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Embedded Energy in Water Studies
Study 2: Water Agency and Function Component Study and Embedded Energy-Water Load Profiles

Prepared by
GEI Consultants, Inc./Navigant Consulting, Inc.

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Contra Costa Water District
East Bay Municipal Utility District
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Inland Empire Utilities Agency
Los Angeles County Sanitation District
Marin Municipal Water District
Monterey Regional Water Pollution Control Agency
Natomas Mutual Water Company
Orange County Sanitation District
Orange County Water District
Rancho California Water District
San Gabriel Water Company
San Jose Water Company
Semitropic Water Storage District
Sonoma County Water Agency
Suburban Water Systems
The City of Calexico
The City of Oceanside
Valley Center Water District
Westlands Water District

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Abbreviations and Acronyms

ACWA	Association of California Water Agencies
AF	Acre-foot
ATT	Advanced Treatment Technologies
CASA	California Association of Sanitation Agencies
CEC	California Energy Commission
CIEE	California Institute for Energy and Environment
CPUC	California Public Utilities Commission
CRA	Colorado River Aqueduct
CVP	Central Valley Project
CVWD	Coachella Valley Water District
CWA	California Water Association
DWR	California Department of Water Resources
EC	Energy consumption
EDR	Electrodialysis Reversal
EM&V	Evaluation, Measurement & Verification
EPRI	Electric Power Research Institute
ESRI	Environmental Systems Research Institute
GIS	Geographic Information System
GUI	Graphical User Interface
GWH	Gigawatt hours
IID	Imperial Irrigation District
IOU	Investor-Owned Utility

kWh	Kilowatt hour
kWh/AF	Kilowatt hours per acre-foot
LADWP	Los Angeles Department of Water and Power
MBR	Membrane bio-reactor
MID	Modesto Irrigation District
MMBTU	Million British Thermal Units
MWD	Metropolitan Water District of Southern California
NAICS	North American Industry Classification System
PWRPA	Power and Water Resources Pooling Authority
RFP	Request for Proposals
RO	Reverse Osmosis
SCVWD	Santa Clara Valley Water District
SDCWA	San Diego County Water Authority
SFPUC	San Francisco Public Utilities Commission
SIC	Standard Industrial Code
SWP	State Water Project
TDS	Total dissolved solids
USBR	United States Bureau of Reclamation
UV	Ultra-violet
WELP	Water Energy Load Profiling Tool

Executive Summary

Background and Context

Following the California Energy Commission's landmark finding – that water-related energy uses account for nearly 20% of the state's total energy requirements – on January 19, 2007, the California Public Utilities Commission (CPUC) initiated a formal proceeding investigating California's water-energy relationships (Application 07-01-024). Although water-energy relationships are interdependent, water systems and operations impact energy resources and infrastructure, and vice versa. The focus of this investigation is on the former; i.e., water sector impacts on the energy sector.

> In 2005, the California Energy Commission estimated that water-related energy accounts for about 19.2% of the state's electricity requirements and 30% of non-power plant related natural gas consumption. These estimates included both direct electricity use by water and wastewater systems (4.9%) and operations, and electricity used in the consumption of water (14.3% for heating and pumping water during end use). Natural gas consumption occurred principally in the water end use segment – very little natural gas is used in the transport or treatment of water by water agencies.

There are two distinctly different types of water impacts on the energy sector:

- ***Energy Use by the Water Sector***- the amount, timing, and location of energy needed to support water sector operations.
- ***Energy Use by Water Customers*** - the amount of energy used by water customers during the consumption of water, whether for pumping, heating or other purposes.

California's investor-owned energy utilities already have many programs designed to help the water sector and their customers (water users) reduce their direct energy use. The CPUC is currently considering the following policy issues:

1. Whether energy embedded in water can be quantified and relied upon as an energy efficiency resource, and
2. Whether it is worthwhile for the CPUC to pursue energy efficiency through water conservation programs.

The CPUC's energy efficiency policies do not presently recognize energy embedded in water. Since this is a new area of study, there is no established methodology for computing water-related embedded energy. In addition, as the Study Team can vouch, data is not presently captured at the level and type needed to support these computations. While it is clear that measurement of embedded energy will not be a simple task, the potential for significant energy savings and associated greenhouse gases (GHGs) and other resource and environmental benefits is compelling.

Scope of this Study

In its Decision 12-07-050 on December 20, 2007, the CPUC authorized water-energy pilot projects and three studies designed to (a) validate claims that saving water can save energy, and (b) to explore whether embedded energy savings associated with water use efficiency are measurable and verifiable. The CPUC engaged the California Institute for Energy and Environment (CIEE) to manage the conduct of the three studies. The team of GEI Consultants, Inc. and Navigant Consulting, Inc. (the Study Team) was engaged to conduct two studies:

- Study 1 - Statewide and Regional Water Energy Relationship Study
- Study 2 - Water Agency and Function Component Study and Embedded Energy -Water Load Profiles

Another firm, Aquacraft, Inc., was selected to conduct Study 3 - End-Use Water Demand Profile Study. A Technical Working Group comprised of staff and consultants from CIEE and the CPUC was formed to provide guidance in the conduct of these studies.

This report presents the detailed findings of Study 2 that involved collection, analysis and compilation of detailed water and energy data from 22 water and wastewater agencies throughout the state that were deemed to collectively represent more than 90% of the primary types of energy impacts of California's water sector. In Chapter 5, we also present a structured framework for computing energy embedded in water that integrates the findings of Studies 1 and 2.

Study Goals and Objectives

CPUC Decision 07-12-050 stipulated the following goals for Study 2:

- "Develop [a] representative range of energy intensities for water agencies in California, and representative ranges of energy intensities for the various *functional components* of the water system in California."[1]
- "Develop [a] representative range of water energy load profiles for water agencies in California, and representative ranges of energy load profiles for the various *functional components* of the water system in California."[2]

To achieve these goals, the CPUC requested that the following data be collected and compiled for each participating water and wastewater agency:

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[1] CPUC Decision 07-12-050, Appendix B, p.5.
[2] CPUC Decision 07-12-050, Appendix B, p.9.

1. Water deliveries for seven “representative” days (winter high, low and average water demand; summer high, low and average water demand; and energy use by the water system on the peak energy day of the serving energy provider)
2. Quantity of energy used by each representative water agency for the representative days by functional component
3. Embedded energy in water “for both the system and functional components” for the seven “representative” days
4. Marginal water source and the embedded energy of that water source
5. Twenty-four (24) hour energy load profiles by water “functional component” and for the agency’s system overall (at a minimum, for the 7 representative days)

In addition, the CPUC requested the “expected range of embedded energy by energy utility.”

To conduct this work, detailed data about water operations and associated energy consumption needed to be collected from thousands of meters and operations records in many different formats and media. Since the CPUC requested 24 hour energy use profiles by functional component, the Study Team targeted hourly data wherever available. Many energy uses, however, are not recorded on an hourly basis. Similarly, while some water operations data (volume of water pumped or treated) were available on an hourly basis, most available data were provided on a monthly basis with a smaller population able to provide some daily water data.

In order to streamline and expedite the process of analyzing and compiling these disparate forms of voluminous data, the Study Team developed a Water Energy Load Profiling Tool (WELP) in Microsoft Access 2007. In addition to assuring that data was compiled consistently for all participating agencies, the WELP Tool enabled the Study Team to increase the population of water and wastewater agencies studied within the Study 2 schedule and budget from the initial fifteen (15) requested in CIEE’s Request for Proposals to twenty two (22).

