WATER SUPPLY-RELATED ELECTRICITY DEMAND IN CALIFORNIA

PIER FINAL PROJECT REPORT

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Preface

The Public Interest Energy Research (PIER) Program supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The PIER Program, managed by the California Energy Commission (Energy Commission), conducts public interest research, development, and demonstration (RD&D) projects to benefit California.

The PIER Program strives to conduct the most promising public interest energy research by partnering with RD&D entities, including individuals, businesses, utilities, and public or private research institutions.

PIER funding efforts are focused on the following RD&D program areas:

- Buildings End-Use Energy Efficiency
- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

The *Water Supply-Related Electricity Demand in California* is a final report for the Demand Response Research Center (contract number 500-03-026) conducted by Water and Energy Consulting. The information from this project contributes to PIER's Energy Systems Integration Program.

For more information on the PIER Program, please visit the Commission's website at:

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Abstract

This report estimates the water supply-related peak electrical demands for investor-owned electric utilities in California, based on data from the California Energy Commission and California investor-owned utilities. Water supply-related electrical demands exceed 2,000 megawatts on summer peak days in California. Agricultural groundwater and surface water pumping represent 60 percent of the total water supply-related peak day electrical demand, with water agency demands representing the remaining 40 percent. Over 500 megawatts of water agency electrical demand is used for providing water/sewer services to residential water customers. This study also forecasts future peak-day electrical loads and estimates peak demand impacts of population growth and the impact of potential demand reduction programs.

Key Words: water supply-related electrical demand, energy use for water conveyance, agricultural groundwater pumping, surface water pumping, water pumping, water agency electrical demand

Executive Summary

This study sought to determine a previously unquantified number – the amount of electric demand that is related to the treatment, distribution, and disposal of water within California. This report estimates the water supply-related peak electrical demands for investor-owned electric utilities in California, based on data from the California Energy Commission (Energy Commission) and California investor-owned utilities. Water supply-related electrical demands exceed 2,000 megawatts (MW) on peak days in California. Agricultural groundwater and surface water pumping are almost 60 percent of the total water supply-related peak day electrical demand, with the majority (80 percent) of this agricultural demand in the Pacific Gas and Electric (PG&E) area.

Water agency demands compose 40 percent of the water supply-related peak electrical demands in the state, with the majority of this demand being for fresh water supply. Sewer/wastewater facilities, at least in the southern part of the state, self-generate a major portion of the electricity they use. The electrical demand by water agencies in California during the on-peak hours is almost 25 percent lower than their non-coincident peak demand, through the use of storage, alternative pumping schemes, and in response to routine afternoon reductions in residential water demands.

The water agency demand was further divided into the residential and commercial/industrial sectors. Typical residential water use profiles were used to determine residential water customer's contribution to utility peak day electrical demands. Over 500 MW of water agency electrical demand is used for providing water/sewer services to residential water customers. An average residential embedded peak electrical demand intensity of 1,445 kilowatts/million gallons (kW/Mgal) and 0.06 kW/residence was determined.

Water-related peak day electrical demand profiles were developed for fresh water supply, sewer/wastewater, and agricultural pumping and were used to predict future peak day electrical loads. Residential embedded peak electrical demand intensities were used to demonstrate water supply-related peak demand impacts of population growth and the impact of potential demand reduction programs.

This report identified additional research needs in several areas:

- The development of commercial/industrial water use profiles.
- Further investigation into the discrepancies in reported agricultural pumping.
- The demonstration and implementation of water time-of-use infrastructure and rates.
- The assessment of additional above ground water storage as a peak electricity demand reduction measure.
- The identification of potential water agency self-generation and barriers to implementation.

1.0 Introduction

The movement and treatment of water is an important component in electrical demand. The Energy Commission noted the significance of water related electricity use in California in the *2005 Integrated Energy Policy Report* (*IEPR*):

> "California's water infrastructure uses a tremendous amount of energy to collect, move, and treat water; dispose of wastewater; and power the large pumps that move water throughout the state. California consumers also use energy to heat, cool, and pressurize the water they use in their homes and businesses. Together these water related energy uses annually account for roughly 20 percent of the state's electricity consumption, one-third of non-power plant natural gas consumption, and about 88 million gallons of diesel fuel consumption." (Energy Commission, 2005c)

Total water related electrical consumption for the state of California amounts to approximately 52,000 gigawatt-hours (GWh). Electricity to pump water by the water purveyors in the state amounts to 20,278 GWh, which is approximately 8 percent of the statewide total electrical use. The distribution of this power among the state planning areas is shown in Table 1. The remaining 32,000 GWh represent electricity used on the customer side of the meter, that is, electricity that customers use to move, heat, pressurize, filter, and cool water.

Table 1. Electricity Use for Pumping and Treating Water in California

Planning Area	Agriculture and Water Pumping (GWh)
Pacific Gas & Electric	6,325
Sacramento Municipal Utility District	181
Southern California Edison	4,051
Los Angeles Water and Power	163
San Diego Gas and Electric	231
Burbank, Glendale, Pasadena	16
Other	446
Department of Water Resources	8,865
Subtotal	20,278
State Total Consumption	264,824

While the *IEPR* focused on, and reported on, primarily energy kilowatt-hour (kWh) use, it recognized the impact of water related energy use on peak demands:

> "If not coordinated and properly managed on a statewide basis, water-related electricity demand could affect reliability of the electric system during peak load periods when reserve margins are low." (Energy Commission, 2005c)

This report was commissioned primarily due to the lack of actual demand data related to water use in the state and due to the concern that the water community was facing substantial increases in its energy use during the next decade:

> "The state's growing population is increasing the demand for water and the amount of energy needed to deliver and treat it. Water and energy demands are growing at

> roughly the same rate and are most critical in the state's urban areas. However, water related electricity use is likely to grow at a faster rate because of: increasing and more energy-intensive water treatment requirements; conversion of diesel agricultural pumps to electric; increasing long-distance water transfers, which often have the impact of shifting water from agricultural to urban areas; and changes in crop patterns that require more energy-intensive irrigation methods." (Energy Commission, 2005c)

The purpose of this report is to obtain a better understanding of the relationship between existing water agency electrical demands and water agency customer water use, and to understand how this water use relates to the associated electrical energy used by the water agency providing this water. Of specific interest is the ability to estimate the amount of electrical load that water agencies can reduce or shift from on-peak to off-peak as a result of time of use (TOU) changes in the water agency customer water use patterns in support of the *IEPR* recommendation that:

> "California can implement strategies now to increase water use efficiency, energy efficiency, peak operational flexibility, and renewable generation potential to serve the state's water and wastewater infrastructure. (Energy Commission, 2005c)

In addition to the present relationship between water use and water agency electrical demands, future growth in water related electrical demand, both annual energy use and on-peak demand, are considered.

1.1 Scope of this Study

The focus of this report is the electrical demand necessary to treat water and get it to the customer, to take the wastewater from the customer and dispose of it, and to provide groundwater pumping and surface water pumping for the agricultural community. Because of limitations on the scope of work, several areas of demand have been excluded from consideration.

This report examines the water supply-related peak day demands of the California investor-owned utilities (IOUs): PG&E, Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E). Figure 1 shows the service areas of these utilities. The water supply-related demands of the public electric utilities (e.g., Sacramento Municipal Utility District (SMUD), Los Angeles Water and Power (LADWP), Imperial Irrigation District (IID) etc.) are not included in this analysis; the public utilities do not sell electricity to a separate water agency so data regarding their water related electrical demand is not readily available.

In addition, this report also excludes the electrical demand of the State Water Project used to convey water from Northern California to Southern California. The amount of electricity used for this intrastate conveyance is impressive – approximately 3 percent of all the electricity consumed in the state is used to ship water via the State Water Project from Northern California to Southern California. The State Water Project was not included in this analysis, primarily because it does not draw off the electric utilities during on-peak hours, and also because it does its own electrical generation.

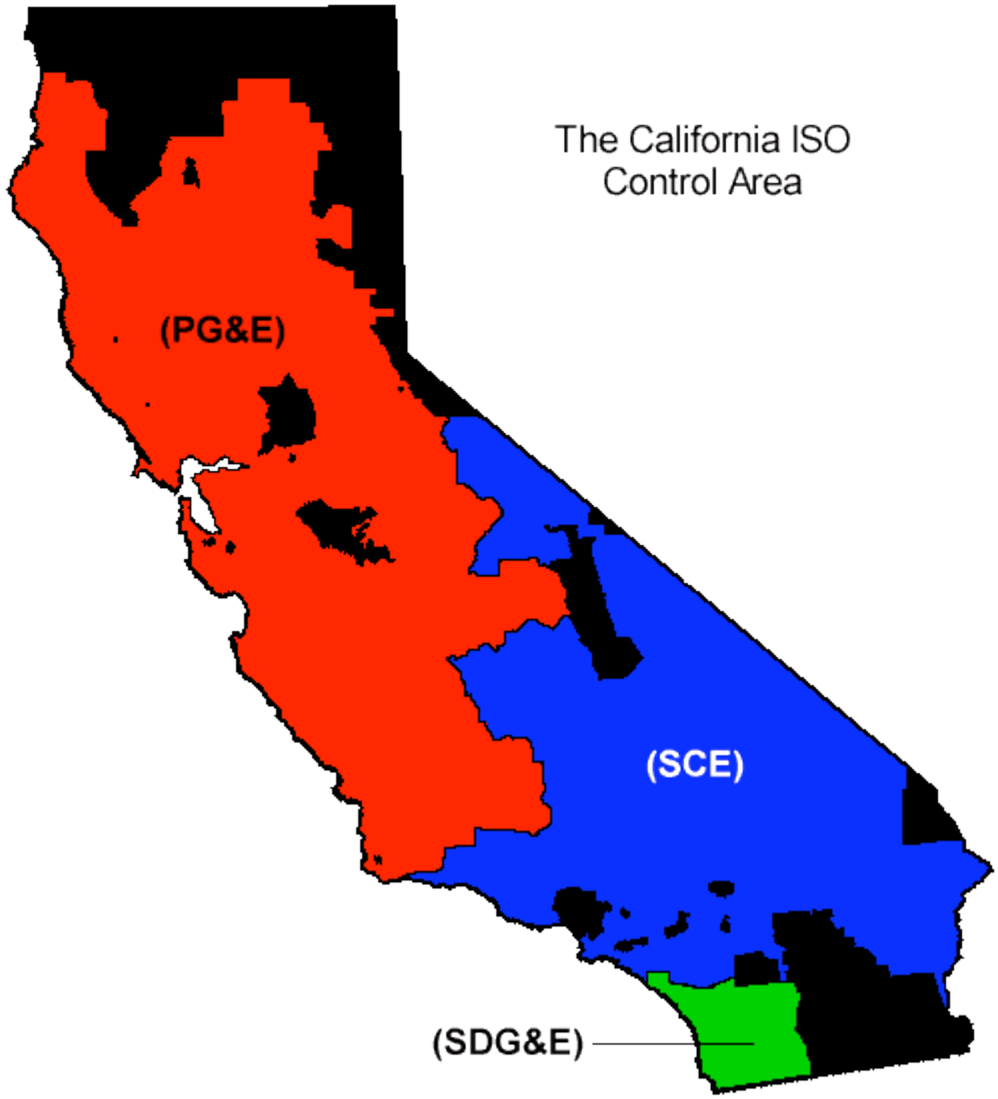


Figure 1. California IOU Service Territories

Finally, this report excludes electrical demand associated with customer use of the water, that is, uses on the customer side of the water meter. In the residential sector these energy demands include those related to water include water treatment (filtering and softening), water heating, hot water circulation loops, cooling (icemakers and chilled water systems for heating, ventilation and air conditioning (HVAC) and chilled drinking water), and circulation (spa and pool pumps). Commercial and industrial customer-side water uses include all those found in residences, plus high-rise supplemental pressurization to serve upper floors, steam ovens and tables, car and truck washes, process hot water and steam, process chilling, equipment cooling (x-ray machines, for example), and cooling towers.

1.2 Prior Studies

A major challenge in carrying out this study is the lack of adequate data and previous studies. In reviewing the literature, we found no studies that estimated peak electrical demand due to the water sector. Prior studies on the water-energy relationship have mostly investigated energy (kWh) requirements, while this study focuses on peak-use and electrical demand (kW). The focus on peak-use brings additional complexities and there are even fewer existing data regarding peak use than energy use. For this reason, we reviewed previous studies on water demand profiles to become familiar with usage profiles for later comparison to electrical demand profiles. This section summarizes the findings on water use profiles.

Even for a topic as important to California as water demand, the available data and literature are lacking. As the Pacific Institute (2005) has stated:

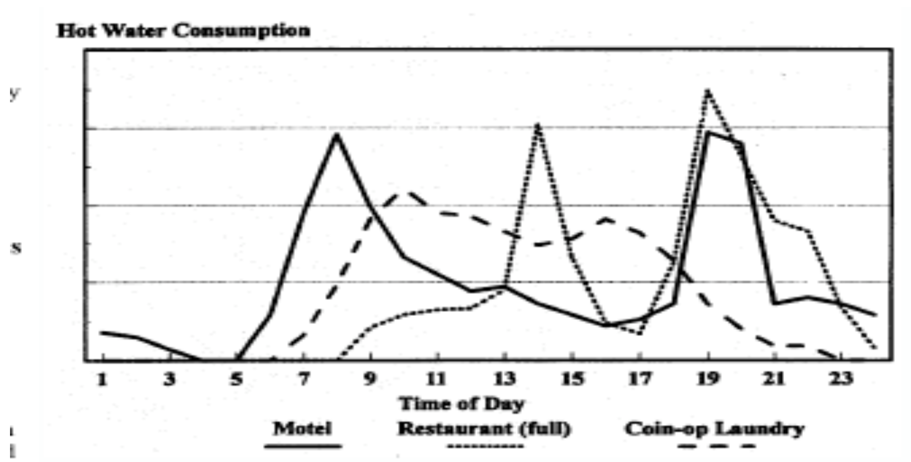
> "One of the many challenges to studying water issues in California is the lack of a consistent, comprehensive, and accurate estimate of actual water use, by sector or region. Different institutions and groups track, record, and report water use in different ways and no single accepted historical record exists. Indeed, not all water uses are actually measured and monitored—thus, reported water use is a combination of measurements of use and estimates of uses not actually measured. For example, some cities still do not require residential water monitoring, especially for multifamily homes. Many agricultural groundwater withdrawals are not monitored or reported.
>
> The Pacific Institute has tracked these different estimates over the past decade, and we conclude—to our dismay—that no single estimate is likely to be either accurate or appropriate."

Our review of available literature and previously documented research revealed that the development of water demand or time of use profiles for most customer classes is problematic. Specifically, there is such diversity in volumetric water usage and hourly demands among individual commercial, industrial and agricultural customers that previous attempts to establish representative usage patterns have been limited to gross volumetric water usage estimates for various customer classes (DeOreo et al, 2000).

While there is a good deal information on electrical time-of-use in the commercial/industrial sector, there is a dearth of information on water use throughout the day. This is primarily due to the fact that good time-of-use electrical meters have existed for years, and that information from them is routinely collected for billing purposes. This, in turn, is in part due to the fact that electricity – unlike water – cannot be stored so interest in peak electricity usage developed earlier. Water, on the other hand, is billed volumetrically and there are virtually no time-of-use water meters and time-of-use water billing in existence (DeOreo et al, 2000). No viable published hourly water usage data for commercial, industrial or agricultural customer classes was identified during the literature review phase of this investigation.

Commercial/industrial water use hourly profiles have sometimes been collected in specialized studies, usually associated with some energy use, such as hot water production. Oak Ridge National Laboratory (ORNL) (1997) reported data on the hot water daily use profile in motels, restaurants, and laundries. Their findings support the notion that there is little consistency of use among these three groups, as is shown in Figure 2. Motels use the most hot water in the morning and evening, restaurants during the lunch and dinner periods, and commercial laundries during the mid-morning and mid-afternoon hours.

Figure 2. Hot Water Use Profile in Motels, Restaurants, and Commercial Laundries

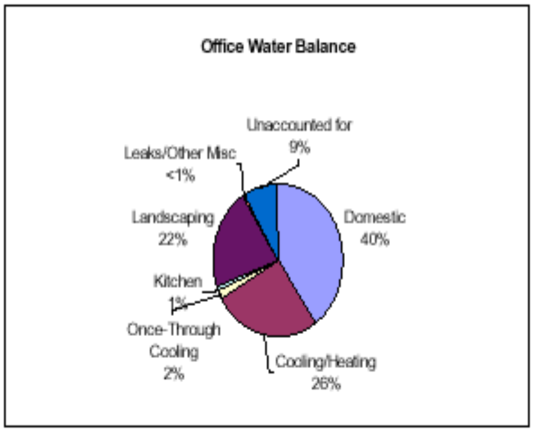


Source: Oak Ridge National Laboratory (1997).

The North Carolina Department of Environment and Natural Resources reported on a 1991 Non-residential Water Audit Program, which also found high degree of variability in water use across business types in the commercial/industrial sector, and that commercial/industrial water use is highly dependant upon the particular application of the water. Figure 3 shows examples of water use distribution (water balances) for common commercial, institutional, and industrial facilities. Manufacturers sampled include metal fabricators, rubber products, aeronautical, and cardboard products manufacturers. Note that the proportion of total water use by domestic (drinking, showering, bathrooms) varies from 3 percent to 48 percent, depending upon the facility.

