent for four-foot fluorescent fixtures. We estimate the saturation of T8/EB systems among the smallest customers to be significantly lower (probably around 20 to 25 percent). At the time of the 1997, the saturation of T8/EB in four-four foot fixtures was about two and half times higher for large as compared with small customers.[3]

Data from the 1997 PG&E Commercial Building Survey also show that compact fluorescent lamps (CFLs) had a much higher relative saturation among larger customers. However, the average saturation level for all commercial customers was fairly low at the time of study (around 20 percent). Over the past 3 years, CFLs have become the most popular measure installed in the statewide Express Efficiency program, surpassing T8/EB systems.[4] As a result of this surge in CFL penetration, we estimate the saturation of CFLs may have tripled over the past 5 years.[5] Combining data we have analyzed from the 1997 PG&E Building Survey and analysis of multi-year tracking data from the Express Efficiency and nonresidential SPC programs, it appears that the remaining potential for CFLs may be small. However, there may be inconsistencies in the data sources that lead to our forming this conclusion.

The observation that high-efficiency lighting equipment has succeeded in disproportionately penetrating large customers has been made for some years now. As a result, since 1998 both the CPUC and the utilities have been making special efforts to focus lighting interventions on smaller customers. As shown in our companion report on program impacts, these efforts have met with some success: small (<20 kW) customer participation in the Express Efficiency program increased significantly in PY2000. Through the first half of 2001, the relative participation of small customers decreased again, partly because of increases in participation among large customers.

In summary, there is no gap between the potential for T8/EB systems and CFLs and the program achievements at an aggregate level. The programs have achieved significant savings; but it is likely that a gap remains between the level of saturation of these measures for large customers, and the level for small customers. We recommend a continued focus on promoting and installing

[3] California Measurement Advisory Committee Report on Public Workshops on PY2001 Energy Efficiency Programs, Appendix C3: Energy Efficiency Measure Saturation, Response to Ordering Paragraphs #51 and #54, September 25, 2000.

[4] XENERGY, Quantum Consulting, and RER Inc 2001. *Compilation of Recent and Historic Nonresidential Program Impacts for PG&E, SCE, and SDG&E*, prepared for Pacific Gas & Electric Company, December.

[5] We caution that such estimates are difficult to make without a more up-to-date saturation survey from a statistically representative sample of commercial buildings. As noted previously, a new statewide commercial building survey is expected around 2003 from the CEC.

these measures in smaller customer facilities. Policy makers must recognize, however, that effectively reaching these smaller customers is significantly more expensive than reaching larger customers.

8.2.2 Lighting Controls

Significant potential was identified for lighting controls systems such as occupancy sensors (1,100 GWh and 290 MW) and dimming systems (1,700 GWh and 770 MW).[6] It is difficult to estimate the amount of program savings associated with these measures over the past decade; however, based on tracking data from the past 4 years, we estimate that total savings from lighting controls between 1998 and 2001 were on the order of 50 GWh, most of which is associated with occupancy type controls. If we double this figure to account for activities in the preceding years, it appears that roughly 10 percent of the occupancy controls market may have been captured. In the case of automated dimming, 1997 PG&E commercial building survey and anecdotal information indicates that only a small fraction of the potential market has been tapped.

In the case of occupancy sensors, the gap between potential and program savings is probably related more to market barriers, such as concern over product performance and application appropriateness, than to cost effectiveness. Despite widespread availability throughout the 1990s, market penetration has been modest at best. Clearly, customers and contractors have had concerns over product applicability and performance. The economics of installing occupancy sensors are reasonable in that they range from 1- to 3-year paybacks in the market segments where they are most applicable (see Appendix D for paybacks by measure and market segment). Occupancy sensors have generally been relegated to marginally used spaces such as bathrooms and conference rooms. Although there are clear limits to the feasibility of using occupancy sensors in many spaces, we believe that there remains significant opportunity to increase their use. This will likely require continued support for the technology in the form of improved awareness and knowledge of benefits, improving equipment performance, and financial incentives.