“Energy Intensity” (EI) refers to the average amount of energy needed to transport or treat water or wastewater on a per unit basis. For Study 1, energy intensity is the amount of energy used to collect or produce water, and then to transport wholesale water. “Supply and Conveyance” energy intensity is reported net of any in-conduit hydropower generated during the process of delivering the water through that conduit. For Study 2, energy intensity is defined as the amount of energy needed to treat or distribute agricultural or urban water, to treat wastewater effluent, and/or to treat and deliver recycled water, expressed in kilowatt hours per acre-foot of water [kWh/AF] or in kilowatt hours per million gallons [kWh/MG], depending on the unit appropriate to the type of system or operation.

Summary of Findings

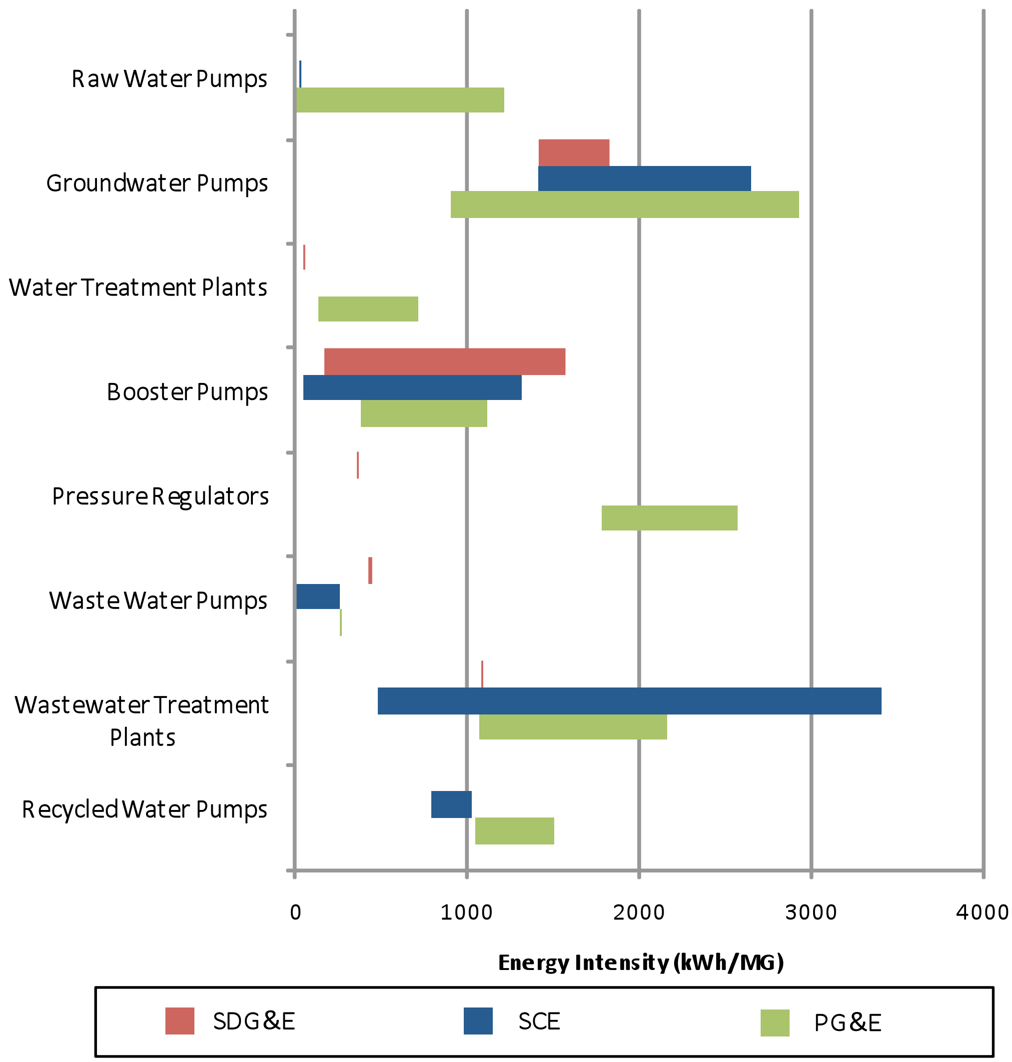
The Study Team attempted to identify clear patterns in the amount and timing of energy used by water and wastewater agencies that could support development of a methodology for evaluating the amount of energy embedded in water upstream of water end use, and energy embedded in wastewater systems downstream of water end use. To facilitate comparison across water and wastewater systems of different sizes, water and energy data was converted to a common metric, "energy intensity," the amount of energy needed to transport or treat a unit of water.

Prior studies hypothesized that certain types of water and wastewater systems and functions had similar energy drivers. Thus, while it was recognized that every agency had a unique mix of resources, plant configurations, systems and processes, it seemed reasonable to expect that some patterns could be found for certain functions. For example, prior studies documented distinctly different energy characteristics of large wholesale water conveyance systems with respect to the amount of energy needed to traverse the distances and elevations needed to deliver water supplies to their customers. The energy use profiles of the state's wholesale water systems were documented in Study 1. Similarly, the energy use by any system that transports water, including water and wastewater distribution systems that were documented in Study 2, is determined principally by the distances and elevations over which that water or wastewater must be transported. These energy drivers are unique for each agency's service area and customer base. The Study Team expected to see, and did observe, large ranges of energy intensity in the distribution systems studied.

For the treatment segment of the water use cycle, however, whether for water or wastewater, the Study Team did expect to be able to find a reasonable range of energy use experience for certain key energy drivers. Engineering studies are able to predict within a reasonable range the amount of energy needed to disinfect and purify water through technologies such as reverse osmosis, ozonation and ultraviolet light treatment. However since each treatment plant configuration is customized for that agency's resources, service area and customer base, the results were highly variable, even within key energy driver(s) and/or functional components of the water use cycle.

Figure ES-1 depicts the wide range of energy intensities observed through Study 2 by functional water and wastewater component and by IOU service area. Note that the objective in Study 2 was to depict the *range of energy intensities* (EIs) experienced by functional water and wastewater component within each of the IOUs' service areas. Thus, while these EIs are representative of the range of experience observed, they are not based on a statistical sample and thus cannot be used to extrapolate total water-related electricity consumption within each IOU's service area.

Figure ES-1. Energy Intensity Range by Functional Component for Each IOU (kWh/MG)



Based on the data collected through Studies 1 and 2, the Study Team found that electricity use by the water sector is higher than the CEC's conservative 2005 estimate of 5 percent of statewide electricity requirements. By combining data from both Studies 1 and 2 and comparing them with the CEC's prior estimates, the Study Team believes that water sector electricity use is at least 7.7 percent of statewide electricity requirements, and could be higher. The significance of this finding is that the amount of energy deemed embedded in water is likely understated. The bases for the Study Team's recommended adjustments are described in detail in Appendix E, Comparison of Study 1 and Study 2 Findings with Prior Studies.

In the absence of better data, the Study Team recommends conservative adjustments which we believe understate the amount of energy embedded in the state's water. These conservative estimates increase water sector electricity use in 2001 from 4.9 percent to 7.7 percent. The Study Team does not, however, have a basis for increasing the CEC's estimate that 19.2 percent of all electricity used in California is in some way related to water, since the increase in water sector use may be a reallocation of electricity counted towards water end use.