Figure 3. Water Use By Commercial and Industrial Users

FIGURE 4



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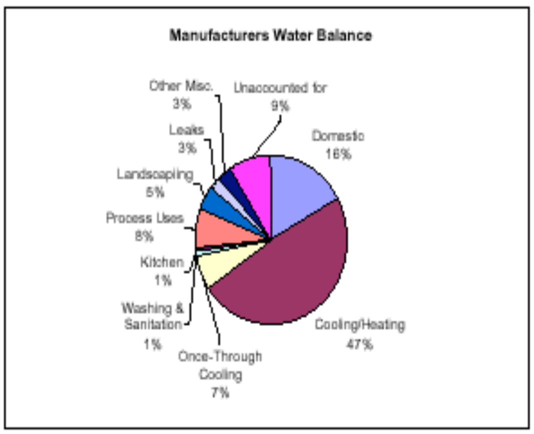


FIGURE 6

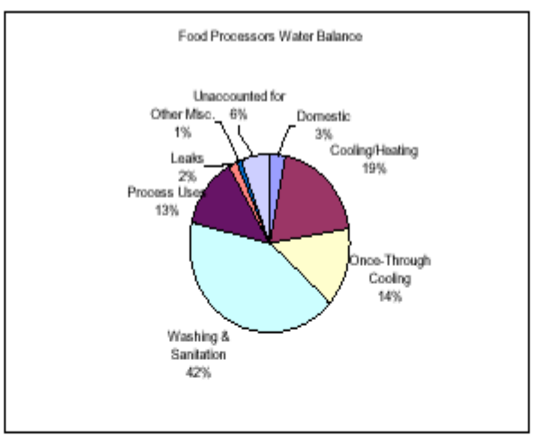
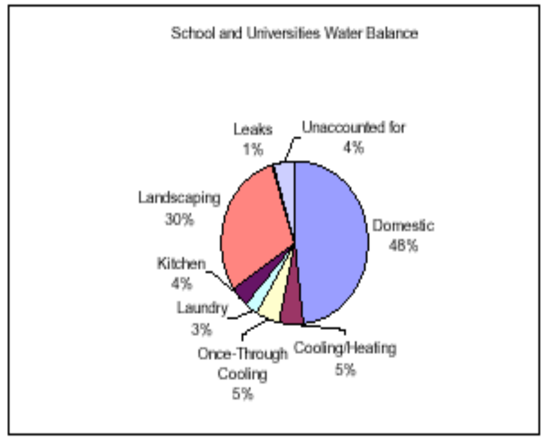


FIGURE 7



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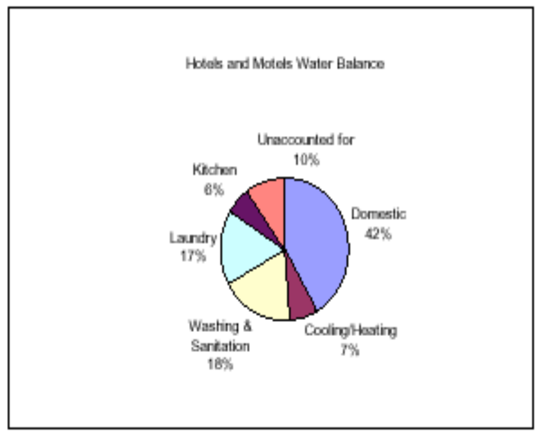

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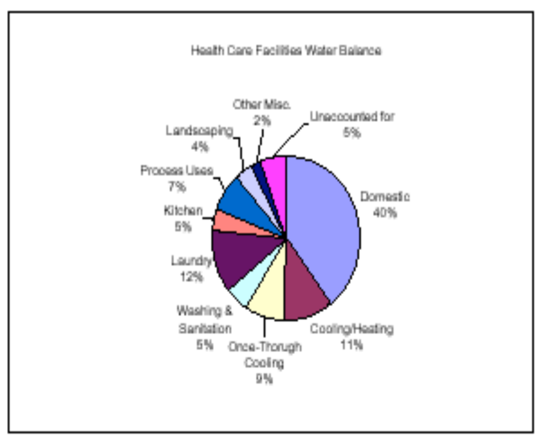


Source: North Carolina Department of Environment and Natural Resources

Further complicating the analysis of the commercial sector, the hot water proportion of usage varies considerably, as Table 2 shows.

Table 2. Typical Commercial Hot Water Usage

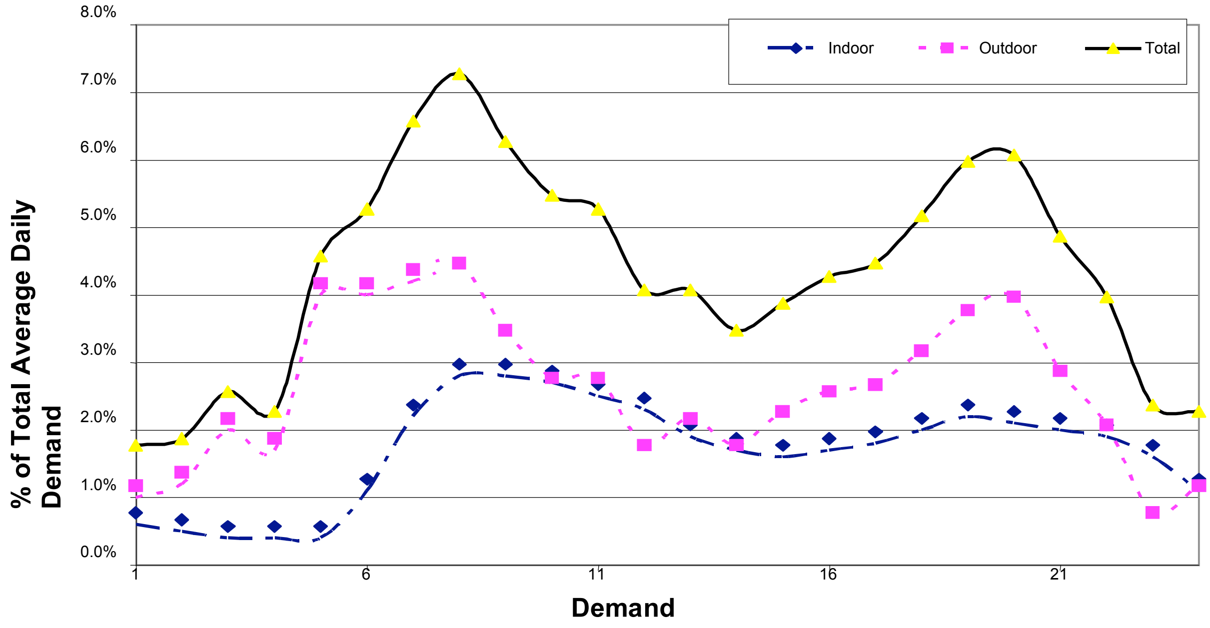
Application		Unit	Gallons (max./hour/unit)	Gallons (max./day/unit)	Gallons (avg./day/unit)
Motels	20 units or less	room	6	35	20
	60 units		5	25	14
	100 units or more		4	15	10
Nursing homes		bed	4.5	30	18.4
Office buildings		person	0.4	2	1
Food Service	Full service	meal	1.5	11	2.4
	Snack bar		0.7	6	0.7
Dormitories	Men s	student	3.8	22.0	13.1
	Women s		5.0	26.5	12.3
Schools	Elementary	student	0.6	1.5	0.6
	Jr./Sr. High		1.0	3.6	1.8

Source: Oak Ridge National Laboratory (1997)

While water use in the commercial and industrial sectors appears highly variable across sites and applications, there exist several previous studies that document hourly water usage patterns for residential customers and the data establishes that temporal residential water usage is not only quantifiable, but predictable.

One of the only examples of documented hourly residential water use patterns is a 1999 study (DeOreo et al, 1999) sponsored by the American Water Works Association Research Foundation (AWWARF) that quantified residential water usage in 12 cities within the United States, of which 4 are located in California. Although these researchers found that there is some volumetric diversity of water use over the 12 locations, a striking conclusion of this study was that there are distinct similarities between the 12 locations in the amount of water fixtures and hourly pattern of daily water usage. The draw patterns were estimated from a residential water use database containing nearly one million individual water use "events" collected using real-time data loggers in 1,188 residences in the 12 study sites; extensive household level information obtained through surveying of approximately 6,000 households; and historic water billing records from 12,000 residences. The study estimated hourly patterns for indoor, outdoor and total water usage. The derived time pattern of overall residential water use followed a classic diurnal pattern, as shown in Figure 4 below:

Figure 4. Residential Hourly Water Demand



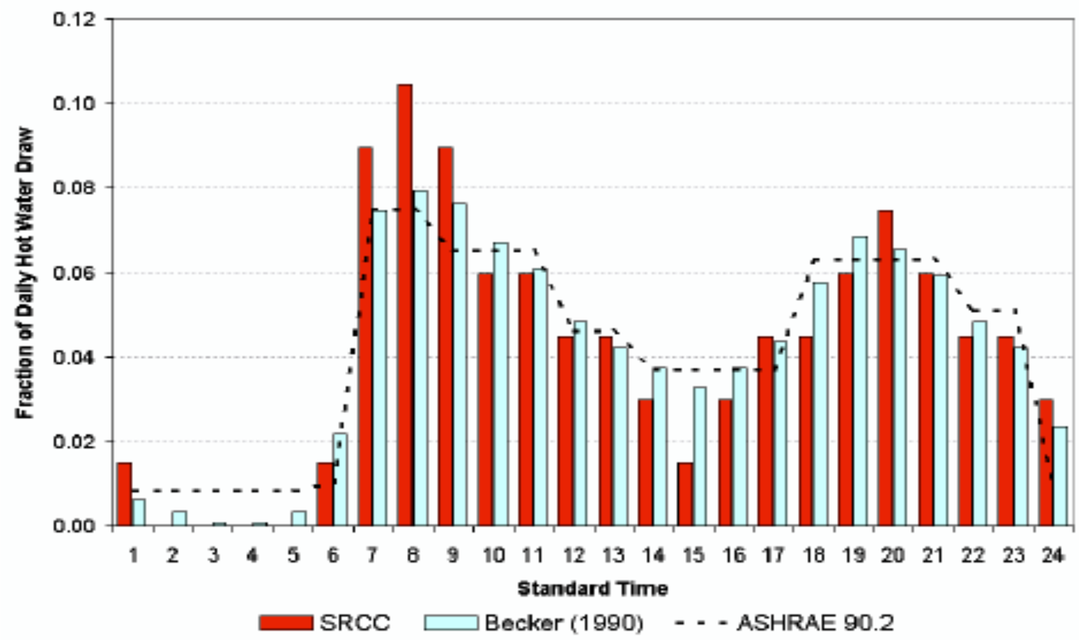
The diurnal water usage pattern depicts four distinct typical characteristics, which include the following:

- Lowest usage during the night (11 p.m. to 5 a.m.)
- Highest usage in the morning (5 a.m. to 11 a.m.)
- Moderate usage during midday (11 a.m. to 6 p.m.)
- High evening usage (6 p.m. to 11 p.m.)

A similar diurnal pattern in overall water use was observed in all 12 study sites.

This daily bimodal residential water use is closely mirrored by the daily usage of hot water. Fairey and Parker (2004), in their review of residential water use, note a great deal of conformity between water use profiles found in the residential sector (see Figure 5).

Figure 5 Comparison of Residential Hot Water Draw Profiles



Source: Fairey and Parker (2004)

In summary, residential water use has a relatively consistent shape - as opposed to the situation found in the commercial / industrial sector. There is a distinctive bimodal distribution to residential water energy use. The residential demand for water peaks in the mid-morning hours, when people get up and get ready for the day. There is another secondary peak in the early evening, when people return home and fix dinner and prepare for bed (Loh and Coghlan 2003; Abbot, 2004).

Not only is water use in the residential sector better understood, but it is also the largest sector of urban water use. As an example, the Metropolitan Water District of Southern California (MWD), whose service area covers approximately 15 million people living along the Southern California coast from Oxnard to San Diego, residential uses account for 67 percent of total municipal and industrial (M&I) use (Hanemann, 1998). Commercial, industrial, public and other uses follow in that order, as is shown in Table 3.

Table 3. Water Use in MWD Service Area (under normal weather)

Sector	Water Use (gallons per capita per day)	Percentage of Total Use
Residential	130	66.7%
Commercial and Institutional	33	16.9%
Industrial	11	5.6%
Public Uses	7	3.6%
Fire Fighting, Line Cleaning, Other	5	2.6%
Meter Error & System Losses	9	4.6%

Source: Metropolitan Water District (1993)

2.0 Method

In order to quantify the electrical demand related to the treatment, distribution, and disposal of water within California, Energy Commission and electric utility data were used to determine the water supply-related peak electrical demands for investor-owned electric utilities in California. Typical residential water use profiles were used to determine residential water customer's contribution to the utility peak day electrical demands.

Water use is typically separated into three end-use sectors: agricultural, commercial and industrial, and residential. Combined demand in these three sectors is termed the water system demand. Water agency electrical demand is the sum of water system electrical demand (with its three sectors) plus sewage electrical demands. Crop production represents primarily utility customer accounts that are separate from water agency accounts (i.e., end-use customers who get water for crop production not from a water agency but directly from ground or surface water). Total water related electrical demand in the utility service area is the sum of water agency demand and these individual utility customer demands for crop production.

2.1 Water Related Electrical Demand by Customer Class

Figure 6 summarizes the data sources and analysis steps used in this study. The output of this study is water related electrical demand profiles for three sectors: agricultural, residential, and other (commercial, industrial, energy, landscaping, and other). The agricultural water related electrical profile was taken directly from the Peak Demand Forecast – agricultural water related electrical demand could be identified directly from the utility data, as agricultural accounts have specific tariffs. Residential demand was determined by combining the Water Related Peak Day Electrical Demands with the Hourly Water Use Profiles, and taking their relative proportion of the water and sewage water related electrical demands. This is depicted in Figure 7. The remaining water related electrical demand is Commercial/Industrial, which includes energy, landscaping and other miscellaneous uses.

The utilities were asked to provide peak day[1] water and sewer agency and agricultural water pumping hourly demands by standard industrial classification. Since the scope of this study is restricted to the IOU utilities, the population of the IOU area was estimated by subtracting the populations of the public utilities from the state population and the statewide consumptions scaled proportionately, resulting in water consumption estimates for the IOU area.

To determine water-supply-related electrical demands, annual forecasts (8,760 hourly values) for Water System, Crop Production and Sewage were obtained for each utility service area. Data came from the Energy Commission demand forecast for 2005 (Energy Commission, 2005a, 2005d). The annual Water System and Crop Production estimates are based on the forecast Agricultural and Water Pumping Demand category, subcategories Domestic Water Pumping

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1. 2005, but PG&E could only provide 2004 peak day values.

(SIC 4941, 4971, NAICS 22130, 22131) [2] and Crop Production Pumping (SIC 01, NAICS 11)[3]. Dairy and Livestock Demand was omitted because it refers to the electrical demand associated with running the facilities not water use or pumping. The annual Sewage estimate is based upon the Energy Commission's "Transportation, Communication & Utility" or "Other" category, the Sewage/Wastewater (SIC 4952, NAICS 22132). From these annual forecasts peak day forecasts for each utility was constructed.

The peak day profiles from the Energy Commission 2005 Demand Forecast (24 hourly values) were compared with the utility supplied 2005 peak day demands for water, crop production (agricultural), and sewage for consistency in shape and magnitude[4]. If there was a discrepancy, data from the Quarterly Fuel and Energy Report (QFER) – reports filed by the utilities with the Energy Commission – were used to determine the reasonableness of the data. If there was an irreconcilable discrepancy between the Energy Commission numbers and the utility provided numbers, the Energy Commission demand forecast was used in this report. This method was chosen because the utility numbers provided for this report are un-audited, whereas the Energy Commission demand forecast was the subject of lengthy hearings and adopted by the full Energy Commission. The forecast is used in policy and planning for the state – for example, the Energy Commission demand forecast is used by the California Public Utilities Commission in their Resource Adequacy Review of utility supply plans.

In submitting data for this study, the three utilities recorded and reported data somewhat differently. Some utilities reported the data by Standard Industrial Classification (SIC) code and some utilities used North American Industrial Classification System (NAICS) code; the details of coding are described below in the sections describing the utility-specific results. The utilities also do not define tariffs identically (for example, the definition of what is classified as an agricultural account differs among utilities). To assure accuracy the data was reviewed iteratively with consultation with the utility companies.

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2. As a result of NAFTA, the federal government replaced the SIC system with the NAICS system (North America Industrial Classification System). Some of the utilities still maintain the SIC code database.

3. Crop production is composed of groundwater pumping, and surface water pumping and distribution.

4. Both the Energy Commission and the utilities report utility service area demand, which includes both the electricity provided to customers by Energy Service Providers (ESPs) and by the utilities. The values in this report are utility service area values, and do not depend on whom the customer purchases electricity from. For both drinking water and wastewater treatment, the amount of electricity provided by ESPs in the PG&E and SDG&E area is negligible. In 2004, ESPs provided 23 percent of the water treatment electricity in the SCE area. For raw water extraction and conveyance, ESPs play a relatively small role, providing 1 percent of the electricity used for this purpose in the PG&E area, 4 percent of SCE area, and 9 percent of the SDG&E area in 2004. It should be noted that water/wastewater treatment plants are generally large accounts and run continuously and thus have less contribution to peak demand than the smaller (water and sewer) accounts.

California Residential Peak Water-Related Electrical Demand Intensity by utility service area was determined by dividing the maximum daily electrical demand for residential water in each service area by the residential water deliveries in that utility service area.

