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This appendix describes the baseline and energy efficiency measure data used in the study. The remaining appendices contain a complete listing of the data used in our modeling process.

A.1 Baseline Data

The principal baseline data used in this study consist of end use and technology specific data as well as economic data (avoided costs and commercial rates).

A.1.1 End Use and Technology Specific Data

Estimating the potential for energy-efficiency improvements requires a 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. Data that were required at the utility service area and building type level for each end use studied included:

- Annual natural gas consumption per business;
- End use saturations, and
- Technology shares.

Sources for and development of each of these key data elements are discussed in the following subsections.

End Use Energy Consumption

The primary sources for the end-use energy consumption estimates were the PG&E and SDG&E Commercial End Use Studies (CEUS) (PG&E 1999; SDG&E 1999). In the end-use forecasting approach, end-use natural gas consumption is expressed as the product of building floor space (in square feet), the fraction of floor space associated with a given end-use fuel (the end-use fuel saturation), and the EUI (the energy-use intensity of an end use expressed in therms per square foot). These three data elements have been collected and estimated from various sources over time and utilized as key inputs into the CEC natural gas forecasts. After review of the CEC commercial forecast inputs, we determined that their end use detail was not sufficiently reliable for this study (in contrast to the CEC's end-use electric data, which was determined to be more reliable and consistent with utility end use estimates). We therefore relied more heavily on the utility EUI and saturation data from the CEUS studies to develop our baseline natural gas end-use consumption and intensity estimates. CEC commercial floorspace estimates we then recalibrated to ensure that the product of the EUI's, saturations, and floorspace equaled current estimates of commercial natural gas usage.

Figure A-1 summarizes commercial natural gas usage by business type. In 2000, commercial natural gas usage for the three major California natural gas utilities was about 2,100 Mth. Restaurants account for the largest share of natural gas usage at around 22 percent, or roughly

461 Mth. The next largest gas-consuming building types were miscellaneous buildings (such as auto repair shops), accounting for about 16 percent of commercial usage or about 333 Mth.

Figure A-1
Commercial Natural Gas Usage by Building Type within the Major IOU territories

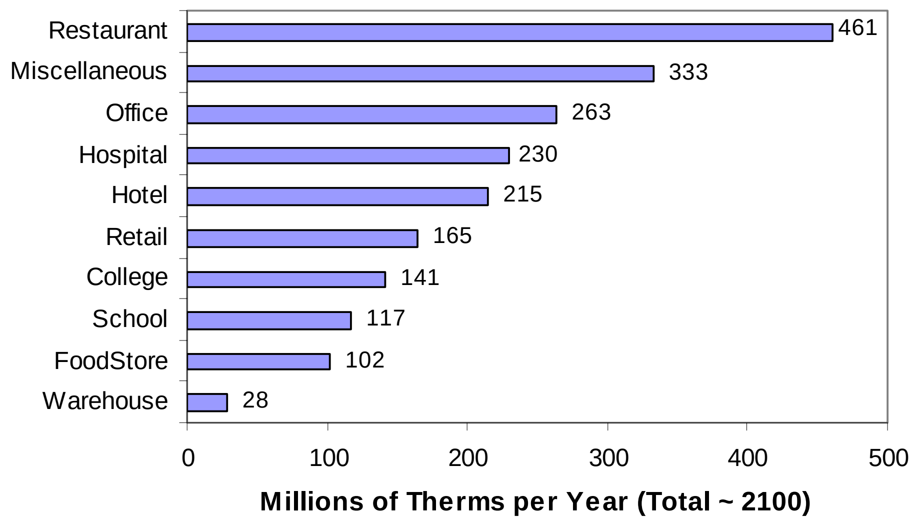
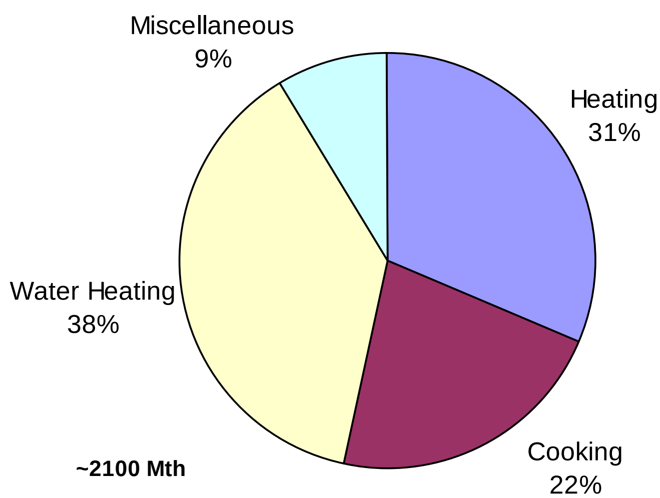