The primary significance of these findings is that the value of energy embedded in water is higher than that initially estimated in the CEC's 2005 and 2006 studies. Notably, the estimates developed by the CEC were purposely conservative because the CEC did not want to overstate the potential water-energy relationship.[3] Since water sector energy use establishes the value of energy deemed "embedded" in a unit of water, the energy value of water efficiency measures increases as more electricity consumption is allocated to the water sector itself.

Recommendations

The key recommendations indicated by these studies entail improving the body of water-energy data, methods and tools to enable more accurate measurement of the state's water-energy relationships. In particular, the Study Team recommends the following actions:

- Collect more water-energy data, and with more granularity
- Develop and adopt a methodology for computing the energy embedded in a unit of water
- Quantify water losses throughout the water use cycle

These recommendations are discussed in more detail in Chapter 5 Recommendations that also provides a proposed framework for integrating the findings of Studies 1 and 2 to compute the amount of energy embedded in water.

The Access database, program and the meter data collected and compiled through this study are available for download on the CPUC website at:
http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm .

[3] Interview with Lorraine White, Senior Energy Specialist and Advisor to Commissioner Anthony Eggert, California Energy Commission, May 19, 2010.

1 Introduction

1.1 Background

In 2005, the California Energy Commission (CEC) found that water-related energy consumption and demand accounted for a significant portion - nearly 20 percent – of the state's electricity requirements.[4] Of this amount, more than 12,000 GWh (26 percent, about 5 percent of the state's total energy requirements) was deemed attributable to energy used by water and wastewater systems and their operations.[5] The balance of water-related energy was attributed to the amount of energy needed to apply and use water for agricultural, residential, commercial, and industrial purposes.

"***Energy Embedded in Water***" refers to the amount of energy that is used to collect, convey, treat, and distribute a unit of water to end users, and the amount of energy that is used to collect and transport used water for treatment prior to safe discharge of the effluent in accordance with regulatory rules.

This finding launched a series of initiatives related to increasing understanding and quantifying the interdependencies of water and energy resources and infrastructure in California. In particular, the California Public Utilities Commission (CPUC) is considering whether energy "*embedded*" in water can be quantified and relied upon as an energy efficiency resource, and whether it is worthwhile for the CPUC to pursue energy efficiency through water conservation programs.

Following several informal public meetings where members of both the water and energy industries came together to explore opportunities for leveraging the joint benefits of water and energy, on January 19, 2007, the CPUC opened a proceeding to consider applications from the state's investor-owned utilities (IOUs) to conduct water-energy pilot projects. These applications were consolidated into a single proceeding, Application 07-01-024 (A.07-01-024).[6]

The CPUC's December 20, 2007 Decision 12-07-050 (D.12-07-050) authorized the IOUs to conduct water-energy pilots and to evaluate the results of the pilot projects for the dual purposes of (a) validating claims that saving water can save energy, and (b) to explore whether embedded energy savings associated with water use efficiency are measurable and verifiable. In addition,

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[4] "California's Water-Energy Relationship", California Energy Commission, Final Staff Report CEC-700-2005-011-SF, November 2005.
[5] Subsequent studies indicate this number may be 8 percent or more, see Study 1
[6] California Public Utilities Commission website, http://docs.cpuc.ca.gov/published/proceedings/A0701024.htm

the CPUC directed that three studies be conducted. Two of these studies were structured to work in concert to enhance understanding of the types and quantities of water-energy interdependencies in the state's wholesale and retail water systems and operations. The third study focused on understanding time-of-use water consumption patterns at the end user level.

- Study 1 - Statewide and Regional Water Energy Relationship Study
- Study 2 - Water Agency and Function Component Study and Embedded Energy -Water Load Profiles
- Study 3 - End-Use Water Demand Profile Study

"Energy Intensity" refers to the average amount of energy needed to transport or treat water or wastewater on a per unit basis. For Study 1, energy intensity is the amount of energy used to collect or produce water, and then to

These three studies were to be conducted in parallel with the water-energy pilot projects and evaluation, measurement, and verification (EM&V) of the pilot projects' results.

On April 30, 2008, the California Institute for Energy and Environment (CIEE) issued a Request for Proposals (RFP) on behalf of the CPUC. The team of GEI Consultants, Inc. and Navigant Consulting, Inc., hereafter referred to as the Study Team, was engaged to conduct Studies 1 and 2. Another firm, Aquacraft, Inc., was selected to conduct Study 3. A Technical Working Group comprised of staff and consultants from CIEE and the CPUC was formed to provide guidance in the conduct of these studies.

This report addresses the findings of Study 2.

1.2 Study 2 Goals and Objectives

The primary purpose of Study 2 is to increase understanding of both the quantity and timing of energy use by water and wastewater agencies. To achieve this goal, the CPUC established the following objectives:

- "Develop [a] representative range of energy intensities for water agencies in California, and representative ranges of energy intensities for the various *functional components* of the water system in California."[7]
- "Develop [a] representative range of water energy load profiles for water agencies in California, and representative ranges of energy load profiles for the various *functional components* of the water system in California."[8]

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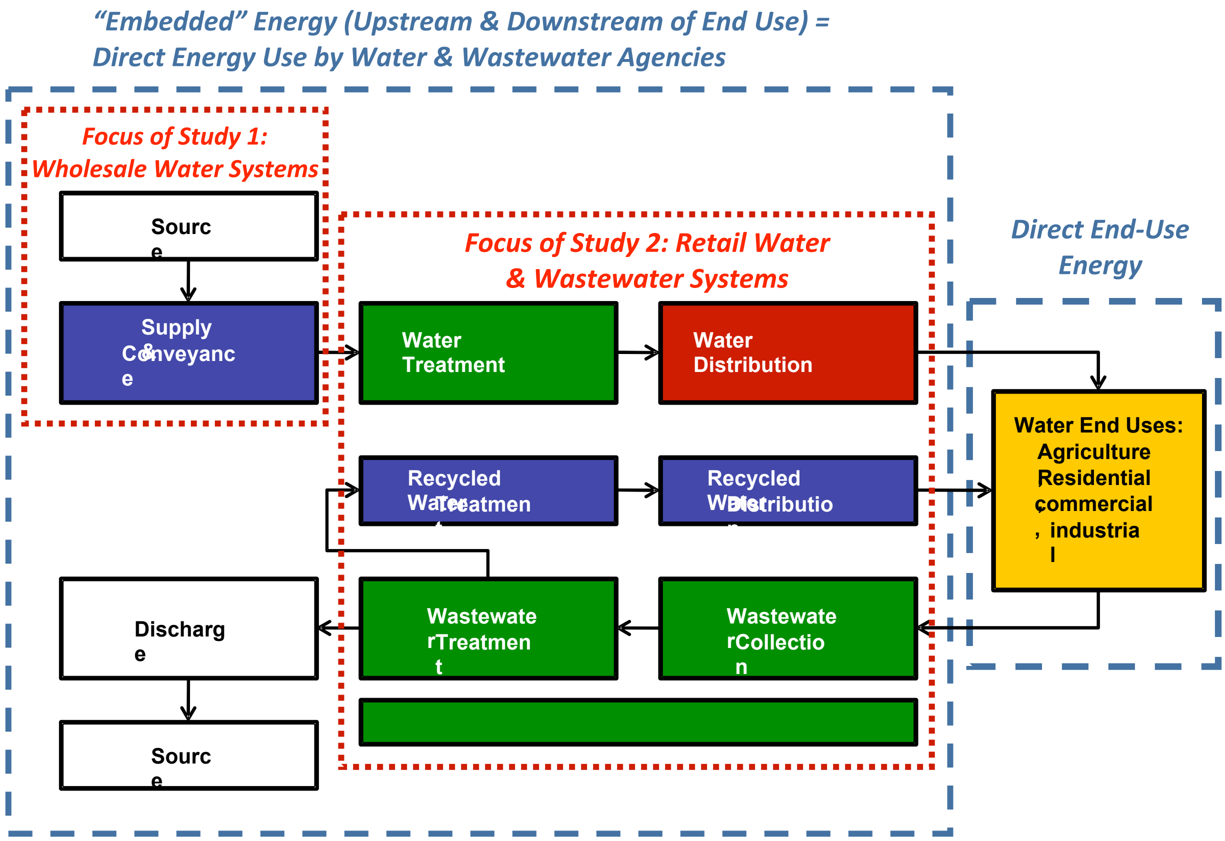
[7] CPUC Decision 07-12-050, Appendix B, p.5.
[8] CPUC Decision 07-12-050, Appendix B, p.9.