Figure 6. Utility Peak Day Water Related Electrical Demands Determination

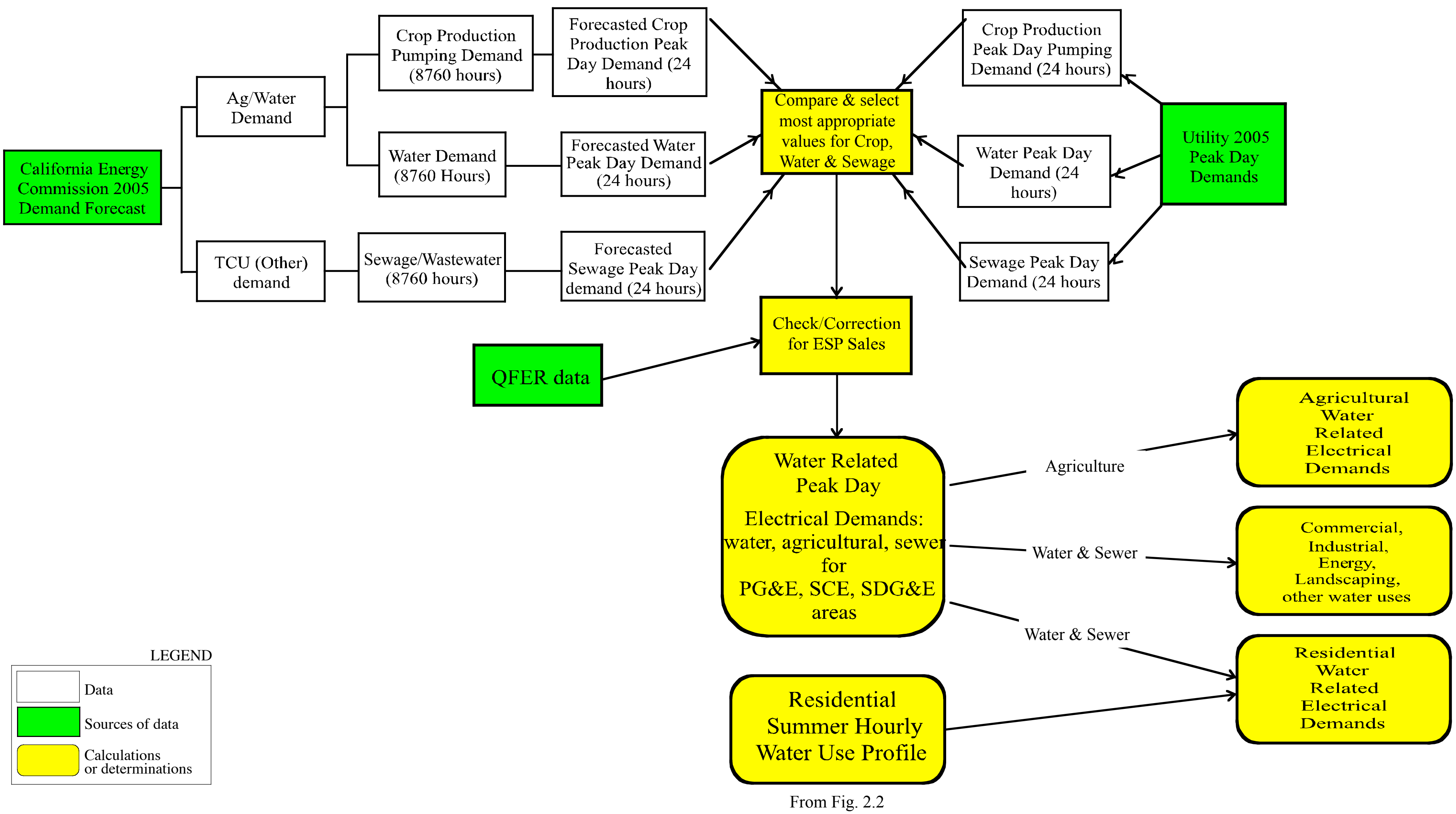
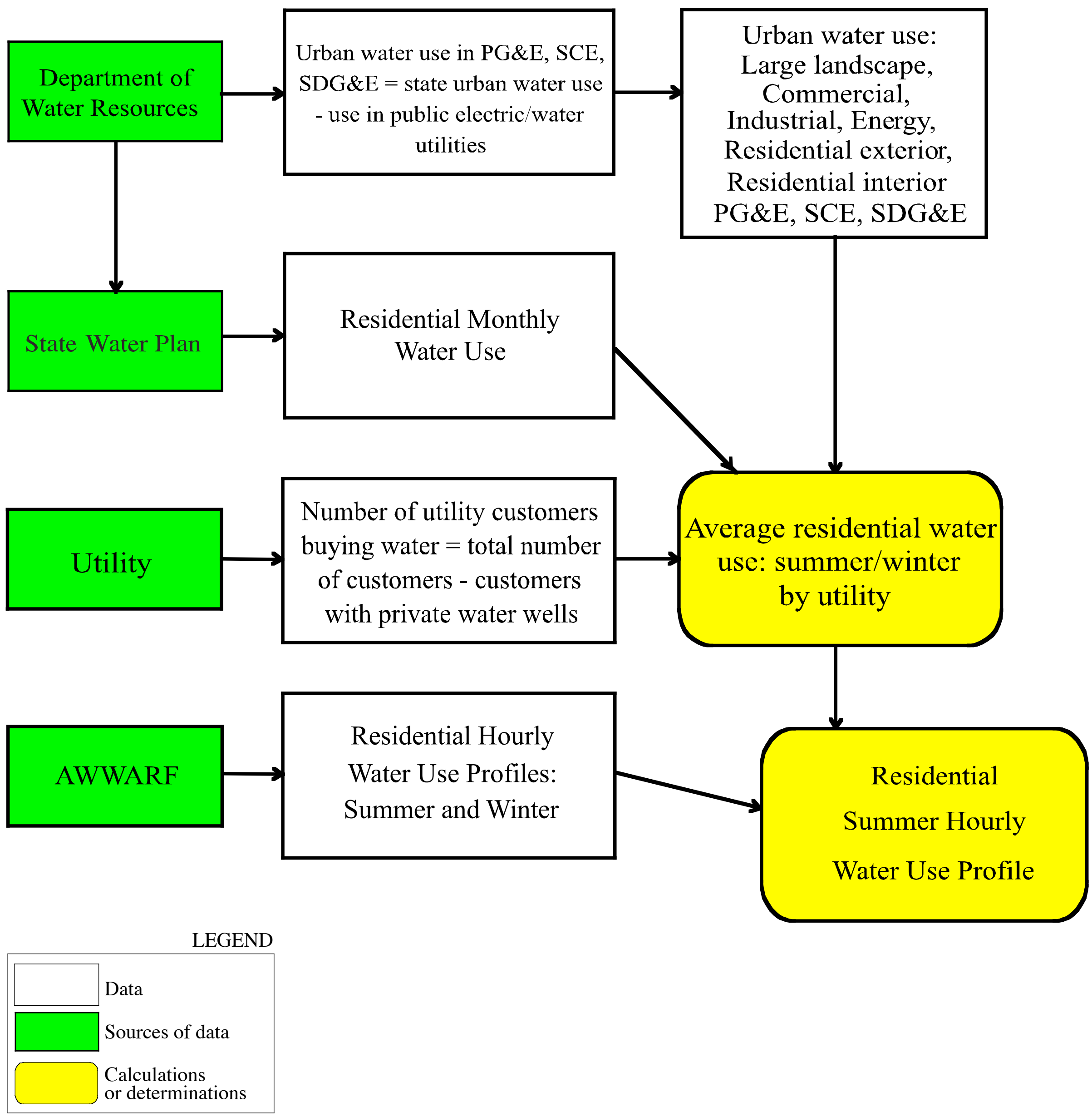


Figure 7. Determination of the Residential Summer Water Use Profile



2.2 Peak Day Water Demand

As a reference point, we wanted to start off with what one might expect to be a relatively straightforward number: the average water consumption by households in California. There are, however difficulties in arriving at an entirely satisfactory estimate for this number. Residential sector water use varies considerable in different locations. For example, Heaney et. al. (1998) found that residential water consumption nationally can vary by a factor of three, and the amount of water used for outdoor uses can vary by a factor of two, as shown in Table 4.

Table 4. Annual Indoor and Outdoor Water Use for 1,000 Houses in Each of 12 Cities

Study Site	Total	Indoor	Outdoor	Indoor	Outdoor
	1,000 gallons per house per year			%	
Boulder, CO	134.1	57.4	76.7	42.8%	57.2%
Denver, CO	159.9	64.4	95.5	40.3%	59.7%
Eugene, OR	107.9	63.9	44	59.2%	40.8%
Las Virgenes, CA	301.1	71.6	229.5	23.8%	76.2%
Lompoc, CA	103	62.9	40.1	61.1%	38.9%
Phoenix, AZ	172.4	71.2	101.2	41.3%	58.7%
San Diego, CA	150.1	55.8	94.3	37.2%	62.8%
Scottsdale/Tempe, AZ	184.9	61.9	123	33.5%	66.5%
Seattle, WA	80.1	49.5	30.6	61.8%	38.2%
Tampa, FL	98.9	53.9	45	54.5%	45.5%
Walnut, CA	208.8	75.3	133.5	36.1%	63.9%
Waterloo, ON	69.9	54.3	15.6	77.7%	22.3%
Average	147.6	61.8	85.8	41.9%	58.1%
Standard Deviation	64.80	8.00	58.98		
Coefficient of Variation	0.44	0.13	0.69		
Estimates are based on one year of monthly meter readings. Indoor water use is estimated by averaging water use during the non-irrigation season.					

Source: Heaney et al. Basin Boulder Area Sustainability Information Network.

Department of Water Resources figures show that within California, estimated water consumption can vary by almost an order of magnitude depending upon location, varying from summer low of 150 gallons per household in the San Francisco Bay area to 1,000 gallons per day in the El Centro area, as shown in Table 5.

Table 5. California Single Family Residential Monthly Water Use

Area	City	Average Summer Use		Average Winter Use	
		100 Cubic Feet per month	Gallons per day	100 Cubic Feet per month	Gallons per day
North Coast	Crescent City	10	250	8	200
Bay Area	San Francisco	6	150	6	150
East Bay	San Jose	23	575	18	450
Central Coast	Monterrey	11	275	8	200
Central Valley	Stockton	22	550	13	325
North Valley	Chico	17	425	9	225
Foothills	Grass Valley	26	650	13	325
South Valley	Fresno	28	700	12	300
Mountain	Susanville	29	725	11	275
South Coast	Los Angeles	20	500	10	250
South Desert	Hemet	15	375	12	300
San Diego	Oceanside	14	350	11	275
Inland	Barstow	35	875	25	625
South Desert	El Centro	40	1000	30	750

Source: California Department of Water Resources, 1994.

Because of these local differences in overall consumption and in the ratio of indoor to outdoor usage an ideal analysis would use localized water consumption figures.

Unfortunately the hydrologic regions (Figure 7) used to develop the water use in Table 5 do not match the electric utility boundaries (shown in Figure 1) for which we have the electric demand data, so matching data for water use and electrical demand at regional levels is difficult at best and such an effort would be beyond the scope of this project.

Figure 8. California Hydrologic Regions

SOURCE: Department of Water Resources.

Because of the difficulties in reconciling the available water data regionally with utility reported electrical use, the methodological decision was made to use California's statewide average water consumption values in this analysis.

The basic water data used in this study came from the Department of Water Resources 2005 Water Plan Update, and was scaled to the population of the California Independent System Operator (ISO) utility service area populations. Residential consumption is the largest component of consumption, comprising 65% of overall consumption, and split 37% to 27% between indoor and outdoor usage. The next largest component is Commercial, comprising 19%, with Industrial, large landscape, and energy production following in that order. These results are displayed in Table 6.

Table 6. Population and Water Consumption Assumptions

California population	34,800,000	(1)	
- SMUD	567,176		
- LADWP	3,900,000		
Remainder	30,332,824	(2)	
% of state	87%		
Water Use (million acre-feet/yr)	**CA (3)**	**Study (4)**	**% of Total Use**
Large landscape	0.6	0.52	7.2%
Commercial	1.6	1.39	19.3%
Industrial	0.6	0.52	7.2%
Energy	0.1	0.09	1.2%
Residential interior	3.1	2.70	37.3%
Residential exterior	2.3	2.00	27.7%
Annual Water Consumption by Household (5)			
gallons per year	50,490		

Notes:
(1) Source: Department of Water Resources, Bulletin 160, Update 2005, Vol. 5
(2) Population of PG&E, SCE, and SDG&E used in this analysis
(3) Department of Water Resources, Bulletin 160, Update 2005,Vol. 3, Table 1-6, pg.1-2
(4) ISO control area. Study residential water consumption = 4.7 maf/year.
(5) Based on average household size of 2.87 persons/household from 2000 U.S. Census. Calculation by author.

2.3 Residential Water Usage Profiles

The customer water usage profile determination started with data from the Department of Water Resources State Water Plan Bulletin 160 (Department of Water Resources, 2005). Urban water use for PG&E, SCE, and SDG&E areas was determined by subtracting the public electric/water utilities (such as LADWP, IID, Modesto Irrigation District (MID), etc.) from the state total, resulting in water deliveries for the utility areas for the following categories: commercial, industrial, energy, large landscape, residential interior, and residential exterior.

The number of PG&E, SCE, and SDG&E customers who procured water from water agencies was determined by subtracting the number of utility customers with private water wells[5] from the total number of residential customers in each service area.

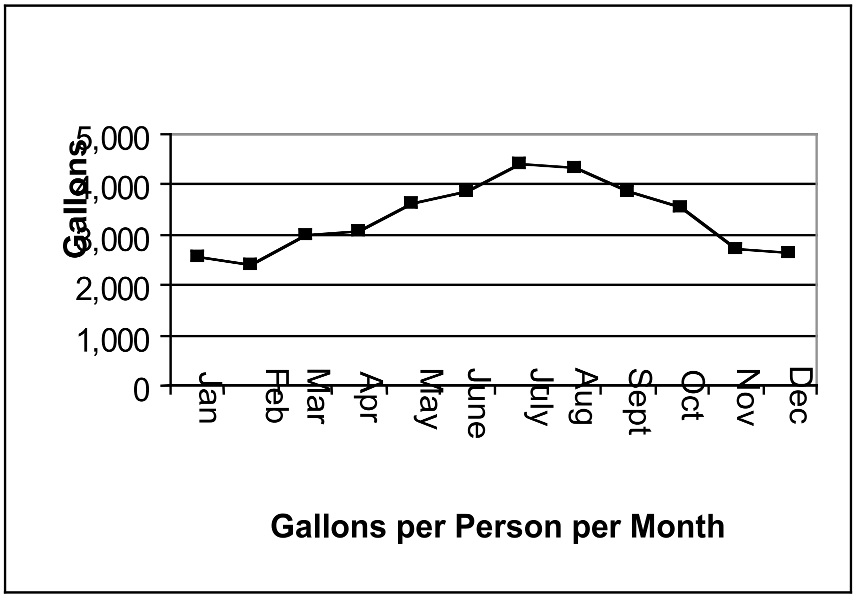
The average residential water use by season (summer and winter) was determined by combining the residential monthly water use with the number of customers who don't supply their own water with the amount of residential (interior and exterior) water used[6].

In California, with its Mediterranean climate, there is a significant increase in the amount of water used by residences in the summer (Figure 9). The increase in the summer water consumption is primarily related to outdoor water use.

5. Utility responses to data request RCRC-1 in CPUC proceeding R.01-05-047.

6. Residences that supply their own water via private wells are excluded from this report.

Figure 9. Residential Water Use in California



Source: Department of Water Resources (1994)

The average summer residential water was scaled to match the time of use profile reported in the AWWARF study (DeOreo 1999).

The AWWARF study concluded that among the 12 study sites, the average residential water usage ranged from 192 gallons per day per household to 825 gallons per day per household. The peak (maximum) residential water usage ranged from approximately 300 gallons per day per household to in excess of 3,000 gallons per day per household. The importance of the peak day conditions is that they are most likely to occur during the hot, summer months when critical peak power demand conditions can be anticipated. The large difference between average conditions and peak conditions is climate related and associated with dramatic increases in outside water usage, including landscape irrigation. Across all 12 study sites, approximately 42 percent of the residential water usage was for indoor purposes and 58 percent for outdoor purposes. The percentage of outdoor water demand increases significantly in hotter climates, such as the Central Valley and Southern California desert regions. In these areas, outdoor water usage can account for nearly 70 percent of all residential demands.

Average indoor water usage ranged from 141 to 200 gallons per day per household in the winter months and from 155 to 237 gallons per day per household in the summer months. It is apparent, based on this usage data, that indoor water usage is predictable within a nominal range of values. Further, the end use of the indoor water usage can be generally categorized as follows:

- Toilet Usage – 18.5 gallons per capita per day (gpcd)
- Clothes Washer Usage – 15.0 gpcd

- Shower Usage – 11.6 gpcd
- Faucet Usage – 10.9 gpcd
- Baths – 1.2 gpcd
- Dishwasher Usage – 1.0 gpcd
- Other Domestic Usage – 1.6 gpcd
- Leaks – 9.5 gpcd

The AWWARF typical residential hourly water use profiles (summer and winter) were combined with the total residential water use (indoor and outdoor) in each utility service area to arrive at Residential Hourly Water Use Profiles for each utility. The Residential Summer Hourly Water Use Profile was used in this analysis, since California utilities peak during the summer time.

The diurnal pattern already described is also observed in numerous water systems throughout California in studies performed by the authors of the AAWARF paper, where the customer base was predominately residential. The observed summer residential water pattern is numerically quantified in Table 7.

Table 7. Residential Summer Water Usage Profile

Hour	Indoor	Outdoor	Total
1	0.6%	1.0%	1.6%
2	0.5%	1.2%	1.7%
3	0.4%	2.0%	2.4%
4	0.4%	1.7%	2.1%
5	0.4%	4.0%	4.4%
6	1.1%	4.0%	5.1%
7	2.2%	4.2%	6.4%
8	2.8%	4.3%	7.1%
9	2.8%	3.3%	6.1%
10	2.7%	2.6%	5.3%
11	2.5%	2.6%	5.1%
12	2.3%	1.6%	3.9%
13	1.9%	2.0%	3.9%
14	1.7%	1.6%	3.3%
15	1.6%	2.1%	3.7%
16	1.7%	2.4%	4.1%
17	1.8%	2.5%	4.3%
18	2.0%	3.0%	5.0%
19	2.2%	3.6%	5.8%
20	2.1%	3.8%	5.9%
21	2.0%	2.7%	4.7%
22	1.9%	1.9%	3.8%
23	1.6%	0.6%	2.2%
24	1.1%	1.0%	2.1%
Total	40.3%	59.7%	100%
Source: AAWARF (DeOreo et al 1999)			

Observed data indicate that indoor and outdoor residential water use typically both follow diurnal patterns similar to the overall pattern but with some important differences. Outdoor use typically ramps up steeply at 5:00 a.m., several hours earlier than the morning increase for indoor water use that increases at 7:00 a.m. Outdoor water use decreases significantly from 10:00 a.m. until 5:00 p.m., while indoor use reaches a peak at 9:00 a.m. and decreases slowly until 4:00 p.m. Outdoor use achieves a secondary peak in the early evening from 6:00 p.m. to 9:00 p.m. Indoor water use increases slightly from 6:00 p.m. to 10:00 p.m., before decreasing for the night. Indoor water use is at a minimum from 1:00 a.m. until 5:00 a.m.