With respect to automated dimming systems, the insignificant market penetration to date is largely a function of poor economics and, secondarily, concerns over performance. Retrofitting existing lighting systems to sense and adjust to daylight levels requires replacement of existing ballasts with dimmable ballasts, wiring of photocell sensors, and integration with a controller. Based on the cost and savings estimates used in this study, paybacks range from 7 to 20 years depending on hours of use, even under today's extremely high rates.[7] There are a few segments

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[6] Note that we did not assume universal feasibility for these measures. As documented in Appendix C, our feasibility factors for occupancy sensors ranges from 10 to 50 percent of floor space depending on business type. For perimeter dimming, we estimated the percent of building floor space accounted for by 15 feet of depth from exterior walls using the prototype buildings developed in the CCIG Technology Energy Savings Study (NEOS, 1994).

[7] Note that so-called "stepped" dimming systems offer a lower cost alternative to automated dimming systems (which provide a continuous range of dimming). We have not explicitly modeled stepped systems in this study.

where these systems pass the societal total resource cost test under the Base scenario avoided costs. Given the high value of peak demand reductions embedded in these energy-crisis-based avoided costs, this is not surprising. If the State continues to place a premium on peak demand reductions, then it may be worthwhile to provide incentives and other program services to support increased utilization of dimming systems. Ultimately, if the costs of properly installing automated dimming systems can be reduced, an enormous potential may be achievable. If not, few significant gains in market penetration should be expected.

8.2.3 Reflectors/Delamping

Combining specular reflectors with high-efficiency fluorescent lighting components can result in significant energy savings when applied appropriately and correctly. These savings are often among the most cost-effective of lighting retrofits, with levelized costs per unit of conserved energy as low as $0.01 per kWh and paybacks of less than 1 year. Of course, light levels and patterns may change as a result of this type of retrofit. Application of reflectors with delamping requires careful consideration of the illumination requirements of the space being considered for retrofit. For our potential estimates, we assumed that this measure was suitable for only 20 percent of existing floorspace. Even with this assumption, reflectors with delamping show a remaining potential of roughly 1,000 GWh and 200 MW. Although we do not have measure-level, statewide program tracking data for the past 10 years, anecdotal evidence suggests that reflectors with delamping accounted for a large share of commercial lighting savings in the early to mid-1990s, but that their application diminished in more recent program years. This is likely a deliberate programmatic effect that results from decreases in prescriptive rebate levels for this measure. For example, PG&E paid $10 per four-foot fluorescent lamp removed (with application of reflectors) in 1994, had decreased the amount to $5.50 by 1997, and reduced it significantly further to $1.25 in 1998. Given the attractive economics of the measure, general awareness of the measure among larger and more energy conscious end users, and the shift in 1998 away from a resource acquisition toward a market transformation focus, this change was appropriate. If, however, policy makers are interested in achieving fairly low-cost, near-term energy savings among smaller and hard-to-reach customers, they should consider increasing incentives for this measure for selected market segments.

8.2.4 T5 Lamps

We did not include T5 lamps in our analysis of total cumulative potential, but we did include it in our screening results (shown in Appendix D). T5s offer some incremental benefits as compared with T8 and T12 lamps, but their efficacy relative to T8s is modest, and they are not a simple like-for-like substitution for T8s or T12 in existing fixtures. To capture the energy savings and illumination benefits of T5s typically requires a redesign of an existing lighting system, such as might accompany a major remodel or renovation. Estimates of T5 costs in the recent 2001 DEER Update Study indicate that their cost premium relative to T8 lamps is still significant. Appropriately, the Express Efficiency program has been providing incentives for T5s to encourage their use in appropriate applications. Such support may lead to increases product demand and decreases in price as occurred in the T8 market. However, expectations for this measure should be modest, as it is likely to achieve only a niche penetration within the existing commercial construction market.