In its decision, the CPUC used the term "functional components" to mean "water supply, freshwater treatment, distribution system, administration, and wastewater treatment."[9] These categories correspond generally with the water use cycle framework developed by the CEC in its 2005 staff report (see Figure 1-1. California's Water-Use Cycle), except that administrative uses are treated as support functions ancillary to the primary systems and processes represented in the water use cycle.

Figure 1-1. California's Water Use Cycle

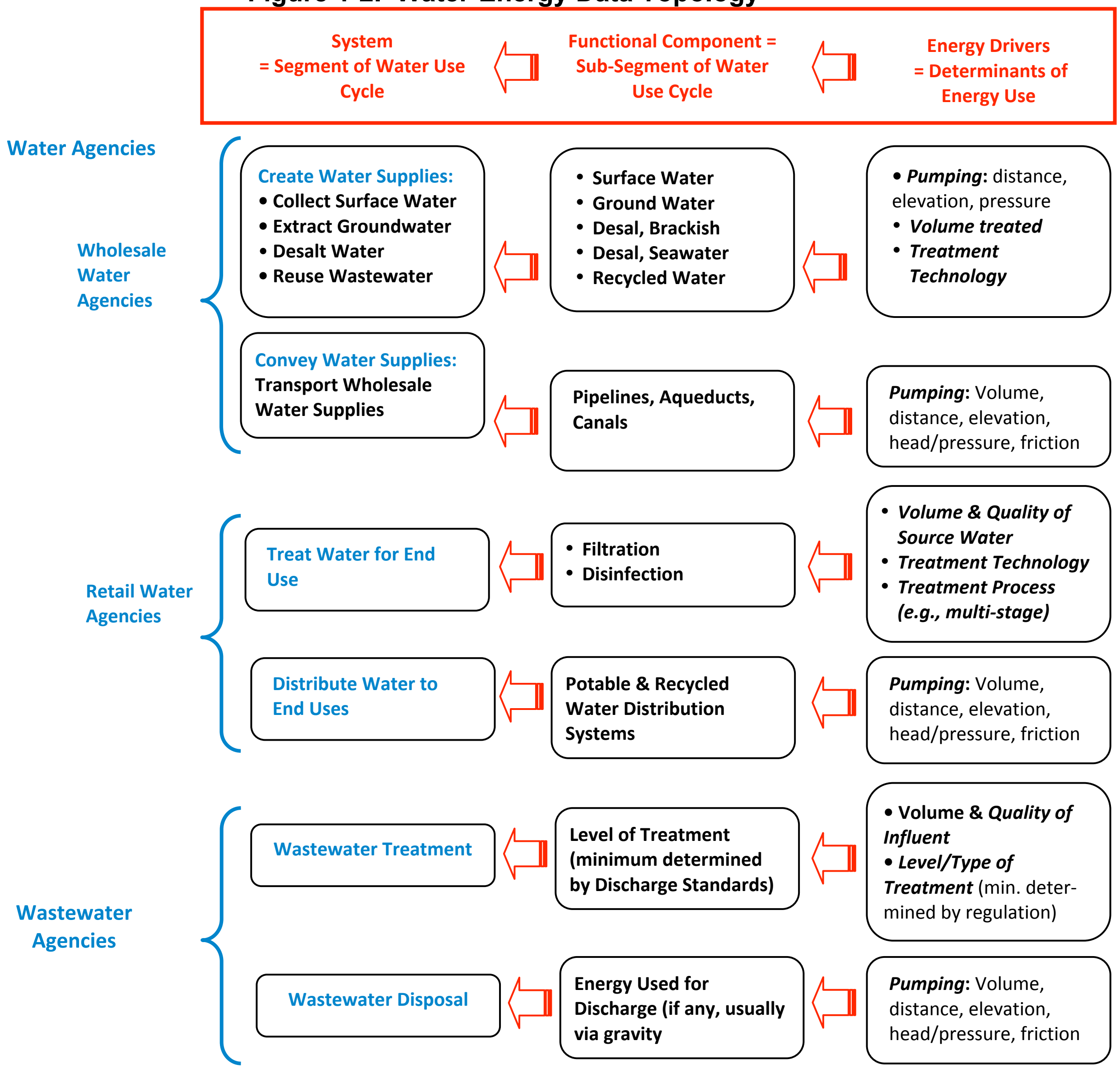


Total Embedded Energy in Water = Sum of Energy Upstream and Downstream of End Use

For purposes of Study 2, the Study Team used the term "system" as equivalent with the applicable segment of the water use cycle (i.e., each of the colored blocks above is deemed to be a "water system" or "segment of the water use cycle." The Study Team used the term "functional component" to mean the types of water resources, water and wastewater treatment processes and technologies, and the types of water delivery systems (wholesale conveyance or retail distribution) that make up the water use cycle. The water-energy data topology used in Study 2 is described in Figure 1-2 on the next page.

[9] CPUC Decision 07-12-050, Appendix B, p.7.

Figure 1-2. Water-Energy Data Topology



To achieve the Study 2 objectives, the CPUC established the following guidelines for water-energy data collection and analysis:

- Select "representative water agencies" that comprise a sampling of high, average, and low energy intensities from the four major types of water agencies in California: wholesalers, retailers, wastewater, and irrigation districts.[10]

[10] CPUC Decision 07-12-050, Appendix B, p.6.

- Relate time-of-use energy consumption to water operations for seven types of "representative" days (also referred to as "water day types"):[11]
  - Winter high, average, and low water demand
  - Summer high, average, and low water demand
  - Energy demand during the serving electric utility's peak energy demand day (typically, summer)

The above scope of work was intended to support development of the following primary deliverables identified by the CPUC:[12]

1. For each water agency studied, document the following:
   a. Water deliveries for the seven "representative" days
   b. Quantity of energy used by each representative water agency for the representative days by functional component
   c. Embedded energy in water "for both the system and functional components" for the 7 representative days
   d. Marginal water source and the embedded energy of that water source
   e. 24 hour energy load profiles by water functional component and for the agency's system overall (at a minimum, for the seven representative days)
2. Compute the expected range of embedded energy by energy utility

These deliverables help illustrate how, where, when, and how much energy is used by the state's water and wastewater agencies in their systems and operations. A strong understanding of these factors is essential when designing an energy efficiency incentive program; one of the potential outcomes contemplated by the CPUC's investigations. In addition to helping the CPUC prioritize high potential opportunities to reduce energy consumption by the state's water sector,[13] the time-of-use profile enables identifying the contribution of energy use by the water sector to system peak demand.