Utilizing residential customer data provided from each of the investor-owned utilities in the state, estimates were made of the cumulative water demand profile. Table 8 provides a summary of the residential characteristics of the various utility service areas.

Table 8. Residential Household Water Consumers

Utility	**SDG&E**	**SCE**	**PG&E**	
Total Number of Residential Customers	1,198,811	4,147,358	5,113,098	
Number of Private Wells	10,700	85,000	370,000	
Number of Residences with Water Related Electrical Demands	1,188,111	4,062,358	4,743,098	
Average Residential Winter Daily Usage (Gallons Per Day)				271
Average Residential Summer Daily Usage (Gallons Per Day)				567
Note: While this report is concerned with peak electrical demands (which occur in the summer), winter water use information was necessary in order to make sure that the annual residential use of water balanced out. Calculations by author.				

Figure 10 shows the summer peak day residential water use in the PG&E, SCE, and SDG&E service areas determined by this report. Water deliveries to residential customers in these service areas peak at over 400,000,000 gallons at 8 a.m. in the morning, with a secondary peak at over 334,000,000 gallons at 8 p.m. at night. Note that outdoor water use during the summer is significantly higher than indoor water use, and the evening outdoor water peak demand is almost as high as the morning demand peak.

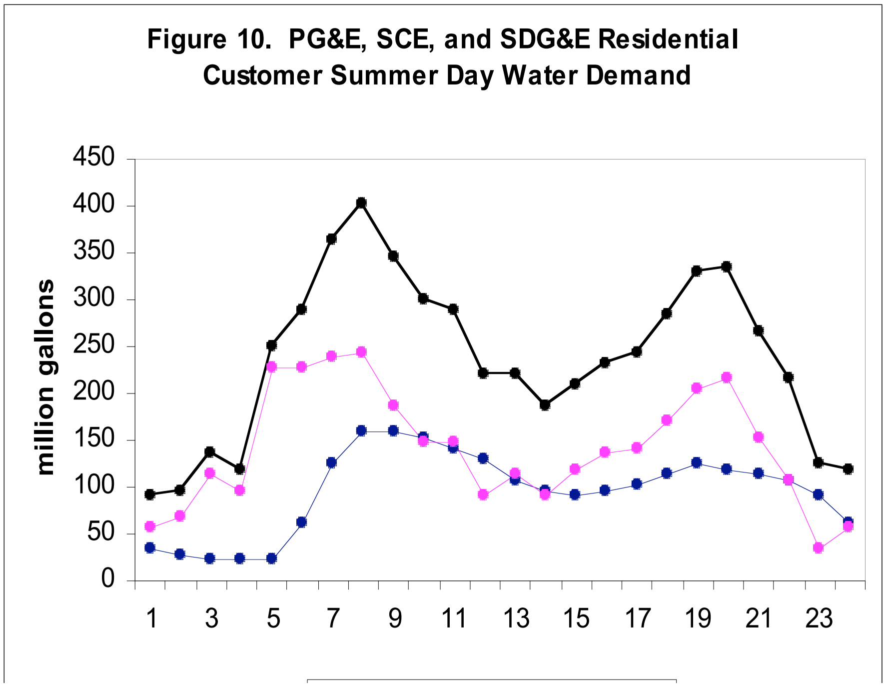


Figure 10. PG&E, SCE, and SDG&E Residential
Customer Summer Day Water Demand
million gallons
450
400
350
300
250
200
150
100
50
0
1
3
5
7
9
11
13
15
17
19
21
23

3.0 Results

3.1 Investor-Owned Utilities Peak Day Water Related Demand

3.1.1 PG&E Service Area

PG&E reported their peak day hourly water related electrical demand by NAICS codes (codes 221300 – water, sewage, and other systems, 221310 – water supply and irrigation systems, 221320 – sewage treatment facilities and 111 – crop production) for their 2004 peak day and the California ISO peak day (September 8, 2004). In 2004, the PG&E system peak day was the same day as the California ISO peak day.

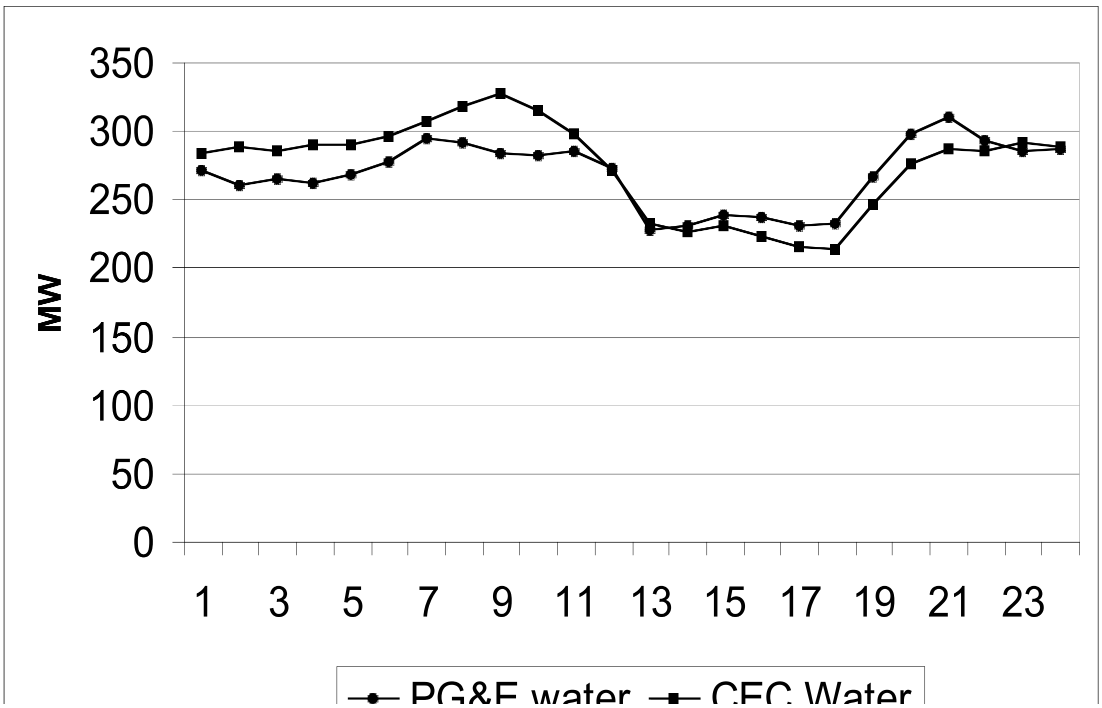
Table 9 provides the Energy Commission 2004 Energy Demand Forecast for PG&E, and compares the 2004 Energy Commission average on-peak (noon to 6 p.m.) electrical demands with the average on-peak (1-6 p.m.) water related electrical demands reported by PG&E. Urban water average on-peak electrical demands are close, but the agricultural and sewer demand reported by PG&E are less than half those predicted by the Energy Commission. We believe that the values submitted by PG&E for peak demand in the agricultural groundwater and surface water pumping and the sewer/wastewater sectors are not plausible. For these demand values to be consistent with PG&E's reported annual energy numbers would require load factors of greater than 100%, which is physically impossible (assuming that the system coincident peak demands reported here are similar in magnitude to the non-coincident demands for these sectors). For this report the Energy Commission values for these sectors were used.

Table 9. PG&E Forecasted Energy Use and Average On-Peak Demand

2004 Energy Commission Water Sector Forecasted Energy Use		Comparison of Average Peak Day On Peak Demand		
	PG&E		2004 Energy Commission	2004 PG&E
	(GWH)		(MW)	(MW)
Urban Water	1,358	Urban Water	222.9	232.4
Ag Groundwater Pumping	2,257	Ag Groundwater & Surface Water Pumping	882.8	345.1
Ag Surface Water Pumping	2,056			
Sewer/Wastewater	537	Sewer/Wastewater	137.3	53.4

Figure 11 shows the Energy Commission forecasted peak day demands for the urban water supply sector, and the PG&E reported peak day demands. While the shapes are similar, the PG&E 2004 reported data is a bit anomalous in that the water agency electrical peak for this day occurred in the evening, instead of occurring in the morning as is typical with California water agencies summer peak demands. In addition, the 2004 peak day was unusual in that it occurred very late in the season. One of the most significant factors influencing residential water use in the summer is the number of children at home. In 2004, the statewide electrical peak day occurred the second week in September, after most of the children in the state were already back in school, which further makes the PG&E actual recorded water agency values somewhat atypical.

Figure 11. 2004 Energy Commission Forecasted and PG&E Reported Water Agency Peak Day Demands



Since these two sets of peak day values are very close (the total energy for urban water use for the peak varied by approximately 2 percent between the PG&E reported and Energy Commission forecasted) the Energy Commission forecasted values are used in this report. These are more typical of what could be expected in the future.

The PG&E water related peak day electrical demand by sector is shown in Figure 12. Sewerage electrical demand has a relatively constant shape, while water agency demand has the typical bimodal daily peaks, with maximum demand at 9 a.m. Agricultural customers' demands follow a single daily peak demand profile with a maximum demand around noon.

Figure 12. PG&E Area Water Related Peak Day Demand

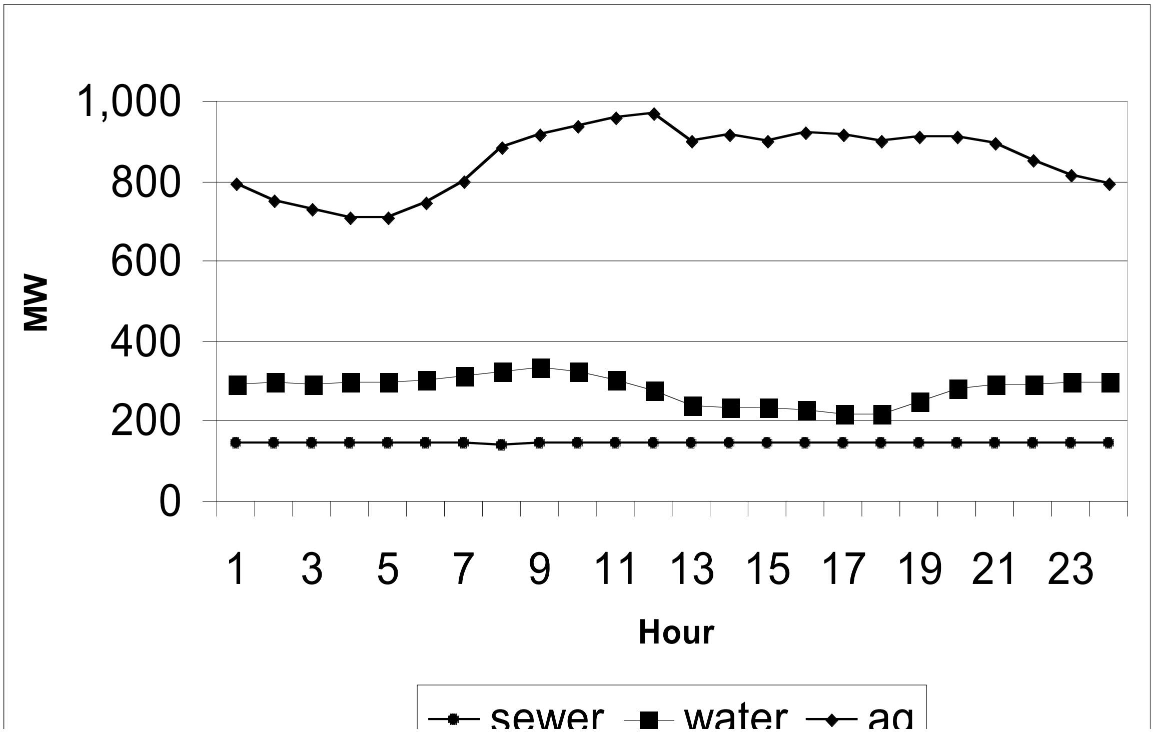


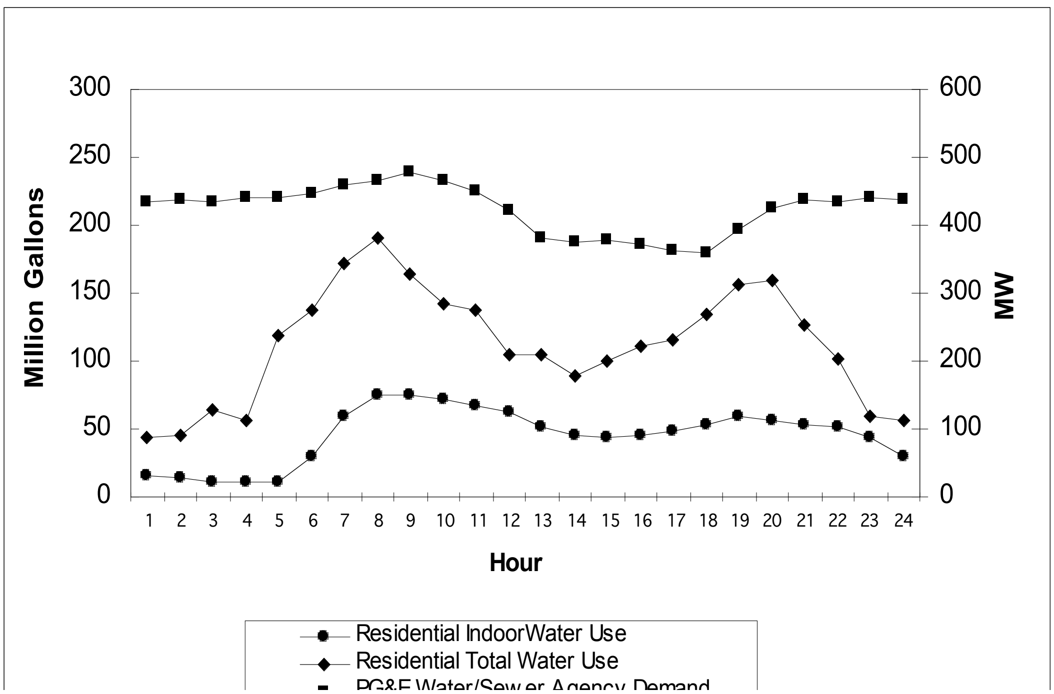
Table 10 shows the characteristics of the PG&E peak day water supply-related demands. Approximately 60 percent of the water related electricity demand is due to agricultural pumping, with the remaining 40 percent used by the water agencies. As noted earlier, there was no difference between the PG&E peak day and the ISO peak day in 2004.

Table 10. PG&E Area 2005 Peak Day Water Related Demand Characteristics

	Water/sewer Agency MW	Total Water Demand MW (1)
Peak Period		
Ave MW	371.7	1279.2
Max MW	381.1	1291.6
4 pm MW	372.3	1291.6
Coincidence with ISO peak		
	1	1
Mid Peak Period		
Ave MW	438.4	1366.2
Max MW	477.9	1404.3
Off Peak Period		
Ave MW	443.1	1222.0
Max MW	465.6	1346.5
TOU Accounts as % of Peak Demand		
	22%	

Figure 13 compares the residential demand for water described in Section 2.3 with the PG&E water/sewer agency[7] electrical demands. PG&E water related electrical demand starts climbing in the early morning and peaks around 9 a.m. The electrical demand drops off during the afternoon as residential water use drops and the water agencies continue to drain their storage. Electrical demand starts climbing again in the late afternoon to try and keep up with the residential evening water demands. PG&E electrical demand continues to climb throughout the evening as water agencies refill their storage facilities for the next day, even as residential demand drops off dramatically.

Figure 13. PG&E Peak Day Water/Sewer Electrical Demand and Residential Water Demand



The PG&E area's embedded residential peak water supply-related electrical demand intensity is found in Table 11.

Table 11. California Residential Peak Water Supply-Related Demand Intensity – PG&E

	kW/Mgal	kW/residence
PG&E	1650	0.066
Note: Determined by dividing maximum electricity demand by water deliveries within that utility area		

7. Water/sewer agency demands do not include individual utility electrical accounts – which are recorded under "crop production" or "agricultural."

The peak day electrical demand profiles for fresh water supply, sewerage, and crop production determined by this report in the PG&E area are provided in Table 12.

Table 12. PG&E Peak Day Electrical Demand Profiles

	Water	Sewer	Crop (Agriculture)
Hour	% of Maximum Demand		
1	0.870	0.993	0.817
2	0.885	0.993	0.776
3	0.874	0.988	0.756
4	0.889	0.993	0.729
5	0.888	0.993	0.729
6	0.908	0.993	0.773
7	0.941	0.993	0.826
8	0.975	0.969	0.911
9	1.000	0.995	0.949
10	0.962	0.995	0.968
11	0.912	0.995	0.989
12	0.830	0.995	1.000
13	0.711	0.995	0.930
14	0.691	0.993	0.948
15	0.706	0.995	0.930
16	0.683	1.000	0.951
17	0.656	0.993	0.944
18	0.653	0.988	0.929
19	0.753	0.988	0.942
20	0.845	0.993	0.944
21	0.878	0.993	0.927
22	0.874	0.995	0.882
23	0.891	0.993	0.841
24	0.882	0.995	0.823

3.1.2 SCE Service Area

SCE reported their peak day hourly water related electrical demand by SIC codes (codes 4941 – water, 4971 – water supply and irrigation systems, 4952 – sewage treatment facilities, and 01 – crop production) for their 2005 peak day and the California ISO peak day (July 20th).

Table 13 provides the Energy Commission 2004 Energy Demand Forecast and compares the Energy Commission peak day forecast values to the SCE reported 2005 peak day values.