Figure A-2 summarizes commercial natural gas consumption by end use. Our final EUIs are shown, by technology, in Appendix C. As indicated in the figure, water heating and space heating are by far the largest users of natural gas, accounting for 38 percent (782 Mth) and 31 percent (643 Mth) of total commercial consumption respectively. Cooking is the next largest end use, accounting for about 22 percent of total consumption.

Figure A-2
Commercial Natural Gas End-Use Breakdown for Major IOUs



Source: PG&E, SCE, and SDG&E CEUS and XENERGY analysis.

A.1.2 Energy Cost Data

Energy cost data is another important component of this study. These data are described in Section 5. Tables A-4 and A-5 summarize our natural gas energy cost and rate assumptions.

Table A-1
Summary of Base Energy Cost Element

Cost Type	Description	Source
Avoided Costs	Annual avoided cost averages 46 cents per therm and remains relatively unchanged in real terms throughout the forecast horizon.	CPUC authorized avoided costs for 2002 program cost-effectiveness analyses (CPUC 2001).
Commercial Rates	Annual average rate of 56 cents per therm in 2003 that remains relatively flat, in real terms, throughout the forecast horizon.	EIA average commercial prices for California, 12 months ending March 2000; CPUC authorized avoided costs for 2002 program cost-effectiveness analyses (CPUC 2001).

Table A-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.	50 percent higher than Base avoided costs.
Commercial Rates	50 percent lower than Base avoided costs.	50 percent higher than Base avoided costs.

A.2 ENERGY EFFICIENCY MEASURE DATA

This subsection presents information on the energy efficiency measures included in the study. Cost and savings fraction sources are listed and measure descriptions are provided.

A.2.1 Measures Included

The set of measures included in this potential study is shown in Table A-3 below. In reviewing this list, readers should be aware of the following:

- Measures are generally organized around base case technologies. These base case technologies are intentional aggregations of the wide variety of actual base case technologies in the market. Thus, the measure list for the potential study is not as detailed as measure lists that are necessary for actual program implementation.
- The measures shown in the tables were selected by starting with the *DEER 2001 Update Study*, with some aggregation to prototypical applications. We then reviewed utility and

third-party PY2002 filings and program documentation and added measures that could have significant potential but were not on the DEER list. Another key source was the *Conservation Potential Study* conducted by XENERGY for SCG in 1992 (XENERGY 1992b). We also identified and reviewed other sources of information on gas measures including publications from the Federal Energy Management Program, industry organizations, and others.

Table A-3
Commercial Natural Gas Measure List

End Use	Measure #	Measure Name
Heating	100	Base Heating
Heating	102	Ceiling Insulation (In Situ R5 to R24)
Heating	105	Double Pane Low Emissivity Windows
Heating	107	Duct Insulation Installed
Heating	113	HE Furnace/Boiler 95% efficiency (In Situ Base = 82%)
Heating	115	Boiler- Heating Pipe Insulation
Heating	117	Boiler Tune-Up
Heating	119	EMS install
Heating	121	EMS Optimization
Heating	127	Heat Recovery from Air to Air
Water Heating	200	Base Water Heating
Water Heating	201	HE Gas Water Heater 95% Efficiency (Base=76%)
Water Heating	203	Instant Water Heater <=200 MBTUH
Water Heating	205	Circulation Pump Timeclocks Retrofit
Water Heating	208	Tank Insulation
Water Heating	209	Pipe Insulation
Water Heating	211	Low Flow Showerheads
Water Heating	212	Faucet Aerator
Water Heating	213	Solar DHW System Active
Cooking	300	Base Cooking
Cooking	302	Efficient Infrared Griddle
Cooking	303	Convection Oven
Cooking	305	Infrared Conveyer Oven
Cooking	306	Infrared Fryer
Cooking	312	Power Burner Oven
Cooking	313	Power Burner Fryer
Pool Heating	400	Base Pool Heating
Pool Heating	401	HE Pool Heater, Eff.=0.97
Pool Heating	402	Pool Cover
Pool Heating	403	Solar Pool Heater

A.2.2 Measure Cost and Savings Sources

Most of the measure cost and savings data for this study were developed as part of the DEER 2001 Update study. Part of that study involved collection and analysis of residential and commercial measure cost data. All measure cost and savings estimates are shown in Appendix C.