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[11] CPUC Decision 07-12-050, Appendix B, pp.6-7.
[12] CPUC Decision 07-12-050, Appendix B, pp.5-10.
[13] For purposes of this study, "water sector" includes both wholesale and retail water supply and wastewater treatment agencies.

The RFP requested detailed study of 15 water and wastewater agencies that would provide energy intensity information along all segments of the water use cycle. The Study Team recommended instead increasing the number of agencies for detailed study as follows:

- Increase wholesale water agencies in Study 1 from the three large inter-basin transfer systems requested by the CPUC to nine major wholesalers that have significant roles and represent a diverse range of energy intensities.

- Focus Study 2 data collection on the retail water and wastewater agencies, and expand the number of participating agencies from 15 to 25 or more.

The Study Team felt it was important to increase the sample size as much as the schedule and budget would allow. For Study 2, 34 agencies were initially targeted via a stratified sampling approach (see Chapter 2). By May 26, 2010, the Study Team completed detailed water-energy profiles for 22 water and wastewater agencies. Those detailed profiles are provided in Appendix C of this report.

In combination with the nine wholesale water agencies that participated in Study 1, the Study Team was able to develop detailed water-energy profiles for 31 water and wastewater agencies in California. These studies represent the most significant effort to-date to collect and analyze data about energy use by the state's water sector.

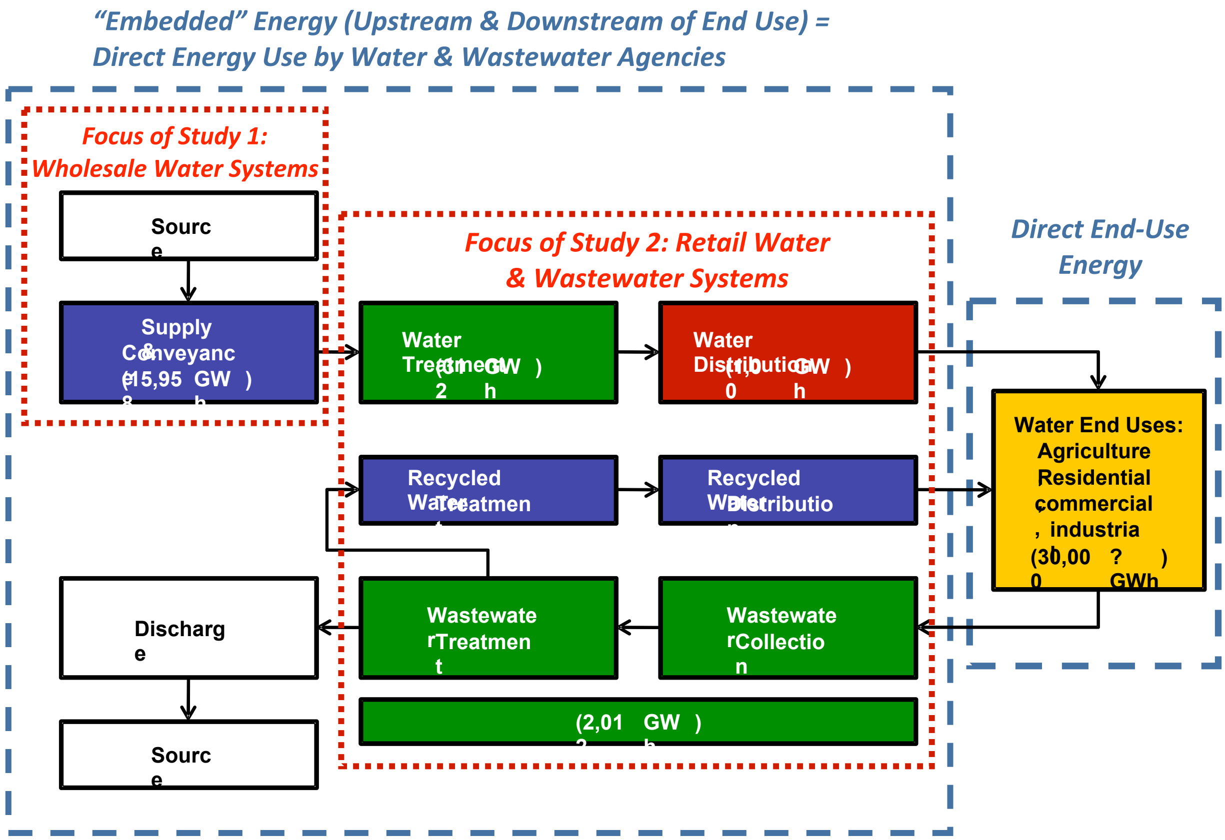
Study 2 produces two distinctly different types of information that help to inform the CPUC's water-energy policy deliberations:

- ***Water Sector Energy Use*** – The data collected through Study 2 about energy use by water sector systems and functions help the CPUC refine its existing energy efficiency programs to encourage water and wastewater agencies to become as energy efficient as possible. The CPUC already authorizes regulated energy utilities to offer energy efficiency incentives for reductions of direct energy use by water and wastewater agencies, as well as by other energy customers.

- ***Embedded Energy in Marginal Water Supplies*** – Information about the energy intensity of each water supplier's marginal water supply(s) provides a basis for estimating the amount of embedded energy that could be saved by reducing water consumption.

The water use cycle provides a framework for understanding the relationship of water sector energy use and the amount of energy deemed embedded in water supplies.

Figure 1-3. CY2001 Energy Consumption by Segment of California's Water-Use Cycle[14]



These concepts provide an important framework for the Study 2 findings (Chapter 4) and recommendations (Chapter 5).

1.3 Approach

The Study 2 scope of work contemplated by D.07-12-050 was challenging for the following reasons:

There are more than 7,000 water and wastewater systems and agencies in California.

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[14] Estimated statewide energy consumption by segment of the water use cycle was developed by the Study Team by comparing the results of the CEC's and other prior studies, and adjusting these estimates for data collected through Studies 1 and 2. The bases for these adjustments are described in Appendix E, Comparison of Findings with Prior Studies, and in Chapter 4 of this report.

- The U.S. Environmental Protection Agency lists 7,200 public water systems in California. Of these, approximately 450 are public agencies and members of the Association of California Water Agencies (ACWA). About 6,600 serve populations less than 5,000.

- The California Association of Sanitation Agencies (CASA) has 114 members.

- In addition, there are 478 cities in California, many of which manage their own water and/or wastewater systems. Some of these are also members of ACWA and/or CASA.

- Further, the CPUC regulates 140 privately owned water agencies. The California Water Association represents the interests of 130 investor-owned water utilities, most of which are included in some of the above numbers.

In its decision, the CPUC stipulated that "Sufficient water agencies in each category should be analyzed in order to be stati[sti]cally representative of the class."[15] A statistical approach would require first establishing a comprehensive inventory of all major water and wastewater agencies in California that includes information about the quantity of water collected, treated, and/or delivered to their customers; the types and quantities of water supplies in their respective portfolios; key data about their system configurations and functional components; and other data that would provide insights as to the primary energy drivers of their systems. If such an inventory existed, we would then be able to develop a statistical sample. Through prior water-energy studies, including a literature search for relevant studies conducted by others, the Study Team realized that these types of data are not yet readily available in the form needed to support a statistical approach to this study.