8.3 POTENTIAL-PROGRAM COMPARISON – HVAC

As discussed in Section 6, there is significant potential for commercial cooling and ventilation measures in the existing building stock, particularly with respect to peak demand. Measures with significant potential impact include high-efficiency chillers and packaged units, “tune-ups,” and controls. We noted that further research was need to better estimate the potential of cool roofs and pre-coolers for DX units, particularly with respect to the relative cost-effectiveness of these measures as compared to other opportunities. As shown in Figure 8-2, PY2000 program savings from commercial HVAC measures appear to have captured roughly 3 percent of total potential economic savings. If we annualize the commercial HVAC potential over 10 and 15 years, the percent of annual potential achieved is 32 and 49 percent respectively. In either case, this is a reasonable share of the economic potential to have captured, given existing budget levels and the fact that this end use can be challenging to reach. As shown in Section 6, with an increase in program budgets, a larger share of the economic potential for this and other end uses could be tapped.

As shown in Figures 6-8 and 6-9, high-efficiency (HE) chillers and DX were estimated to have the most potential and lowest relative costs of conserved energy and peak demand. On June 1, 2001, new standards adopted by the California Energy Commission went into effect. These so-called “emergency” standards were developed in response to the California energy crisis as mandated in Assembly Bill 970.[8]

We initially estimated HE DX savings using the base efficiency level required prior to AB 970. We then re-ran the results using the new AB 970 standards for the base case. We used a prototypical 10-ton, air-cooled unit for our analysis. AB 970 increased the base EER for this unit from 8.9 to 10.3 in 2001. Over the past few years, the utility upstream incentive programs have targeted DX units with a minimum qualifying EER of 10.3 (equivalent to ASHRAE 90.1 Tier 1 efficiency levels).

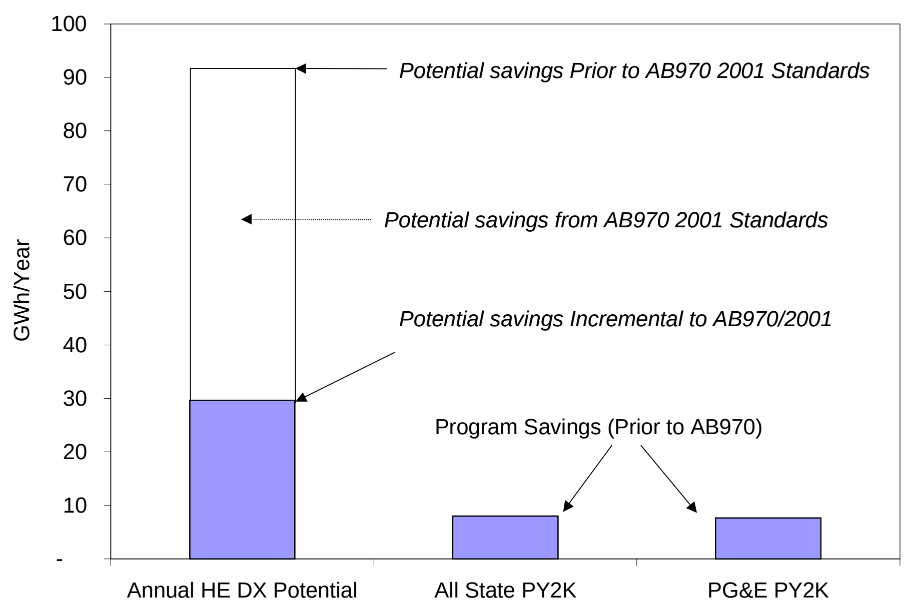
To estimate the remaining potential beyond the new standards, we specified a unit with a 10.9 EER. Readers should note that although there are units on the market today with this level of efficiency, availability is currently limited. Our estimates of total potential savings for HE DX units prior to and after the 2001 savings are shown in Figure 8-3, alongside reported utility savings for upstream commercial DX programs in PY2000. The potential savings have been annualized to account for the fact that DX units turn over very slowly. Annualizing the potential savings allows them to be directly compared to savings associated with the utilities’ PY2000

[8] 2001 *Energy Efficiency Standards for Residential and Nonresidential Buildings*, prepared by the California Energy Commission, P400-01-024, August 2001.

programs.[9] As shown in the figure, on a statewide basis, the PY2000 programs appear to have captured about 10 percent of the annual potential savings, with the bulk (over 90 percent) of the savings coming from PG&E.