A.2.3 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 were developed from available data sources. Key sources for this study were the utility CEUS data. For "replace on burnout" measures such as high efficiency boilers and furnaces, saturations were based on rough estimates of current market penetrations.

A.2.4 Description of Measures Included in the Study

This subsection provides brief descriptions of the measures included in this study.

HVAC - Shell

Ceiling Insulation: Installing fiberglass or cellulose insulation material in floor, wall or roof cavities will reduce heat transfer across these surfaces. The type of building construction limits insulation possibilities. Choice of insulation material will vary depending on the roof construction type. Nominal R-values are used as the performance factor for insulation levels. The overall R-values include the thermal resistances of construction layers (gypsum, air gaps, framing, sheathing, concrete, roofing, etc.). One ceiling insulation measure is included in this study: increasing insulation from R-5 to R-24.

Double Pane Low EmissivityWindows: The important energy performance parameters for windows are U-value, shading coefficient, visible light transmission and air leakage. The window U-value will vary as a function of the number of panes, gap thickness, gap fill (air or inert gas), presence of low-emissivity (low-e) coatings, and frame type. The shading coefficient and visible transmission will vary as a function of glass type and low-e coatings. Air leakage will depend on the type of frame and window design (casement vs. slider). Replacing single pane with double pane windows reduces the U-value and heat transfer considerably. Adding a low-e coating will improve the U-value by about 15%.

Duct Insulation: Insulation material inhibits the transfer of heat through the air-supply duct. Several types of ducts and duct insulation are available, including flexible duct, pre-insulated flexible duct, duct board, duct wrap, tacked or glued rigid insulation, and water proof hard shell materials for exterior ducts.

High-Efficiency Furnace/Boilers: High-efficiency condensing gas furnaces and boilers have AFUEs of greater than 90% compared to base efficiencies in the 80% range.

For furnaces, efficiencies above 90% can be achieved with a number of technologies, pulse combustion being just one of many design approaches. High-efficiency gas furnaces can be installed in new construction or can be retrofitted to existing commercial structures which have other heating systems. In most cases, a condensate drain must be added and a new or modified venting system must be installed.

Condensing boilers are available which operate with thermal efficiencies as high as 95% or more. These condensing units achieve their high efficiency by operating with stack gas temperatures around 100°F. At this low stack temperature the water vapor in the products of combustion is condensed. When the water vapor is condensed, its latent heat from the phase change is recovered, resulting in very high efficiencies.

Boiler Pipe Insulation: Insulating accessible steam or hot water supply pipes in the boiler room is a cost-effective way to save energy. Savings will vary depending on the temperature of the hot water or steam and the ambient temperature. An estimate of 2% savings are utilized in this study.

Boiler Tune-Up: A high-efficiency boiler tune-up performed by a properly trained technician can improve average combustion efficiency by 2 to 10 percent. To ensure that the boiler tune-up is a success, the tune-up technician should use an electronic flue-gas analyzer that is capable of continuously monitoring stack temperature, oxygen (O2 in percent), and carbon monoxide (CO in ppm). In addition, the technician should determine the boiler's actual gas input rate (cubic feet per minute). Some boilers can't be tuned up because there is no way to control the excess air or gas flow. Before examining this measure the technician or auditor must determine if the boiler is tunable. For this study, a conservative savings estimate of 2% was utilized.

EMS installation: The term Energy Management System (EMS) refers to a complete building control system which usually can include controls for both lighting and HVAC systems. The HVAC control system may include on/off scheduling and warm-up routines. The complete lighting and HVAC control systems are generally integrated using a personal computer with control system software.

EMS optimization: Energy management systems are frequently underutilized and have hundreds of minor inefficiencies throughout the system. Optimization of the existing system frequently results in substantial savings to the measures controlled by the EMS (e.g. lighting, HVAC) by minimizing waste.

Heat Recovery: Air-to-Air Heat Exchangers: Air-to-air heat exchangers can be used to transfer heat between the intake ventilation air stream and the HVAC exhaust air stream. During periods when the outside air is colder than the inside air, the heat exchanger transfers heat from the exhaust air to the incoming air reducing heating energy use. When the outside air is warmer than the inside air, the heat exchanger transfers heat from the incoming air to the exhaust air, lowering the temperature of the incoming air, and reducing cooling energy use. Installing an air-to-air heat exchanger will cause a slight increase in fan energy due to increased air flow resistance through the heat exchanger. The increase in fan energy is more than compensated for by energy savings in buildings with high outdoor air ventilation requirements. Air-to-air heat exchangers are most cost-effective in buildings having high outdoor air ventilation rates such as hospitals, hotels (kitchens), and restaurants.