Relevant data is not readily available and inconsistently collected, compiled, and reported. This is a new area of study for the state. While most water and wastewater agencies collect and compile some water and/or energy data, the types and frequency of the data vary significantly. In fact, during the course of this study, while some agencies were able to provide daily (and in some cases, hourly) water and/or energy data, others could provide very little data at all. Some agencies provided water data but referred the Study Team to their energy provider to obtain energy consumption data. Several agencies were able to provide copies of studies that they have conducted on their own to understand their water-energy relationship. Most agencies have not yet begun to analyze those relationships.

The California Energy Commission developed its conservative 2005 estimate of the magnitude of water-related energy consumption on the basis of annual sales data reported by energy service providers by SIC or NAICS code. As seen in Study 1, the data compiled by SIC or NAICS

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[15] CPUC Decision 07-12-050, p.6.

codes does not directly correlate with source data collected by the Study Team from these same agencies.[16]

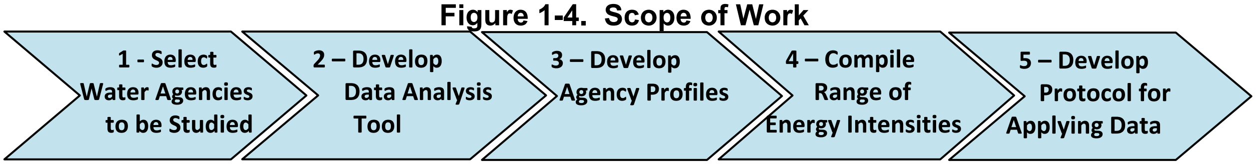
In fact, as shown in Study 1, the body of data available today is not sufficient to produce a reliable estimate of the true magnitude of the state's water-related energy consumption. While Studies 1 and 2 represent the most significant data collection effort conducted to-date with respect to understanding energy use by the state's water sector, Study 1 found significant gaps in data about the quantity of energy used for groundwater pumping.[17]

1.4 Scope of Work

Prior to commencing work, the Study Team conducted a literature search to establish a baseline understanding of the state of knowledge about the state's water-energy relationships at the retail water and wastewater system level. As noted in Appendix A Literature Review, since this is a new area of study, little was found that was directly relevant.[18]

Figure 1-4 describes the work that was performed in Study 2.

Figure 1-4. Scope of Work



The following section describes the work that was performed, the issues encountered, and the remedies deployed.

1.4.1 Select Water Agencies to be Studied

A critical aspect of this study required engaging a diverse group of water and wastewater agencies, irrigation districts, and other types of providers of water supplies and services (e.g., water storage and "banking"[19]) that were deemed "representative" of the majority of the state's water-energy relationships and associated energy intensities, and that had sufficient data to enable the Study Team to compute energy intensities for their water supplies, systems and

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[16] See Appendix E.
[17] See Study 1, Chapter 6, pp. 131 and Appendix N.
[18] The most extensive body of work to-date about the energy intensity of water and wastewater treatment systems and functions (i.e., technologies and processes) was conducted by the Electric Power Research Institute (EPRI) in 2001. In that study, EPRI compiled the experience of water and wastewater agencies throughout the U.S. into average national energy intensities.
[19] "Water banking" refers to the ability to store water supplies, or "bank" them, with another water agency that promises to return the banked water or suitable replacement water supplies when needed, or "called," by the owner of the water supplies.

functional components. This diversity of water-energy data is needed to inform California's policymakers about the nature, types and breadth of California's water-energy relationships.

Prior studies conducted by the California Energy Commission and others estimated ranges of energy intensity for a wide variety of systems, resources, technologies, and operations factors. These diverse factors can be generally described as

The approach initially contemplated by the RFP entailed developing an inventory of water and wastewater agencies in California and their energy consumption characteristics. As noted earlier, given the very large number of water and wastewater agencies in California and the difficulty, time and cost required to compile such a database, the Study Team recommended instead building upon prior studies that had already identified the primary drivers of the quantity and timing of energy consumption by water and wastewater agencies. In this manner, the number of study participants could be increased.

A study conducted by Navigant Consulting for the California Energy Commission in December 2006 documented the range of energy intensities reported in other studies by sub-segment of the water use cycle. Navigant's 2006 study of "*sub-segments*" correlates to the Study 2 "*functional components*." The Navigant study also suggested a framework for conducting further inquiry into the primary energy drivers that produced the observed ranges of energy intensities. The sources of the below estimates were documented in Appendix B of that study. [20]

[20] "Refining Estimates of Water-Related Energy Use in California," Navigant Consulting, Inc. for California Energy Commission, CEC-500-2006-118, December 2006.

Table 1-1. Urban Water Intensity Matrix (kWh/MG)

Water				Wastewater		
Supply	**Conveyance**	**Treatment**	**Distribution**	**Collection**	**Treatment**	**Disposal**
Surface Water (0)	SWP-L.A. Basin (8,325)	EPRI Avg. (100)	EPRI Avg. (1,200)	Avg 140 (incl. in Treatment)	Trickling Filter (955)	Gravity Discharge (0)
Groundwater (4.45 mg/AF)	SWP-Bay Area (3,150)		Flat Topography (TBD)		Activated Sludge (1,322)	Pump Discharge (400)
Ocean Desalination (13,800)	SWP-Central Coast (3,150)		Moderate Topography (TBD)		Advanced (1,541)	
Brackish Desal (1,240-5,220)	SWP-San Joaquin Valley (1,510)		Hilly Topography (TBD)		Advanced w/ Nitrification (1,911)	
Recycled Water (0)	CRA-L.A. Basin (6,140)		Recycled Water (1,200 – 3,000)			
	Hetch Hetchy – Bay Area (0)					
	Mokelumne Aqueduct (160					
	Local - Intrabasin (120)					

Source: "Refining Estimates of Water-Related Energy Use in California," Table 9. Urban water intensity matrix (kWh/MG), Navigant Consulting, Inc. for the California Energy Commission, CEC-500-2006-118, December 2006, p.25.

Given that the overarching objective of Study 2 is to document the range of energy intensities experienced by water and wastewater agencies throughout California, and then to analyze the resulting data to determine the predictors of those energy intensities, the Study Team used the Urban Water Intensity Matrix in Table 1-1 to guide development of an inventory of the primary energy drivers that determine the energy intensity of each sub-segment (functional component) of the water use cycle (Table 1-2). These drivers helped to determine the types of water and wastewater resources, systems, and operational characteristics that were desirable to capture in the study sample.

Table 1-2. Sampling Strategy for Urban Water & Wastewater Agencies

Segment of the Water Use Cycle	Sub-Segment of the Water Use Cycle	Primary Energy Drivers	Sampling Strategy
Supply	Surface Water	n/a	Diversity of types of water supplies within each geographic region being studied
	Groundwater	Volume of water pumped, depth of well, pump & motor efficiency	
	Desalination, Brackish & Seawater	Source water quality, volume & quantity of water treated, technology used	
	Recycled Water	Wastewater discharge standard & level of additional treatment needed to convert wastewater effluent into usable supplies	
Conveyance	Pipelines, Aqueducts & Irrigation Canals	Volume of water being conveyed over what distance and elevations Conveyance system efficiency: condition, vintage & efficiency of pumps & motors; type of conduit (pipeline vs. open channel, lined vs. unlined); rate of water leaks, seepage & evaporation)	Diversity of types of water conveyances, systems, and efficiencies
Water Treatment	Filtration	▪ Treatment plant configurations ▪ The number of times water is treated ▪ The types of water disinfection technologies used ▪ Water quality standards	Diversity of types of water treatment technologies & number of times water is treated (e.g., multi-stage disinfection processes)
	Reverse Osmosis		
	Ozone		
	Ultraviolet		
Distribution	Flat	▪ Pumping energy determined by volume, system size & pressure, topography of distribution network, system age ▪ Distribution system water losses ("leakage")	▪ Diversity of distribution system topographies Both potable & recycled water distribution systems ▪ Diversity of infrastructure ages (indicative of magnitude of potential losses due to leakage)
	Moderate		
	Hilly		
	Variable		
Wastewater Treatment	Primary	▪ Plant capacity ▪ Level of treatment ▪ Treatment technology(s) used ▪ Wastewater influent quality ▪ Discharge requirements	Diversity of levels of treatment, types of technologies, plant sizes, and wastewater influent
	Secondary		
	Tertiary		

The Study Team then created a comparable table of primary energy drivers of agricultural irrigation to develop a sampling strategy for the agricultural sector.