Because of their long service life, installation of low-efficiency packaged units represents a major lost opportunity. Although the upstream programs have had some important effects, the standards have clearly locked in a much larger share of savings then would be possible through the recent program efforts.[10] More importantly, however, the utility programs to promote units meeting ASHRAE Tier 1, along with other utility efforts to do the same throughout the country, played a critical role in increasing availability of these units and demonstrating their cost effectiveness. Without these efforts, it is unlikely that the emergency 2001 standards would have been politically viable. Programs promoting HE DX units should focus on units that exceed the new standards in the future. We estimate that there is an additional 30 GWh per year (17 MW) of technical potential associated with units that would beat the new standards by 6 percent.

Figure 8-3
Potential and PY2000 Savings for High-Efficiency Commercial Packaged Units



For chillers, the situation resulting from the new standards is similar to that associated with packaged units. We ran estimates of HE chiller potential under both pre- and post-AB 970 scenarios. Under the pre-AB 970 baseline we used a base efficiency of 0.65 kW per ton for a prototypical 300-ton, water-cooled centrifugal chiller. For the post-standards, we used a 0.58 kW per ton base. In both cases we used 0.51 kW per ton as the efficiency of the HE unit. Our

[9] As a rough approximation of the turnover rate, we divided the total potential by the average service life of packaged units, which we assumed to be 15 years.

[10] We estimate that the new standards could lead to savings of 500 MW for DX units over the next 15 years.

resulting estimates of chiller savings were 853 GWh (563 MW) and 478 GWh (315 MW) for the pre- and post-standards cases, respectively. (Thus, our estimates of the savings associated with the standards are 375 GWh and 248 MW.) Capturing a share of the remaining potential will require a focus on the most efficient chillers available, many of which are likely to be equipped with VSD.

We do not have the data available to easily compare program and remaining potential for the other HVAC measures on a measure-specific basis. Nonetheless, we offer a few additional observations. First, there appears to be moderate potential available associated with measures that improve the performance of existing package and chiller units through better maintenance and operating practices. However, the cost-effectiveness of these measures is somewhat uncertain. Both the utilities and third parties have recently begun programs aimed at demonstrating these savings and proving their cost-effectiveness. These efforts should be closely evaluated, particularly with respect to costs, measured savings, and the period of time over which savings persist. Similarly, we believe further research is needed on cool roofs before the amount of cost-effective potential can be accurately estimated. As discussed in Table 2-3, we found the data available for our key inputs of this measure (costs, savings, and service length) to be very limited. Given that the CEC is implementing a program to promote cool roofs, we recommend that the resulting projects be used to improve savings estimates. In addition, estimates of cool roof savings from simulation models such as DOE-2 should be calibrated and improved using these new data. These calibrated models can then be used to estimate savings across a diversified set of buildings that is representative of the population of commercial buildings in the State. Evaporative pre-coolers are a promising measure for larger, air-cooled packaged systems. However, at current costs the measure is generally not cost effective. Ongoing research and development of this measure should continue with a focus on reducing costs. Finally, partly as a result of fairly high existing measure saturations, we found relatively small remaining potential for measures that have been widely available for years, such as EMS, programmable thermostats, and window film.

8.4 POTENTIAL-PROGRAM COMPARISON – REFRIGERATION

The results of this study indicate that the refrigeration end use is a very high profile target for future intervention efforts, with a large theoretical potential for savings. Adequate economic incentives exist for most all of the measures included in this study. However, being a complex end-use, even given the level of attention given to refrigeration in DSM and research, it is important to point out that refrigeration is also one of the least understood end uses; especially in terms of the degree of accuracy surrounding impact and cost-effectiveness results for most of the identified energy-efficiency measures.