Water Heater

Gas Water Heater: Efficient Gas Water Heaters consist of a high efficiency natural gas, storage-type hot water heater and tank. According to the State of California Appliance Standards, the minimum efficiency level for gas water heaters is EF=0.62-0.0019*(storage volume in gallons). (CEC 1991B) Many small commercial buildings and even some large commercial buildings use residential-sized water heaters to meet their needs for hand washing in restrooms or janitorial purposes (i.e. small office, small retail, supermarket, warehouse). There are four categories of residential-sized gas-fired, storage-type water heaters: condensing gas water heaters (0.86 EF), high efficiency gas water heaters (0.70 EF), efficient gas water heaters (0.62 EF), and standard water heaters (0.54). This study uses and upgrade from a 76% to a 95% system efficiency.

Instantaneous or Demand Hot Water Heater: Demand water heaters are available in propane (LP), natural gas, or electric models. Unlike "conventional" tank water heaters, tankless or instantaneous water heaters heat water only as it is used, or on demand. A tankless unit has a heating device that is activated by the flow of water when a hot water valve is opened. Once activated, the heater delivers a constant supply of hot water. The output of the heater, however, limits the rate of the heated water flow. They come in a variety of sizes for different applications, such as a whole-building water heater, a hot water source for a remote bathroom, or as a boiler to provide hot water for a heating system. They can also be used as a booster for dishwashers, washing machines, and a solar or wood-fired domestic hot water system. They are either installed centrally or at the point of use, depending on the amount of hot water required.

DHW Circulation Pump Timeclock Retrofit: Installing a time clock on the circulation pump for the domestic hot water system can reduce demand during periods when the building is unoccupied. Since, systems must be protected from damage from freeze in all California climates timeclocks may include an override setting if the tempurature reaches below a pre-determined set point.

Tank Insulation: Commercial water heater insulation is available either by the blanket or by square foot of fiberglass insulation with protective facing. Insulation blankets range from 50 to 82 gallon tank sizes, with thicknesses of 2 to 4 inches, and R-values ranging from 5 to 14. Many retailers and wholesalers surveyed suggested using two or more blankets for larger tanks, and double-wrapping tanks for increased R-value. They also note that squeezing the blanket to fit into tight applications lowers the R-value.

DHW Pipe Insulation: The first five feet of pipe closest to the domestic water heater should be insulated. Small pipes are insulated with cylindrical half-sections of insulation with factory applied jackets that form a hinge-and-lap or with flexible closed cell material. Current Title 24 Energy Standards require insulation only on the portion of DHW piping through which water is recirculated. Some energy savings are possible by insulating non-recirculating branch piping, depending on the frequency of hot water use through this piping. If usage is infrequent, savings will be low.

Low Flow Shower Heads: Standard non conserving shower heads have a flow rate of 3.5 to 6 gallons per minute (gpm at 80 psi). Typical water saving shower heads use 1 to 2.4 gpm and are designed to provide a good quality shower with less water. Water saving shower heads are available in a variety of styles to produce vigorous or misty showers. Current California standards require measured flow rates of no greater than 2.45 gpm (at 80 psi) for all shower heads.

Faucet Aerators: Standard non conserving faucet aerators have a flow rate of 3-5 gpm (at 40 to 60 psi). Water saving faucet aerators for bathroom applications have flow rates of 0.5-1.0 gpm and water saving faucet aerators for kitchen applications have average flow rates of 1.5-2.0 gpm. The kitchen requires a slightly greater flow rate to wash dishes and food and also to fill pots when cooking. A lower flow rate in bathrooms is allowable for the tasks of washing hands and faces, brushing teeth or shaving. Water saving faucet aerators deliver water at a lower flow rate, but there is usually no perceptible reduction in service because the aerators are designed to entrain more air into the water, creating a foamier flow that tends to wet objects more thoroughly rather than water bouncing off objects.

Active Solar DHW Systems: Solar water heaters preheat water supplied to a conventional domestic hot water heating system. In addition to system design and component quality, solar water heater performance depends on solar radiation, outdoor temperature, and daily water use. There are active and passive solar DHW system. This study uses an active solar system.