Table 1-3. Sampling Strategy for Agricultural Water Agencies

Segment of the Water Use Cycle	Primary Energy Drivers	Sampling Strategy
Agricultural Irrigation	▪ Type of water resource(s) used for irrigation ○ Surface Water: volume, distance, elevation, pump equipment vintage, and efficiency ○ Groundwater: volume, depth of well(s); pump and motor efficiency ▪ Type of irrigation technology (surface, drip, sprinklers, others)	▪ Diversity of types of water supplies within each geographic region being used for agricultural irrigation ▪ Diversity of irrigation systems' vintages & efficiency ▪ Diversity of irrigation technologies

By starting with an inventory of primary energy drivers by sub-segment of the water use cycle, the Study Team was able to confer with major water and wastewater agencies and their membership associations to quickly identify and map candidate agencies to the energy drivers being evaluated. The stratification criteria included study parameters established by the CPUC such as obtaining a representative sample within each energy IOU's service area. The Association of California Water Agencies (ACWA), the California Association of Sanitation Agencies (CASA), the California Water Association (CWA), and members of the California Sustainability Alliance's Water-Energy Advisory Committee[21] assisted in recommending agencies that had the types of energy drivers and diversity of geography, climate, and utility service provider characteristics targeted for evaluation in Study 2.

Since a comprehensive database of California water and wastewater agencies with detailed information about their energy characteristics does not yet exist, the Study Team developed the following definition of a "representative" agency:

- The selected agencies collectively represent most of the energy drivers of California's water and wastewater resources, systems, functional components, and operations.
- The selected agencies also represent a diversity of geography, climate, and topology.
- The selected agencies represent the major types of water and wastewater energy drivers within each IOU's service area.

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[21] Founded in 2006, the California Sustainability Alliance (Alliance) is funded by California utility customers and administered by Southern California Gas Co. (The Gas Company[SM]) under the auspices of the California Public Utilities Commission, through a contract awarded to Navigant Consulting. In order to help accelerate energy efficiency in the water sector, the Alliance established a Water-Energy Advisory Committee comprised of policymakers, members of state agencies and senior water managers throughout California. For more information about the California Sustainability Alliance's Water-Energy Advisory Committee, see the Alliance's website at: http://sustainca.org/water_energy_pac.

Primary energy drivers and their role in determining the quantity and timing of energy use by various segments and sub-segments of the water use cycle are described in more detail in Chapter 2, along with the stratified sampling methodology that was used to select representative water and wastewater agencies for this study.

1.4.2 Develop Data Analysis Tool

Study 2 required collection and compilation of thousands of water and energy records obtained in many different file and data formats. The primary sources of data were water operations records and energy meters/bill data. The number of meters and data points varied significantly from one agency to another.[22]

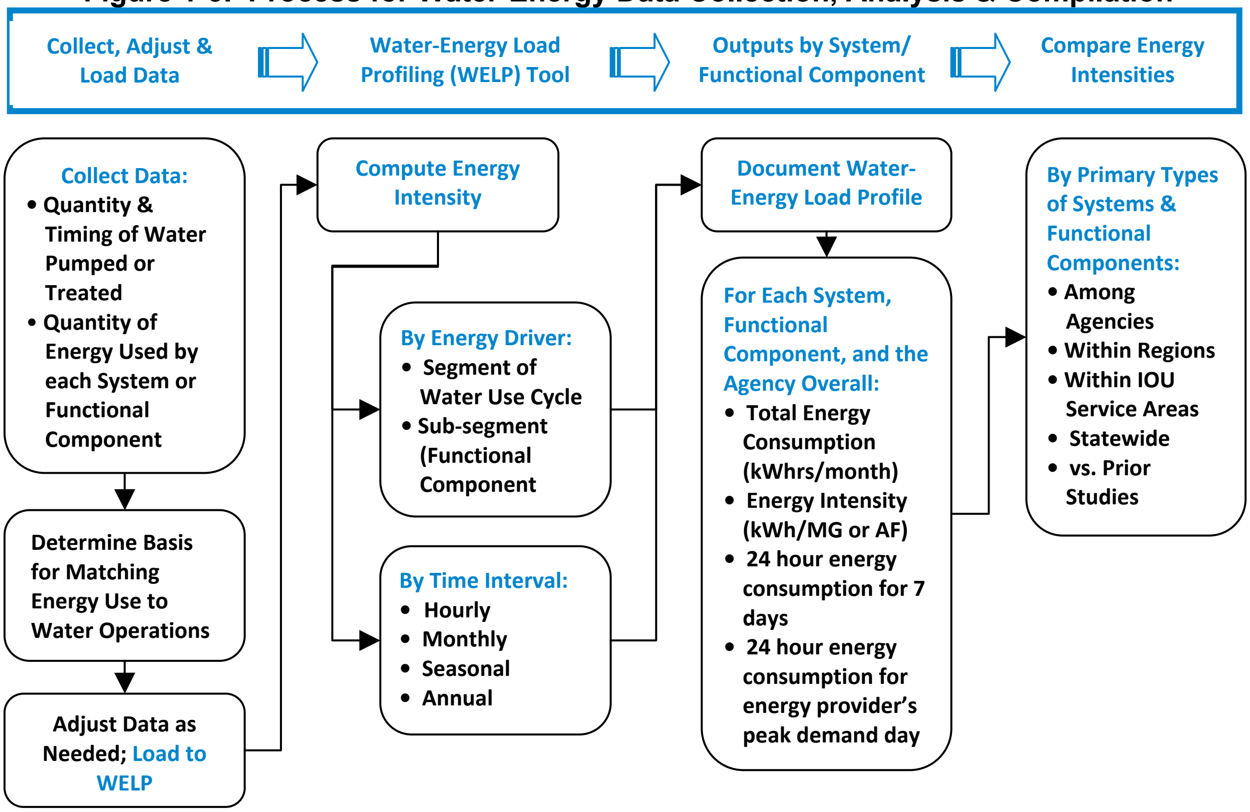
The Study Team targeted 30 water and wastewater agencies for participation in Study 2. The data collection process alone was daunting. Detailed data for all 366 days in calendar year 2008 needed to be collected and analyzed in order to even make the determination as to which were high, low and average water demand days. The process and time needed to identify, review, and adjust data exceptions and then to compile, analyze, and graph the results needed to be significantly streamlined in order to complete this study within the targeted budget and timeline.

The Study Team therefore developed a Water-Energy Load Profiling (WELP) Tool in Microsoft Access 2007 to streamline data processing and to ensure that the data was adjusted and compiled consistently for all water and wastewater agencies participating in this study. The data structures were developed in the Access 2007 database file (.accdb). The data processing algorithms were programmed in VBA (Visual Basic for Applications).

