Title

California Baseline Energy Demands to 2050 for Advanced Energy Pathways

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California Baseline Energy Demands to 2050 for Advanced Energy Pathways

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1. INTRODUCTION

This report covers the development of a baseline scenario for energy demand in California for a projection period to 2050 as part of the Advanced Energy Pathways (AEP) project. The baseline scenario will provide a useful point of comparison for the impacts of choices or changes in policy that can be thought of as alternatives to the current trends. The baseline scenario, described here, covers the State's main energy demands - electricity, natural gas and transportation fuel - and provides a forecasted demand for each out to the year 2050. It is based, as much as possible, on the California Energy Commission's (CEC) baseline forecasts. This report will cover the methodology and assumptions for the baseline scenario and review the forecasts and implications. The report is also accompanied by several data files that contain the projections, which can be visualized and disaggregated spatially, temporally and by sector.

Advanced Energy Pathways (AEP) is a project of the California Energy Commission's Public Interest Energy Research (PIER) program with contributing researchers from the University of California, Davis (UCD), Lawrence Livermore National Laboratory (LLNL), Global Environment and Technology Foundation (GETF) and University of California, Berkeley (UCB). The major objective of the project is to analyze the impacts of alternative energy pathways within the transportation sector on California's natural gas and electricity sectors within the timeframe of 2005-2050. Several of the alternative transportation energy pathways entail significant changes from the current transportation fuel infrastructure (e.g. hydrogen fuel cell vehicles and plug-in hybrid electric vehicles) and the project will attempt to assess the impacts of such a change on the State's energy systems.

This baseline scenario is one example of many possible scenarios that characterize the range of possible futures for California. The baseline scenario is not necessarily the most likely of possible scenarios, but rather, it is used to represent a likely future given a continuation of current trends and policies. Alternate scenarios are used to imagine different futures that would require significant shifts from current demographic, societal or policy trends. Each of these energy demand scenarios will be used to provide the inputs to a LLNL computer model that will optimize the structure and layout of the California energy supply system to meet these demands.

2. OUTPUTS AND METHODOLOGY

2.1. CEC Projections

The baseline scenario is based on existing CEC projections for each of the energy categories. For the Integrated Energy Policy Report (IEPR), the CEC develops energy demand projections for transportation fuels, electricity and natural gas and highlights important energy policy challenges for the state, such as climate change, renewable energy supplies, and water issues. Typically, these energy demand projections may extend 10, 20 or 25 years into the future, depending on the type of projections. The goal of this baseline scenario is to extend the expected trends captured in these projections to 2050. Whenever possible, we matched the baseline scenario to the CEC projection for the years that they overlap and continue the specific technology and market trends to project beyond the CEC projection timeframe.

Table 1. Regional disaggregation in CEC projections, adopted for baseline scenario.

<table>
<tr><th>Climate zone</th><th>Electricity planning area</th><th>Natural gas planning area</th></tr>
<tr><td>Climate zone 1
Climate zone 2
Climate zone 3
Climate zone 4
Climate zone 5</td><td>Pacific Gas & Electric (PG&E)</td><td rowspan="2">PG&E</td></tr>
<tr><td>Climate zone 6</td><td>Sacramento Municipal Utility District (SMUD)</td></tr>
<tr><td>Climate zone 7
Climate zone 8
Climate zone 9
Climate zone 10</td><td>Southern California Edison (SCE)</td><td rowspan="3">Southern California Gas (SCG)</td></tr>
<tr><td>Climate zone 11
Climate zone 12</td><td>Los Angeles Department of Water and Power (LADWP)</td></tr>
<tr><td>Climate zone 16</td><td>Burbank, Glendale, and Pasadena (BGP)</td></tr>
<tr><td>Climate zone 13</td><td>San Diego Gas & Electric (SDG&E)</td><td>SDG&E</td></tr>
<tr><td>Climate zone 14
Climate zone 15</td><td>Other</td><td>Other</td></tr>
</table>

The CEC disaggregates electricity and natural gas demands regionally, to account for variability in energy usage trends based on demographics, economics, and climate. The regional classifications used by the CEC are outlined in Table 1, above. The state is divided into 16 climate zones to account for variable heating and cooling loads.[1] These are aggregated into seven electricity utility planning regions,[2] which in turn are aggregated into four natural gas

[1] The climate zones referred to here are those used by the CEC in their energy forecasts for the state. They differ from the 16 climate zones defined by the Title 24 Building Standards.

[2] An eighth electricity utility areas, the Department of Water Resources (DWR), is defined only for water pumping in the agricultural sector.

utility planning areas. The baseline scenario projections are defined in terms of the seven electricity planning areas and four natural gas planning areas. Only projections for residential electricity consumption include disaggregation at the climate zone level. For the purposes of aggregating sectoral electricity demands into a statewide total, we convert residential electricity demand based upon climate zone to electricity planning area.

Figure 1 shows the population and economic assumptions associated with the baseline scenario projections for California. The population projection is supplied by the California Department of Finance and population is expected to increase to about 55 million residents by 2050. GSP assumes a 2.5% annual growth rate and triples from 2005 to 2050. With the fast growth in GSP, GSP per capita also grows significantly at an average annual rate of 1.6%/yr. Changes in these two parameters will be one of the major influences on the many of the energy demands in the alternative scenarios.

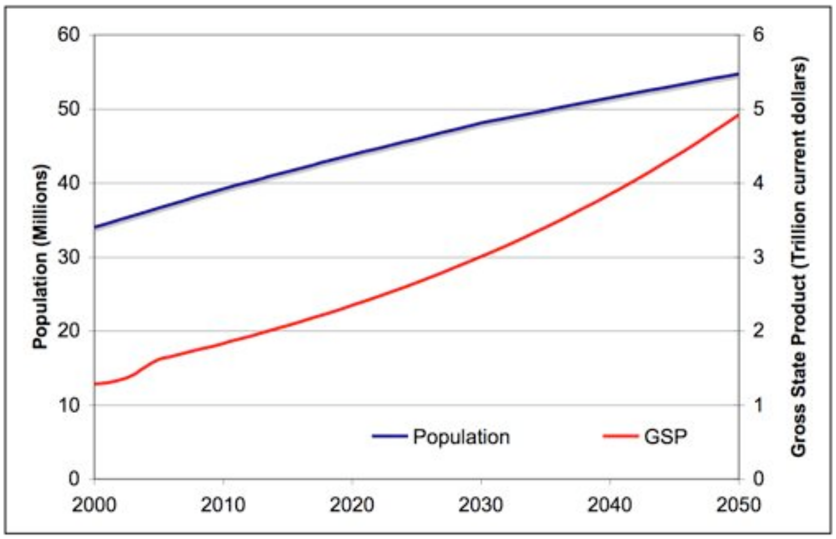

Figure 1 Population and gross state product (GSP) projections.

2.2. Outputs

The major output of developing a baseline scenario is a series of detailed quantitative projections of major energy demands within California for the modeling period (from the present out to the year 2050). These projections are organized into Microsoft Excel® spreadsheets, which contain the temporally and spatially disaggregated data series for the three major energy demand categories for California: electricity, natural gas and transportation fuels. These spreadsheets are annotated to provide the user with useful information about how the scenarios were derived, the methods used, and the critical assumptions. The spreadsheets also contain graphs of the demand data and compare the baseline projection to alternative input assumptions, such as frozen efficiency cases.[3] The energy demand data series can be imported into a modeling program to optimize the structure and operation of the supply infrastructure. Table 2 shows a list of the

[3] A frozen efficiency case is one which assumes that energy efficiency or energy intensity for a particular energy-using device, vehicle, or process is held constant over the forecast period, which leads to total energy use that is proportional to the stock (number) of the energy user (population, households, vehicles, floorspace, etc.).

Excel spreadsheets that contain the baseline scenario energy demand projections. The files in bold font are summaries for each of energy demands (electricity, natural gas and fuel), while the others provide further detail for energy demand disaggregated by sector.

Table 2. Table of Baseline Scenario Output Files.

Filename	***Description***
Electricity summary_AEPbaseline.xls	Electricity demand and peak summary (by sector, regional and hourly)
Residential electricity_AEPbaseline.xls	Residential households and electricity demand by end use, climate zone and planning area
Commercial electricity_AEPbaseline.xls	Commercial floorspace and electricity demand by planning area and building type
Industrial electricity_AEPbaseline.xls	Industrial shipments and electricity demand by planning area and industrial type
Agricultural & Other electricity_AEPbaseline.xls	Agricultural and other sector electricity demand by end use.
Natural gas summary_AEPbaseline.xls	Annual and monthly natural gas demand summary (by sector and region)
Residential NG_AEPbaseline.xls	Residential households and natural gas demand by end use, planning area and climate zone.
Fuel summary_AEPbaseline.xls	Annual, monthly and hourly fuel demand summary

2.3. Electricity

Electricity projections are disaggregated by sector (residential, commercial, industrial, agricultural, and other), by region (see Table 1), and temporally (hourly). The projections are based upon trends in energy intensity parameters which are scaled to total electricity use by multiplying by households, commercial floorspace, or value of industrial shipments, which are derived from demographic and economic forecasts. Table 3 summarizes the level of disaggregation that exists in the electricity projections.

Table 3. Level of disaggregation and variables used in projecting electricity demand for each sector.

Sector	**Regional disaggregation**	**Other disaggregation**	**Activity variables**	**Sources**
Residential	Climate zone (14) Planning areas (7)	End use (18) Household type (2)	End use saturation Unit energy consumption Households	Quantum (2006) CEC (2005a) CA DOF (2004)
Commercial	Planning areas (7)	End use (10) Building type (12)	Floorspace Energy intensity	CEC (2003) CEC (2005b)
Industrial	Planning areas (7)	Industrial classification (33)	Shipments Energy intensity	CEC (2003)
Agricultural	Planning areas (8)	Industrial classification (4)	None	CEC (2003)
Other	Planning areas (7)	Industrial classification (19)	None	CEC (2003)

The input data from the IEPR electricity projections extend to 2016 for the residential sector and 2013 for the other sectors. Electricity demand is calculated for each sector, as the sum of disaggregated consumption in terms of end uses, building types, and/or industrial classification. Projections to 2050 are made at the disaggregated level by extending trends in specific industrial size or share, share or saturation of end use, and energy intensity within the subgroups. These projected trends are multiplied by projected activity to determine total energy use for the sector.

Projections for the residential sector are based upon work by Quantum/Itron for annual residential electricity consumption through 2050. Saturation and unit electricity consumption are projected for 18 end uses and two household types (single family and multi family), which are multiplied by the projected number of households to determine electricity use within a region.

Commercial projections are disaggregated into 10 end uses for each of 12 building types. End use energy consumption per square-foot and floorspace are forecast according to recent and projected near-term trends. Electricity consumption is defined as the product of the two, and is summed across building types to determine sector-wide consumption.

The industrial sector is divided into 33 industrial classes and projections are based upon trends in energy intensity as a function of the value of shipments. Total electricity usage is the product of projected industrial shipments and energy intensity.

The agriculture and other sectors are broken into four and 19 industrial classes, respectively. The data do not permit further disaggregation of these classes. Consequently, the forecast is based on annual electricity consumption for each classification.

Peak and hourly demand projections are derived from an hourly demand profile for California from 2003. This profile is subdivided by sector and utility planning area and is assumed to be representative of an hourly profile for any forecast year. Given the annual energy demand for a given sector or planning area, the hourly profile is scaled to provide peak annual demand and a load duration curve or hourly profile for all 8760 hours of the year.

A more detailed discussion of the methodologies used to project electricity use in each sector can be found in Appendix A.

2.4. Natural Gas

Natural gas projections are made only for the five sectors shown in Table 4 and do not include natural gas used for electricity generation. The methods used to project natural gas demands are similar to those used in the electricity forecast, where possible. But in many cases, data regarding historical and projected near-term natural gas consumption lack the level of disaggregation that exists for electricity. Consequently, projection methods for some sectors differ for natural gas as compared to electricity.

Table 4. Level of disaggregation and variables used in projecting natural gas consumption for each sector.

Sector	Regional disaggregation	Other disaggregation	Activity variables	Sources
Residential	Planning areas (3)	End use (12) Household type (2)	End use saturation Unit energy consumption Households	CEC (2003) Quantum (2006) CA DOF (2004)
Commercial	Planning areas (4)	None	Floorspace Energy intensity	CEC (2003) CEC (2005b)
Industrial	Planning areas (4)	None	None	CEC (2003)
Agricultural	Planning areas (4)	None	None	CEC (2003)
Other	Planning areas (4)	None	None	CEC (2003)

All data used in the natural gas projections derive from IEPR2003, with the exception of the household projections, which come from the projections for electricity consumption in the residential sector.

In the residential sector, annual natural gas consumption is defined as the product of end use appliance saturation, UEC, and the number of households for each of three natural gas utility planning areas (the Other region is lumped into PG&E and SCG). Appliance saturation rates are projected to 2050 based on CEC projections of average annual percentage near-term growth. Unit energy consumption is projected similarly, but is constrained according to feasible efficiency gains or losses.

Annual natural gas consumption in the commercial sector is defined as the product of energy intensity and floorspace for the four natural gas utility planning areas. The parameters are projected similar to those for electricity consumption. Natural gas consumption in the industrial, agricultural, and other sectors is projected by extending historical and projected near-term consumption linearly through 2050 for each of the four planning regions. A lack of disaggregated demand data for the sectors prevents more refined projections.

A more detailed discussion of the methodologies used to project natural gas use in each sector can be found in Appendix A.

2.5. Transportation Fuel

The transportation fuel usage demand is developed using CEC projections from the CalCARS model which projects new car sales, vehicle miles traveled and fuel economy for 45 different vehicles – 15 body types for 3 different drivetrains (conventional, hybrid and diesel) – out to 2025. This information is input into a vehicle stock turnover model, which accounts for vehicle retirements and mileage reductions and projects overall fuel usage for each vehicle type and total gasoline and diesel demand for each year to 2050. The model tracks the numbers, ages, fuel economy and VMT for each of the classes of vehicles sold in each of the modeling years to determine total fleet VMT, fuel economy and total fuel consumption. Projections for VMT and fuel economy from 2025-2050 are estimated by extrapolating trends from 2005-2025. New vehicle sales were estimated by extrapolating the trend in vehicle sales per person for this period out to 2050. The fuel demand projections are disaggregated by vehicle class, drive train and fuel type but not by region. Table 5 shows the level of disaggregation, key input variables and data sources used for developing the transportation fuel baseline scenario.

Historical data for monthly fuel demand is used to develop a monthly fueling profile as a function of annual demand. Data from gasoline refueling stations is used to develop demand profiles of fuel demand as a function of day of the week and hour of the day.

Table 5. Level of disaggregation and variables used in projecting vehicle fuel demand.

Sector	**Regional Disaggregation**	**Other disaggregation**	**Key input variables**	**Data Sources**
Light-duty vehicles	None	Vehicle class (15) Drive train (3)	New Sales VMT/year Fuel economy	CEC (2003) CA DOF (2004)
Non-light duty vehicles	None	None	None	CEC (2003)

3. BASELINE SCENARIO – ELECTRICITY

Electricity is one of the critical areas for California's energy system. Disruptions to California's electricity sector led to rolling blackouts and price escalation in 2000 and 2001. Adequate planning is critical because electricity must be generated and distributed to the point of use at the exact time of use. Especially during summer months, electricity demand can become volatile with large swings in demand due to weather events.

Annual electricity projections are made on the basis of population growth forecasts for specific climate zones, economic growth for commercial and industrial sectors and projections for energy intensities and efficiencies for specific end use technologies, sectors and buildings. The baseline scenario includes projected energy demand for each sector and utility planning area.

3.1. Annual Energy Projections

Figure 2 shows the projected annual electrical energy demand for the five sectors from 2005-2050. The commercial sector shows the highest absolute growth in electricity demand. Total energy demand increases 45%, from 269,102 GWh in 2005 to 390,629 GWh in 2050. While total electricity demand increases, per capita energy consumption is relatively constant, decreasing only slightly (approximately 3%) over the entire forecasting period (see Figure 4). Residential, industrial and agricultural per capita electricity demand decrease by 9%, 12% and 4%, respectively, over the forecast period, while commercial and other electricity demands increase by 4% and 18%, respectively. This projection continues a trend of constant electricity use per capita for California dating back to the early 1970s.

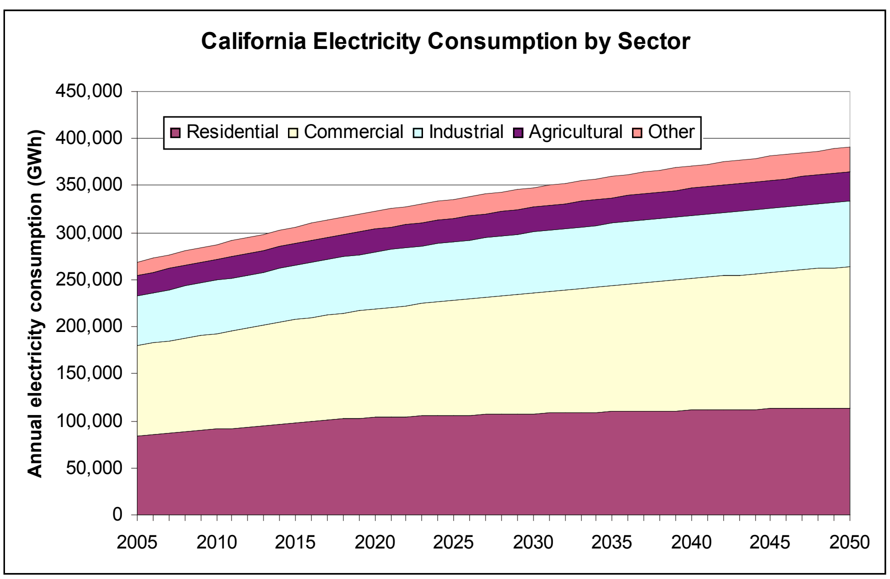

Figure 2 Annual electricity consumption by sector.

Table 6. Electricity demand disaggregated by sector

	California electricity consumption (GWh)					2006-2050 growth	Avg. annual growth rate
	2006	**2013**	**2016**	**2025**	**2050**		
Residential	85,170	95,315	100,018	105,682	113,732	33.5%	0.7%
Commercial	97,642	105,906	110,143	122,148	150,327	54.0%	1.0%
Industrial	53,387	57,018	58,549	62,477	69,613	30.4%	0.6%
Agricultural	21,569	22,873	23,494	25,356	30,533	41.6%	0.8%
Other	15,150	16,960	17,715	19,999	26,425	74.4%	1.3%
All CA	272,917	298,071	309,919	335,661	390,629	43.1%	0.8%
2003 IEPR	273,329	299,586	---	---	---	---	1.3%
2005 IEPR	279,886	304,400	313,397	---	---	---	1.1%

Over two-thirds of total electricity demand is concentrated in the residential and commercial (i.e. buildings) sectors while 75% of total electricity demand is concentrated into the two largest investor owned utilities (IOUs), PG&E and SoCal Edison (see Figure 3 and Table 7).

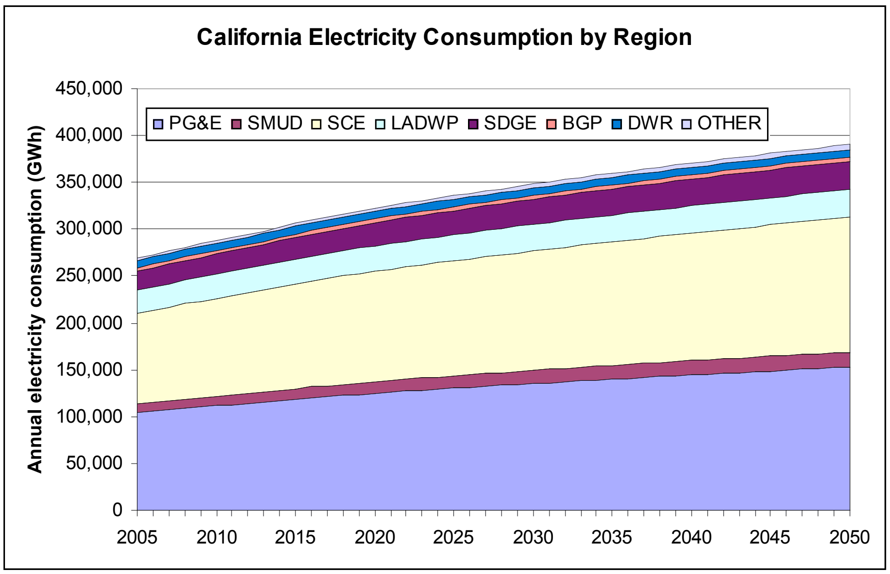

Figure 3 Annual electricity consumption by planning area.