Active solar systems preheat the water that is fed to a conventional domestic water heater. The components of active systems are one or more flat plate collectors, a storage tank, a pump, piping, and controls. Systems must be protected from damage from freeze in all California climates. Active systems typically are less cost-effective than passive systems.
The energy savings for these systems depend on solar radiation, air temperatures, and water temperature at the site and the hot water use pattern. Solar system savings per collector area decline as the fraction of total load met increases. The cost-effectiveness of the system is a linear function of the price of conventional fuel.

Cooking Appliances

Infrared Griddle: A griddle is a thick slab of flat steel heated from below by electric or gas burners. Electric griddles are rated at 3-32 kW, and gas griddles are rated at 60-80 kBtu/hour. In an infrared (IR) griddle, standard burners are replaced with a porous ceramic plate having about

200 holes per inch. Combustion is designed to take place very near the ceramic burner surface, causing it to glow red at a temperature of about 1,650° F. Efficiency is increased because the red-hot ceramic burner increases heat transfer to the griddle plate.

Convection Oven: Convection ovens use a small fan to circulate hot air within the oven cavity. Circulating air can heat food more efficiently than the still air found in conventional ovens.   The hot air in the oven can be heated by gas or electricity. In general, a convection oven will save 30% of the energy used by an oven. These savings result from burners cycling off for a longer period of time.

Instantaneous Infrared Broiler/Conveyor Oven: The instantaneous infrared broiler uses the weight of the food or plate to actuate the broiler flame instead of leaving the flame burning continuously. The broiler is designed to reach full operating temperatures quickly, eliminating preheat time.

Catalytic Infrared Fryer: Fryers cook foods by submerging them in hot animal or vegetable oils. The oil is heated by gas-burners with the flame traveling through several tubes that are submerged in the oil. Gas-fired fryers have ratings of 72-163 kBtu/hour and can cook 50-160 lb/hour of french fried potatoes. Average expected life for a gas fired fryer is about 10 to 14 years depending on how much the fryer is used. Standard natural gas-fired fryers are about 50% efficient. Infrared fryers use internal fins or other heat-absorbing obstructions attached to the inside of the tubes. The fins or obstructions pick up more heat from the flame, resulting in less exhausted heat (lower temperature exhaust).   Infrared fryers are about 65% efficient. Catalytic fryers have woven wire or steel wool-like material inside the fire tubes. These materials capture even more heat from the flame that can then be radiated to the tube walls and to the oil. Catalytic infrared fryers are about 72% efficient and save about 30% of the energy used by standard gas-fired fryers.

Power Burner Range/Fryers: The power burner range is an improved atmospheric burner. The term "power" means that a blower drives gas and air flow to the burner. Gas and air are mixed in a plenum and the mixture is regulated to achieve more efficient combustion. During combustion, the flame moves sideways from the burner and impinges on a bowl made of low-carbon stainless steel located underneath the burner. This bowl glows bright orange and increases the amount of radiant heat transmitted to the cooking utensil. The power burner can be adjusted from a maximum of 20,000 Btu/hour down to 6 Btu/hour and has a design life expectancy of 7 years. The thermal efficiency of the power burner is 63% compared to 42% for standard atmospheric burners found on conventional cooktop ranges and conventional fryers.

Pools

Pool Heater: High efficiency pool heaters are now available with efficiencies of over 90%. These heaters utilized technologies similar to those of high efficiency boilers.

Pool Cover: Installing a pool cover is one of the most cost-effective ways to reduce energy use with a heated swimming pool. Pool covers typically save about 50 to 65% of the energy used to heat the pool if the cover is on 12 hours per day. A pool cover entirely eliminates evaporative heat losses, and reduces convective and radiative heat losses. Pool covers are available in three basic styles; transparent bubble covers similar to very thick bubble wrap type packaging, thin transparent plastic covers, and insulating opaque foam covers. The plastic bubble cover is the most widely used type of cover. Covers can be installed with an automatic or manual roller to allow easier on-off operation. Security pool covers attach firmly to the edges of the pool, preventing small children from accidentally falling under the cover and into the pool.

Solar Pool Heater: One of the most common solar pool heaters used in California is a draindown system that uses a differential thermostat. The pool filter pump is used to pump pool water through the solar collector. When it's cloudy or when the sun goes down, a sensor tells the control unit to shut the system off and water is drained from the solar collector back into the pool. The modes are controlled by solenoid valves or other automatic valves in conjunction with a vacuum breaker relief valve, which allows draindown.