Throughout the 1990s, substantial attention has been paid to the energy use of refrigeration equipment, especially in the large retail grocery segment. For this reason, this initial potential study has concentrated on this segment. Many energy-efficiency measures and improvements have been developed to address energy and demand reduction in grocery stores. In fact, in developing the refrigeration end-use engineering models for this study, more than 30 measures were considered for inclusion in this assessment of the technical and economic potential for refrigeration measures. Of those, 13 refrigeration measures were eventually included in the technical and economic potential model, split roughly in thirds across load affecting measures, display-based measures and central plant measures.

- **Load affecting measures** are those that reduce the refrigeration load at the central plant by modifying the thermal load of store displays and other end uses directly. Load affecting measures include strip curtains for walk-in coolers, night covers for display cases, and the addition of glass doors on store displays.
- **Display-based measures** are those that reduce the use of electricity at the displays and other refrigeration end uses directly, which often also affects the thermal load. Display-based measures include anti-sweat (humidistat) controls, more efficient evaporator fans and controls, and defrost technologies and controls.
- **Central plant measures** are those that reduce the use of electricity in the refrigeration plant itself, involving the compressor and condenser (or heat rejection) systems. Central plant measures include floating head pressure controls, refrigeration commissioning, high-efficiency compressors, and a compressor VSD retrofit.

The measures selected for this study were selected for a number of reasons including: low estimated saturation in the existing market, applicability to different customer sizes and segments, applicability to hard to reach segments, and consideration of measures that are expected to be important in the market in the near future. Measures were rejected based on overlap in efficiency with other measures selected, applicability to the new construction market, inadequacy as a long-term energy-efficiency objective, the necessity of a large investment, and inapplicability to certain segments.

As mentioned earlier, some sources suggest that there has been substantial market movement for high-efficiency refrigeration measures in the California market, beyond what has taken place in the national market. This success is due in part to the DSM program efforts undertaken by the utilities during the 1990's. Below is a market-level description of the accomplishments to date and the gaps that exist for ongoing improvement in this important market segment.

8.4.1 Load Affecting Measures

Available data sources suggest that strip curtains are installed in 70 percent of the walk-in coolers and freezers in large grocery stores. This reflects the fact that this measure is relatively easy and inexpensive to install in a market segment that is both very energy conscious and willing to capitalize on this "low-hanging fruit." We assume that, though this measure applies equally to the restaurant and convenience store markets, it will achieve far less penetration in those harder to reach segments.

Night covers, on the other hand, are not applicable to the large grocery segment, where 24-hour-per-day operation is common, and product stocking is completed during the hours that a store is closed or less busy. This technology is very applicable to the smaller mom-and-pop groceries and convenience stores.

Refrigeration case displays have undergone radical changes in recent years, the most significant of which is the use of freezers with glass doors, replacing the more traditional open displays, especially the coffin-type single displays. Industry experts believe that medium temperature displays, which are still largely open, are likely to be converted next where appropriate, such as for beverage displays. While most convenience store, retail and restaurants already have medium temperature displays with doors, tremendous potential remains in the large grocery segment for this application.

Some of the above measures are more applicable to small and hard-to-reach customers, and some are more applicable to large groceries. Altogether, there is substantial room for market movement across the board.

Refrigeration measure participation in the Express program has historically been very limited, with the majority of the measure impacts being achieved in the SPC program or its predecessors such as PG&E's Customized Incentives program. However, the types of measures discussed here are ideal for the Express program participation format.

8.4.2 Display-Based Measures

There are substantial remaining opportunities for evaporator fan motor improvements using high-efficiency motor designs and controls. For example, saturation is estimated to be only 20 percent for evaporator fan controls in medium-temperature walk-in coolers.

Similarly, for anti-sweat controls using both humidistat and cycling strategies, there is still room for improvement, although some studies suggest that this technology is quickly becoming saturated in California.

Similarly to the load-affecting measures, display-based measures (excepting defrost technologies and controls) are also ideally suited for the Express program format. Industry experts that we interviewed indicate that demand defrost controls are not yet ready for market, but once improved will likely be another measure that will receive substantial attention in the near future.