Table 7. Electricity demand by planning area.

	California electricity consumption (GWh)					2006-2050 growth	Avg. annual growth rate
	2006	**2013**	**2016**	**2025**	**2050**		
PG&E	105,687	115,266	119,853	130,098	152,549	44.3%	0.8%
SMUD	9,825	11,184	11,846	13,305	16,196	64.8%	1.1%
SCE	98,075	108,466	113,034	122,930	143,767	46.6%	0.9%
LADWP	24,893	26,028	26,699	27,770	29,505	18.5%	0.4%
SDGE	20,498	22,592	23,613	25,807	30,701	49.8%	0.9%
BGP	3,611	3,709	3,833	4,072	4,533	25.5%	0.5%
DWR	7,889	7,889	7,889	7,889	7,889	0.0%	0.0%
Other	2,439	2,937	3,153	3,791	5,489	125.0%	1.9%
All CA	272,917	298,071	309,919	335,661	390,629	43.1%	0.8%
2003 IEPR	273,329	299,586	---	---	---	---	1.3%
2005 IEPR	279,886	304,400	313,397	---	---	---	1.1%

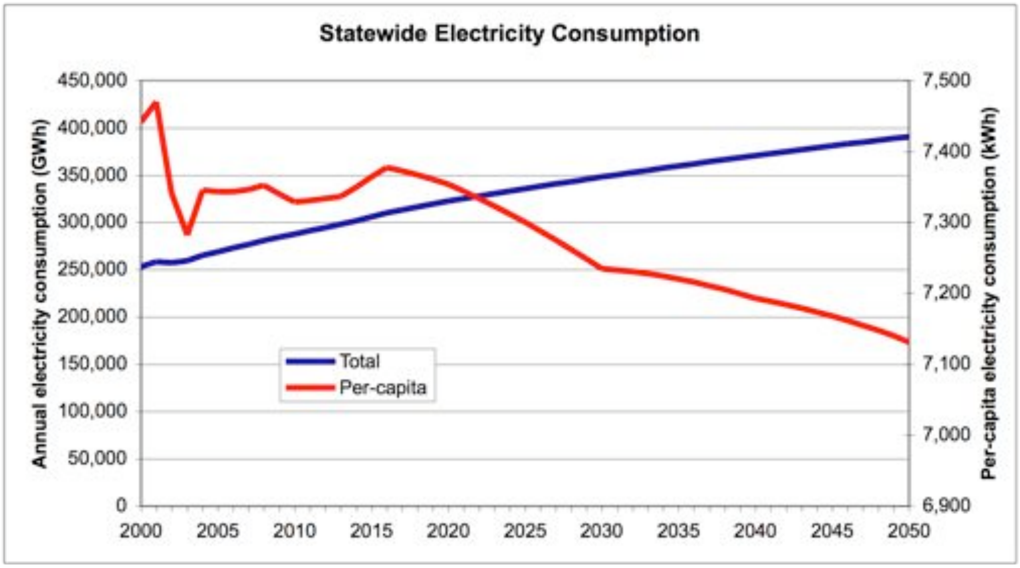

Figure 4   Annual and per-capita electricity consumption.

Residential sector

Residential energy use in California is modeled in 14 different climate zones to account for regional variability in heating and cooling electricity demands (climate zones 14 and 15, each which has few residents, are combined with climate zones 1 and 10, respectively). Peak electricity demand is driven by air conditioning, and although it only makes up 5-6% of energy demand for the year, it is concentrated in specific climate zones and during summer daytime hours, leading to large demand peaks (relative to average demand). Electricity demand at the climate zone level is aggregated into demands in terms of the utility planning areas (outlined in Table 1). These regional demand projections are illustrated in Figure 5 and listed in Table 8.

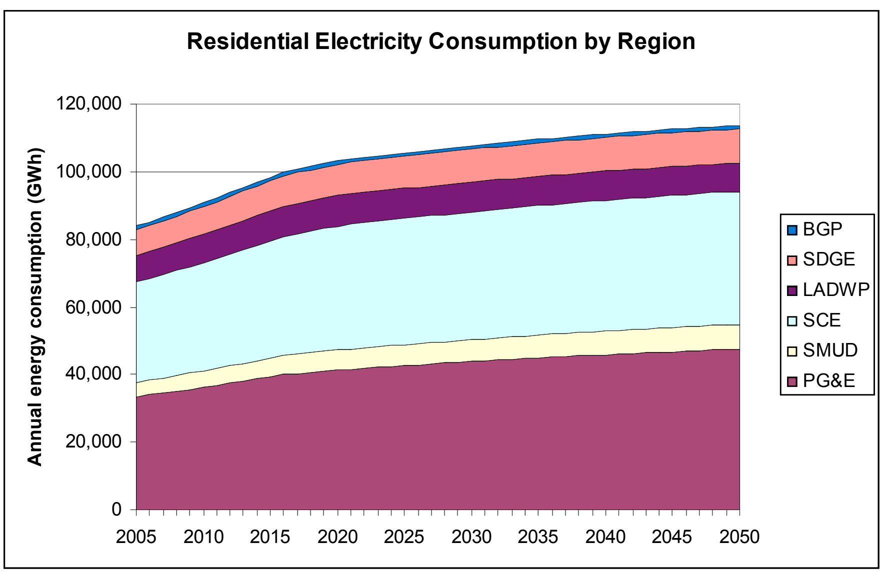

Figure 5   Annual residential electricity consumption by planning area.

Table 8. Residential electricity demand by planning area.

	Residential electricity consumption (GWh)				2006-2050 growth	Avg. annual growth rate
	2006	**2016**	**2025**	**2050**		
PG&E	33,970	39,933	42,624	47,423	39.6%	0.8%
SMUD	4,364	5,555	6,215	7,408	69.7%	1.2%
SCE	30,017	35,408	37,259	39,325	31.0%	0.6%
LADWP	8,029	8,927	8,935	8,327	3.7%	0.1%
SDGE	7,737	9,030	9,490	10,179	31.6%	0.6%
BGP	1,054	1,165	1,160	1,070	1.6%	0.0%
Other	N/A	N/A	N/A	N/A	N/A	N/A
All CA	85,170	100,018	105,682	113,732	33.5%	0.7%
2005 IEPR	88,032	104,128	---	---	---	1.7%

Table 9. Projected number of household by planning area.

	Projected households by electricity planning area					2006-2050 growth	Avg. annual growth rate
	2006	**2010**	**2020**	**2025**	**2050**		
PG&E	4,727,725	5,001,607	5,686,311	5,972,382	7,402,736	56.6%	1.0%
SMUD	523,158	579,811	721,442	777,758	1,059,337	102.5%	1.6%
SCE	4,322,640	4,570,874	5,191,460	5,375,789	6,297,435	45.7%	0.9%
LADWP	1,318,322	1,359,857	1,463,695	1,475,755	1,536,053	16.5%	0.3%
SDGE	1,173,513	1,234,201	1,385,922	1,441,389	1,718,722	46.5%	0.9%
BGP	170,651	175,683	188,263	189,815	197,570	15.8%	0.3%
Other	N/A	N/A	N/A	N/A	N/A	N/A	N/A
All CA	12,236,009	12,922,033	14,637,094	15,232,887	18,211,854	48.8%	0.9%

Table 10. Residential energy intensity by planning area.

	Residential energy intensity (kWh/HH)			2006-2050 growth	Avg. annual growth rate
	2006	**2025**	**2050**		
PG&E	7,185	7,137	6,406	-10.8%	-0.3%
SMUD	8,342	7,991	6,993	-16.2%	-0.4%
SCE	6,944	6,931	6,245	-10.1%	-0.2%
LADWP	6,090	6,054	5,421	-11.0%	-0.3%
SDGE	6,593	6,584	5,922	-10.2%	-0.2%
BGP	6,175	6,112	5,418	-12.3%	-0.3%
Other	N/A	N/A	N/A	N/A	N/A
CA avg.	6,961	6,938	6,245	-10.3%	-0.2%

The location of a household within a state (and the corresponding effect on climate, age and size of house, household demographics and numbers of appliances) leads to large differences in energy use. Population growth is a large determinant in the projected increase in regional electricity demand. Comparing Table 8 and Table 9, it can be seen that the relative growth in electricity demand among regions matches the relative growth in regional population, despite some regional variability in energy usage trends (described in Table 10). SMUD sees the greatest percentage growth rate in energy demand, primarily due to a projected doubling of households within the planning region by 2050.

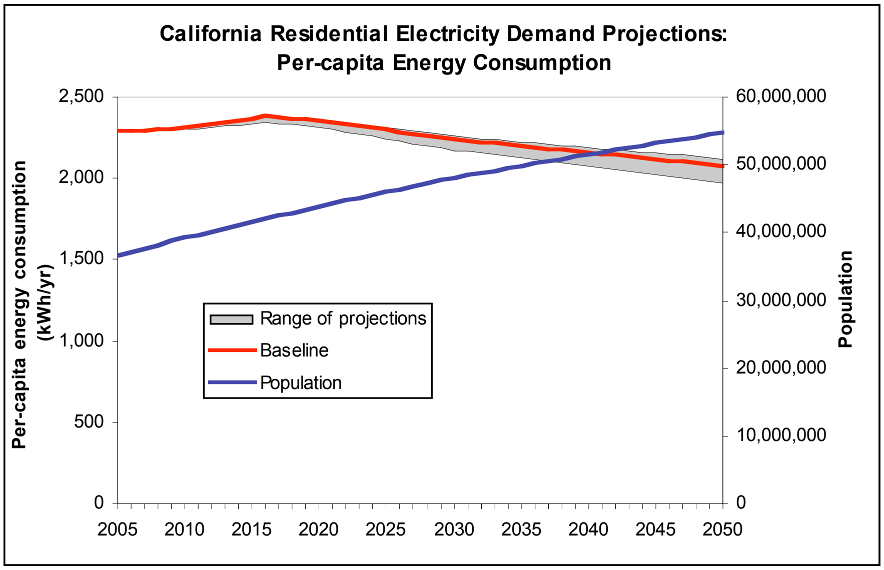

Figure 6 State-wide population and per-capita residential electricity consumption.

The baseline scenario is determined by changes in end uses, changes in appliance/end use efficiency, and numbers, size, and distribution of households. Figure 6 shows the population projection and per capita residential energy consumption and it is clear that population is the dominant variable in determining residential electricity demand. Despite projected increases in energy efficiency, residential electricity consumption is projected to increase due to increases in population. The baseline scenario assumes moderate increases in end use appliance efficiency, which leads to lower per-capita energy intensity. The figure also shows a gray region, which defines the range of projections bounded by optimistic and pessimistic assumptions about appliance and other end use efficiency.

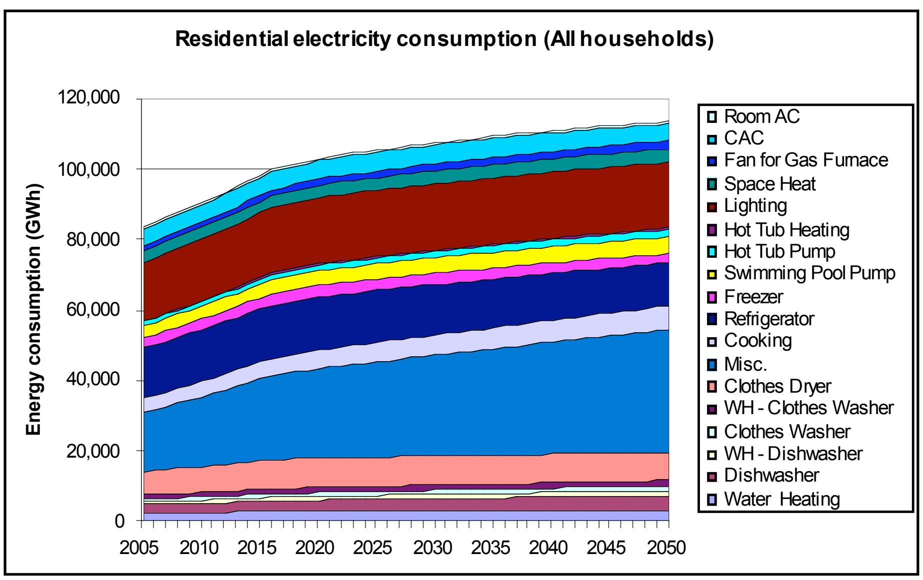

Figure 7 Breakdown of residential electricity consumption by end use.

Figure 7 shows the distribution of residential electricity demand according to the 18 residential end use categories. The largest categories are lighting and miscellaneous, which includes TVs, computers and other home electronics, swimming pools, waterbeds, evaporative coolers, and other appliances defined as miscellaneous in the CEC forecasts (CEC, 2005b). About one half of the total increase in residential energy consumption is projected to occur in the miscellaneous category, and lighting is projected to account for about 10% of the increase as well.

Commercial sector

The major building types that contribute electricity demand for the commercial sector include office buildings, hospitals, food stores, restaurants, retail stores, warehouses, hotels and motels and colleges and schools. Figure 8 shows the breakdown of electricity usage by building type.

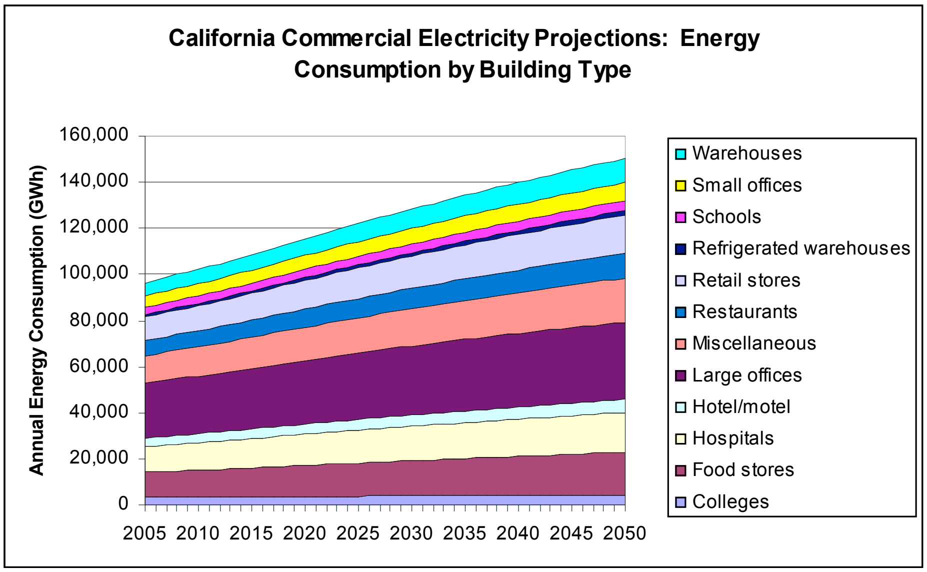

Figure 8 Breakdown of commercial electricity consumption by end use.

Table 11. Commercial electricity demand by planning area.

	Commercial electricity consumption (GWh)						
	2006	**2013**	**2016**	**2025**	**2050**	**2006-2050 growth**	**Avg. annual growth rate**
PG&E	35,142	38,392	40,081	44,978	57,328	63.1%	1.1%
SMUD	3,885	4,220	4,442	5,057	6,388	64.4%	1.1%
SCE	34,420	37,785	39,189	43,068	51,415	49.4%	0.9%
LADWP	11,435	11,918	12,254	13,186	15,223	33.1%	0.7%
SDGE	9,119	9,861	10,297	11,555	14,666	60.8%	1.1%
BGP	2,158	2,154	2,229	2,440	2,918	35.2%	0.7%
Other	1,482	1,576	1,650	1,864	2,388	61.1%	1.1%
All CA	97,642	105,906	110,143	122,148	150,327	54.0%	1.0%
2003 IEPR	99,326	107,601	---	---	---	---	1.1%
2005 IEPR	102,562	109,227	111,624	---	---	---	0.9%

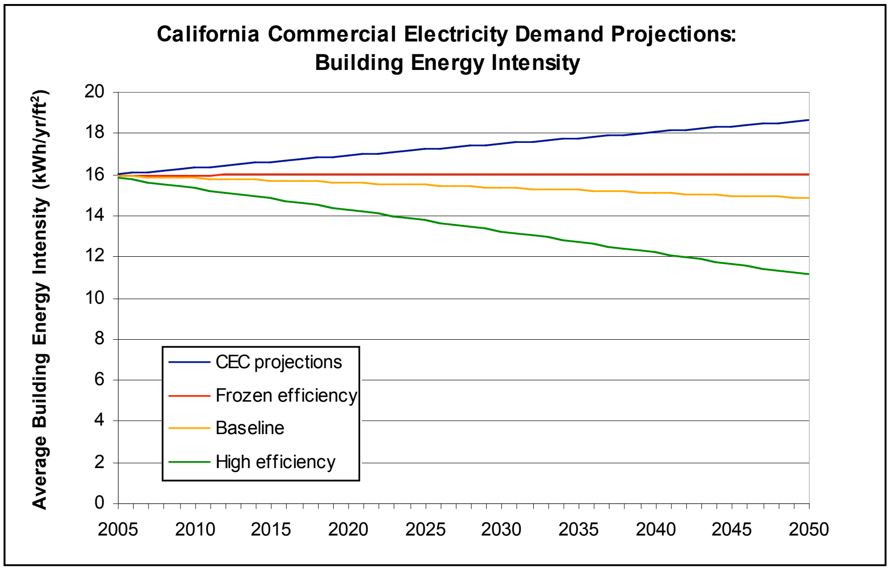

Figure 9 Commercial electricity energy intensity assumptions.

The baseline scenario shows a very slight decline in average building energy intensity over the 45 year forecast period. The other scenarios shown on the graph highlight different building efficiency assumptions, which is useful for understanding the technology assumptions involved.

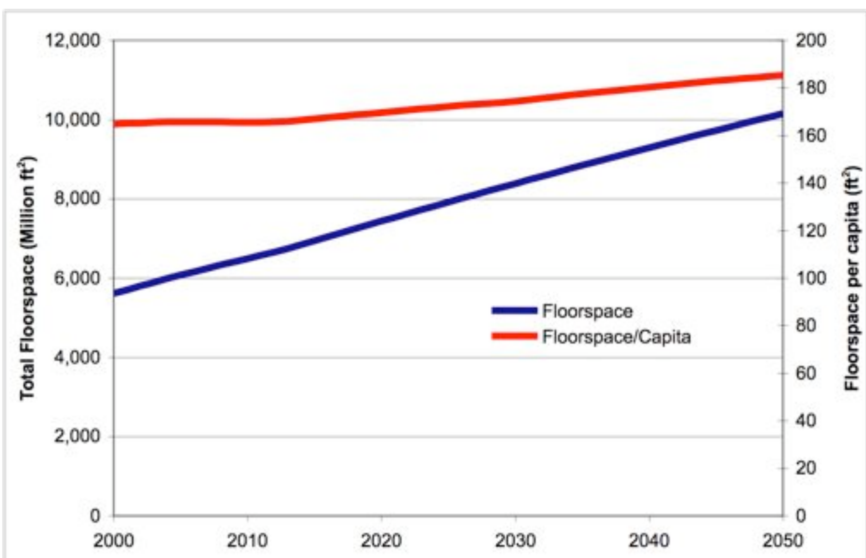

Figure 10 Commercial floorspace and floorspace per capita assumptions

Floorspace is the activity driver for commercial electricity (and natural gas) consumption, which is multiplied by energy intensity to obtain total commercial energy use. Projections for total statewide floorspace from 2000-2050 are illustrated in Figure 10. Total floorspace increases 81% and per-capita floorspace increases 12% over the projection period. The floorspace projection is based upon the methods used in projections by the CEC (2005b), and assumes an annual decay rate of 0.5% and constant additions equal to the average annual floorspace additions from 1990-2013.

Industrial sector

Baseline projections of industrial sector electricity consumption are illustrated in Figure 11 and listed in Table 12. Industrial electricity consumption is projected to increase at an average annual rate of 0.6% statewide through 2050, and is primarily located in the PG&E and SCE planning areas. SDG&E sees the greatest percentage growth rate, but the region remains a minor contributor to statewide industrial electricity demand.