Table 13. SCE Area Forecasted Energy and Peak Demand

		2004 Energy Commission Water Sector Forecasted Energy Use (GWH)
Urban Water		1,846
Agricultural Groundwater Pumping		704
Agricultural Surface Water Pumping		86
Sewer/Wastewater		607
-w/selfgen		930
Comparison of Peak Day Average On Peak Demand		
	2004 Energy Commission (MW)	**2005 SCE (MW)**
Urban	233.0	249.0
Agricultural Groundwater & Surface Water Pumping	233.6	138.9
Sewer/Wastewater	171.1	66.4

The reported sewer/wastewater value was less than half of what the Energy Commission reported, but when self-generation by sewer and wastewater facilities was added back into this category, the capacity values are much closer. Since this report is interested in sales of electricity, self-generation is ignored, but it is a big factor in this sector, as SCE area wastewater plants produce a significant amount of the electricity they consume. Based on the 2005 Energy Commission Demand Forecast (Energy Commission, 2005d) in 2004, SCE area wastewater facilities used 930 GWh; producing 323 GWh from self-generation, while purchasing 394 GWh from SCE and 213 GWh from ESPs.

The values provided by SCE for agricultural groundwater and surface water pumping have an unreasonably high annual load factor – SCE's reported annual agricultural load factor is almost 65 percent, far in excess of expected agricultural annual load factors below 40 percent. For this report, the Energy Commission's agricultural demand numbers were judged to be more reasonable and used in this report.

The adjusted SCE reported water supply-related peak day electrical demand by sector is shown in Figure 14. Sewerage electrical demand has a relatively constant shape, while water agency demand has the typical bimodal daily peaks, with maximum demand at 9 a.m.

Agricultural customers demands follow a single daily peak demand profile with a maximum demand around 10 a.m.

Figure 14. SCE Area Water Related Peak Day Electrical Demand

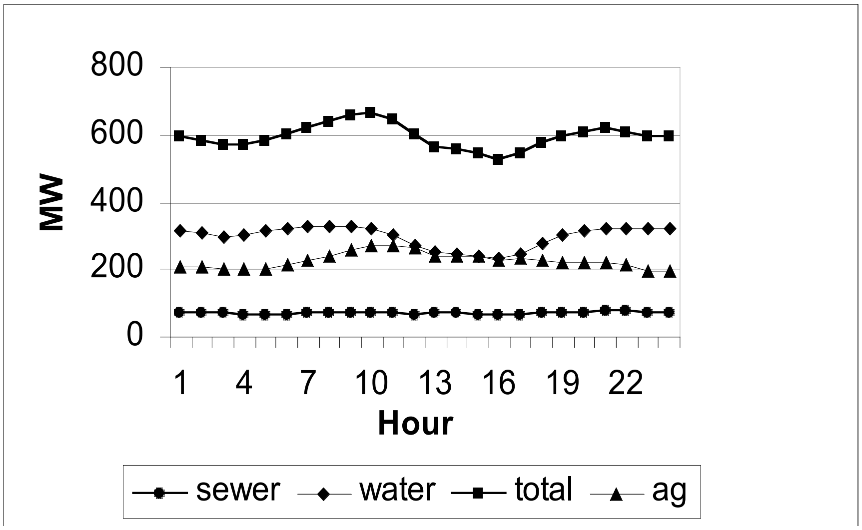


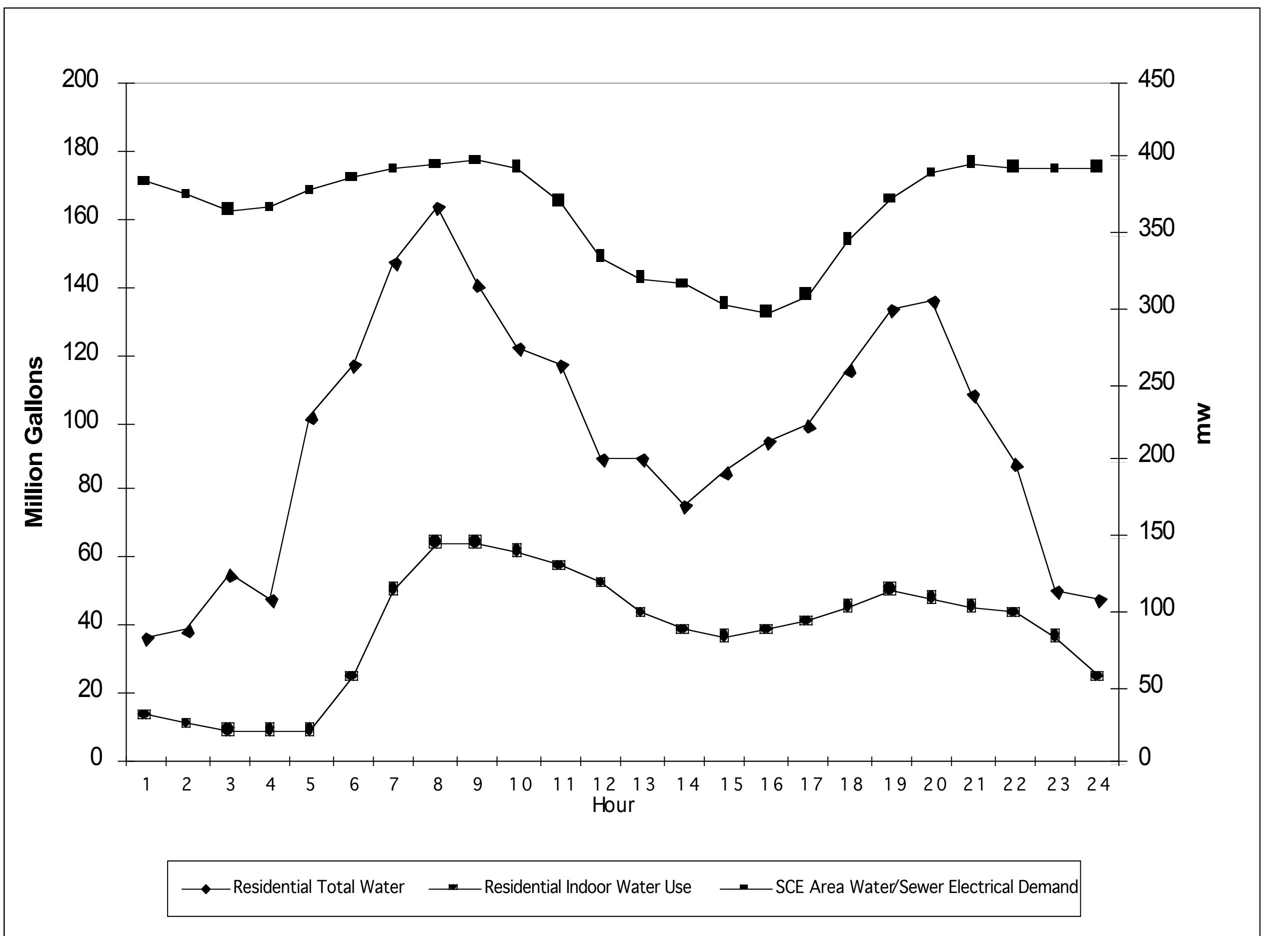
Table 14 shows the characteristics of the SCE area supplied peak day water supply-related demands. Approximately 38 percent of the electricity demand is due to agricultural pumping, with the remaining 62 percent used by the water agencies. As noted earlier, there was no difference between the SCE peak day and the ISO peak day in 2005.

Table 14. SCE 2005 Area Peak Day Water Related Demand Characteristics

	Water/sewer Agency MW	Total Water Demand MW (1)
Peak Period		
ave MW	315.4	549.0
max MW	345.7	572.1
4 pm MW	297.7	522.8
Coincidence with ISO peak		
	1.00	1.00
Mid Peak Period		
ave MW	382.4	618.8
Max MW	397.7	664.2
Off Peak Period		
ave MW	381.9	592.3
Max MW	395.0	635.6
TOU Accounts as % of Peak Demand		
	19%	

Figure 15 shows the residential demand for water determined by this report compared with the SCE water / sewer agency[8] electrical demands. SCE water supply-related electrical demand starts climbing about 5 a.m. to try to keep up with the residential morning peak water demands. The electrical demand drops off during the afternoon as residential water use drops and the water agencies continue to drain their storage, as well as using their natural gas-fired pumps during the afternoon peak period to reduce electrical demand. Electrical demand starts climbing again in the late afternoon to try to keep up with the residential evening peak demands. SCE electrical demand continues to climb throughout the evening as water agencies refill their storage facilities for the next day, even as residential demand drops off.

Figure 15. SCE Area Peak Day Water / Sewer Electrical Demand and Residential Water Demand



8. Water / sewer agency demands do not include individual utility electrical accounts – which are recorded under "crop production" or "agricultural".

SCE areas embedded residential peak water supply-related electrical demand is found in Table 15.

Table 15. California Residential Peak Water Supply-Related Demand Intensity – SCE

	kW/mgal	kW/residence
SCE	1600	0.064
Note: Determined by dividing maximum electricity demand by water deliveries within that utility area.		

The peak day electrical demand profiles for fresh water supply, sewerage, and crop production in the SCE area determined by this report are provided in Table 16.

Table 16. SCE Area Peak Day Electrical Demand Profile

Hour	Water	Sewer	Crop (Agricultural)
	% of Maximum Demand		
1	0.956	0.943	0.778
2	0.935	0.933	0.756
3	0.911	0.906	0.750
4	0.920	0.881	0.741
5	0.953	0.886	0.735
6	0.977	0.887	0.780
7	0.992	0.908	0.837
8	0.997	0.919	0.888
9	1.000	0.941	0.949
10	0.982	0.962	1.000
11	0.921	0.934	0.992
12	0.818	0.891	0.966
13	0.769	0.925	0.890
14	0.758	0.906	0.885
15	0.726	0.889	0.876
16	0.708	0.887	0.831
17	0.741	0.884	0.858
18	0.851	0.898	0.836
19	0.925	0.939	0.819
20	0.967	0.974	0.805
21	0.982	1.000	0.805
22	0.979	0.985	0.788
23	0.976	0.972	0.732
24	0.980	0.974	0.726

3.1.3 SDG&E Service Area

San Diego Gas and Electric (SDG&E) reported their peak day hourly water related electrical demand by SIC codes (codes 4941 – water, 4971 – water supply and irrigation systems, 4952 –

sewage treatment facilities, and 01 – crop production) for both their 2005 peak day (July 22, 2005) and the ISO peak day (July 20, 2005).

Table 17 provides the Energy Commission 2004 Energy Demand Forecast for SDG&E and the peak day forecast values are compared with the SDG&E reported 2005 peak day values. The reported sewer/wastewater value was less than half of what the Energy Commission reported, but when self-generation by sewer and wastewater facilities was added back into this category, the capacity values were quite close. Since this report is interested in sales of electricity, self-generation is ignored, but it is a big factor in this sector, as SDG&E area wastewater plants produce the majority of the electricity they consume.

Table 17. SDG&E Area Forecasted Energy and Peak Demands

	2004 Energy Commission Water Sector Forecasted Energy Use (GWH)		
Urban		181	
Ag Groundwater Pumping		76	
Ag Surface Water Pumping		1	
Sewer/Wastewater		27	
-w/selfgen		67	
Comparison of Peak Day Average On Peak Demand			
	2004 Energy Commission (MW)	**2005 SDG&E (MW)**	
Urban Water	11.7	24.6	
Ag Groundwater & Surface Water Pumping	11.9	6.6	
Sewer/Wastewater	7.4	1.6	
-w/selfgen		7.6	

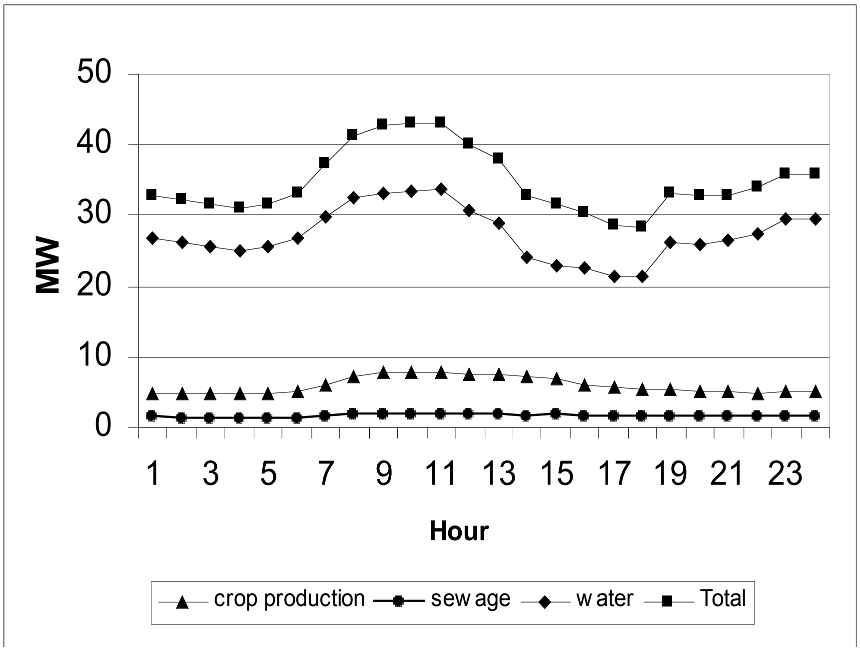
SDG&E reported an unusually low electricity demand by wastewater (sewer) facilities (approximately 1.5 MW). Referencing QFER data supplied by the Energy Commission, from 2000-2004, wastewater treatment facilities averaged utility purchases of electricity of 26 GWh/year (or an average demand of approximately 3 MW), while they produced more than they used (average 2000-2004 self-gen production of 34 GWh). In 2004, SDG&E area wastewater facilities used 67 GWh, producing 40 GWh with their self-gen, and purchasing 27 GWh from SDG&E. These results are summarized in Table 18.

Table 18. SDG&E Water/Wastewater Facility Generation Electrical Generation and Use

Year	SDG&E supplied	Self-generation	Total GWh
2000	27	22	49
2001	27	41	69
2002	25	24	49
2003	26	42	67
2004	27	40	67

The SDG&E reported water supply-related peak day electrical demand is shown in Figure 16. During the on peak period (11-6 p.m. for SDG&E) the average water sector (including agriculture) demand from the Energy Commission 2005 Demand Forecast was 5 percent lower than the utility supplied 2005 data (Energy Commission forecasted on-peak average = 31.1 MW, adjusted SDG&E recorded = 32.8 MW).

Figure 16. SDG&E Water Related Peak Day Electrical Demand



The predominant SDG&E area water related demand is for urban water supply (over 80 percent of the average on-peak demand). Note that the water supply electrical demand peaks at 11 a.m., which falls into SDG&E's tariff designed peak period (11-6 p.m. weekdays).

Table 19 shows the characteristics of the SDG&E supplied peak day water supply-related demands. Approximately 20 percent of the electricity use is due to agricultural pumping, with the remaining 80 percent being provided by the water/sewer agencies.

Table 19. SDG&E 2005 Peak Day Water Related Demand Characteristics

	Water/Sewer Agency	Total Water Demand (1)
Peak Period		
Ave MW	26.2	32.9
Max MW	32.5	40.0
4 pm MW	24.2	30.3
Coincidence with ISO peak		
	0.92	0.93
Mid Peak Period		
Ave MW	31.4	37.8
Max MW	35.5	43.2
Off Peak Period		33.1
Ave MW	28.3	35.6
Max MW	31.0	0.0
TOU Accounts as % of Total Demand		
	28%	

There was little difference between the SDG&E peak day and the ISO peak day. Average on-peak period water related demand only varied by 0.7 percent between the SDG&E peak day and the ISO peak day, while the 4 p.m. ISO water related peak demand was 7 percent lower than SDG&E's peak day value (Figure 17).

Figure 17. Comparison of 2005 SDG&E System Peak Day and ISO Peak Day Water Related Demands