8.4.3 Central Plant Measures

Central plant measures tend to offer greater energy savings per installation than the load and display-based measures, but also require greater capital expenditures at the outset. For many store managers this type of retrofit is easier to swallow, as it occurs out of sight of the customers and can be done, if everything goes as planned, seamlessly, without interruption to normal store operation. While one would think that this type of retrofit would be more likely to fall under a program format like SPC, the utilities still package this type of retrofit under the Express program, reserving SPC for refrigerated warehouses and the agricultural sector.

8.4.4 General Market Observations

The grocery segment is difficult to influence. However, the recent power crisis will likely catch the attention of senior management in this very low-profit-margin business. One key consideration for the utilities is the concept of participating in the normal store renovation cycle, which happens roughly every 10 years, and is a great opportunity to influence decision makers to invest in energy efficiency at a time when customer disruption is already planned. The fear of customer disruption presents a serious barrier to store retrofits at all other times.

Refrigeration plant commissioning offers substantial potential in the refrigerated warehouse segment, especially where new systems are brought on line under SPC.

8.5 OFFICE EQUIPMENT

Office plug load, along with its associated air conditioning needs, is a growing electricity end use in the commercial sector. Our estimates suggest that power management and other measures for office equipment could save up to about 1,000 GWh. Despite this potential, relatively few programs have been directed at this end use, and therefore savings and incremental costs from energy efficiency in this sector have not been well described. This is partly attributable to the fact that much of the available savings is related to achieving changes in end user behavior. However, PG&E has contracted for a third-party initiative aimed at demonstrating savings from improved network enabling of power management.

The most common energy-efficiency measure for computers and monitors is through “power management.” Power management senses when a specified time has passed with no “activity” (usually from the keyboard or mouse) and initiates a sequence of low-power modes. Delay times usually range from a few minutes up to an hour. When activity occurs while the device is in a low-power state, it automatically wakes itself up and returns to the full-on state. While power management is now available on most new machines,[11] it is common practice for information technology staff to disable power management on arrival of new equipment, in particular when the equipment is hooked up to a network. The literature suggests that, typically, *less than half* of the machines in offices have enabled their power management controls.[12] Manual enabling is the only currently viable opportunity for CPUs, since widely available network enabling tools do not include CPU enabling as an option. The U.S. DOE has developed “EZ STAR,” a free software tool that activates power management settings for computer monitor through a site’s local area network. EZ star also has an audit tool that reports how many machines are already enabled and an enabling tool that allows central control of sleep settings.

Additional details on office equipment opportunities are provided in Appendix H. Further research on the feasibility of achieving measurable changes in office equipment energy and peak demand from the measures described is warranted.

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[11] As of early 1996, EPA estimated that upwards of 70% of all new PCs and nearly 100% of all PC monitors sold had power management capability.

[12] Piette, et.al. “Measured Energy Savings and Performance of Power-Managed Personal Computers.”

9 ISSUES AND NEXT STEPS

In this section we present a brief summary of the key issues associated with the results of this study, and suggestions for next steps in the research process.

All of the program potential scenarios were estimated cost-effective based on the total resource cost (TRC) test and program cost-effectiveness was much more sensitive to avoided-cost estimates than to program funding levels. As discussed in Section 7, all of the program funding scenarios that we forecasted were cost effective based on the TRC test. The range of TRC values across the avoided-cost scenarios was roughly 1.2,[1] while the range of TRC values across funding levels within each avoided cost scenario was of the order of 0.4. This pattern of results was somewhat expected, however, because incentives are treated as a societal transfer payment in the TRC test and do not directly affect it. In addition, only those measures that passed the measure-level TRC test were included in the program potential estimates.