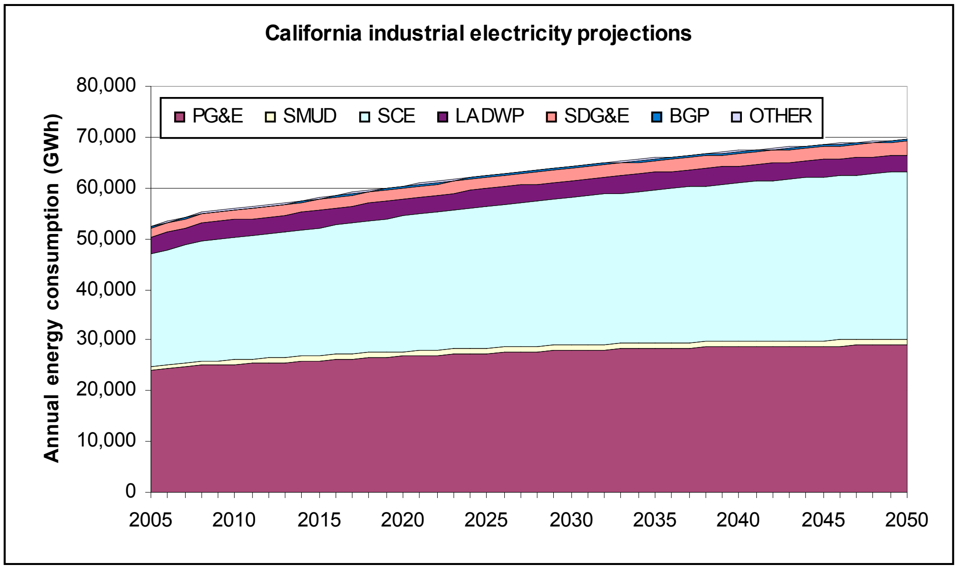

Figure 11 Industrial sector annual electricity consumption by planning area.

Table 12. Industrial electricity demand by planning area.

	Industrial electricity consumption (GWh)					2006-2050	Avg. annual
	2006	2013	2016	2025	2050	growth	growth rate
PG&E	24,254	25,594	26,146	27,439	28,948	19.4%	0.4%
SMUD	828	945	979	1,053	1,114	34.6%	0.7%
SCE	22,745	24,676	25,521	27,849	33,123	45.6%	0.9%
LADWP	3,434	3,387	3,394	3,405	3,354	-2.3%	-0.1%
SDGE	1,688	1,967	2,055	2,264	2,598	53.9%	1.0%
BGP	241	256	262	279	305	26.6%	0.5%
Other	196	193	191	187	172	-12.6%	-0.3%
All CA	53,387	57,018	58,549	62,477	69,613	30.4%	0.6%
2003 IEPR	54,026	57,018	---	---	---	---	0.8%
2005 IEPR	51,396	55,626	56,338	---	---	---	0.9%

Industrial shipments (i.e. the value of the goods and commodities that industries produce) are the activity driver for industrial electricity (and natural gas) demand. Figure 12 illustrates projected energy intensity in the industrial sector through 2050, bounded by forecast optimistic and pessimistic efficiency scenarios. Despite the projected 40% improvement in energy intensity in 2050 compared to 2006, electricity consumption is projected to increase in the industrial sector due to a more-than doubling of shipments. By far, the electronic components industry contributes most significantly to the increase in shipments, as it is expected to increase its production value more than six times its 2006 value. But 13 other industrial groups are projected to double their shipments by 2050, as well. Five industries see a decline in shipments, including apparel and petroleum refining.

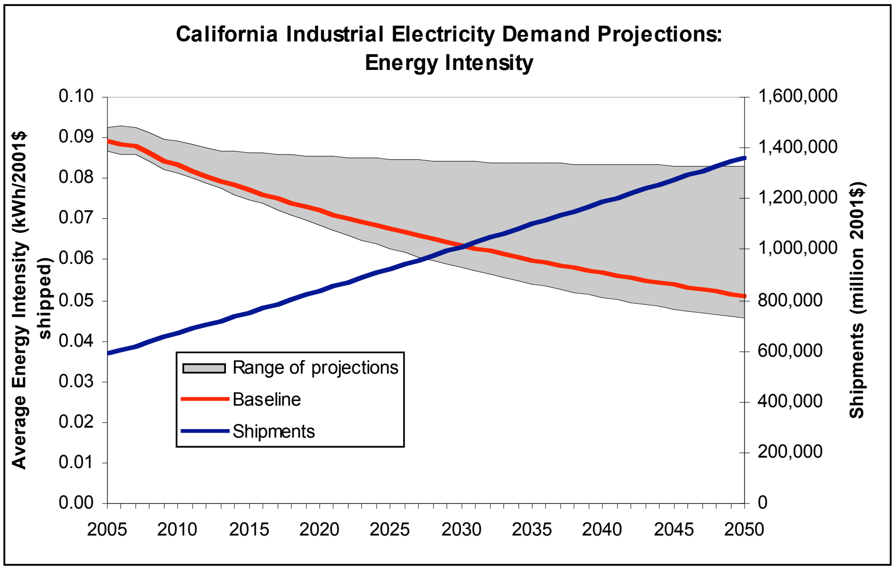

Figure 12 Industrial sector shipment and energy intensity assumptions.

Agricultural and other sectors

The main electricity demands for the agricultural sector are water supply and irrigation, while the 'other' sector includes electricity demands for street lighting, traffic signals, light rail and other non-classified sectors. Agricultural electricity consumption is projected to increase at an average annual rate of 0.8%, and electricity consumption in the 'other' sectors is projected to increase 1.3% annually.

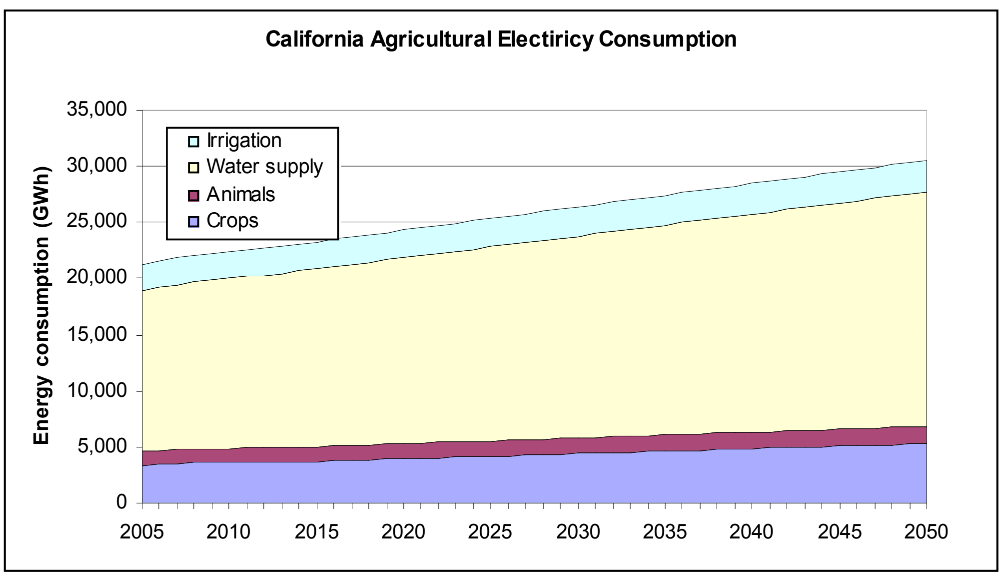

Figure 13 Agricultural sector annual electricity consumption by end use.

Table 13. Agricultural sector electricity demand by planning area.

	Agricultural electricity consumption (GWh)					2006-2050	Avg. annual
	2006	**2013**	**2016**	**2025**	**2050**	**growth**	**growth rate**
PG&E	6,589	6,852	7,022	7,531	8,948	35.8%	0.7%
SMUD	171	191	200	226	299	75.0%	1.3%
SCE	5,975	6,898	7,296	8,491	11,810	97.7%	1.6%
LADWP	186	197	202	215	251	34.8%	0.7%
SDGE	298	337	355	411	567	89.9%	1.5%
BGP	29	29	29	29	29	0.0%	0.0%
DWR	7,889	7,889	7,889	7,889	7,889	0.0%	0.0%
Other	431	479	500	564	740	71.9%	1.2%
All CA	21,569	22,873	23,494	25,356	30,533	41.6%	0.8%
2003 IEPR	20,806	22,873	---	---	---	---	1.4%
2005 IEPR	22,305	24,041	24,571	---	---	---	1.0%

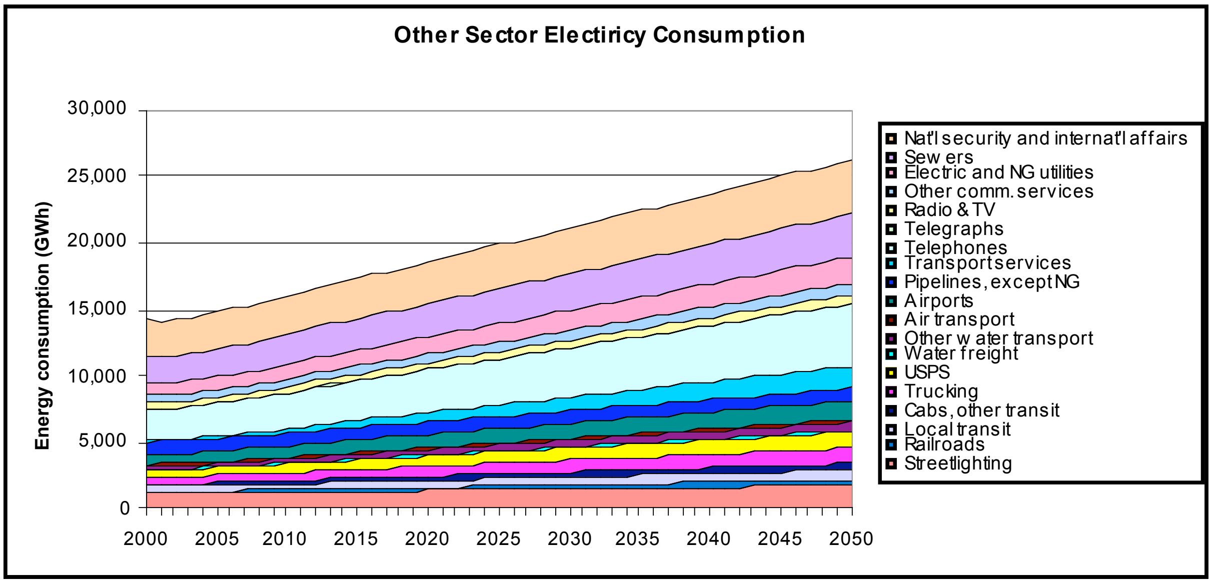

Figure 14 Other sector annual electricity consumption by end use.

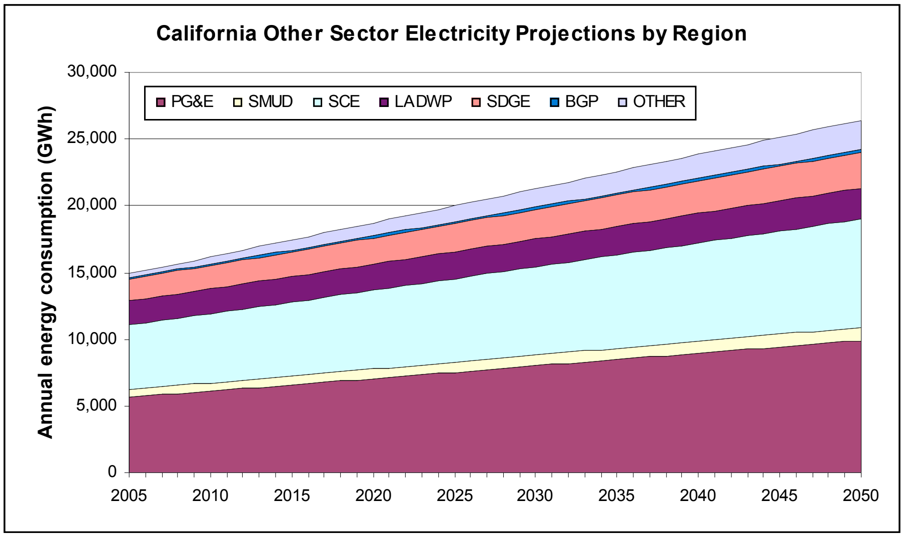

Figure 15 Other sector annual electricity consumption by planning area.

Table 14. "Other" sector electricity demand by planning area.

	Other sector electricity consumption (GWh)					2006-2050 growth	Avg. annual growth rate
	2006	2013	2016	2025	2050		
PG&E	5,732	6,385	6,670	7,526	9,903	72.8%	1.3%
SMUD	578	643	670	754	987	71.0%	1.2%
SCE	4,918	5,407	5,619	6,263	8,095	64.6%	1.1%
LADWP	1,808	1,888	1,922	2,029	2,349	29.9%	0.6%
SDGE	1,655	1,807	1,876	2,088	2,691	62.6%	1.1%
BGP	129	142	147	164	210	62.9%	1.1%
Other	330	689	811	1,175	2,189	563.8%	4.4%
All CA	15,150	16,960	17,715	19,999	26,425	74.4%	1.3%
2003 IEPR	15,176	16,960	---	---	---	---	1.6%
2005 IEPR	15,592	16,421	16,736	---	---	---	0.7%

3.1.1. Peak Demand Projections

Peak electricity requirements have a significant influence on the size and composition of the electric generation sector. In the baseline scenario, peak annual electricity demand is projected to increase to about 75 GW in 2050, based on the 2003 hourly load curve (see Figure 16 and Table 15). This represents a 0.8% annual increase in peak demand. The total peak demand increases significantly by over 22 GW or 43% of the peak demand in 2006.

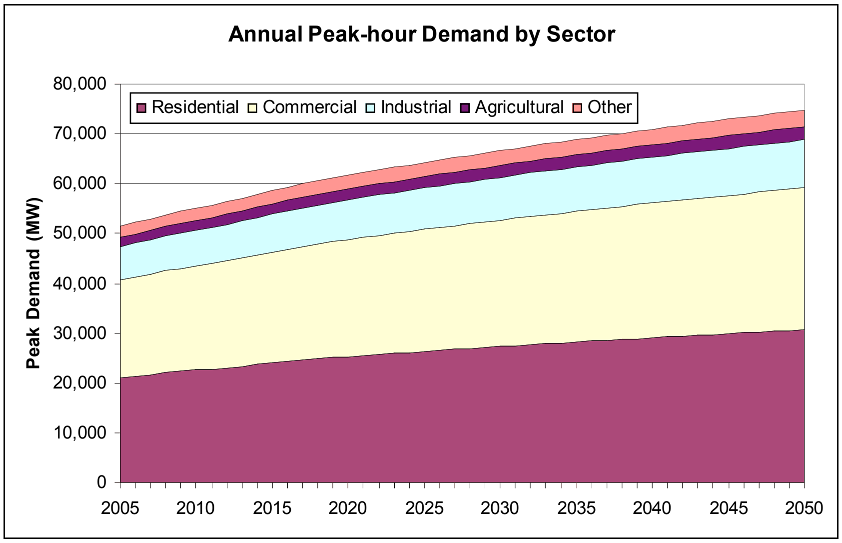

Figure 16 Annual peak electricity demand by sector.

Table 15. Peak hour power demand by sector.

	Peak-hour demand by sector (MW)					2006-2050	Avg. annual
	2006	2013	2016	2025	2050	growth	growth rate
Residential	21,411	23,385	24,314	26,334	30,646	43.1%	0.8%
Commercial	19,904	21,739	22,603	24,480	28,489	43.1%	0.8%
Industrial	6,758	7,381	7,675	8,312	9,673	43.1%	0.8%
Agricultural	1,855	2,026	2,107	2,282	2,656	43.1%	0.8%
Other	2,326	2,540	2,641	2,861	3,329	43.1%	0.8%
Total	52,255	57,071	59,340	64,269	74,793	43.1%	0.8%

Table 16. Non-coincident peak demand by sector.

	Projected non-coincident peak demand (MW)					2006-2050	Avg. annual
	2006	2013	2016	2025	2050	growth	growth rate
Residential	21,125	23,642	24,808	26,213	28,210	33.5%	0.7%
Commercial	19,809	21,486	22,346	24,781	30,498	54.0%	1.0%
Industrial	8,832	9,432	9,686	10,335	11,516	30.4%	0.6%
Agricultural	4,660	4,942	5,076	5,478	6,597	41.6%	0.8%
Other	2,264	2,534	2,647	2,988	3,948	74.4%	1.3%
Total	56,690	62,036	64,562	69,796	80,769	42.5%	0.8%
2003 IEPR	54,139	59,043	---	---	---	---	1.2%
2005 IEPR	56,555	61,932	64,038	---	---	---	1.3%

3.1.2. Hourly Demand Profile

The baseline scenario includes an hourly electricity demand (i.e. power) profile for each of the 8760 hours in a given forecast year for a given utility planning area or the entire state. This hourly profile is critical for understanding the temporal distribution of demand and of electricity generation requirements. The more that demand growth coincides with peak demand times (e.g. AC loads for newer and larger households), the more "peaky" it is. The extent of "peakiness" of demand, which can be visualized by the load duration curve, dictates the types of plants required for generating electricity, and ultimately, the cost of electricity to the consumer.

Figure 17 shows the load duration curve for the year 2003, which shows the number of hours per year in which the demand is above a certain level (it is scaled so that the 2003 peak demand, 39 GW, equals 100%). The graph shows that all 8760 hours of the year have a demand greater than 14.5 GW (37% of peak demand) and only 2100 hours of the year have a demand greater than 26.2 GW (67% of peak demand). The annual load factor is 59%. The load factor and shape of the load duration curve have significant impacts on how the electric generation system is structured and operated. Each sector has a different load factor, which depends upon the specific types of demands. Residential and commercial demand has a significant portion of heating and cooling demand, which leads to lower load factors (46% and 56% respectively). The industrial, agricultural and other sectors show more constant electricity demand and higher load factors (67-69%). Because the 2003 hourly profile is used to generate the hourly profile for each of the projected years, this load duration curve is applicable for all forecast years.

Figure 18 shows the hourly profile for the week of August 25, 2005, the peak demand week of the year. The peak demand is greater than double the minimum demand for the week, highlighting the significant range of electricity generation capacity that must be ramped up and down to follow this demand load.

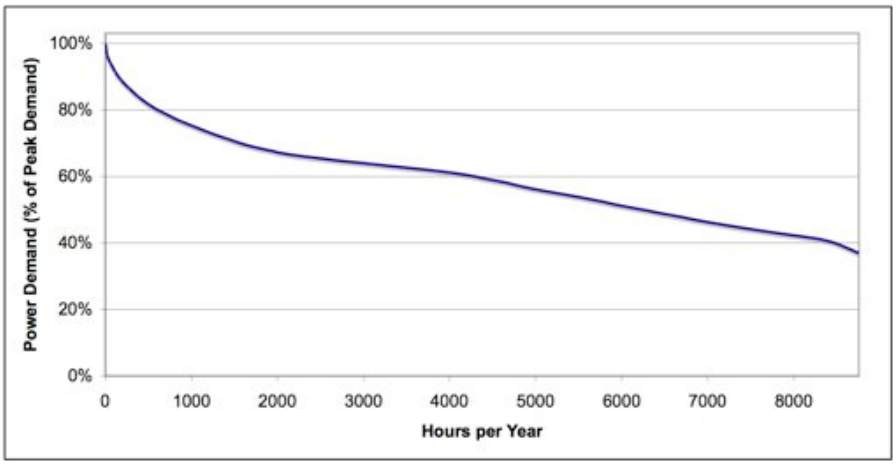

Figure 17 Load duration curve for representative year (2003).

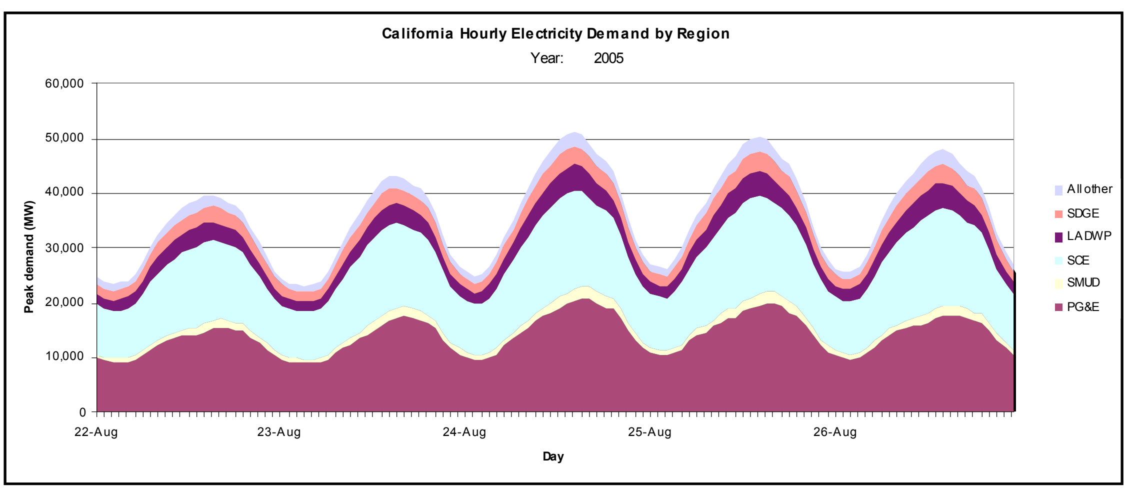

Figure 18 Hourly electricity demand by planning area for peak demand week (August 25).