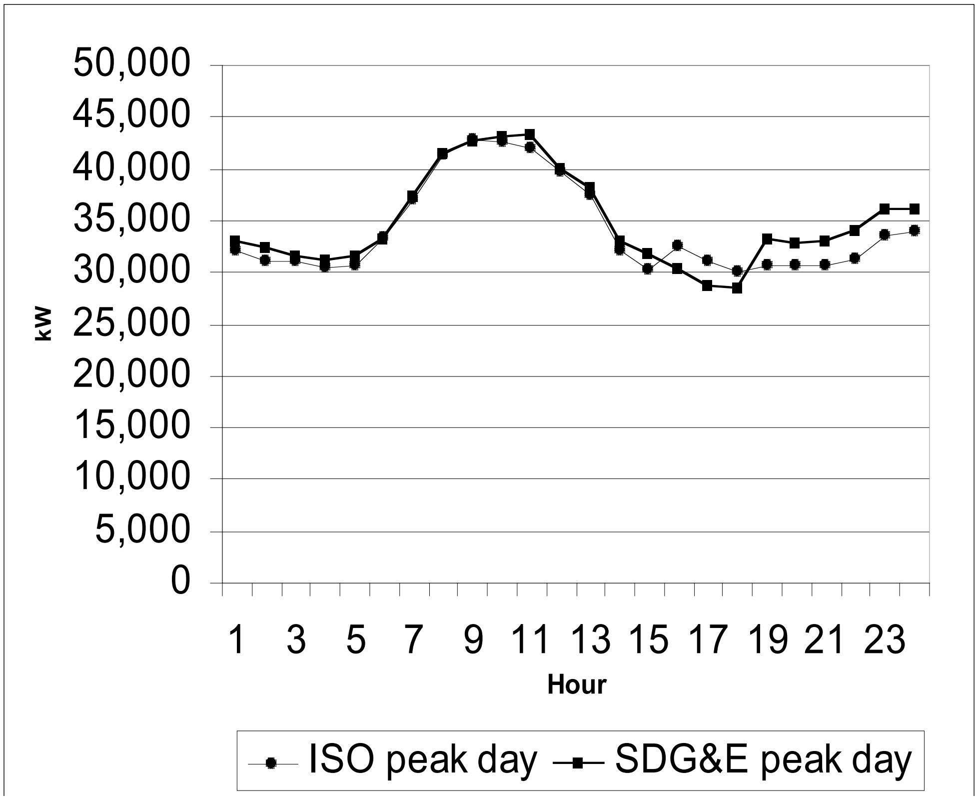
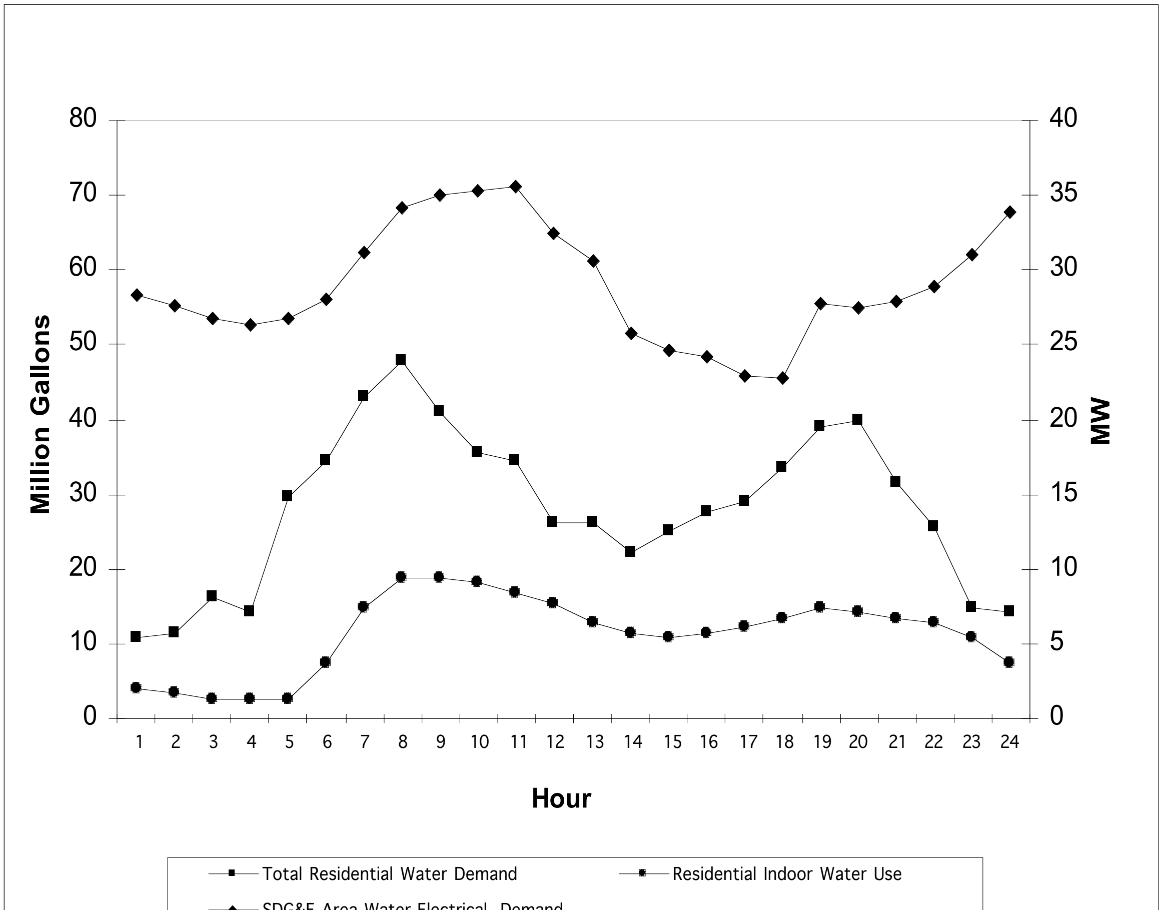


Figure 18 shows the residential demand for water determined for this report compared with the SDG&E water agency[9] electrical demands. Note that the SDG&E electrical demand starts climbing about 5 a.m. to try to keep up with the residential morning peak water demands, drops in the peak period as water agencies continue to drain storage and use their natural gas engines for pumping, and starts climbing again in the late afternoon to try to keep up with the residential evening peak demands and as they turn off their natural gas engines at the end of the afternoon peak period. SDG&E electrical demand continues to climb throughout the evening as water agencies refill their storage facilities for the next day, even as residential demand drops off dramatically.

9. Water agency demands do not include individual utility electrical accounts – which are recorded under "crop production" or "agriculture."

Figure 18. SDG&E Area Water/Sewer Electrical Demand and Residential Water Demand



SDG&E has the lowest embedded residential peak water supply-related electrical demand of any of the utility service areas (Table 20). The San Diego area is at the end of the pipeline. Almost all of their water is treated somewhere else (generally in the SCE service area at the big Metropolitan Water District treatment plants) and shipped to the San Diego area. Stated differently, residential water demand in the San Diego area results in electrical demand increases in the SCE area for treatment and shipping.

Table 20. California Residential Peak Water Supply-Related Demand Intensity – SDG&E

	kW/mgal	kW/residence
SDG&E	475	0.02
Note: Determined by dividing maximum electricity demand by water deliveries within that utility area.		

However, an even greater factor that accounts for the low embedded peak electrical demand for water in the SDG&E area can be found in Table 21. Years of collaboration between SDG&E and the water agencies in the area has resulted in most of the treatment (fresh water and sewer) facilities in this area having their own self-generation, dramatically reducing the utility electrical demand for the water sector as the treatment facilities produce most of their own electricity.

Table 21. SDG&E Area Water Treatment Plants Size and Generation Characteristics

Agency	Treatment Plant	Capacity	Generation	
		(MGD)	(MW)	Type
Escondidio/Vista ID	Escondido/Vista	65	1.9	hydro
Helix Wd	Levy	106		
Olivenhain MWD	Olivenhain	34	0.45	hydro
Oceanside	Weese	25	0.35	hydro
Poway	Berglund	24		
Ramona MWD	Bargar	4	0.5	hydro
San Diego	Alvarado	150	1.99	hydro
			1	solar
San Diego	Miramar	140	0.8	hydro
San Diego	Lower Otay	40		
San Dieguito WD/Santa Fe ID	Badger	40	1.49	hydro
Sweetwater	Perdue	30		
San Diego	Point Loma	240	5.7	biogas
			1.35	hydro
	North County			

The peak day electrical demand profiles for fresh water supply, sewerage, and crop production in the SDG&E area determined by this report are provided in Table 22.

Table 22. SDG&E Peak Day Wate
Electric Demand Profiles

Hour	Water	Sewer	Crop (Ag
	% of Maximum Demand		
1	0.796	0.779	0.60
2	0.776	0.705	0.61
3	0.755	0.676	0.60
4	0.742	0.712	0.60
5	0.754	0.719	0.60
6	0.791	0.719	0.65
7	0.877	0.789	0.79
8	0.960	0.944	0.94
9	0.984	0.971	0.99
10	0.992	1.000	1.00
11	1.000	0.999	0.99
12	0.914	0.994	0.97
13	0.861	0.987	0.96
14	0.724	0.934	0.93
15	0.694	0.985	0.89
16	0.680	0.890	0.79
17	0.646	0.845	0.73
18	0.643	0.823	0.71
19	0.781	0.852	0.70
20	0.775	0.883	0.67
21	0.784	0.834	0.66
22	0.815	0.819	0.64
23	0.872	0.828	0.64
24	0.872	0.812	0.64

3.2 Combined Peak Day Load Profiles

Figure 19 provides the summer peak day load profile for California investor-owned utilities (IOU) water supply-related electrical demands. Summer on-peak[10] water supply-related electrical demand is almost 2,200 MW. Maximum agricultural use demand (of over 1,200 MW) occurs about noon.

10. The on-peak period is defined somewhat differently among the utilities. PG&E's on-peak period is noon to 6 p.m. weekdays from May 1-October 31; SCE's on-peak is noon to 6 p.m. weekdays from June–September, and SDG&E's on peak is 11 a.m. to 6 p.m. weekdays from May 1-September 30. In this section, "on peak" will reference the summer noon to 6 p.m. period.

Figure 19. PG&E, SCE, and SDG&E Summer Peak Day Water Related Electricity Demand

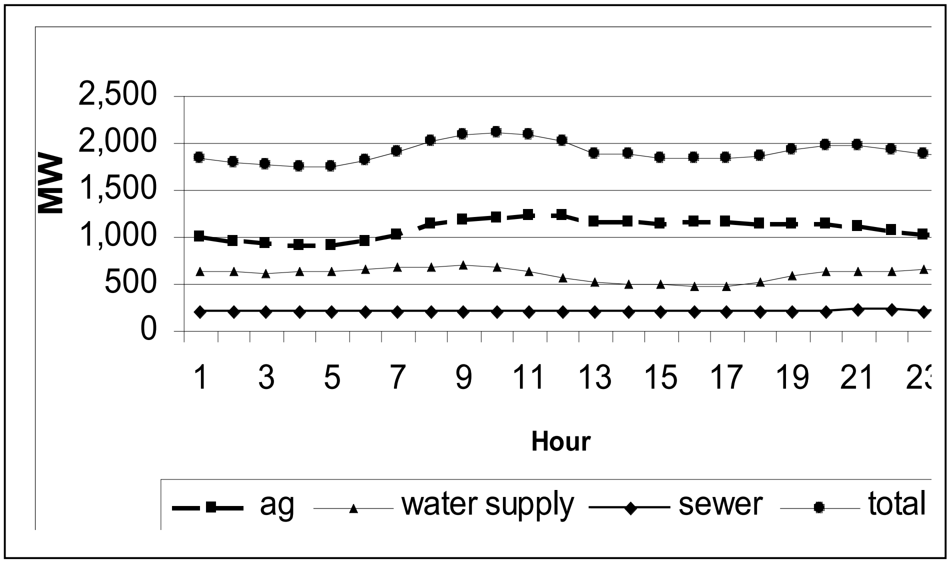


Table 23 shows characteristics of water supply-related peak day demand by service area[11]. Almost 80 percent of the total agricultural pumping demand occurs in the PG&E service area. Note the relatively high percentage of sewage demand in the PG&E area. In the other utility service areas (SCE and SDG&E) the wastewater facilities have a large amount of self-generation, something the wastewater facilities in the PG&E area don't take advantage of.

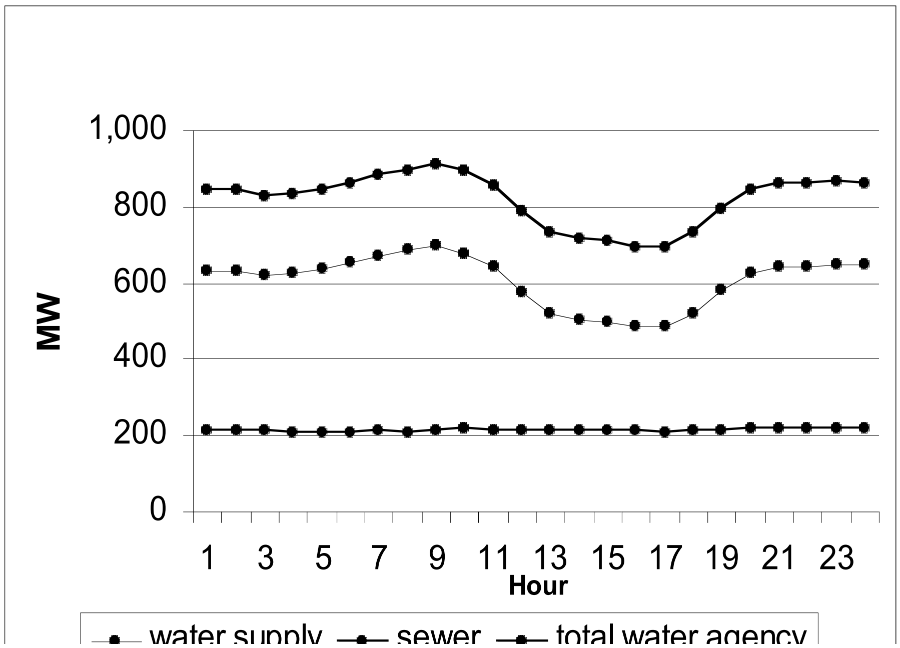
Table 23. Peak Day Demand Characteristics by Utility Service Area

	Ag	Water	Sewer
PG&E	78.2%	48.1%	65.9%
SCE	21.9%	47.1%	33.9%
SDG&E	0.6%	4.8%	0.8%
	Maximum MW (MW)		
PG&E	967	335	143
SCE	271	328	74
SDG&E	8	34	2
	Average on Peak Demand (MW)		
PG&E	907	229	143
SCE	234	249	66
SDG&E	7	25	2

11. This table provides the gives the maximum daily peak demand, regardless of costing period, while the individual utility tables provide the demands by costing period, so the values are not directly comparable.

Figure 20 shows the water/sewer agency peak day electrical demands. Maximum water/sewer agency demand occurs during the morning hours, around 10 a.m. Minimum water agency demands occur in the afternoon around 4 p.m., as the agencies drop almost 225 MW daily during the on-peak period. Statewide, water agencies currently reduce their maximum demand by 23 percent during the on-peak period. Agency electrical demand remains high throughout the night hours, a result of refilling their storage for the next day.

Figure 20. Water/Sewer Agency Peak Day Electrical Demand



The majority of the water/sewer agency demand comes from fresh water use, as well as the majority of the on-peak demand reduction. We noted previously that, at least for the southern part of the state, the sewer / wastewater agencies generate the majority of the electricity they consume. As to be expected, sewerage facilities are an around-the-clock operation, don't usually have a significant ability to store raw sewage for treatment later, and thus have limited options to reduce on-peak electrical demands.

Figure 21 shows the peak day fresh water and sewer electrical demand[12] and total water deliveries to residences. Note that the residential water supply-related electrical demand does not necessarily track water deliveries.

12. Total residential water related electrical demand consists of both fresh water delivered to the residence and wastewater (sewerage) received from the residence.

Figure 21. Residential Water Use and Peak Day Electrical Demands

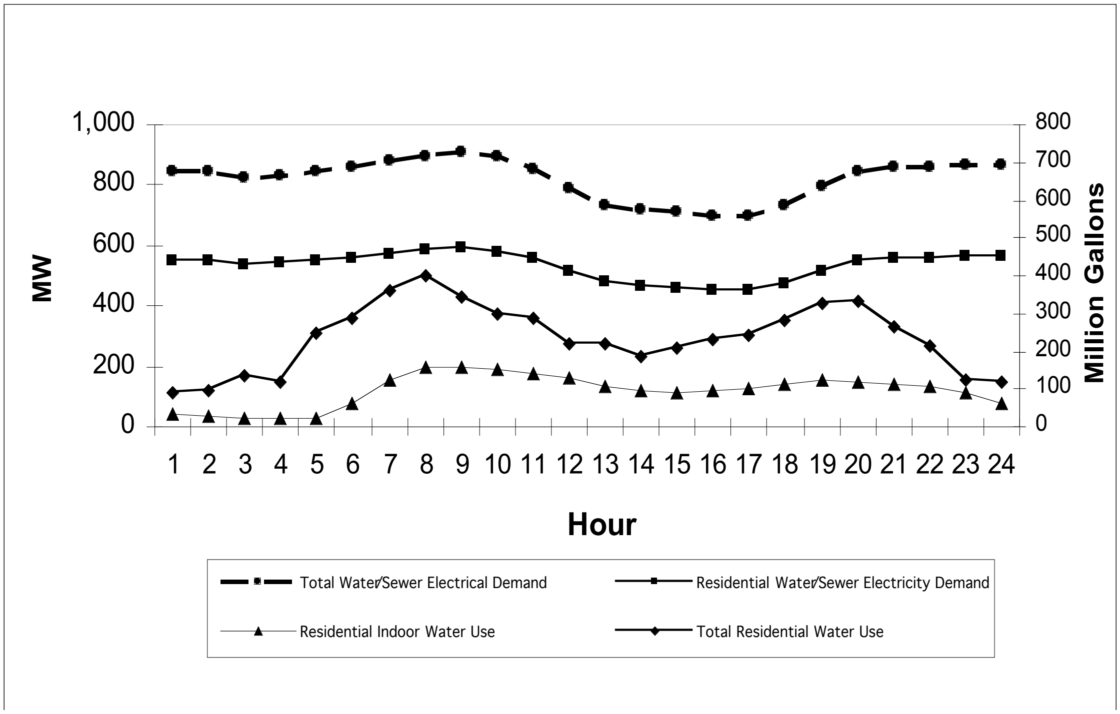


Table 24 provides the summer peak day water related demands by customer class. It should be noted that most (80 percent) of the agricultural demand is found in the PG&E service area.

Table 24. Utility Water Related Peak Summer Demand By Customer Class

Average Water Related Electrical Demand (MW)			
	On Peak	Mid Peak	Off Peak
Residential	502	552	556
Agricultural	1,160	1,180	986
Commercial Industrial	271	297	299
Total	1,925	2,029	1,842

Table 25 provides the peak day water supply-related electric demand profiles for the California investor-owned electric utilities determined by this report.

Table 25. PG&E, SCE, and SDG&E Peak Day Water Electrical Demand Profile

Hour	Water	Sewer	Crop (Agricultural)
	% of Maximum Demand		
1	0.9070	0.9804	0.8136
2	0.9036	0.9762	0.7765
3	0.8860	0.9639	0.7596
4	0.8967	0.9587	0.7366
5	0.9121	0.9604	0.7355
6	0.9350	0.9607	0.7794
7	0.9626	0.9685	0.8342
8	0.9850	0.9577	0.9134
9	1.0000	0.9828	0.9562
10	0.9739	0.9899	0.9829
11	0.9220	0.9806	0.9969
12	0.8295	0.9659	1.0000
13	0.7465	0.9772	0.9289
14	0.7244	0.9691	0.9412
15	0.7144	0.9651	0.9254
16	0.6943	0.9668	0.9309
17	0.6957	0.9607	0.9310
18	0.7458	0.9624	0.9142
19	0.8353	0.9763	0.9207
20	0.8991	0.9916	0.9187
21	0.9224	1.0000	0.9057
22	0.9209	0.9965	0.8668
23	0.9308	0.9906	0.8226
24	0.9282	0.9927	0.8063

3.3 Peak Water Supply-Related Electrical Demand Intensity

Peak water supply-related electrical demand intensity values were determined by taking the maximum water and wastewater related residential electrical demand and allocating it over the amount of water used in that particular utility area. The reason for focusing on residential demand is that because a larger proportion of residences are at higher elevations, residential water has the highest rate of embedded energy. This is useful for setting an upper bound on the valuation of demand reductions or for storage. There has been work on the energy (as opposed to demand) intensity of water deliveries in California. Estimates for the energy requirements (kWh) associated with water use in Northern California range from 4,100 kWh/mgal (PG&E, 2003) to 6,000 kWh/mgal (PG&E, 2003). The amount of energy required is even higher in Southern California, average embodied energy is 8,400 kWh/mgal and marginal water supplies can range as high as 11,000 kWh/mgal (Wilkerson, 2000), this estimate includes the energy required by DWR to ship the water to Southern California. The

2005 California *IEPR* (Energy Commission, 2005c) states that water energy intensity can range from 1,900 kWh/mgal to 23,7000 kWh/mgal. This report determines that peak electrical demand (kW) for water in California averages about 1,445 kW/mgal. Table 26 shows the residential electrical peak demand intensity results.