However, use of a static cost-effectiveness test, like the TRC, does not provide all of the information necessary to determine the optimal level of investment in energy efficiency. While it is useful to know that all of the program potential forecasts were cost effective under all of our energy cost scenarios, cost-effectiveness screening does not answer the larger resource-planning question of how much energy efficiency ought to be purchased through the public goods process. Although the program potential results are important to consider and understand, it is also important to remember that they are static and deterministic because they are based on static avoided-cost forecasts. The avoided-cost forecasts do not change in response to increasing levels of demand reduction, increases in supply, increases in the percentage of supply from renewable energy, increases in the amount of price-induced conservation behavior, uncertain future events, or the volatility of underlying fuel prices like natural gas. In short, static avoided costs do not provide adequate information for determining the optimal mix of all possible resources (e.g., energy efficiency, demand response/load management, distributed generation, conventional supply, renewables, etc.). In order to determine the optimal mix of resources, a broader analytical framework is necessary. Developing such a framework was not a part of the current study, though efforts should be undertaken to address this issue in the future.

We believe new analytical methods are needed to improve upon strategic resource planning processes developed during the period of integrated resource planning in the early 1990s. Research is needed that explicitly tackles the question of how investments in demand- and supply-side resources should be optimized in California given the events of the past 2 years. We need an approach that builds on the lessons learned from both the integrated resource planning period of the late 1980s and early 1990s, and the market-based experiments of the last 5 years. Such an approach would require supply-side forecasts and integration analyses that explicitly

[1] Total resource cost test ratios for the program portfolios we forecasted ranged from values around 2.5 under our Base avoided costs to roughly 1.9 under the Low avoided costs and 3.0 for the high avoided costs.

incorporate price uncertainty, price volatility, and significant probabilities of future energy "events" such as supply shortages and concomitant price spikes.

Historically, the development of energy efficiency strategy has been based on integrated resource plans. While this work was admirable, its core elements were based directly on supply planning, planning that was grounded on an investment paradigm that focused on the net present value of revenue and cost streams.[2] By contrast, modern investment theory considers not only the revenue and cost streams, but also the uncertainty around those streams. This consideration of risk causes modern finance to seek methods of risk mitigation that cause the risk taken to be commensurate with the likely return. The level of cost uncertainty or volatility seen in electricity markets is very high as compared with many other commodity markets.

To help protect ratepayers from future price uncertainty, energy providers and policy makers need to consider risk mitigation alternatives. Energy efficiency and demand response/load management provide clear risk management opportunities. These considerations should put energy efficiency in the forefront of policy discussions in contrast to other risk mitigation alternatives requiring market premiums.

There is significant remaining potential in the existing commercial buildings market, however, the potential is smaller than that estimated in the early1990s. As presented in Sections 6 and 7, the remaining potential identified in this study represents an important resource opportunity that could, if captured, displace several large power plants. However, the size of the economic potential resource identified in the current study is smaller than estimates of potential made in the late 1980s and early 1990s. For example, studies during this time of commercial efficiency potential in California found technical and economic potential of roughly 30 percent (XENERGY, 1989, 1990, and 1992; Rufo 1993). We believe the current estimates of economic potential are lower for the following reasons:

- The set of measures used in the current study is not significantly different than the measure sets used in the early 1990s. For example, many of the core measures from the early 1990s, such as T8 lamps, electronic ballasts, dimming systems, high-efficiency HVAC equipment, variable-speed drives, energy management systems, etc., remain core measures today. As discussed below, this is a result of the fact that the scope of the current study focused on commercial available measures, not emerging technologies. Conversely, many of the technologies in the current study were included in studies in the early 1990s as emerging technologies.
- Although many of the core measures remain the same, the current saturation of these measures is significantly higher than what they were in the early 1990s. This is a positive result of the program accomplishments of the last decade. As shown in Section 8, commercial programs from 1990 to 2000 resulted in savings of almost 8,000 GWh, which is similar to what we estimate as the maximum achievable remaining potential.

[2] For example, in many cases a "least cost" resource plan often resulted in a plan, selected solely on expected costs, that relied on a single type of resource to meet most or all of a utility's new resource needs.