4. BASELINE SCENARIO – NATURAL GAS

Natural gas is a critical primary energy resource in the state, given its key contribution to electricity generation as well as residential, commercial and industrial fuels usage. Natural gas demand has been rising in California and this trend is expected to continue into the future. Recent high prices, uncertain supply, and growing dependence on imports, including liquefied natural gas (LNG), are critical issues for the state, given its reliance on natural gas. The baseline scenario does not include natural gas demand associated with electricity generation, only demand associated with the residential, commercial, industrial, agricultural and other sectors.

4.1. Annual Energy Projections

Statewide natural gas demand is projected to increase 0.4% annually, from 14,456 MM therms in 2006 to 17,115 MM therms in 2050. Figure 19 and Table 17 outline the projected demand growth by sector. The residential sector leads to the largest percentage of demand growth, which is driven by population growth. Population growth drives the increase in energy demands since saturation rates for end use appliances remain relatively stable and energy intensity is projected to decline.

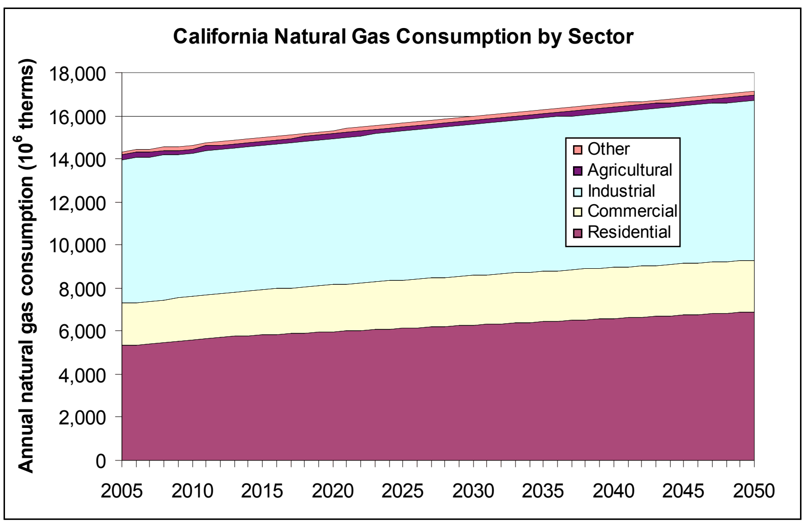

Figure 19 Annual natural gas consumption by sector.

Table 17. Natural gas demand by sector.

	California natural gas consumption (10^6 therms)					2006-2050 growth	Avg. annual growth rate
	2006	2013	2016	2025	2050		
Residential	5,364	5,748	5,841	6,118	6,889	28.4%	0.6%
Commercial	1,977	2,072	2,124	2,252	2,401	21.5%	0.4%
Industrial	6,753	6,653	6,716	6,904	7,427	10.0%	0.2%
Agricultural	201	203	205	210	224	11.4%	0.2%
Other	162	164	165	168	175	8.3%	0.2%
All CA	14,456	14,841	15,051	15,652	17,115	18.4%	0.4%
2003 IEPR	14,475	14,852	---	---	---	---	0.4%
2005 IEPR	13,414	13,935	14,091	---	---	---	0.5%

Figure 20 and Table 18 outline natural gas demands by planning region. SCG and PG&E account for the vast majority of natural gas consumption in the state. SDG&E sees the greatest percentage growth in demand by 2050, but comprises less than 5% of statewide demand. Natural gas demands in the 'Other' planning region are slightly misrepresented in the baseline scenario, as the projections in for the residential sector omit it as a planning region (due to the methods used to aggregate households by climate zone). The residential sector comprises about 40% of statewide natural gas demand (excluding electricity generation), so this emission leads to an underestimate of natural gas demand in the 'other' planning region, and a slight overestimate in PG&E and SCG, where portions of the 'other' region are allocated.

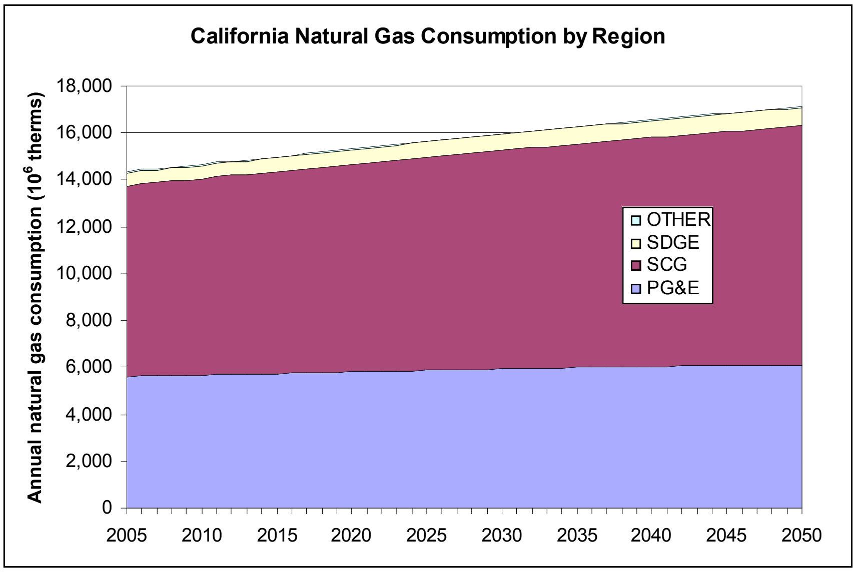

Figure 20 Annual natural gas consumption by planning area.

Table 18. Natural gas demand by planning area.

	California natural gas consumption (10^6 therms)					2006-2050 growth	Avg. annual growth rate
	2006	2013	2016	2025	2050		
PG&E	5,652	5,701	5,749	5,876	6,113	8.2%	0.2%
SCG	8,209	8,531	8,673	9,091	10,186	24.1%	0.5%
SDGE	552	569	589	646	789	43.0%	0.8%
Other	43	40	40	38	27	-36.7%	-1.0%
All CA	14,456	14,841	15,051	15,652	17,115	18.4%	0.4%
2003 IEPR	14,475	14,852	---	---	---	---	0.4%
2005 IEPR	13,414	13,935	14,091	---	---	---	0.5%

Per-capita natural gas consumption is projected to decline by 20% from 2006-2050, as illustrated in Figure 21.

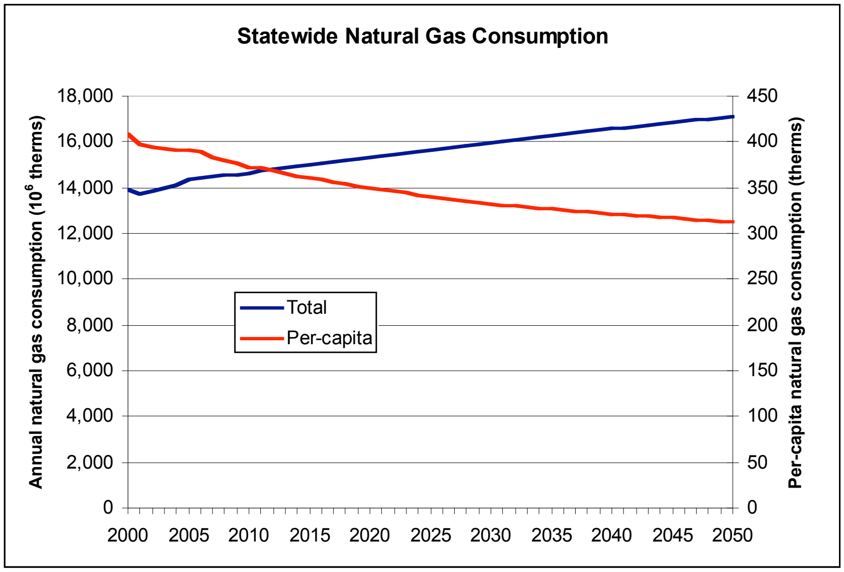

Figure 21 Annual natural gas consumption and per-capita consumption.

Residential Sector

Figure 22 and Table 19 outline the projections of residential natural gas consumption by region. PG&E and SCG account for more than 90% of demand in 2050, despite greater relative growth in consumption in the SDG&E planning area.

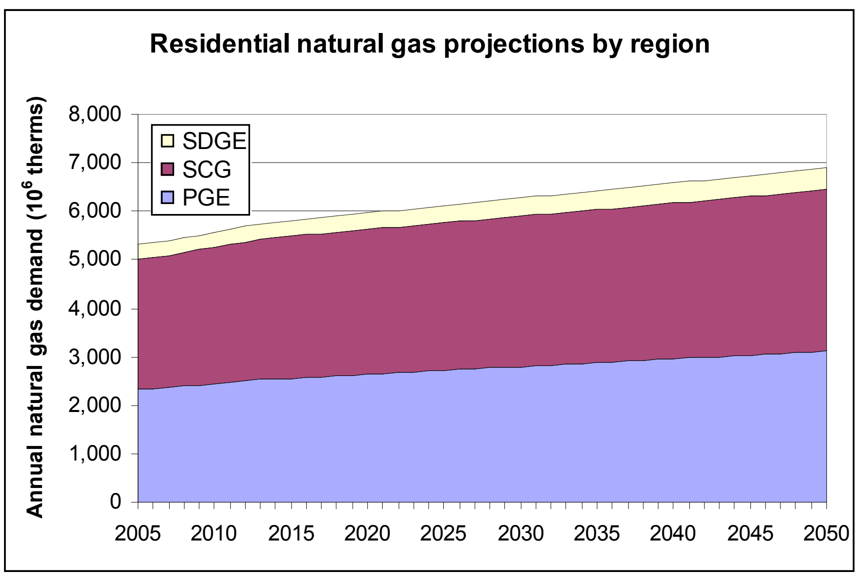

Figure 22 Annual residential natural gas consumption by planning area.

Table 19. Residential natural gas demand by planning area.

	Residential natural gas consumption (10^6 therms)					2006-2050 growth	Avg. annual growth rate
	2006	**2013**	**2016**	**2025**	**2050**		
PG&E	2,345	2,526	2,574	2,717	3,115	32.9%	0.6%
SCG	2,701	2,904	2,938	3,042	3,329	23.3%	0.5%
SDGE	318	318	329	360	445	39.9%	0.8%
Other	N/A	N/A	N/A	N/A	N/A	N/A	N/A
All CA	5,364	5,748	5,841	6,118	6,889	28.4%	0.6%
2003 IEPR	5,353	5,718	---	---	---	---	0.9%
2005 IEPR	5,196	5,514	5,667	---	---	---	0.9%

As discussed above, the methods used to aggregate households by climate zone and planning area combined households in 'other' planning areas into PG&E and SCG territory. Consequently, the projections for residential natural gas consumption omit the 'other' planning area, and likely overestimate consumption in the PG&E and SCG regions. The impact is assumed to be quite small, however, as very few households are located in the 'other' natural gas planning region, which includes Climate Zones 14 and 15 (refer to Table 1 and Figure A-2).

We projected upper and lower bounds for residential natural gas consumption based on a low and high efficiency cases. The range of these projections is depicted in Figure 23 and Figure 24. Average energy intensity is projected to decrease in the baseline scenario (Interestingly, in the low efficiency case, which assumes that appliance energy intensity is frozen at 2004 levels, average energy intensity is projected to increase slightly by 2050. This is due to disproportionate growth in the number of households in regions with higher end use energy intensities).

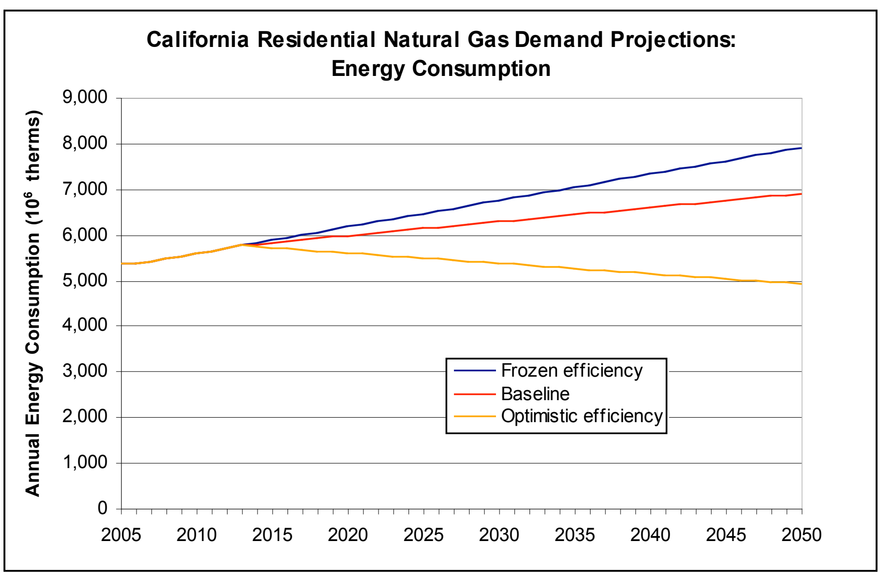

Figure 23 Annual residential natural gas consumption for various intensity assumptions.

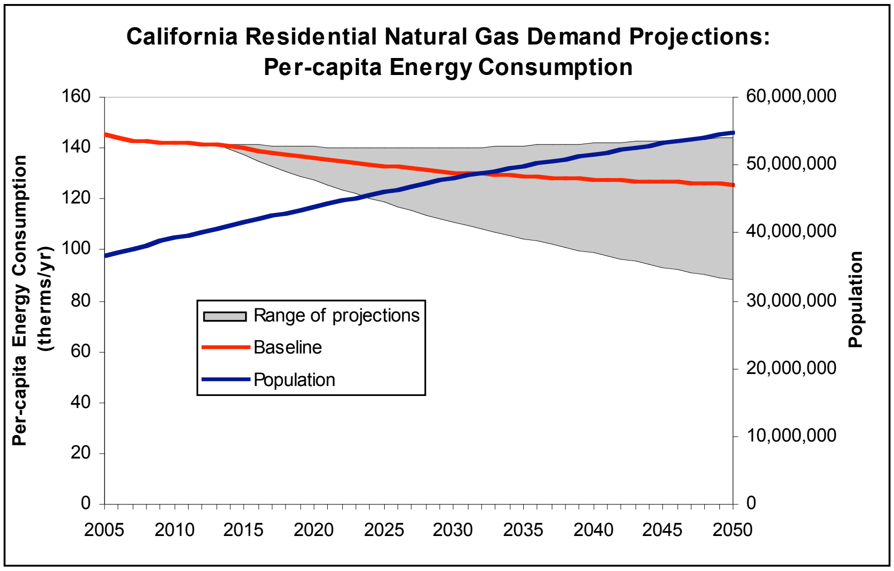

Figure 24 Annual residential natural gas per-capita consumption and population assumptions.

Figure 25 shows that hot water and space heating are the major residential end uses for natural gas. While space heating demand is expected to decline, hot water drives the growth in demand for natural gas in the projection period.

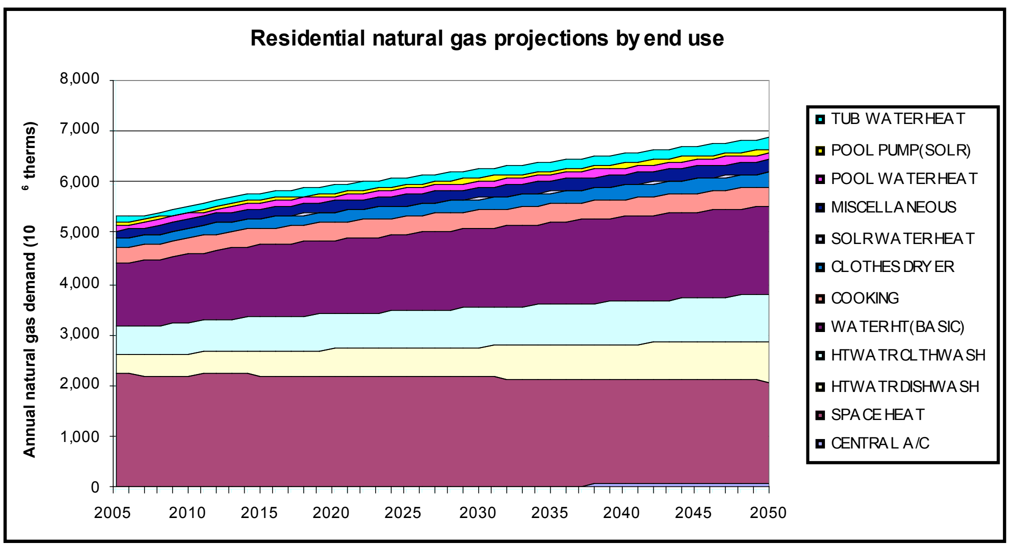

Figure 25 Annual residential natural gas consumption by end use.

Commercial Sector

Natural gas consumption in the commercial sector is outlined in Figure 26 and Table 20 by planning region. SCG comprises the majority of natural gas consumption and sees the greatest demand growth over the course of the projections. PG&E is projected to see its natural gas consumption decline after 2030, despite projected continual increases in floorspace. This is a result of the projected energy intensities for natural gas being scaled off those for electricity, due to a lack of disaggregated data (see section A2.2. for further discussion on these methods).

These results might suggest an underestimate in the projected energy intensity in the PG&E planning area, and consequently, and underestimate in regional natural gas demand.

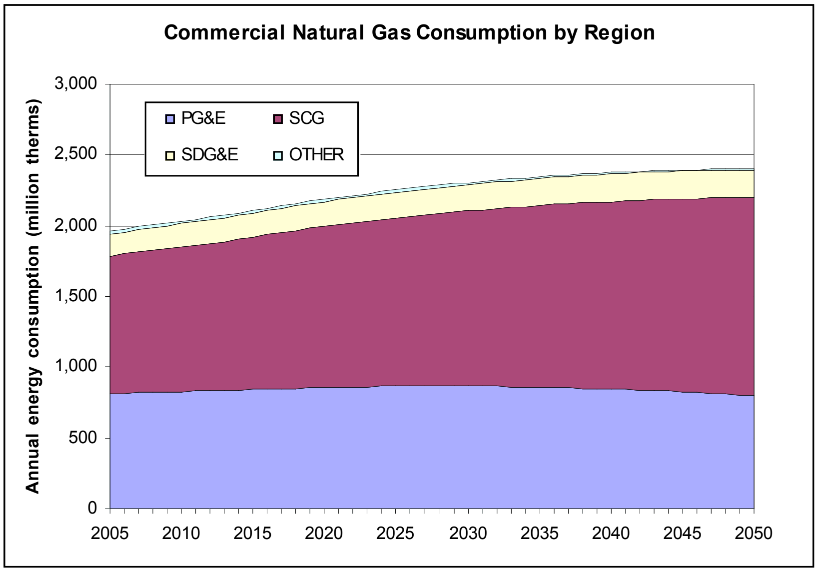

Figure 26 Annual commercial natural gas consumption by planning area.

Table 20. Commercial natural gas demand by planning area.

	Commercial natural gas consumption (10^6 therms)					2006-2050 growth	Avg. annual growth rate
	2006	**2013**	**2016**	**2025**	**2050**		
PG&E	814	833	845	864	801	-1.7%	0.0%
SCG	986	1,056	1,092	1,190	1,397	41.7%	0.8%
SDGE	156	164	169	181	198	27.0%	0.5%
Other	21	19	19	17	5	-74.4%	-3.0%
All CA	1,977	2,072	2,124	2,252	2,401	21.5%	0.4%
2003 IEPR	2,007	2,113	---	---	---	---	0.7%
2005 IEPR	2,035	2,082	2,090	---	---	---	0.3%

Figure 27 outlines the baseline scenario, and where it falls relative to projected higher and lower efficiency cases, described in the methodology section of the Appendix. Energy intensity is projected to decline in the base scenario, illustrated in Figure 27, by about 25% from 2006-2050. Increases in floorspace lead to increased natural gas demand in the sector, despite the projected efficiency improvements.