Table 26. California Residential Peak Water Supply-Related Electrical Demand Intensity

	kW/Mgal	kW/Residence
PG&E	1,650	0.066
SCE	1,600	0.064
SDG&E	475	0.020
Weighted average	1,445	0.059

Note: determined by dividing maximum electricity demand by water deliveries

3.4 Expected Future Peak Day Profiles

Water agencies demand for electricity could more than double during the next decade. Factors contributing to this increased demand include increased treatment requirements, growth of in-ground storage and the desalinization of brackish inland water and ocean water. The Energy Commission estimates suggest that water related electrical demand could increase by 3,500 MW during the next 10 years. These estimates of increased demand can be combined with the peak profiles from Table 25 to yield added demand by usage category. Table 27 shows the estimated new demand and the allocation to usage categories. Desalinization and increased treatment facilities are expected to run rather constantly, so they were assigned to the wastewater/sewage treatment category.

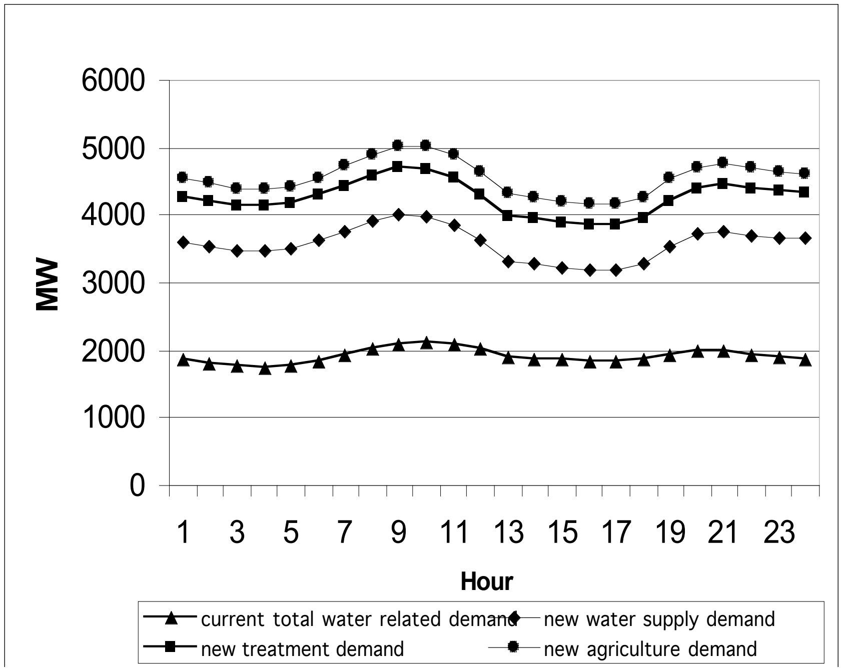
Table 27. Potential Water Related Demand Increase in 10 Years by Category

Source of New Demand (1)	Demand added (1)	Category
Existing conjunctive use in drought/dry years	~350 MW	Water Supply
Proposed conjunctive use development/drought	+1,350 MW	Water Supply
Desalinization -	+500 MW	Treatment sewer
Electrification of Ag diesel pumps	+350 MW	Agricultural
Increased treatment requirements	+160 MW	Treatment sewer
Increased water marketing	+230 MW	Water Supply
Increased recycled water use	+685 MW	Treatment sewer

(1) Source: Energy Commission, 2005a

The predicted new maximum demand for each source of new water related demand can be multiplied by the category hourly profiles (Table 25) to arrive at expected peak day hourly demands associated with the new water supplies. Figure 22 shows current water supply-related electrical demand, and the expected electrical demand if the new water related demands materialize. It should be noted that the demand estimate in this table apply to drought years, since they include the estimate for conjunctive use; normal years would of course have lower needs.

Figure 22. Expected Combined Peak Day Utility Water Supply-Related Demands: 2016



4.0 Impacts of Potential On-peak Demand Reduction

It is critically important for California to get a handle on the water related demand in the state if it is to successfully manage its peak demand in the upcoming years. Water agencies demand for electricity could more than double during the next decade, as increased treatment requirements combine with growth of in-ground storage and the desalinization of brackish inland water and ocean water.

There is a large untapped potential if water agencies could participate in the equivalent of demand side response with water customers via something like time-of-use water meters, and persuade their water customers to shift water use out of the on-peak period.

SCE has approximately 4 million residences[13] in its service area. Table 7 shows that approximately 60 percent of the summer water use is for outdoor uses. If the installation of time-of-use residential water meters would result in SCE residences shifting one-quarter of their outdoor water use out of the on-peak period (noon to 6 p.m. weekdays) a total of almost 40 MW on-peak could be saved in the SCE area:

> 4,062,358 SCE residences * .064kW/household SCE residential peak electricity demand * 60% outdoor water use * 25% of outdoor water shifted out of the on-peak period = 38,999 kW.

If one assumes that residences recover the water they shifted out of the on-peak period over the rest of the day, one can use the SCE water agency load shape in Table 16 to determine the impacts of such a curtailment throughout the day, as Figure 23 shows.

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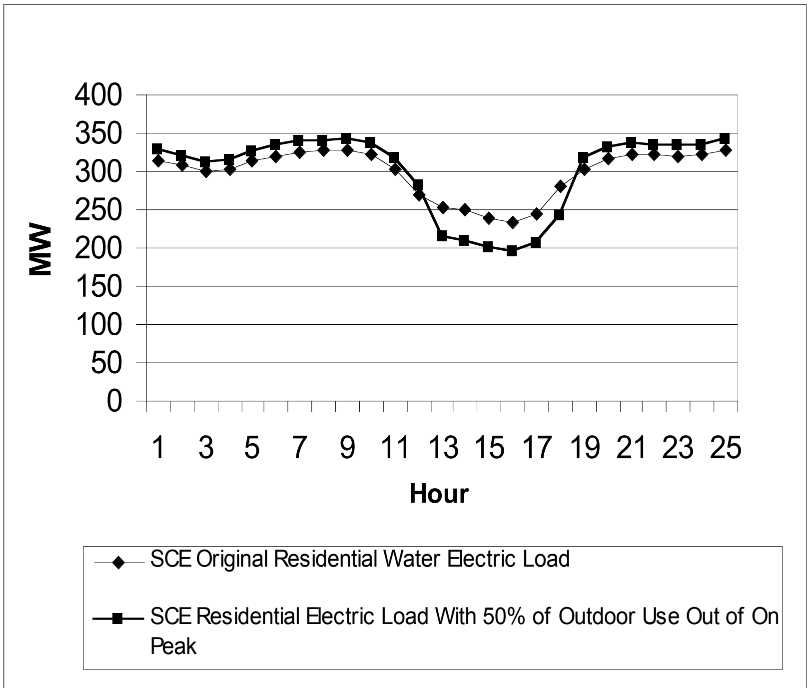
13. 4,062,358 residences that purchase their water supply.

Figure 23. Impact of a 50% SCE On-Peak Reduction in Residential Outdoor Water Use



If residences statewide could be convinced to shift one half of their water use (both indoor and outdoor) out of the on-peak period, a total of approximately 300 MW on-peak electricity demand could be saved:

> 9,993,567 SCE/SDG&E/PG&E residences * .06kW/household average residential peak electricity demand * 50% of residential water shifted out of the on-peak period = 299,807 kW.

Water storage is another method that has a huge on-peak electrical demand reduction potential. There are a number of advantages that water storage has over other electricity storage technologies. Water storage is a technology that water agencies are comfortable with, and all water agencies already own potential water storage sites as part of their long run construction plans. Most of these potential additional water storage sites are located in urban areas, close to the load centers, so additional storage will not only reduce peak electricity demands, it will reduce transmission losses and potentially improve voltage control. Water storage facilities also can serve as multi-function facilities: reducing on-peak electrical demand needs, improving water system operations, contributing to homeland security, and providing reliability and strategic values (such as additional fire-fighting assistance and localized earthquake response).

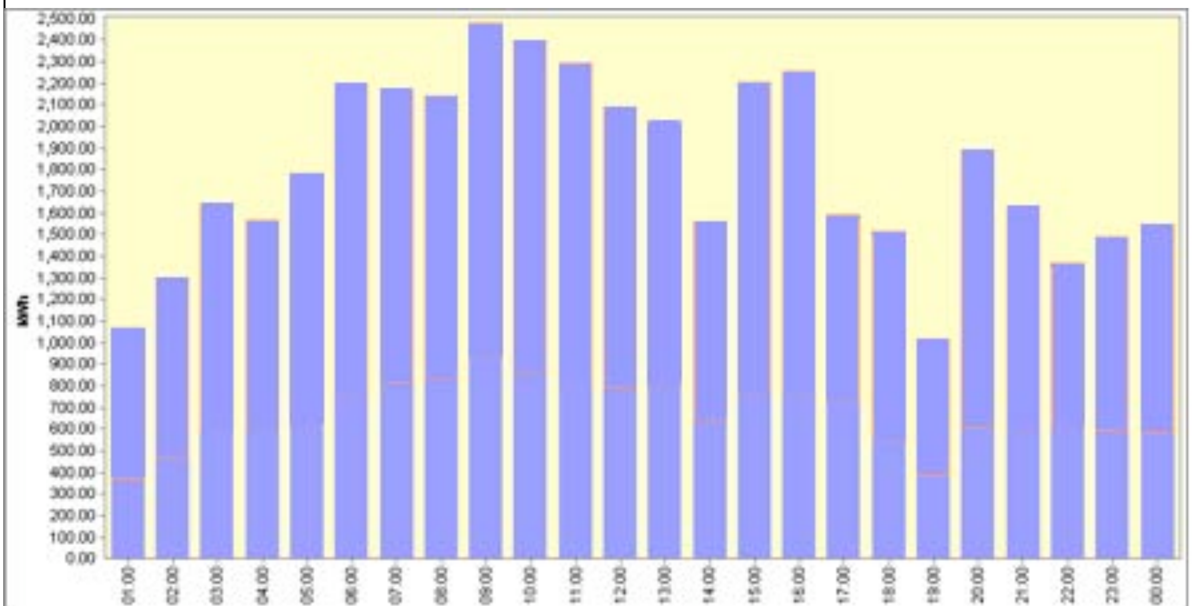
Water storage at elevation is essentially stored electricity. In addition to continued investigation on exotic electric storage technologies (such as flywheels), more research emphasis should be put on additional above ground water storage to reduce on-peak electrical demands as a compliment to the current reason storage is installed – to manage water demands within the water agency. Currently there is little incentive for a water agency to install additional water storage simply to reduce on-peak electrical demands.

The addition of more above ground storage will allow any water agency to shift more pumping demand out of the on-peak period. Most water agencies already have locations reserved for additional storage facilities, but have not constructed them because they do not need them to meet current water demands, and are not sufficiently incentivized to install additional storage as simply a peak electrical demand reduction measure.

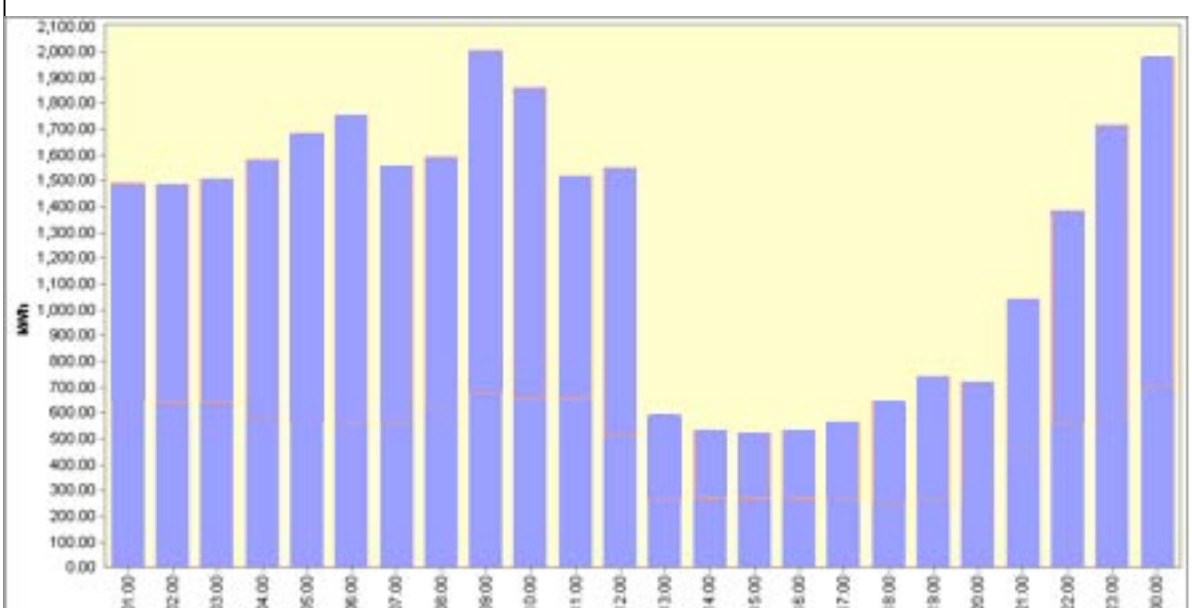
One example, which demonstrates the results of combining more aggressive use of existing storage and adding additional storage is the El Dorado Irrigation District. The District added of an additional storage tank in early 2005, and agreed to allow the tanks to drop to a lower level to reduce pumping during the on-peak period. Over 1 MW of on-peak demand was shifted out of the on-peak period as shown in Figure 24. There are hundreds of MWs of on-peak demand curtailment available from the existing water agency infrastructure.

Figure 24. El Dorado Hills Raw Water Pump Station & Water Treatment Plant Electrical Demand

June 14, 2004



June 14, 2005



5.0 Limitations of this Study

The water agency demand figures provided in this report are likely to underreport actual water agency electrical demand for a couple reasons. First, the industrial classification categories used for reporting consumption may, depending upon the utility allocation to the various industrial categories, miss the water agency office buildings electricity consumption (which may be classified in the "Office Building" category). Second, there is some water pumping in the agricultural category that is really water agency pumping. Particularly in the southern part of the Central Valley, local irrigation districts often have arrangements with private farmers that allow the water agency to spread the water on the land for aquifer recharge, and then use private agricultural wells to pump the water out of the ground for use throughout the system in the summer. This pumping will show up as private agricultural pumping, when it is actually being used by the irrigation district to provide water to their customers.

In assessing the peak demand impacts of water supply and use in California, there has been no attempt to account for changes in the water delivery system. Specifically, it is assumed that future water and sewer treatment facilities are able to supply approximately one-half of their electricity needs through self-generation, as is the current situation. It is also assumed that the water supply systems are able to continue to build storage as their demand increases, and to add natural gas engines for pumping during the on-peak periods. If these assumptions do not prove to be true, the growth in water related electrical demands may be even higher than predicted.

Another caveat is that the Energy Commission forecast figures for Ag/groundwater pumping are considerably different from those reported by the utilities. In all three cases the Energy Commission forecast is approximately double the utility figure. Resolving this discrepancy was not possible within the scope of this study, but the estimates in these sectors should be considered carefully.

Water systems are different from electrical systems in several significant ways. While electricity generation and delivery is essentially instantaneous, transit through a water system is considerably slower. There is a lag time of often several hours between the input of water into the system and the use of that water by a customer (or in the case of large wholesale water systems, the lag time can be several days). This means to meet the 8 a.m. residential water peak demand, additional water must be entered into the system starting at about 5 a.m. -with a resulting increase in electrical demand. The influx of wastewater from the morning period hits the wastewater treatment system sometime after 10 a.m.

A second very significant difference between water systems and electrical systems is that virtually all water systems have varying amounts of storage, particularly the urban systems. Water treatment facilities are typically operated on a rather continuous basis and when water demands are low the treated water is put into storage. When water demands are high water is shipped directly from the treatment facilities as well as being taken from storage to meet demand. The morning peak water demand period is typically the design criteria for a water system, when almost all facilities are operating at close to their maximum output, and storage is being drained to meet the demand. Maximum water agency electrical demand occurs at 10 a.m.

Figure 21 clearly shows this phenomenon in action. During the late evening and early morning hours water agency electrical demand remains high, as storage is being refilled for the next day. As residential demand decreases throughout the day, electrical demand also decreases until the evening, when electrical demand increases again to meet the evening peak demand, and the water agency starts refilling storage. The on-peak period (afternoon) electrical demand is also reduced by some water agencies that turn on natural gas engines during the afternoon to avoid peak demand charges.

There are some significant caveats regarding the residential electrical peak demand intensity figures reported here. The problem is that water is shared among electric utility service areas, and isolating the analysis to electric utility service area boundaries gives a distorted perspective. As noted earlier, the San Diego area is at the end of the pipeline, and has the lowest embedded peak electrical demand for water. Almost all of their water is treated somewhere else (generally in the SCE service area at the big Metropolitan Water District treatment plants) and shipped to the San Diego area. Increases in residential water demand in the San Diego area results in electrical demand increases in the SCE area for treatment and shipping.

Electricity in the water sector is used not only to treat and move water, but also to maintain pressure within the water system. Water agencies generally try to maintain system pressure between 40 pounds per square inch (psi) and 80 psi. Below about 30 psi the customer will usually need to install a booster pump and above 80 psi the customer needs a pressure regulator. During periods of high water demand, not only is a lot of water being pumped through the system, but the pressure drops, necessitating the use of localized pressure pumps to maintain adequate pressure. Temporary low pressure can be caused by heavy water use: a lot of lawn watering, fighting a nearby fire, lots of people taking showers, etc. Residential customers are typically the sector that require the greatest use of pressure increasing pumps, as they are often at higher elevations, have a lot of separate customers on an individual line, and are typically the furthest removed from the treatment facilities, all of which contributes to the residential sector having the highest embedded energy of any water sector. It is also worth noting that low pressure is more than just a nuisance: the water system depends on pressure to keep out any contamination, and if the pressure drops, the possibility of pollutants entering the drinking water system through small fissures in the system increases significantly.