- The "miscellaneous" end use is estimated by the CEC to account for a much larger percentage of total commercial consumption today than was estimated by the utilities in the early 1990s. For example, miscellaneous accounted for only 11 percent of the base usage in the SCE 1992 potential study (XENERGY 1992) but accounts for 23 percent in the CEC's data used in the current study (CEC 2000). Because no measures are applied in the current study to the miscellaneous end use, the larger its share the smaller the total savings for the sector. There is considerable uncertainty in current estimates of commercial miscellaneous energy use. This uncertainty will likely be reduced when results of the new statewide commercial end use survey are available from the CEC.

Our estimates of savings are reasonable representations of potential over the near- and mid-term (i.e., the next 5 years or so), but should be viewed as conservative for the longer term (i.e., 10 plus years from the present). This is because, as mentioned in Section 1, the scope of this report focused on the retrofit of existing buildings. Retrofit opportunities, though important, are more limited in terms of energy-efficiency potential than are major renovations in which entire systems can be completely redesigned to maximize savings. In the medium term, renovations do not account for a large share of the current existing buildings market, but over the long term such renovation opportunities become more important as a share of the existing stock. In addition, our original scope was also limited primarily to commercially available measures; few emerging technologies are included. This is again appropriate for a medium term view of potential, but as one forecasts further into the future, the effect of excluding emerging technologies is to underestimate long-term potential.

There is a moderate amount of uncertainty around our estimates of technical and economic potential for several measures. As outlined in Table 6-2 in Section 6, key uncertainties include the following:

- *Cooling*: Several quasi-emerging technologies and practices were included in this end use (e.g., cool roofs, chiller and DX tune-ups, and evaporative pre-coolers). Costs, savings, and feasibility factors are all fairly uncertain for these measures and warrant additional research.
- *Lighting*: It is clear that there is significant penetration of T8 lamps, electronic ballasts, and compact fluorescent lamps in the commercial market today. We developed estimates of measure saturation using a representative survey of commercial buildings conducted in 1996 by PG&E and program installations from 1995 through 2000. Nonetheless, there is considerable uncertainty around these estimates. Again, the new commercial end-use survey being managed by the CEC should minimize this uncertain when completed in 2003.
- *Refrigeration*: Refrigeration is the most complex of the commercial end uses addressed. Throughout the 1990s, a number of studies were conducted aimed at identifying energy-saving refrigeration measures. These studies identified numerous such measures and began the process of estimating the costs and savings associated with them. This study draws on these previous studies and finds that there appears to be a significant potential for savings in this end use. However, there are few sources

of reliable measure saturation data available. In addition, despite the identified potential, refrigeration savings actually achieved in the 1990s in utility efficiency programs have been fairly modest. This may reflect market barriers to achievement of the identified potential or errors the estimates of potential themselves. Finally, almost all of the technical potential identified in this study is estimated to be economic. This may be correct or may be a result of underestimated measure costs or inconsistencies between cost and savings estimates (which were identified in separate secondary sources). Further research on this end use is recommended.

- *Office Equipment*: Most of the potential in this end use is associated with measures that require some behavioral change, principally in network enabling of power management and manual shutdown actions. It is unclear to what extent the market is actually willing to engage in power management activities. In addition, the percent of the market currently using power management features is uncertain.

Much of this identified potential is likely to be in sub-segments that may be more difficult to reach than those captured in the 1990s. The current study estimates potential using "traditional" end-use forecasting segments (e.g., building types – offices, retail, warehouse, etc.). This is because the underlying data needed for the study is most readily available in this format. However, we know that adoption of energy-efficiency measures in the 1990s was also strongly correlated with customer size, facility ownership, whether the entity is a single location or multi-location organization, among other factors (see, for example, XENERGY 1998, 1999b, and 2000). Larger organizations that own their facilities and are part of multi-location entities are several times more likely to adopt many measures that organizations with the opposite characteristics. We also know that delivering energy-efficiency measures to the organizations with lower adoption rates is more expensive. The current study, however, provides estimates of potential and adoption for the average firm within a building type. As a result, a follow-up study is planned that will focus on estimating the potential and relative costs for historically hard-to-reach commercial customers.

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