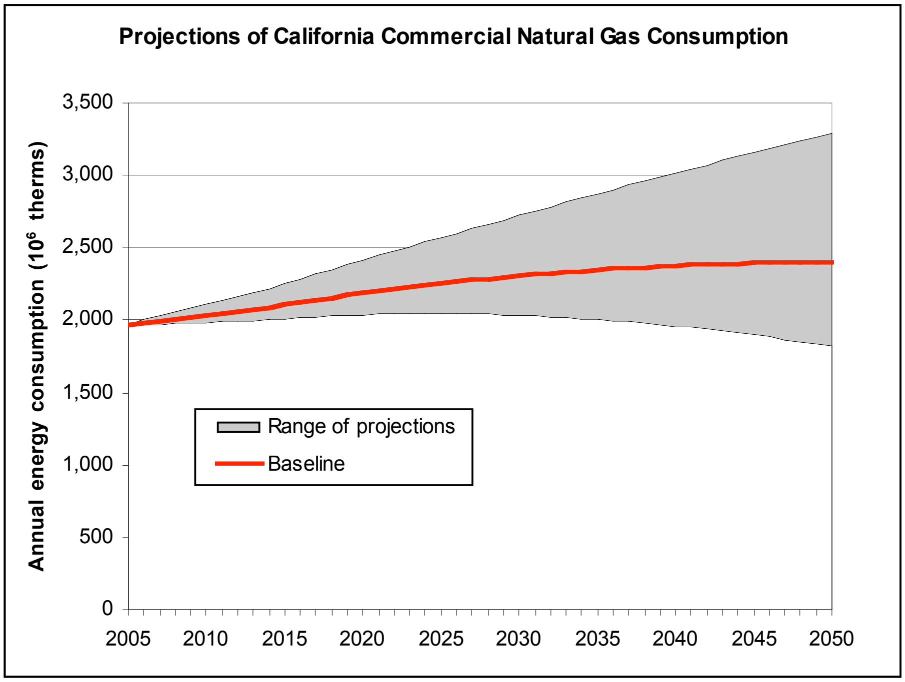

Figure 27 Commercial natural gas consumption for various input intensity assumptions.

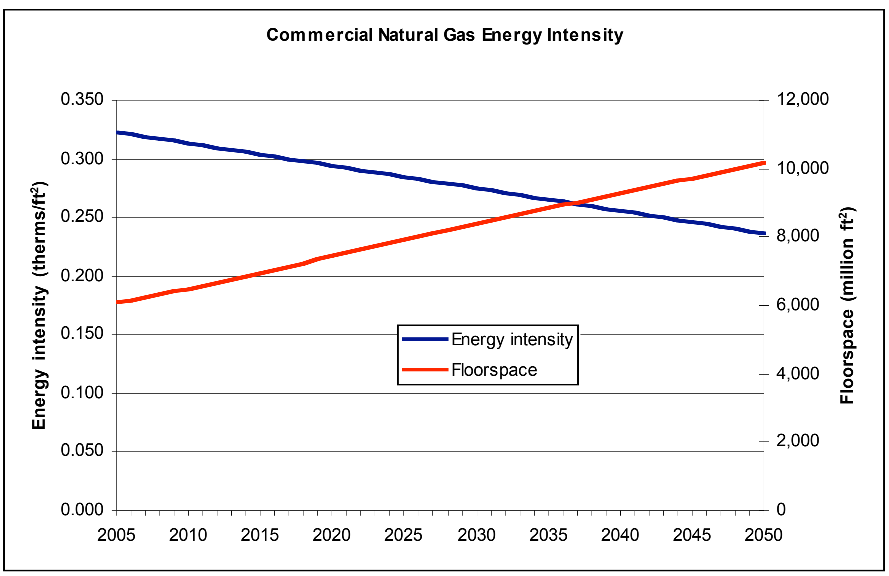

Figure 28 Commercial natural gas floorspace and energy intensity assumptions.

Industrial Sector

The baseline scenario projects a 10% increase in industrial sector natural gas demand in 2050, relative to 2006. Regional industrial sector natural gas demand projections are depicted in Figure 29 and Table 21. The baseline scenario combines mining and industry in the industrial sector. The CEC Demand Forecasts separate the two groups, and project them separately. They forecast declining energy consumption for mining, and increasing natural gas consumption in industry. In the 2003-2013 Forecast, these trends lead to declining natural gas consumption by

2013 (compared to 2006) for the combined industrial and mining groups listed in Table 21. But compared to 2003, natural gas consumption increases slightly. The baseline scenario extends the linear trends projected from 2003-2013 to 2050, leading to projected increase in natural gas demand.

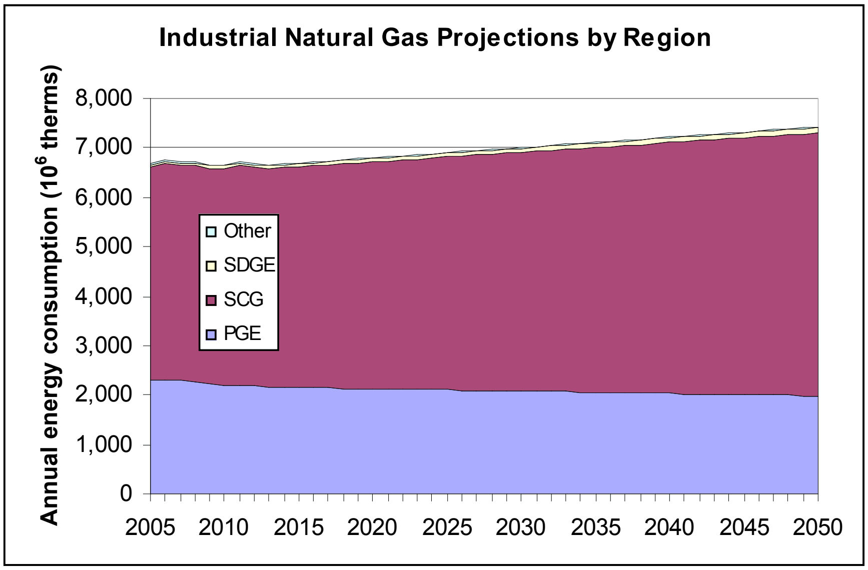

Figure 29 Annual industrial natural gas consumption by planning area.

Table 21. Industrial natural gas demand by planning area.

	Industrial natural gas consumption (10^6 therms)					2006-2050 growth	Avg. annual growth rate
	2006	2013	2016	2025	2050		
PG&E	2,312	2,158	2,144	2,102	1,984	-14.2%	-0.3%
SCG	4,374	4,421	4,494	4,712	5,318	21.6%	0.4%
SDGE	49	56	61	74	110	125.7%	1.9%
Other	19	17	17	17	15	-19.8%	-0.5%
All CA	6,753	6,653	6,716	6,904	7,427	10.0%	0.2%
2003 IEPR	6,753	6,653	---	---	---	---	-0.2%
2005 IEPR	5,838	5,993	5,989	---	---	---	0.3%

Agricultural & Other Sectors

Projected natural gas demand in the agricultural and other sectors are depicted by region in Figure 30 and Figure 31, respectively, and detailed in Table 22 and Table 23. Both sectors are projected to see modest growth of 0.2% annually through 2050.

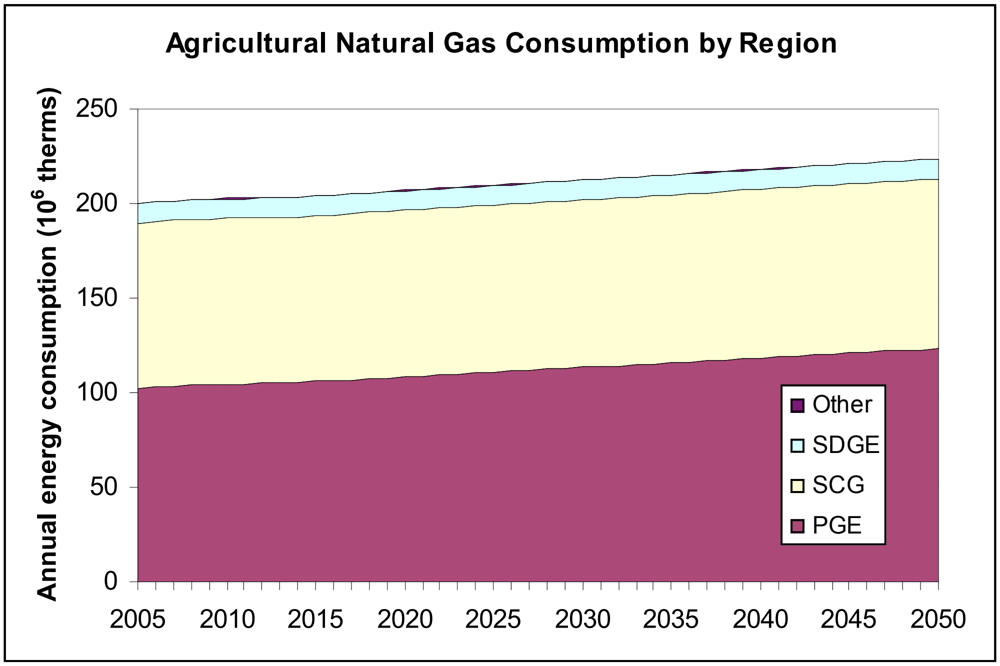

Figure 30 Annual agricultural natural gas consumption by planning area.

Table 22. Agricultural natural gas demand by planning area.

	Agricultural natural gas consumption (10^6 therms)					2006-2050	Avg. annual
	2006	**2013**	**2016**	**2025**	**2050**	**growth**	**growth rate**
PG&E	102.9	104.9	106.4	110.9	123.3	19.9%	0.4%
SCG	87.5	87.6	87.7	88.3	89.8	2.6%	0.1%
SDGE	10.3	10.3	10.3	10.4	10.5	2.5%	0.1%
Other	0.2	0.2	0.2	0.2	0.2	0.0%	0.0%
All CA	200.9	203.0	204.7	209.7	223.9	11.4%	0.2%
2003 IEPR	201	203	---	---	---	---	0.1%
2005 IEPR	196	197	197	---	---	---	0.1%

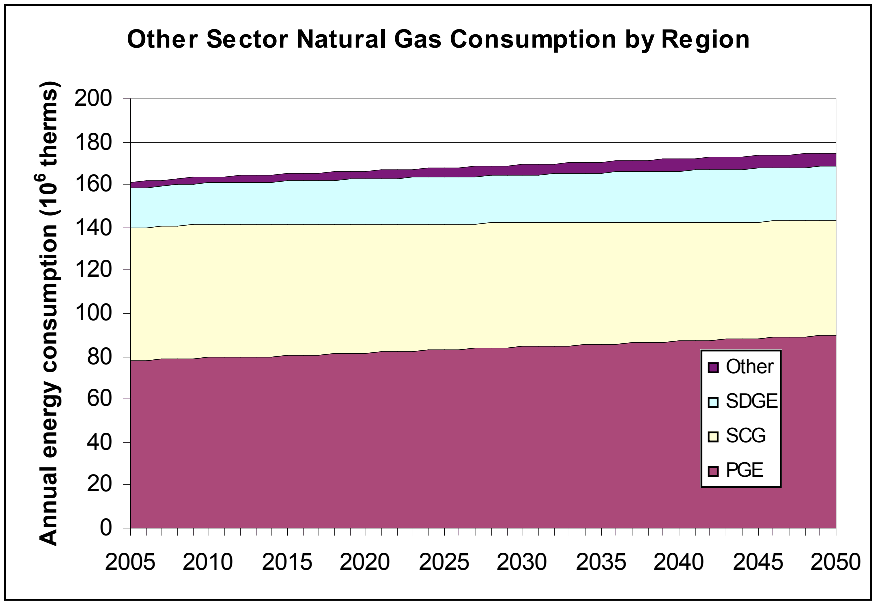

Figure 31 Annual other sector natural gas consumption by planning area.

Table 23. "Other" sector natural gas demand by planning area.

	Other sectors natural gas consumption (10^6 therms)					2006-2050	Avg. annual
	2006	**2013**	**2016**	**2025**	**2050**	**growth**	**growth rate**
PG&E	78.3	79.6	80.5	82.9	89.9	14.8%	0.3%
SCG	62.0	61.7	61.0	58.9	53.1	-14.3%	-0.3%
SDGE	18.7	19.9	20.4	21.7	25.5	36.6%	0.7%
Other	2.6	3.3	3.5	4.3	6.4	142.1%	2.0%
All CA	161.5	164.5	165.3	167.8	174.9	8.3%	0.2%
2003 IEPR	162	164	---	---	---	---	0.2%
2005 IEPR	149	149	149	---	---	---	0.0%

4.1.1. Seasonal Demand Projections

Monthly natural gas demands are depicted in Figure 32 for the year 2006. Natural gas demand (other than electricity generation) exhibits a strong winter peak in residential usage due to heating requirements. Other sectors do not exhibit this strong seasonal dependence in natural gas usage. January typically sees the highest monthly natural gas demand, and peak-month demands are projected to increase about 21% in 2050 to 1,981 million therms.

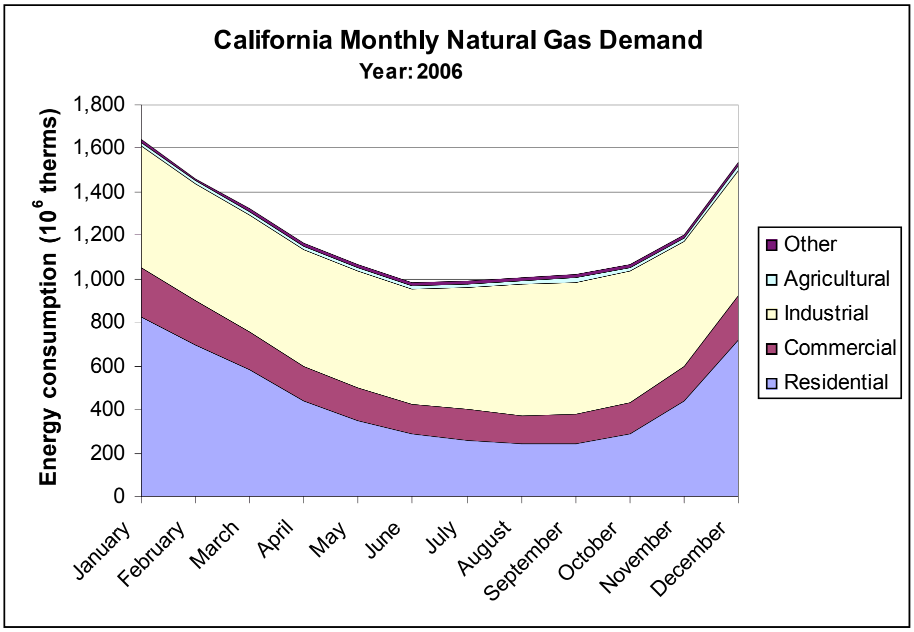

Figure 32 Representative monthly natural gas consumption profile for 2006.

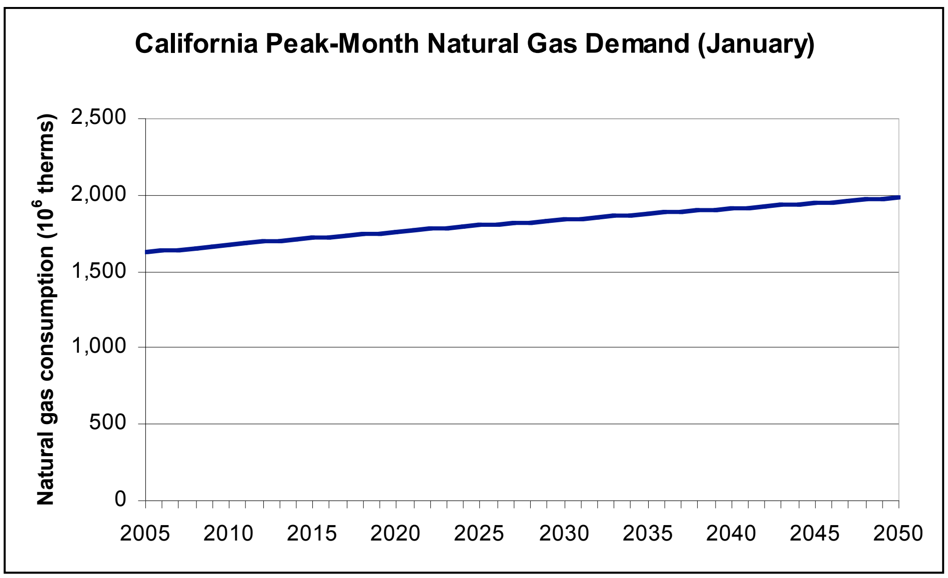

Figure 33 Peak month (January) natural gas consumption projection.

Table 24. Monthly natural gas demand projection

	Monthly natural gas demand projections (10^6 therms)					2006-2050	Avg. annual
	2006	**2010**	**2020**	**2025**	**2050**	**growth**	**growth rate**
January	1,639	1,669	1,760	1,800	1,981	20.9%	0.4%
February	1,462	1,487	1,566	1,602	1,760	20.3%	0.4%
March	1,324	1,343	1,412	1,443	1,583	19.6%	0.4%
April	1,165	1,178	1,235	1,262	1,381	18.5%	0.4%
May	1,066	1,076	1,126	1,149	1,254	17.7%	0.4%
June	983	990	1,034	1,055	1,150	16.9%	0.4%
July	989	995	1,038	1,059	1,151	16.4%	0.3%
August	1,007	1,011	1,053	1,074	1,167	15.9%	0.3%
September	1,017	1,022	1,064	1,086	1,180	16.0%	0.3%
October	1,068	1,075	1,121	1,144	1,245	16.5%	0.3%
November	1,204	1,217	1,275	1,302	1,423	18.2%	0.4%
December	1,532	1,557	1,639	1,676	1,841	20.2%	0.4%

5. BASELINE SCENARIO – TRANSPORTATION FUEL

Transportation fuel, predominately derived from petroleum, accounts for about half of total energy use in California. Given that the in-state refinery capacity is fully utilized, strategies for reducing growth in gasoline and diesel demand are important for reducing price spikes and other disruptions. The baseline scenario incorporates several key trends found in the 2005 IEPR transportation section, growth in market share for more efficient vehicle drive trains (i.e. hybrids and diesels) as well as incremental increases in vehicle efficiency. The baseline scenario does not incorporate green house gas (GHG) emissions policies or any significant alternative fuel penetration.

This baseline scenario is based upon the model runs of CEC's CalCARS model to 2025 with the assumption of the medium fuel price scenario and no greenhouse gas regulations in place. The fuel demand for the baseline scenario is generated by a vehicle stock turnover model with key inputs, such as distribution of sales by vehicle class, fuel economy and average VMT, as the major assumptions that will change in alternative scenarios.

5.1. Annual Fuel Demand Forecasts

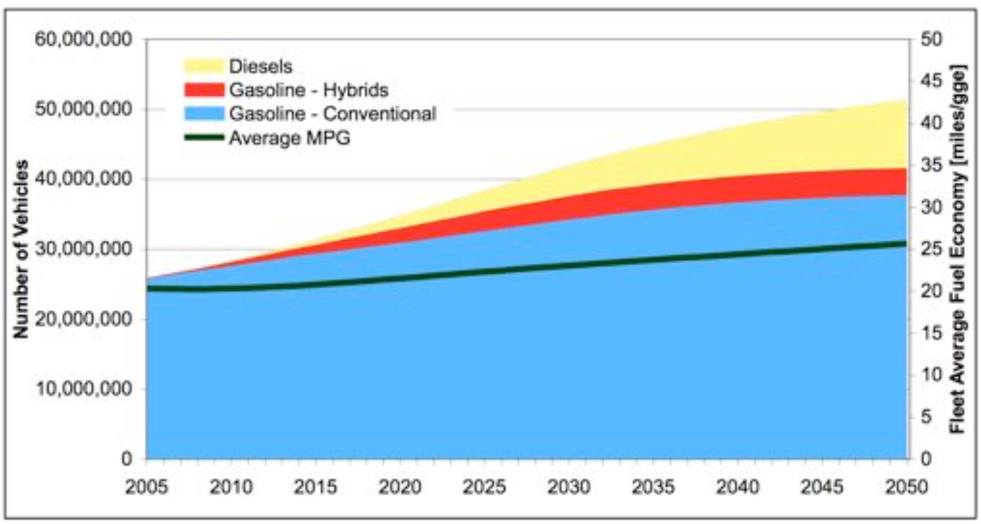

Figure 34 Total stock of vehicles (by vehicle type) and average fleet fuel economy.