6.0 Further Research

While the water sector is currently one of the largest concentrated sources of on-peak electrical demand reduction in the state, there are hundreds of additional mega-watts that can be curtailed in this sector. Various avenues are possible for reducing on-peak demand in the water sector: a more aggressive use of existing storage, the addition of more above ground storage, the ability to self-generate – either add electric pump alternatives (primarily natural gas engines) to do pumping in the on-peak period or add self-generation for constant operations, and the shifting of water agency customer water use out of the on-peak period via time-of-use water meters and tariffs or other means.

6.1 Storage

Contrary to conventional assumptions, additional water storage to reduce on-peak electrical demands often does not result in additional energy (kWh) use, as the El Dorado Irrigation District results cited above have shown. The addition of more storage usually allows water to be pumped to a lower head, at least until the storage is close to filling up, resulting in decreased electricity use. Additionally, water in storage at elevations supplies pressure to the system, which can reduce the need to run pumps to maintain sufficient pressure in the system during periods of high water use.

Additional research on water storage should include: 1) quantification of the number of currently available unused storage sites and potential storage size, 2) estimates of potential on-peak demand reduction available from additional water storage, 3) identification of necessary incentives to entice water agencies to add additional storage for electrical demand reduction, 4) estimates of the costs of additional storage, 5) investigation of the response potential of water storage (how quickly facilities can go from pumping to draining, what proportion of storage can be dedicated to electric demand response as opposed to water use).

6.2 Time-of-Use Water Meters and Tariff Development

Currently there are few mechanisms available to convince water customers to reduce their water demand during the on-peak period, other than public relations appeals. Water is universally volumetrically metered, so it does not matter when a water customer uses the water, they will pay the same amount for the water. Time-of-use tariffs have proven very effective in modifying customer behavior in the electric sector – one would expect similar responses in the water sector.

While there is a great potential in this area, there are significant thresholds to overcome before water can be priced by time-of-use. Time-of-use or interval meters for water have only recently become available, and water agencies have no experience with this type of meters or the necessary meter reading[14]. There are also no time-of-use water tariffs currently in use, and

14. With the exception of a couple isolated test programs currently being installed in California.

the development of such tariffs is a complicated task that most water agencies are not prepared to do.

Additional research needs to be done on the application of time-of-use pricing for water use before it can be an accepted alternative. The availability, installation, and application of time-of-use water meters for the various customer classes needs to be demonstrated. Time-of-use water tariffs need to be developed. Additionally, research on the impact of time-of-use water meters and tariffs on shifting water demand, and the resultant electrical demand shift, needs to be demonstrated. The potential benefits in this area are significant, and could be relatively painless to achieve.

We have already identified a water agency - Coachella Valley Water District, and a utility – SCE, that are interested in participating in a demonstration project for time-of-use water metering. This project would develop standards for time-of-use water meters and their installation, develop template time-of-use water tariffs, and install and monitor time-of-use water meters in residential (and commercial and industrial) facilities to demonstrate the feasibility of time-of-use water metering and to assess the potential impact on water time-of-use on water agency peak electrical demand needs.

6.3 Water Agency Self-Generation Potential and Barriers

Table 28 provides the current generating capacity of the water agencies in California. Water agencies have more than their on-peak electrical demand in existing generation.

As essential services providers, water agencies in California are required to have sufficient back-up generation to maintain the critical portions of their system in event of an electrical outage. Water agencies have over 500 MW of back-up generators, with over 200 MW in the South Coast air basin alone. The existing back-up generation is diesel – due to requirements for on-site fuel storage in event of earthquakes. Operating permits generally prevent water agencies use of back-up generation to prevent blackouts, they can only use them after a blackout has occurred.

Table 28. Existing California Water Agency Generation

Generation Type	Existing MW			
Back-up	500			
Natural Gas Engines	unknown			
Hydro-electric	1,631	Breakdown of hydro-electric		
		Size	No. of facilities	MW
		< 1 MW	42	20
		1-10 MW	54	215
		10-100 MW	25	790
		> 100 MW	3	606
		Total	124	1,631
Biogas	38			
Solar	5			

The Association of California Water Agencies (ACWA) has identified over 590 MW of additional generating capacity that could be installed by water agencies in the state, including over 250 MW of in conduit small hydro generation, but noted that a number of barriers to the deployment of this potential generation exist (Energy Commission, 2005a). Further research needs to be done on identifying the specific potential sites, potential generation options, and total potential generation available from water agencies in the state, in addition to the reasons that this potential generation is not being developed.

In certain southern parts of the state, the water/sewer treatment facilities make more than half of the electricity they consume through self-generation. This self-generation is conspicuously missing from the treatment facilities in the PG&E area. An assessment of the availability and cost of self-generation options available to water agencies should be done, and barriers to the implementation of self-generation within the water community, particularly in the PG&E area, should be identified and recommendations for resolution should be developed.

6.4 Commercial/Industrial Water Use Profiles

The lack of typical commercial/industrial water use profiles hampers the assessment of the potential demand response available from shifting water use in the commercial/ industrial sector. Additional research in this area would include monitoring selected industries and developing hourly water use profiles for those industries. With such information, industries that have a lot of on-peak water use could be identified and targeted for reductions in water use during the on-peak periods.

The commercial/Industrial sector has one advantage the other sectors do not – they can install on site storage of water sufficient to meet their on-peak water pumping demand, provided there are adequate incentives to persuade them that this is an economic solution. Such options currently do not exist, but should be investigated as part of the commercial/industrial water use profile analysis.

6.5 Discrepancies in Reported Agricultural Pumping

There is substantial variation in the amount of agricultural pumping reported by the utilities and that found in the Energy Commission peak demand forecast. Further research needs to be done to determine whether this discrepancy in agricultural water pumping requirements is simply a definitional problem, or something more fundamental.

7.0 Conclusions

California's Water supply-related electrical demand exceeds 2,000 MW on-peak days. Agricultural groundwater and surface water pumping are almost 60 percent of the total water supply-related peak day electrical demand, with the majority (80 percent) of this agricultural demand in the PG&E area.

Water agency demands compose 40 percent of the water supply-related peak electrical demands in the state, with the majority of this demand being for fresh water supply. Sewer/wastewater facilities, at least in the southern part of the state, self-generate a major portion of the electricity they use. Water agencies in California currently drop almost 25 percent of their electrical demand during the on-peak hours by using storage and alternative pumping schemes, and in response to afternoon reductions in residential water demands.

Over 500 MW of water agency electrical demand is used for providing water/sewer services to residential water customers. An average residential embedded peak electrical demand intensity is estimated at 1,445 kW/mgal and .06 kW/residence.

Water related electrical demand is expected to grow by as much as 3,500 MW over the next 10 years.

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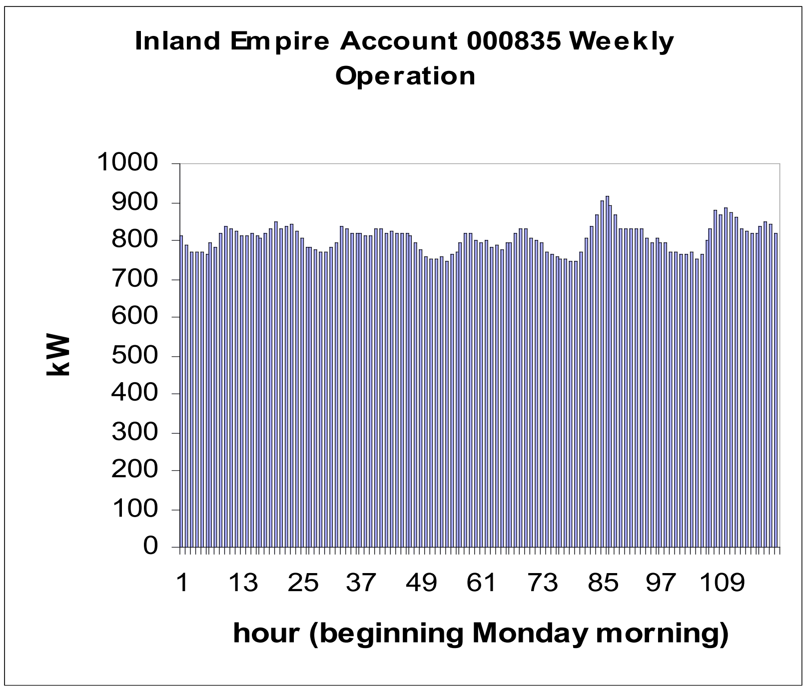
Attachments

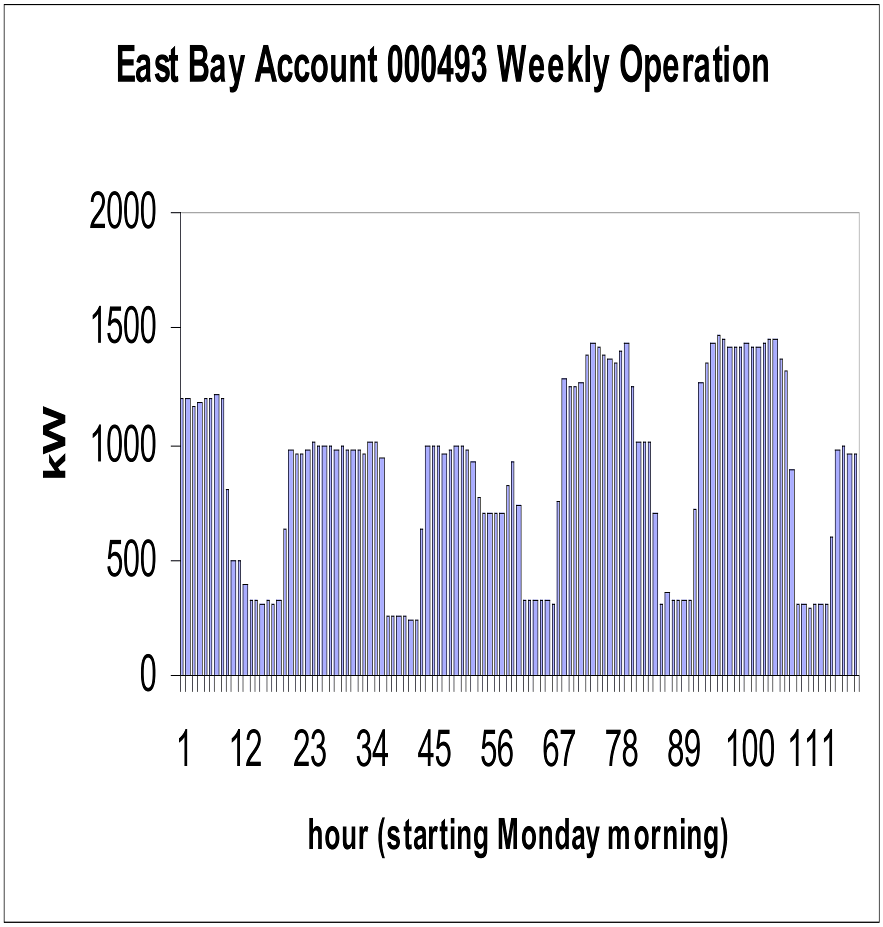
Attachment 1. Sample Water Agency Account Profiles

As part of this analysis we obtained data for hundreds of water agency accounts. The actual electrical use of each account was dictated by where it was within the particular water agency system and what water demands that account was serving. The following are typical of two different system level water agency accounts.

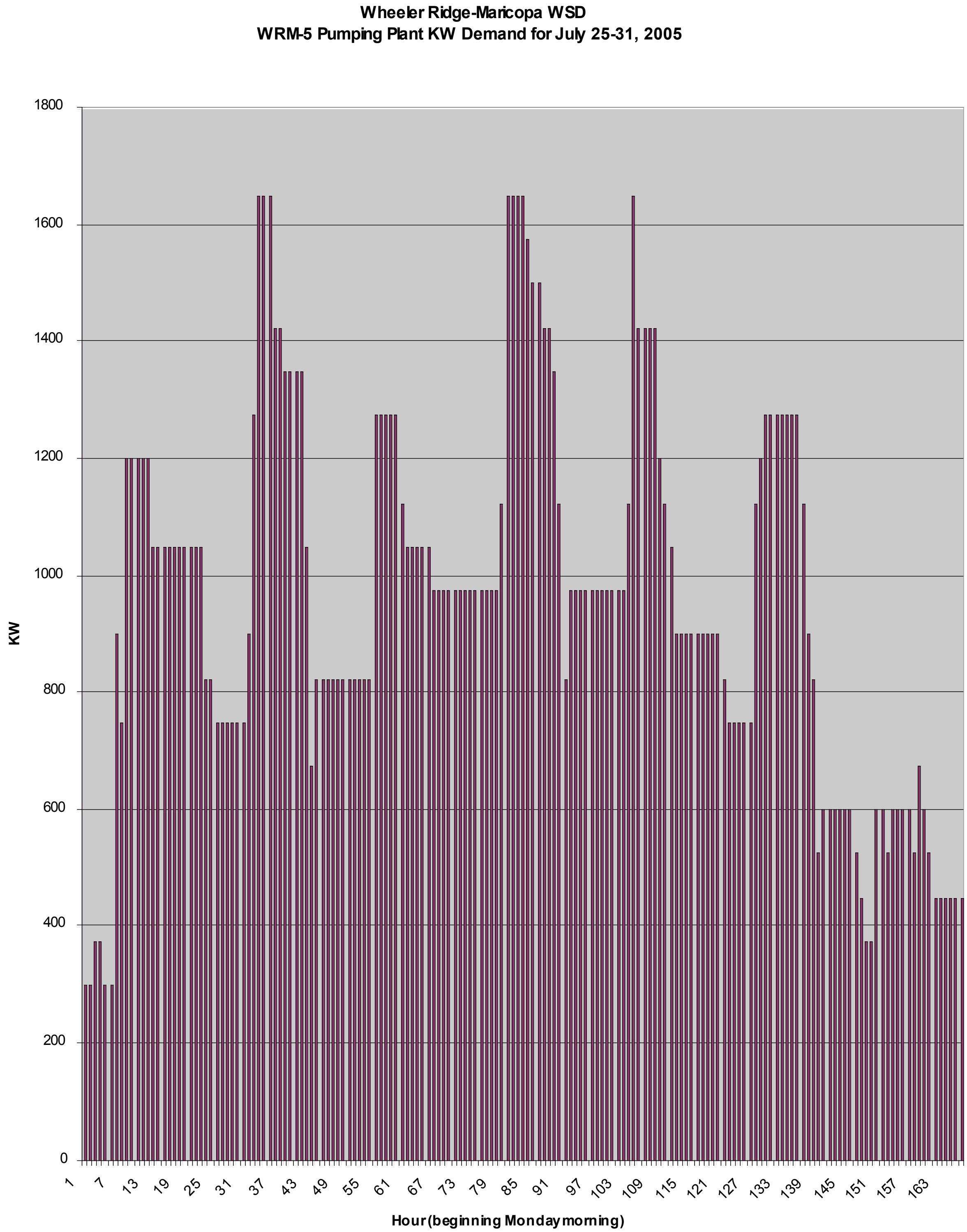
The following is an example of a water agency account with no storage available.



Contrast that with a water agency account that has storage available and uses it to reduce demand during the peak periods.



The following is a peak day profile from one account of Wheeler Ridge-Maricopa Water Storage District. Wheeler Ridge-Maricopa WSD serves 147,000 acres (230 square miles) of land in Kern County with water for crops including cotton, safflower, wheat, alfalfa, carrots, lettuce, melons, onions, peppers, potatoes, tomatoes, wine and table grapes, almonds, pistachios, lemons, oranges, asparagus, walnuts, plums, and grapefruit. For this account no water storage is available, so the electricity use mirrors the agriculture water supplied during each hour.


Wheeler Ridge-Maricopa WSD
WRM-5 Pumping Plant KW Demand for July 25-31, 2005
KW
Hour (beginning Monday morning)
0
200
400
600
800
1000
1200
1400
1600
1800

Attachment 2. Reviewers Comments

Each utility was invited to provide comments on this document, only PG&E took that option.

Pacific Gas and Electric Company Comments

PG&E wishes to thank Dr. House for his effort in preparing this Water Related Electricity Demand in California Report and to express our appreciation for the opportunity to review and comment on the document. PG&E believes that the goal of reducing water related energy consumption during system peak is laudable. Furthermore, PG&E fully supports and vigorously promotes Energy Efficiency as well as Load Management and Demand Response in the water treatment, delivery and disposal customer market segment. This Water Related Electricity Demand Report is an excellent starting point in a heretofore unexplored area of research. We emphasis "starting point" since there is an absence of a robust body of research in this area. PG&E suggests the prudence of undertaking additional research to better understand the interrelationship between water and peak electrical demand as well as the market potential for Energy Efficiency and Demand Response. As such readers of this document should exercise caution when making conclusions based on such a limited body knowledge.

The peak load estimation data that PG&E provided to Dr. House to assist in this report's preparation contained load profile estimates per the specifications requested by Dr. House. Although Dr. House requested 2005 load data, PG&E provided 2004 data as 2005 data was simply unavailable. For 2004, both the PG&E and ISO peaks occurred on September 8th, 2004 at 16:00 hours. A portion of the analyses requested by Dr. House contain less than 30 sample points resulting in less statistically robust estimates. The numbers PG&E delivered to Dr. House are consistent with the peak numbers provided to the CEC in PG&E's 2004 CEC Load Data Delivery for the Water Pumping and Agricultural Sectors. PG&E Load Research Analysts are confident in the magnitude of the numbers provided.

There are variations in the data that appear in the report with data that was provided Dr. House. Some of these variations are minor while others are more significant. It is unclear as to the reason for the discrepancy however PG&E's assumption is that other data sources including CEC forecast estimates may have been used.