The baseline scenario for transportation fuels projects the use of only two fuels out to 2050 – gasoline and diesel. Other alternative fuels, such as electricity and hydrogen, are not found in the baseline scenario. Ethanol is projected within this scenario to be used only as a component of gasoline fuel (as an oxygenate at 5.7% by volume) rather than as a primary component of the fuel. The scenario is built upon projections for new sales, vehicle miles traveled and fuel economy of each of the 15 different classes (see Appendix for detailed list) which can be powered by 3 different powertrains (conventional gasoline, gasoline hybrid, and diesel). The baseline scenario is based upon the output of the CalCars model with the middle fuel price case out to 2025. Figure 34 shows the baseline scenario assumptions for the number of conventional, hybrid and diesel vehicles. It also shows the VMT-averaged fuel economy for the fleet.

Figure 35 shows the gasoline and diesel demands from light-duty and heavy-duty vehicles (LDV and HDVs). Also shown on the figure is a comparison of the baseline scenario and a frozen efficiency case, based upon the baseline vehicle stock scenario. Both the standard baseline scenario and the frozen efficiency case are based upon the same distribution of vehicle sales and VMT assumptions. The only difference is that the frozen efficiency case assumes that vehicle fuel economy does not improve from 2005 levels for any of the vehicles (including diesels and hybrids). In Figure 34, the effect of vehicle fuel economy improvements for the standard baseline scenario is seen when looking at the gasoline and diesel fuel profiles for the standard and frozen efficiency cases. Both the baseline and frozen efficiency case are based upon the same vehicle mix as shown in Figure 34. In the baseline projection, light-duty gasoline demand for the baseline scenario increases from about 15 billion gallons in 2005 to about 20 billion gallons after 2035. LDV gasoline demand peaks in 2039 and declines slightly. The reduction in gasoline usage is a result of increased adoption of diesel vehicles and increasing fuel economy for conventional and hybrid vehicles. In the frozen efficiency case, where vehicles fuel economy is constant held constant at the 2005 level, fuel demand increases more quickly and starts to level off at around 23 billion gallons. Even this case shows leveling gasoline demand, because it still reflects the adoption of hybrids and diesel vehicles. Gasoline demand for other vehicles is quite small. Diesel fuel demand is quite low in 2005 and increases to approximately 3.5 billion gallons (GGE) in 2050, while in the frozen efficiency case, it is about 25% higher or 4.4 billion gallons (GGE). The majority of diesel fuel usage is still from heavy-duty and other vehicles.

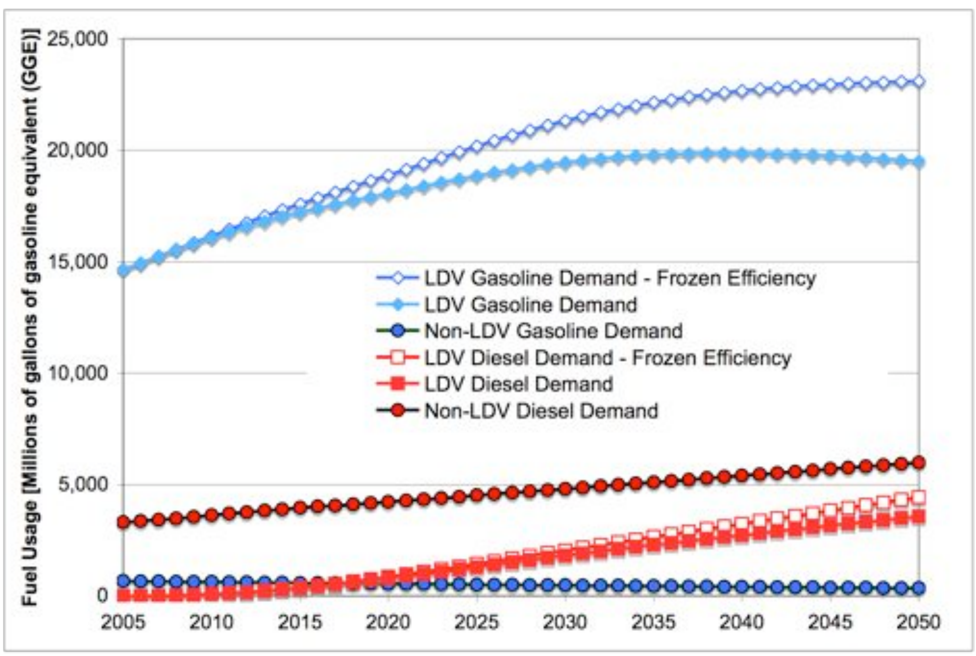

Figure 35 Total annual projected fuel demands (gasoline and diesel) by fuel and sector (LDV vs non-LDV).

To better provide context for the baseline scenario projections out to 2050, Figure 36 displays the vehicle ownership per capita and LDV fuel use per capita. It shows a trend of increasing vehicle ownership from around 70 vehicles per 100 people to 93 vehicles per 100 people. Also shown is the fact that despite the increase in vehicle ownership and the resulting increase in VMT/capita, fuel usage per capita peaks and then begins to decline as a result of rising vehicle fleet fuel economy.

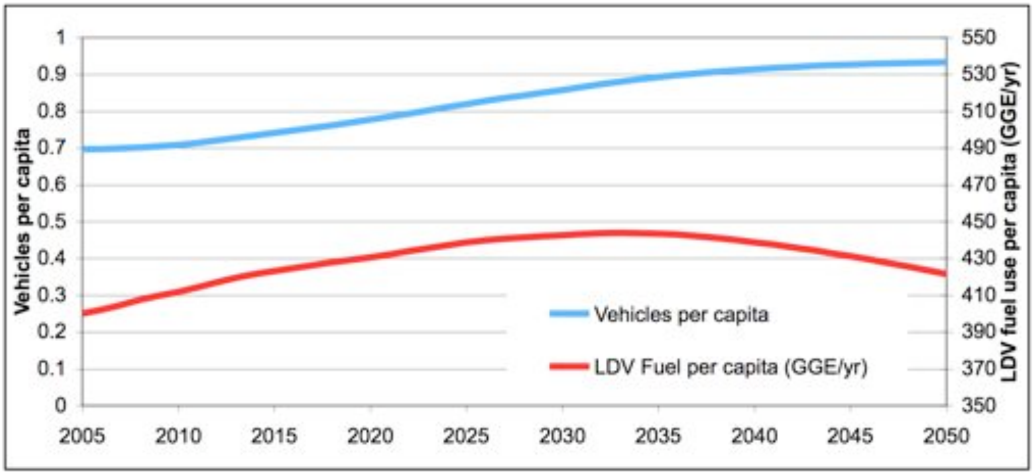

Figure 36 Projected per-capita vehicle ownership and fuel usage.

5.2. Temporal Disaggregation

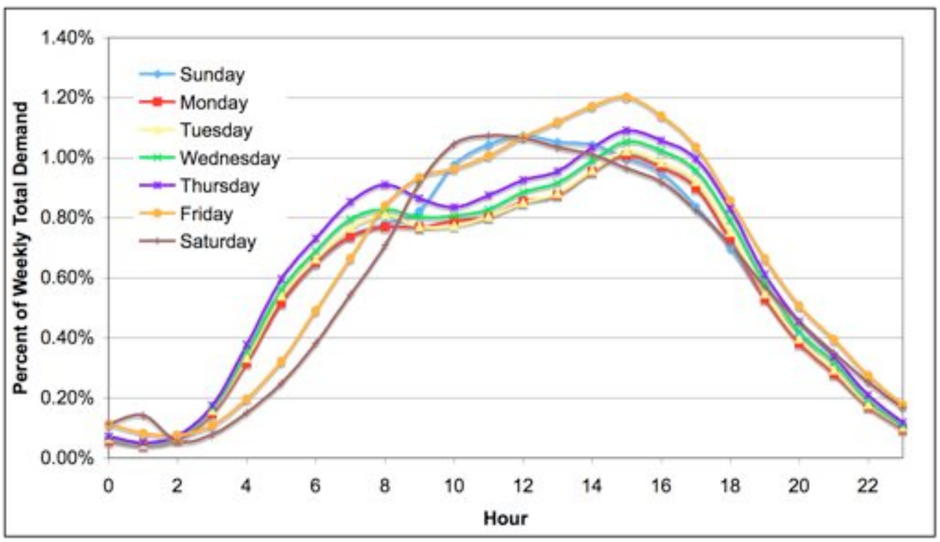

Figure 37 Representative hourly and daily fuel demand at refueling stations.

The previous section outlined the projections for annual fuel demand, but the distribution of demand is not constant on a monthly, daily or hourly basis. Annual fuel usage peaks in the summer months and the baseline scenario disaggregates the annual fuel demand for gasoline, ethanol and diesel by month and again by hour of the week (see Figure 37). Each day of the week has a slightly different total fuel demand and hourly fueling profile. The hourly profile has important implications for the cost and design of refueling stations, especially those that dispense fuel as a compressed gas such as CNG or H_2 (though these do not have any projected demand in the baseline scenario).

6. BASELINE SCENARIO DISCUSSION

Figure 38 and Figure 39 summarize the projected growth in California energy demands forecast in the baseline scenario. Figure 38 illustrates key underlying drivers for energy demand growth for the state. VMT per capita increases by one third over the forecast period, industrial shipments increase dramatically on a per capita basis, commercial floorspace increases only about 12% over the forecast period, and household size stays relatively constant. These trends indicate continued economic growth for the State and very little change in the trends of the past decades. These trends are offset somewhat by continued increases in energy efficiency for each of the various sectors, so the overall energy trends do not grow as fast as population, economic and activity growth.

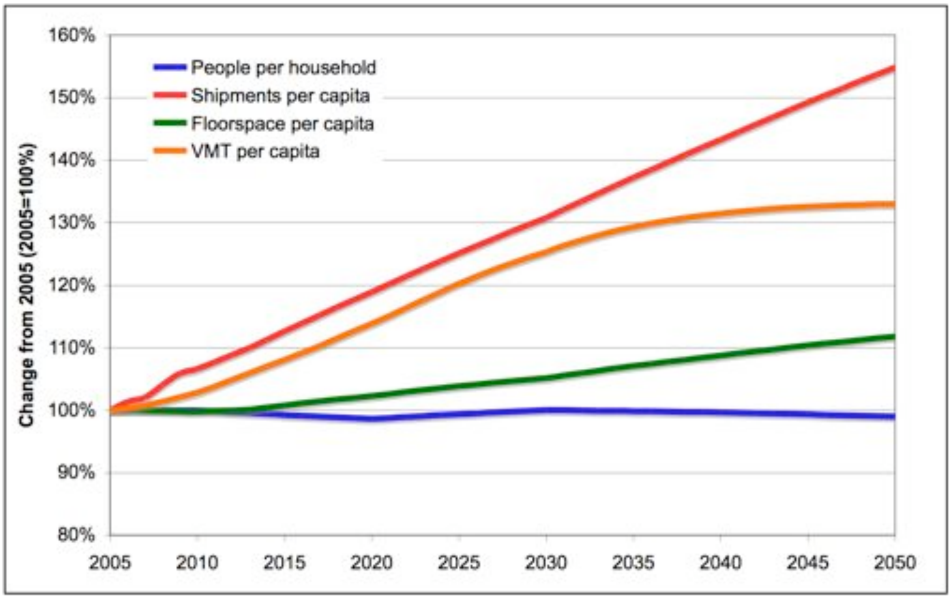

Figure 38 Underlying activity factors which drive energy demand in baseline scenario.

Figure 39 shows the relative growth in the three major energy demands in the state. Fuel demand grows the most over the projection period, driven in part by VMT and population growth (fuel usage per capita increases initially and then declines slightly). Overall electricity demand increases as well, driven entirely by population growth, since per capita electricity demand is essentially constant. Natural gas demand increases the least, because of significantly declining per-capita natural gas use.

The growth in energy demand that is shown in baseline scenario is used to illustrate the potential trajectory of different energy uses in California. The baseline scenario provides a set of potential energy demand growth curves that are based upon extensions of current trends and assumes no significant policy or demographic shifts. This scenario can provide the context to understand what the impact would be of large-scale shifts in technology, demographics, and/or policy.

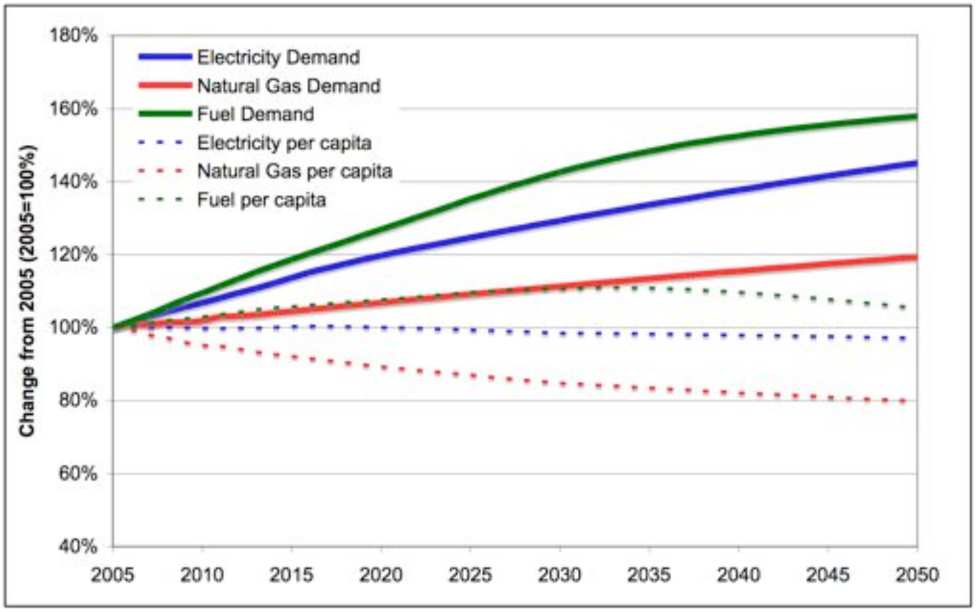

Figure 39 Energy and per capita energy demand growth in the baseline scenario.

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APPENDIX

A. Methodology

A.1. Electricity

A.1.1. Forecast methods

The baseline electricity projections are developed at various levels of disaggregation (e.g., end use, region, industrial classification) for each of five sectors: *residential, commercial, industrial, agricultural,* and *other.* For the residential, commercial, and industrial sectors, CEC projections of independent demographic and economic parameters provide the basis of the baseline scenario projections. In these cases, we determine electricity demand by multiplying energy intensity (kWh per household, ft^2, or \$) by the appropriate demographic or economic parameter. For the agricultural and other sectors, we do not have such data; we project future electricity demand by extrapolating historical and projected near-term demands for various industrial classification groups. Table A-1 (a repeat of Table 3, above) summarizes the levels of dissagregation and the variables used in projecting electricity demands for each sector.

Table A-1. Level of disaggregation and variables used in projecting electricity demand for each sector.

Sector	Regional disaggregation	Other disaggregation	Independent variables	Source(s)
Residential	Climate zone (14) Planning areas (6)	End use (18) Household type (2)	End use saturation Unit energy consumption Households	Quantum (2006) CEC (2005a) CA DOF (2004)
Commercial	Planning areas (7)	End use (10) Building type (12)	Floorspace Energy intensity	CEC (2003) CEC (2005b)
Industrial	Planning areas (7)	Industrial classification (33)	Shipments Energy intensity	CEC (2003)
Agricultural	Planning areas (8)	Industrial classification (4)	None	CEC (2003)
Other	Planning areas (7)	Industrial classification (19)	None	CEC (2003)

Projected energy demands for each of the five sectors are aggregated using a, sector specific load curve to determine hourly electricity demands. The framework for these projections is similar to that used by the CEC in its forecasts, outlined in Figure A-1.

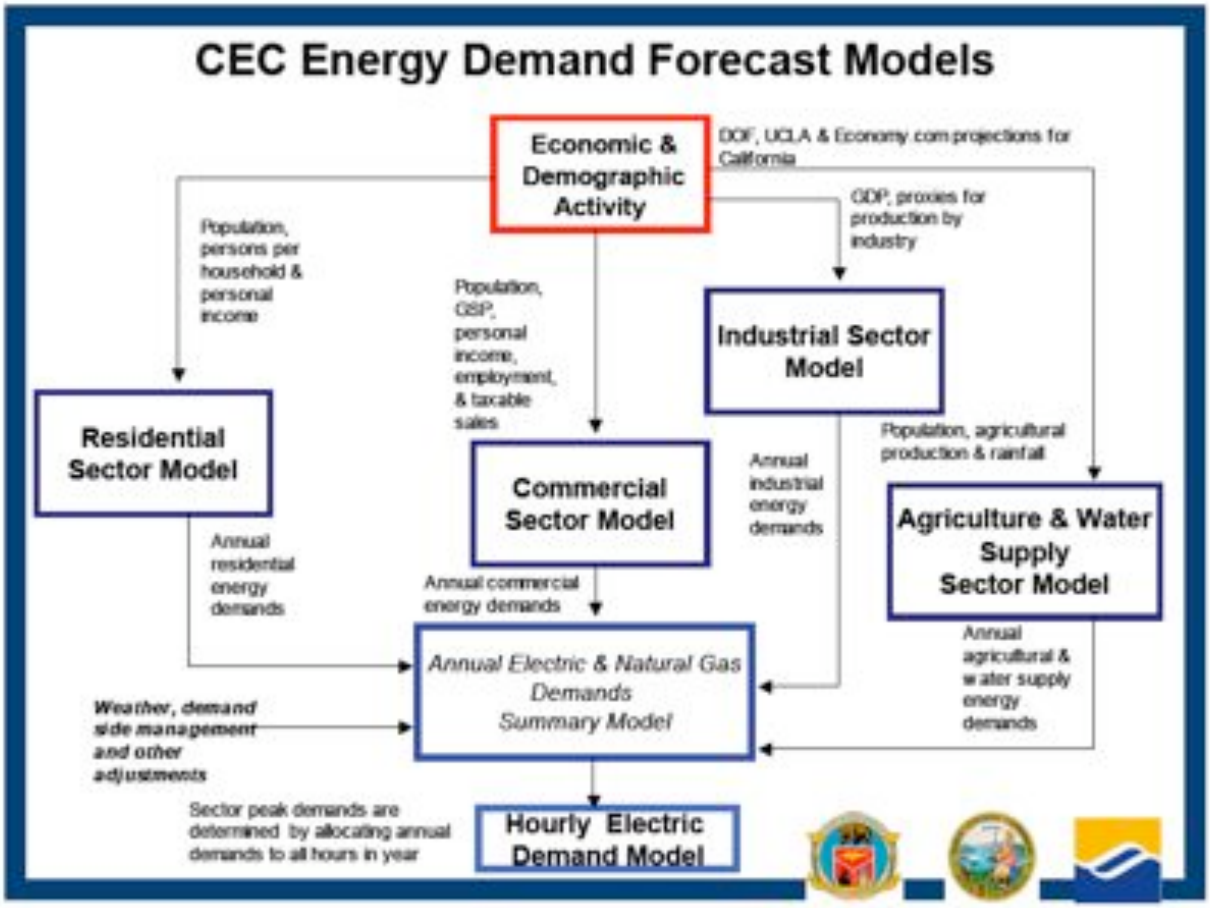


Figure A-1. CEC framework for forecasting California energy demands, which was adopted for projecting the baseline energy demand scenario.

Projections for the residential sector are disaggregated in terms of California's 16 climate zones, which divide the state into regions with similar weather patterns (the baseline scenario is based upon the CEC's climate zone definitions of energy forecasts, rather than those used in the Title 24 Building Standards). The remaining sectors are disaggregated according to utility planning areas defined by the CEC (CEC, 2005b). Figure A-2 outlines the climate zones for California, and the utilities comprising each of the electricity planning regions are summarized in Table 1 A-2 (refer to Table 1 for the relationship between climate zones and utility planning areas).

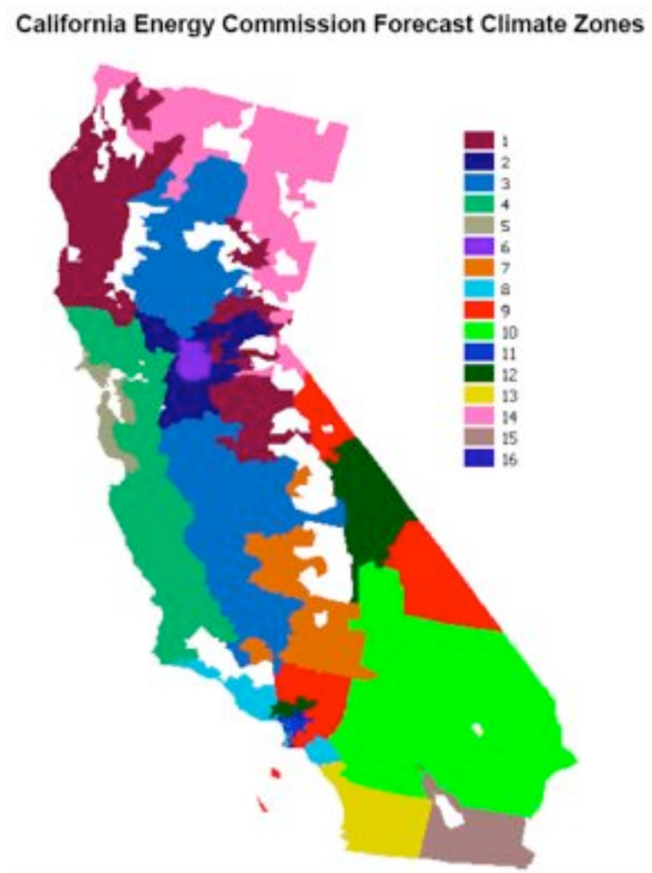


Figure A-2. California climate zone map (CEC).

Table A-2. Description of planning areas used in projections (CEC, 2005a).

Planning area	**Utilities included**		
Pacific Gas and Electric (PG&E)	PG&E Alameda Biggs Calaveras Gridley Healdsburg Lassen MUD Lodi	Lompoc Merced Modesto Palo Alto Plumas – Sierra Redding Roseville	San Francisco Shasta Silicon Valley Tuolumne Turlock Irrigation District Ukaih USBR-CVP
Sacramento Municipal Utility District (SMUD)	SMUD		
Southern California Edison (SCE)	Anaheim Anza Azusa Banning	Colton MWD Riverside SCE	Southern California Water USBR-Parker Davis Valley Electric Vernon
Los Angeles Department of Water and Power (LADWP)	LADWP		
Cities of Burbank, Glendale, and Pasadena (BGP)	Burbank	Glendale	Pasadena
Other planning areas	Pacificorp	Surprise Valley	Imperial Irrigation District

(OTHER)	Sierra Pacific	Truckee-Donner	
Department of Water Resources (DWR)	DWR		

The baseline scenario projections are based upon the CEC 2003-2013 Demand Forecast, with the exception of residential electricity demand, which derives from 2006-2016 Demand Forecast (CEC, 2003; CEC, 2005a). The underlying trends in these demand projections are extended to 2050 based on average annual growth. Generally, those values that are projected to increase in the CEC projections are forecast to 2050 linearly, based on average annual growth during the projection time frame of the CEC study (e.g., 2003-2013). Examples are technology saturation in the residential sector, and electricity demand in the agricultural and other sectors. Values that are projected to see declining near-term growth, such as energy intensities and some electricity demands, are generally forecast to see an exponential decay based on the average (negative) percentage growth rate. This joint approach intends to prevent improbable exponential increases in demand or declines to negative demand. We apply it differentially for the various sectors, and further discussion of the projection methodologies for each follows in the sections below.

A.1.2. Residential sector

We use projections developed by Quantum/Itron for annual residential electricity consumption through 2050 (citation). The baseline scenario is based on their middle scenario (called "optimistic"). It derives from the CEC's 2006-2016 Demand Forecast (CEC, 2005a), and projects end use UEC and saturation in 2050 based on the near term projections and expected efficiency improvements and changes in saturation.

The projections define electricity consumption for 18 end uses at the household level as the product of the average saturation and annual unit electricity consumption (UEC) for each end use. Saturation and UEC for four of the end uses that relate to heating and cooling are climate zone-specific. Parameters for the remaining 14 are similar throughout climate zones.

The model divides households into two categories: single family and multi family. They are projected at the climate zone-level based on CA Department of Finance population projections and historical regional housing mixes (persons-per-household and the share of single to multi-family households is kept constant within a region). Climate zones 14 and 15, each of which is sparsely populated, are similar to Climate Zones 1 and 10, respectively, and are aggregated with those zones. Saturation rates and UECs vary within a climate zone based on household type.

The end uses are listed in Tables A-3 through A-7, along with their projected saturation rates and UEC.

Table A-3. Baseline saturation and UEC values for non-climate dependent residential end uses.

	Single family households				Multi family households			
	Saturation		UEC		Saturation		UEC	
	2006	2050	2006	2050	2006	2050	2006	2050
Water Heating (WH)	8.5%	8.5%	2,222	2,012	15.7%	16.0%	1,790	1,617
Dishwasher	75.4%	80.0%	311	318	61.6%	70.0%	183	177

WH - Dishwasher	6.7%	7.6%	937	962	10.3%	12.4%	715	727
Clothes Washer	95.5%	96.7%	86	92	79.4%	84.4%	51	52
WH - Clothes Washer	8.4%	8.4%	1,069	925	12.9%	13.8%	903	769
Clothes Dryer	48.1%	52.4%	1,336	937	45.9%	50.7%	819	514
Misc.	100.0%	100.0%	1,735	2,343	100.0%	100.0%	659	949
Cooking	44.1%	47.2%	865	870	49.8%	52.7%	523	502
Refrigerator	117.0%	111.5%	1,068	631	105.3%	105.1%	946	535
Freezer	29.0%	33.6%	1,018	542	8.7%	11.0%	995	542
Swimming Pool Pump	14.0%	15.2%	2,702	2,228	2.1%	2.3%	3,544	3,094
Hot Tub Pump	17.0%	21.1%	830	775	N/A	N/A	N/A	N/A
Hot Tub Heating	5.6%	7.4%	486	453	N/A	N/A	N/A	N/A
Lighting	100.0%	100.0%	1,606	1,169	100.0%	100.0%	900	648

Table A-4. Baseline saturation and UEC for residential space heating.

	Space heating							
	Single family households				Multi family households			
	Saturation		UEC		Saturation		UEC	
	2006	2050	2006	2050	2006	2050	2006	2050
Climate zone 1	23.0%	22.6%	3,679	3,128	23.0%	22.6%	3,679	2,929
Climate zone 2	5.6%	6.5%	4,461	2,693	13.9%	13.1%	2,126	1,386
Climate zone 3	5.0%	4.4%	5,635	3,691	13.0%	13.0%	1,596	1,103
Climate zone 4	3.1%	3.1%	4,149	3,194	21.1%	24.3%	2,123	1,700
Climate zone 5	2.6%	4.5%	4,007	3,427	20.5%	22.6%	2,054	1,719
Climate zone 6	16.6%	13.9%	5,402	3,758	45.1%	39.9%	3,243	2,125
Climate zone 7	9.9%	9.6%	2,430	1,765	25.3%	27.8%	1,369	960
Climate zone 8	4.4%	4.6%	2,216	1,872	25.7%	25.5%	1,083	879
Climate zone 9	5.7%	5.8%	2,256	2,081	21.4%	22.4%	951	828
Climate zone 10	8.6%	9.3%	1,762	1,365	26.9%	29.4%	746	549
Climate zone 11	7.5%	9.2%	4,523	3,929	31.2%	37.0%	1,261	1,064
Climate zone 12	5.7%	6.7%	3,678	3,277	31.4%	34.5%	1,412	1,200
Climate zone 13	10.4%	9.4%	1,803	1,379	52.8%	54.3%	509	389
Climate zone 16	3.2%	3.5%	3,139	2,796	26.0%	26.1%	1,434	1,234

Table A-5. Baseline saturation and UEC for residential gas furnace fans.

	Gas furnace fan							
	Single family households				Multi family households			
	Saturation		UEC		Saturation		UEC	
	2006	2050	2006	2050	2006	2050	2006	2050
Climate zone 1	12.2%	11.9%	249	250	12.2%	11.9%	249	234
Climate zone 2	49.9%	57.9%	390	398	65.0%	64.9%	303	290
Climate zone 3	45.4%	51.2%	355	360	49.6%	56.9%	282	268
Climate zone 4	62.7%	68.0%	422	425	69.3%	67.2%	362	342
Climate zone 5	68.0%	68.2%	385	385	29.5%	30.8%	348	326
Climate zone 6	57.2%	70.7%	313	319	30.1%	43.1%	272	259
Climate zone 7	14.6%	8.6%	328	334	12.5%	8.8%	272	260
Climate zone 8	36.6%	32.1%	216	216	12.7%	10.6%	170	159
Climate zone 9	22.3%	15.2%	237	236	8.3%	5.0%	196	183
Climate zone 10	17.1%	9.4%	277	282	9.7%	6.7%	212	202

Climate zone 11	30.8%	30.1%	208	208	8.4%	7.7%	197	184
Climate zone 12	58.0%	59.8%	281	280	22.9%	7.7%	270	252
Climate zone 13	55.9%	61.3%	225	226	17.6%	19.2%	213	201
Climate zone 16	32.0%	31.9%	208	207	9.1%	9.1%	197	184

Table A-6. Baseline saturation and UEC projections for residential central air conditioners.

	Central AC							
	Single family households				**Multi family households**			
	Saturation		**UEC**		**Saturation**		**UEC**	
	2006	**2050**	**2006**	**2050**	**2006**	**2050**	**2006**	**2050**
Climate zone 1	30.1%	35.3%	832	459	30.1%	35.3%	832	430
Climate zone 2	61.0%	72.3%	1,015	436	61.9%	66.7%	254	79
Climate zone 3	58.1%	67.4%	2,724	1,192	61.0%	65.0%	835	343
Climate zone 4	29.0%	34.0%	789	343	29.7%	35.1%	175	66
Climate zone 5	3.5%	4.6%	150	71	3.1%	4.0%	16	5
Climate zone 6	74.0%	80.0%	1,277	710	74.4%	80.0%	285	109
Climate zone 7	54.3%	60.7%	2,651	1,529	68.4%	69.1%	1,358	764
Climate zone 8	28.3%	41.9%	684	326	22.1%	33.4%	123	46
Climate zone 9	47.1%	61.8%	1,022	513	52.0%	68.4%	217	101
Climate zone 10	70.1%	77.8%	1,386	761	64.8%	72.2%	441	184
Climate zone 11	11.1%	12.4%	718	192	16.5%	20.1%	95	34
Climate zone 12	47.8%	52.2%	1,553	872	49.6%	55.2%	283	125
Climate zone 13	27.6%	36.4%	1,055	653	28.7%	37.6%	148	77
Climate zone 16	40.0%	46.2%	1,362	659	42.7%	44.7%	286	136

Table A-7. Baseline saturation and UEC projections for residential room air conditioners.

	Room AC							
	Single family households				**Multi family households**			
	Saturation		**UEC**		**Saturation**		**UEC**	
	2006	**2050**	**2006**	**2050**	**2006**	**2050**	**2006**	**2050**
Climate zone 1	7.3%	5.9%	517	444	7.3%	5.9%	517	415
Climate zone 2	11.8%	5.2%	646	547	22.5%	16.8%	518	419
Climate zone 3	6.5%	4.8%	877	740	23.5%	18.8%	678	561
Climate zone 4	7.1%	5.4%	272	234	13.5%	12.5%	182	150
Climate zone 5	1.5%	1.2%	111	94	2.9%	3.3%	100	83
Climate zone 6	13.0%	7.1%	433	405	19.4%	13.6%	361	314
Climate zone 7	8.0%	7.5%	831	802	4.5%	6.5%	692	619
Climate zone 8	10.1%	9.1%	216	202	16.8%	16.0%	190	171
Climate zone 9	19.9%	14.6%	476	446	31.2%	21.7%	394	355
Climate zone 10	7.0%	4.5%	729	679	20.4%	15.2%	576	521
Climate zone 11	19.6%	20.8%	170	165	16.5%	17.1%	147	133
Climate zone 12	22.8%	21.5%	621	590	31.1%	29.2%	523	467
Climate zone 13	8.8%	7.5%	291	281	17.4%	17.7%	207	190
Climate zone 16	18.5%	17.3%	179	165	45.2%	46.0%	146	133

To bound the projections, we also projected energy use to 2050 based on a frozen efficiency case and using Quantum/Itron's "Green Dream" scenario. In the frozen efficiency case, UEC is frozen at projected 2006 values. "Green Dream" reflects presumed maximum feasible energy efficiency improvements, some of which might require noticeable policy or societal shifts. UEC is projected in 2050 based on literature reviews and expert opinion, and extrapolated linearly from 2006.

A.1.3. Commercial sector

Electricity consumption in the commercial sector is defined as the product of floorspace and energy consumption per square-foot, for 10 end uses in 12 building types, and for seven utility planning areas. Table A-8 lists the end uses and building types included in the projections.

Table A-8. Building types and end uses included in the commercial sector electricity projections.

Building types	**End uses**
Colleges	Cooling
Food stores	Heating
Hospitals	Ventilation
Hotel/Motel	Water heating
Large Offices	Cooking
Miscellaneous	Refrigeration
Refrigerated warehouses	Indoor lighting
Restaurants	Outdoor lighting
Retail stores	Office equipment
Schools	Miscellaneous
Small Offices	
Warehouses	

We use data from the 2003-2013 Demand Forecast, and project floorspace through 2050 according to CEC (2005b), by adding the average of the floorspace additions from 1990-2013 to 99.5% of the previous year's floorspace stock (assumes 0.5% decay rate). Floorspace projections by region are given in Table A-9.

Table A-9. Floorspace projections by region.

	Floorspace (MM ft^2)			
	2006	**2050**	**2006-2050 growth**	**Avg. annaul growth rate**
PG&E	2,181	3,561	63.2%	1.1%
SMUD	224	412	83.9%	1.4%
SCE	2,398	4,047	68.8%	1.2%
LADWP	686	1,017	48.3%	0.9%
SDGE	537	906	68.5%	1.2%
BGP	101	151	49.7%	0.9%
Other	33	56	66.7%	1.2%
All CA	6,160	10,149	64.8%	1.1%

We project energy intensity (kWh/ft^2) for four efficiency scenarios (see Figure 9 in Section 4). Extrapolating projected near-term trends based on average annual percentage growth rate projected by the CEC from 2003-2013 leads to the highest energy intensity (lowest efficiency). Also included is a frozen efficiency scenario, where energy intensity remains constant at projected 2004 levels through 2050. The high efficiency scenario serves as a presumed limit of feasible efficiency improvements. It assumes that energy intensity in the commercial sector is reduced by 15% in 2015 compared to the 2004 value, and that all floorspace added after 2015 uses 40% less electricity compared to 2004. The 15% reduction by 2015 assumes that all technically feasible efficiency improvements are made to existing buildings by 2015 (CEC, 2005c). Beyond that, the high efficiency scenario assumes that all new buildings are LEED-certified Platinum, which we assume consume about 40% less energy than existing buildings (USGBC, 2005).

The baseline scenario takes the minimum of the extrapolated CEC projections and the frozen efficiency case for each end use within each building type. That is, end use energy intensity is not allowed to increase compared to 2004 values. In cases where it is projected to decrease, it is assumed to do so exponentially, based on average annual percentage growth rate from 2003-2013.

A.1.4. Industrial sector

We project electricity consumption in the industrial sector for 33 industrial classification groups (including mining), and seven utility planning areas, based on data from the 2003-2013 Demand Forecast. Energy consumption is defined as the product of energy intensity (kWh/2001$ shipped) and shipments (2001$).

We adopt a bilateral approach to project future shipments. For industries that see positive growth from 2003-2013, we project a linear increase using the average annual growth during that time frame. Shipments for industries with negative projected growth are projected using to decay exponentially, using the average (negative) growth rate from 2003-2013. Projected shipments by industrial classification code are listed in Table A-10.

We adopted this two-sided approach to be conservative, but recognize that it may lead to some inaccuracies. Without the dual approach, some growing industry classifications see huge exponential increases in shipments by 2050, and some declining industries reach negative shipments over the time frame of the study. For example, the industry classification group *electronic components* (SIC code 367) sees an average annual growth rate of 10.4% from 2003-2013 under the Commission's projections. If this growth rate continued through 2050, the industry would see more than a 100-fold increase in shipments compared to 2003. Applying a linear growth trend according to the average annual projected increase in shipments from 2003-2013, we project a nine-fold increase.

We recognize that trends from 2003-2013 are unlikely to continue for some sectors, and we would like to modify our projections on a case-by-case basis in the future. *Petroleum refining* (SIC code 29) is another problematic sector, as the CEC projects an average annual reduction in shipments of $753 million (2001$) in 2003-2013. But this is presumably a consequence of projected petroleum prices, rather than an indication of a declining industry in California. Employment is a better predictor than shipments for industry groups that rely on volatile markets, and the CEC uses these data in their projections for mining and extraction industries (CEC, 2005b). We currently lack these data, however.

Table A-10. Projected shipments (in 2001$) by industrial classification.

Description	SIC code	Shipments (MM 2001$) 2006	2050	2006-2050 growth	Avg. annual growth rate
Metal mining	10	720	1,442	100.3%	1.6%
Oil & gas extraction	13	5,362	7,813	45.7%	0.9%
Nonmetallic materials mining	14	1,334	1,837	37.7%	0.7%
Construction	15	98,076	80,503	-17.9%	-0.4%
Canning, freezing & drying	203	11,670	21,731	86.2%	1.4%
Sugar	206	2,746	5,241	90.8%	1.5%
Food residual	20x	47,949	100,819	110.3%	1.7%
Textile mill products	22	4,528	11,581	155.8%	2.2%
Apparel	23	20,388	11,291	-44.6%	-1.3%
Wood products	24	7,417	10,608	43.0%	0.8%
Furniture & fixtures	25	6,935	15,549	124.2%	1.9%
Pulp mills	261	45	27	-40.6%	-1.2%
Paper mills	262	554	1,032	86.3%	1.4%
Pulp & paper residual	26X	7,484	17,798	137.8%	2.0%
Printing & publishing	27	20,168	22,619	12.2%	0.3%
Chemicals	28	36,071	92,781	157.2%	2.2%
Petroleum refining	29	29,197	6,421	-78.0%	-3.4%
Misc. plastics	308	11,279	13,784	22.2%	0.5%
Rubber products	30X	2,109	3,279	55.5%	1.0%
Leather products	31	701	1,547	120.6%	1.8%
Flat glass	321	217	187	-14.0%	-0.3%
Cement	324	757	1,108	46.3%	0.9%
Cement & glass residual	32X	6,873	9,593	39.6%	0.8%
Primary metals	33	8,891	19,425	118.5%	1.8%
Fabricated metal products	34	20,667	29,123	40.9%	0.8%
Computer & office equip	357	76,700	224,260	192.4%	2.5%
Industry machinery	35X	17,828	32,000	79.5%	1.3%
Communications equip	366	17,759	45,093	153.9%	2.1%
Electronic components	367	53,655	345,791	544.5%	4.3%
Remainder of electric equip	36X	11,048	26,812	142.7%	2.0%
Transportation equip	37	24,613	79,846	224.4%	2.7%
Instruments	38	43,952	113,905	159.2%	2.2%
Misc. manufacturing	39	7,644	8,714	14.0%	0.3%
All	--	605,338	1,363,558	125.3%	1.9%

We consider two efficiency cases: frozen efficiency, and the baseline. In the frozen efficiency case, energy intensity for each industrial group within each region is frozen at projected 2004 levels. State average energy intensity still declines by 2050, due to the variation in the regional distribution of shipments. That is, on average, regions with better-than-average efficiency see greater relative growth in shipments than regions with worse-than-average efficiency.

The baseline scenario adopts a similar bilateral approach used for projecting floorspace energy intensity in the commercial sector. In groups that are projected to see near-term improvements in efficiency, energy intensity continues to decline through 2050 based on the average (negative) percentage growth projected for 2003-2013. If an industry group sees increasing energy intensity over that period, energy intensity for the remainder of the projection is set equal to 2013 levels.

A.1.5. Agricultural and other sectors

Due to a lack of shipments or employment data for agriculture and the other sectors, energy consumption is projected through 2050 based on projected near term trends in electricity consumption for four industrial classifications in the agricultural sector, and 19 industrial groups in the other sector. Projections are disaggregated regionally for each sector, based on the electricity utility planning areas. For the agricultural sector, an eighth planning area is added, the Department of Water Resource to account for water supply in the agricultural sector. Table A-11 lists the industrial classifications for the agricultural and other sectors.

Table A-11. Industrial classification groups included in agricultural and other sectors.

Agricultural sector		Other sectors	
Description	**SIC code**	**Description**	**SIC code**
Crops	01	Streetlighting	0
Animals	02	Railroads	40
Water supply	494	Local transit	411
Irrigation	497	Cabs, other transit	412-417
		Trucking	421423
		USPS	43
		Water freight	441-445
		Other water transport	446
		Air transport	451-452
		Airports	458
		Pipelines, except NG	46
		Transport services	47
		Telephones	481
		Telegraphs	482
		Radio & TV	483
		Other comm. services	489
		Electric and NG utilities	491-493
		Sewers	495
		Nat'l security and internat'l affairs	97

Like for the industrial sector, energy demand for agriculture and other sectors is projected using the linear trend from 2003-2013 if energy consumption in an industrial group is growing, and an exponential decay based on annual growth rates from 2003-2013 if energy consumption in the group is declining.

A.1.6. Peak demand projections

From the energy projections, we calculate sector-specific and region-specific peak electricity demands (MW) using hourly demand data from 2003. Non-coincident peak demands respresent the sum of the individual peak-hour demands of each sector or region. The annual peak demand is partitioned by region or sector based on the fraction of demand accounted for by each during the annual peak-hour. Demand profiles for the BGP and Other planning areas use the statewide demand profile defined as the sum of demands from the other five utilities.

Alternate scenarios may include end use in the demand projections, but the baseline scenario does not include that level of disaggregation.

A.1.7. Hourly Demand Profile

In addition to total annual electricity energy demand and peak power demand, another critical data series to have in order to understand impacts on the electricity sector is the hourly demand profile. This can be used to generate a load duration curve, and can have significant impact the distribution of various types of electric generation facilities, their operation, and ultimately, electricity costs and environmental impacts such as emissions of CO_2 and NOx. In order to develop this hourly profile, we obtained the statewide and sector and utility disaggregated hourly electricity demand for the year 2003. Given the annual energy demand, the hourly power demand profile can be scaled to match this value and provides the total system power required for each of the 8760 hours in the year.

A.2. Natural Gas

Natural gas demand projections are made for those sectors shown in Table 4 and do not include natural gas used for electricity production. The methods used to project natural gas demands are similar to those used in the electricity forecast, where possible. But in many cases, data regarding historical and projected near-term natural gas consumption lack the level of disaggregation that exists for electricity (see Table 3 and Table 4). Consequently, projection methods for some sectors differ for natural gas as compared to electricity. Natural gas projections for the residential sector follow similar methods as for the electricity forecast, including the same level of disaggregation, but derive from data in the 2003-2013 Demand Forecast, rather than the 2006-2016 Forecast. Commercial natural gas demand is projected using the same floorspace projections from the electricity forecast, but lacks disaggregation by building type and end use. Projections for the industrial, agricultural, and other sectors lack any disaggregation beyond the regional level, due to lacking data regarding natural gas consumption by industrial classification.

Natural gas demands are forecast for the four natural gas utility planning areas, outlined in Table 18. All the forecasts derive from the 2003-2013 Demand Forecast (CEC, 2003), with the exception of the household projections, which follow the methodology described for the residential electricity projections. After projecting annual natural gas demands by sector, seasonal demands are forecast on a monthly basis based on historical data from the Energy Information Administration (EIA).

A.2.1. Residential Sector

Annual natural gas consumption is defined as the product of end use appliance saturation, UEC, and number of households for each of three natural gas utility planning areas (the Other region is lumped into PG&E and SCG, due to the aggregation of Climate Zones 14 and 15 into Climate Zones 1 and 10, respectively). The projections derive from disaggregated data from IEPR2003, using household projections from the Quantum/Itron residential electricity projections.

The near-term saturation and UEC projections are disaggregated by electricity planning area and three household types: single family, multi family, and mobile homes. The Quantum/Itron household projections adopted in the baseline combine mobile homes and single family households. We define saturation and UEC in the group using the values for single family households, neglecting the disaggregated saturation and UEC data at the mobile home level. This assumption, coupled with minor variations in household projections between the 2003-2013 Forecast and the Quantum/Itron projections we use, leads to only minor variations in projected natural gas consumption in most cases.

In the baseline scenario, saturation rates are projected to 2050 based on the average annual percentage growth from 2003-2013. Fixing saturation rates at 2004 levels results in very minor differences in sector-wide natural gas consumption, suggesting that natural gas appliances may have reached a saturation point in the California market.

The baseline energy intensity projections also extend 2003-2013 projected growth to 2050 using average annual percentage growth rates. They are constrained, however, within the envelope created by a frozen efficiency and optimistic efficiency case. The frozen efficiency case fixes end use energy intensity at 2004 levels. In the optimistic case, UEC is reduced by 40% of 2004 levels by 2050, reflecting the technically feasible reductions in residential natural gas consumption identified in CEC (2005c). Table A-12 outlines the statewide average UEC projections for each of the natural gas appliances considered in the forecast.

Table A-12. Average UEC for residential natural gas appliances.

	UEC (therms/household)			
	Single family		**Multi family**	
	2006	**2050**	**2006**	**2050**
Central AC	4.64	5.28	3.18	3.56
Space heat	215.36	130.38	102.37	64.93
Hot water_Dishwashe	35.18	46.82	23.02	35.56
Hot water_Clothes washer	50.73	52.45	37.17	42.84
Water heat (basic)	106.56	99.38	92.45	87.24
Cooking	28.63	23.59	18.13	13.85
Clothes dryer	17.00	17.51	7.38	8.65
Solar water heat	0.66	0.51	0.57	0.67
Miscellaneous	11.71	13.56	11.01	13.07

Pool water heat	8.69	7.15	9.48	7.29
Pool pump (solar)	5.84	6.55	0.00	0.00
Tub water heat	13.70	16.62	0.00	0.00
All end uses	498.72	419.81	304.77	277.67

A.2.2. Commercial Sector

Annual natural gas consumption in the commercial sector is defined as the product of energy intensity (therms/ft^2) and floorspace for the four natural gas utility planning areas. Floorspace projections are aggregated from those projected for the electricity utility planning areas, based on the relationships outlined in Table 1.

Energy intensity is projected similar to that for the commercial electricity projections. Four cases are considered: (1) energy intensity is frozen at 2004 levels, (2) continuing the trend projected by the CEC in IEPR2003, based on the average annual percentage growth rate, (3) the baseline scenario, and (4) a high efficiency scenario. The frozen efficiency case results in the highest average UEC, contrary to electricity consumption in the commercial sector, where continuing CEC forecast near-term trends lead to higher UEC than freezing efficiency. Due to a lacking of disaggregated data by end use and building type, UEC in the baseline and high efficiency cases was scaled relative to the continued CEC projected trends using the ratio from the electricity projections. That is, the ratio of UEC in the baseline scenario to that in the CEC continued trend scenario is the same for electricity and natural gas. Natural gas UEC for the optimistic case was defined similarly. This is a somewhat crude method for projecting baseline and optimistic natural gas UECs, and we recognize the potential for inconsistency, especially considering the difference between the continued trend CEC projections and the frozen efficiency case for the electricity and natural gas projections.

A.2.3. Industrial, Agricultural, and Other Sectors

Natural gas consumption in the industrial, agricultural, and other sectors is projected by extending historical and projected near-term consumption linearly through 2050 for each of the four planning regions. A lack of disaggregated demand data for the sectors prevents disaggregated projections.

A.2.4. Seasonal and Peak Demand Projections

Seasonal demands are projected based on California, sector-specific monthly natural gas consumption data from the EIA. We average the month-by-month percentage of a given year's natural gas consumption, and take the monthly average over several years to develop a monthly load curve. Projected monthly natural gas demands are determined by multiplying sector consumption in a given year by the montly load curve. For the residential and commercial sectors, we average 17 years worth of data (1989-2005), and for the industrial sector, 5 years (2001-2005). We apply the industrial sector load curve to agricultural and other sector demands, due to lacking data for seasonal variation in demand for those sectors.

January has the highest average natural gas demand, and peak-month demand is defined as the product of projected annual natural gas consumption and January's average fraction of annual demand.

A.3. Transportation fuel

A vehicle stock turnover model tracks the age distribution and other characteristics of interest for a population of vehicles (e.g. light-duty vehicles). To project vehicle fuel requirements into the future, the vehicle characteristics of interest such as vehicle miles traveled (VMT) and fuel economy in miles per gallon (MPG) for a number of different vehicle body types (classes) and power trains (e.g. conventional gasoline, hybrid, diesel) should be tracked. The baseline scenario (**AEP-BaselineScenario-Fuel.xls**) uses a vehicle stock turnover model as an accounting framework and does not endogenously predict vehicle MPG, VMT or fuel usage. Projections and extrapolations for these parameters are based upon CEC models (CalCARS and Futures models).

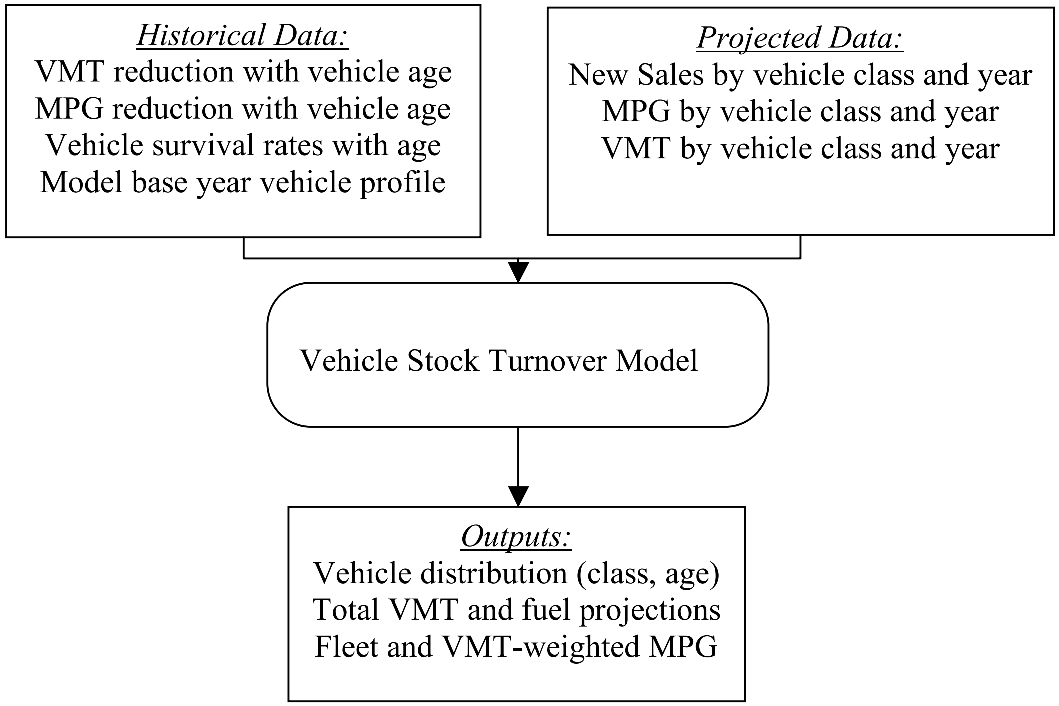
A.3.1. Model Outputs

The baseline scenario provides (on *Summary* sheet) for each of the model years (2003-2050) the number of vehicles, total VMT and VMT-weighted fuel economy, and fuel requirements for three broad classes of vehicles (conventional gasoline, hybrids and diesels). These are summed to get to total number of light duty vehicles (LDVs), VMT, and gasoline and diesel demands for the entire state of California. Added to these numbers are projected fuel demands for non-light duty vehicles. Ethanol demand is calculated based upon a 5.7% by volume oxygenate additive for all gasoline over the entire model period. This sheet provides statewide annual totals for these parameters with no spatial disaggregation. The model also provides monthly fuel demands for the model years in one sheet (*Monthly*).

A.3.2. Model methods

Model framework
This vehicle stock turnover model (VSTM) is modeled in Microsoft Excel and run in Visual Basic. VSTM tracks the age distribution (from new to 25 years old) for 15 different classes of vehicles (as defined by CALCARS 2005) for 3 powertrain options for a total of 45 distinct vehicles. The model tracks these vehicle populations (age and distribution) over the 2003-2050 timeframe and determines the overall vehicle populations, fleet VMT, fleet VMT weighted fuel economy and total fuel (gasoline and diesel) requirements for all years.

Model Diagram



Input requirements and model relationships

There are a number of required exogenous data inputs for the model to accurately track and project vehicle age and class distribution:

1) For a historical base year (2003), the existing vehicle population is characterized in terms of total number of vehicles and age distribution (CALCARS Input) **Sheet("2003_Vintage")**
2) New sales data for each projection year by vehicle class (from CALCARS) **Sheet("Car_Sales")**
3) MPG of new vehicles for each projection year by vehicle class (from CALCARS) **Sheet("MPG")**
4) VMT for each projection year by vehicle class (from CALCARS) **Sheet("VMT_yr")**

Also required for accuracy in the stock turnover model are the following important relationships:

5) VMT reduction for vehicles by age (from EMFAC) **Sheet("VMT_Decay")**
6) Car and truck survival rates as a function of age (from EMFAC) **Sheet("Veh_Survival")**
7) MPG reductions as a function of age (assume to be constant)
8) Monthly fuel demand as a percentage of annual demand (from EIA CA Petroleum data) **Sheet('Monthly')**

CalCARS determines these relationships endogenously as a central part of the model since consumer choices about vehicles and transport modes will affect vehicle retirements as well as

VMT profiles. These historical relationships were extracted from the EMFAC model (for use in the CEC's Futures model) and assumed to apply into the future.

The transportation office has provided CalCARS output files for various model runs based upon three gasoline price scenarios (Lower, Higher and Highest) and two GHG policy environments (Pavley and no Pavley regulations). Our baseline scenario is taken from the CEC projections from CalCARS model runs for (2) New Sales, (3) new vehicle MPG and (4) new vehicle VMT based upon the middle (called "Higher") gasoline price and no GHG policy (i.e. no Pavley regulations) scenario. These other CalCARS model outputs can be used in the stock turnover model to assess the effects of prices changes and policy. The CEC CalCARS model only projects from 2003-2025. Any input requirements or projections beyond this timeframe need to be extrapolated to the 2025-2050 timeframe for use in the model. VMT for new sales by vehicle class is assumed to be constant after 2025 (equal to the VMT in 2025). Vehicle MPG is projected by continuing the linear trend from 2015-2025 out to 2050. Sales projections for each vehicle class are determined by continuing the linearly increasing per capita vehicle sales trends based upon the Futures model projections of 2010-2025. Population is taken from the Department of Finance projections.

The historical relationships for VMT reductions as a function of vehicle age and vehicle survival are derived from the EMFAC model using data from the 1998 model year. The data were extracted and the relationships were modeled using a power law function and a generalized logistic curve, respectively. The equation parameters were solved to fit these equations to the model data. It is assumed that these equations apply to each type of vehicle drivetrain (conventional, hybrids and diesels) and class (compacts, sedans, trucks, etc) and hold into the future as well. No reduction in vehicle fuel economy is assumed as a function of age. Monthly historical data for California transportation fuel demands is also included to predict how the total fuel requirements will be distributed amongst the various months of the year.

Methodology

VSTM – This sheet is the main worksheet for the vehicle stock turnover model (VSTM). It shows the numbers of vehicles in each of the years from age 0 to 25. For each year of the projection period, the model calculates the total number of LDVs, the total VMT and the VMT-weighted fuel economy, and total fuel usage (gallons of gasoline equivalent) for that population of vehicles. To account for vehicle retirements and VMT reductions as a function of vehicle age, an empirical relationship is used based upon data from the CARB's EMFAC model. This sheet looks up a number of inputs from other model worksheets. The sheet models only one vehicle class at a time and when the model year is varied between 2003 and 2050, the sheet calculates the total number of vehicles, VMT, MPG and fuel usage for that vehicle. Running a macro will activate the model, which iterates through each model year and all the vehicle classes and records the results into the **Results1** sheet. If the input parameters are not changed, there is no need to re-run the model.

Temporal Disaggregation

Once the model provides annual fuel demand, it may still be necessary to estimate the seasonal, weekly and hourly distribution of fuel demand because the distribution of demand is not constant over the months of the year, days of the week and hours of the day and can affect the scale and storage requirements for production/refining, distribution and fueling infrastructure. The CEC does not track fuel demand at a finer temporal scale than annual demand. Other data sources are relied upon to provide average disaggregation profiles which can be applied to the annual total. Monthly fuel demand data for California is based upon EIA historical data. Eleven years of diesel fuel demand and 22 years of gasoline demand is averaged to calculate the average fraction of annual demand that falls in a given month. This monthly profile (i.e. percent of annual total in each month) is multiplied by the projected annual demands to estimate monthly demand for any month to 2050.

A daily and hourly profile was obtained for a representative refueling station for a representative week. This profile was used to calculate the fraction of weekly demand that occurs each hour of the week. This profile can then be applied to the monthly demands by assuming that each week of the month has an identical fuel demand profile.

A.3.3. Baseline Scenario Vehicle Classes

1. Subcompact Car
2. Compact Car
3. Midsize Car
4. Large Car
5. Sport Car
6. Small X-Utility Car
7. Small X-Utility Truck
8. Midsize X-Utility
9. Compact SUV
10. Midsize SUV
11. Large SUV
12. Compact Van
13. Standard Van
14. Compact Pickup Truck
15. Standard Pickup Truck

A.3.4. Files, data sources, and further methodology description

FUTNGHG2.xls – CalCARS output file – Obtained from GY. Describes the new LDV sales, and VMT/year and vehicle fuel economy for new sales for 45 classes of vehicles from 2004 to 2025. 2003 data is present but appears to be the total vehicle population, MPG and VMT which is corrected to work in the Futures model – the numbers are reduced so that assuming that these vehicles are all new (as is done in the Futures model) in 2003 still gives the correct total VMT and numbers of vehicles. The FUTURES model uses a "Use Factor" to de-rate the amount of VMT as a function of age (which accounts for survival and VMT reductions) to account for aging of the stock of vehicles in 2003. This data (from 2004-2025) is copied to **AEP-BaselineScenario-Fuel.xls** to sheets (Car_Sales, VMT_yr, and MPG). The 2003 data is corrected for VMT by taking the 2004-2005 trend and extrapolating to 2003, and for new sales by taking the 2004-2006 trend and extrapolating back to 2003. MPG is assumed to be correct in 2003.

VCANGHG2 – CalCARS output file – Obtained from MWG - Describes the total number of vehicles and new sales for 45 vehicle classes from 2003 until 2025. 2003 is the base year and I believe (first suggested by Malachi Weng-Gutierrez from CEC Transportation Office) that the numbers for 2003 were "corrected" by CalCARS so that it could be used in the FUTURES model. Another way to handle this would be (like the VISION model) to have the stock turnover model account for new sales and track stock from some very early year (like 1970 for VISION), which would accurately reflect the vehicle age distribution by 2003. This assumes no Pavley and the middle (called 'Higher') fuel price scenario. This data set was used to validate the stock turnover model results for vehicle population

'2003 Vehicle Fleet Information v2.xls' Obtained from MWG – Describes the 2003 residential, commercial and rental fleets for 15 different classes of vehicles, broken down by age from 1-16 years old as well as 17+ years old. This is a better set of values than the 2003 total vehicle stock given in FUTNGHG2. This was used to provide the data for the sheet 2003_Vintage in **AEP-BaselineScenario-Fuel.xls**. The vehicles that are in the 17+ age bracket were linearly distributed among the 17-25 year old bracket to match the data up with the 25 age classes for the model.

VMT_Decay – Based upon data from CEC/TIAX FUTURES model, which comes from the EMFAC model (CARB). The data is plotted and used to fit parameters for a power-law function. These parameters are then used to calculate the percentage of initial VMT for each year of the vehicles lifetime (up to 25 years).

$$\%VMT = 1 - 0.073(Age)^{0.6}$$

This sheet also includes data from the VISION model, though this data shows a very different VMT profile as a function of age and is not used.

Veh_Survival - Based upon data from CEC/TIAX FUTURES model, which comes from the EMFAC model (CARB). The vehicle survival profile data is plotted and used to fit parameters for a generalized logistic curve function. These parameters are used to calculate the percent of existing vehicles lost each year as a function of age. The sheet also includes data from the VISION model but this data shows a much faster rate of vehicle retirement than the EMFAC model and this data is not used.