The Access database, program and the meter data collected and compiled through this study are available for download on the CPUC website at:
http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm

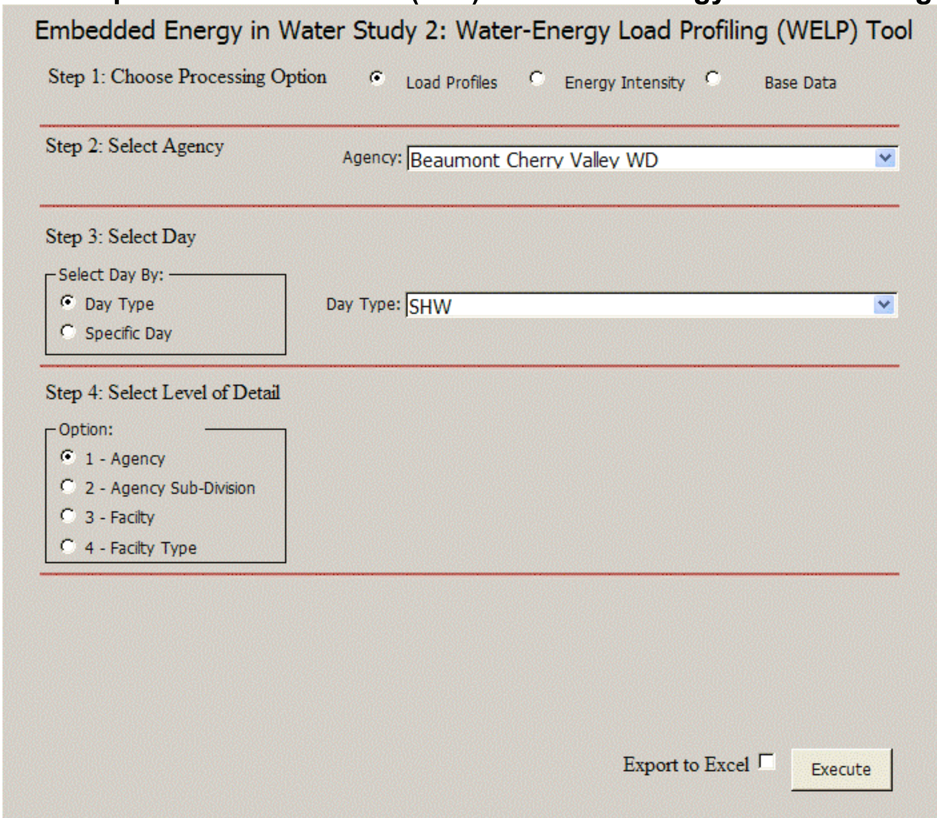
[22] The number of energy meters for the 22 agencies studied ranged from a low of 1 and a high of 124.

Figure 1-5. Process for Water-Energy Data Collection, Analysis & Compilation



Once data is formatted for import into the Access database, the program code is accessed via a simple, easy to use graphical user interface that allows users to query the system for the key outputs requested by the CPUC.

Figure 1-6. Graphical User Interface (GUI) for Water-Energy Load Profiling (WELP) Tool



WELP can be used by the CPUC, water and energy utilities, and other water and energy stakeholders to expeditiously develop detailed water-energy load profiles for other California water and wastewater agencies. The pre-formatted numeric and graphical outputs help policymakers, utilities, and others understand any water or wastewater agency's water-energy relationships at a glance. These data outputs also help to quickly identify systems and functions that appear to have high potential for energy savings and/or energy load shifting.

Documentation for the WELP Tool developed and used for this study is provided in Appendix C, along with a user's manual that describes how to collect and load data into the tool, and descriptions of the specific algorithms that determine how the data is used.

1.4.3 Develop Agency Profiles

Data collected for each agency was first evaluated to determine how best to relate the energy data to water systems, functional components, and operations. The relationship was determined at the meter level, depending on the type and frequency of the data, and the type of water or wastewater system or sub-system. Similar types of energy uses were classified to a common code to enable evaluating the range of energy intensities experienced at different metered locations for similar types of functions.

For example, water and energy meters were classified by the following codes that identified the system function at the facility level:

Table 1-4. WELP Code for Facility Type[23]

Facility Code	Segment of Water Use Cycle	Facility Description
GWATER	SUPPLY	Groundwater Production Station
PSBOOST	PWDIST	Booster Station
PSRAW	SUPPLY	Raw Water Pumping Plant
PSRECYC	SUPPLY	Recycled Water Pump
PSWW	WTREAT	Waste Water Pumping Station
WDADMIN	PWDIST	Water Distribution Administrative Building
WFILTER	WTREAT	Filter Plant
WIMPORT	SUPPLY	Imported Water
WINTAKE	WTREAT	Intakes
WPRESSURE	PWDIST	Pressure System
WWTREAT	WTREAT	Waste Water Treatment Plant

The detailed output for each of the 22 water and wastewater agencies that participated in Study 2 is provided in Appendix B. Summary water-energy data for these agencies is provided in Chapter 3.

1.4.4 Compile Range of Energy Intensities

Once the individual agency water-energy load profiles were completed, the results were compiled into summary tables that indicate the range of experience by type of energy driver within each geographic region and IOU service area. These ranges are reported in Chapter 4 Findings.

1.4.5 Develop Protocol for Applying Data

Finally, in Chapter 5, we provide a proposed framework for integrating the findings of Studies 1 and 2 to compute the amount of energy embedded in water.

[23] WELP database, Table "Fac_Code" – see Appendix C.

2 Selection of Representative Water and Wastewater Agencies

As described in Section 1.4.1, Select Water Agencies to be Studied, the stratified sample methodology began with an analysis of the principal energy drivers by sub-segment of the water use cycle. The terminology and data structure used in Study 2 was described in Chapter 1 and illustrated in Figure 1-2, Water-Energy Data Topology.

In this chapter, we describe the primary energy drivers by sub-segment of the water use cycle that drove sample selection. We also describe the process that we then used to identify targeted representative water and wastewater agencies for participation in this study.

2.1 Primary Energy Drivers of Water and Wastewater Systems

The California water system is comprised of a network of systems and components owned and managed by a diverse group of federal, state, local, and privately owned organizations that collect or create water supply, that treat and convey water to and from water users, and that treat and dispose of, or recycle wastewater from end uses. The below figure illustrates the primary segments of the water use cycle that correspond to the CPUC's "functional components" of the water system. Within each segment, there are a number of sub-segments with distinct energy characteristics.

Table 2-1. Primary Segments & Sub-Segments of California's Water Use Cycle

Supply	Conveyance (Wholesale)	Water Treatment	Water Distribution (Retail)	Wastewater Treatment
Surface Water	Pumping Water via Pipelines, Aqueducts Canals & Irrigation Ditches	Filtration Disinfection	Pumping Treated Water (Potable & Non-Potable) via Distribution Pipelines	Secondary Tertiary
Groundwater				
Desalted Water (Brackish)				
Desalted Water (Seawater)				
Recycled Water				

The segments and sub-segments evaluated in Study 2 are described below.

2.1.1 Supply and Conveyance

The energy intensity of a water resource ("supply") is deemed equivalent to the amount of energy needed to collect, convey, and treat source water to a quality sufficient to be considered a usable water supply. This segment of the water use cycle generally refers to wholesale water supplies. The treatment energy needed to create a usable water supply is not necessarily the same as that needed to treat wholesale water supplies to potable water supplies. Some water resources, for example, can be applied to agricultural and other end uses that do not require treatment to drinking water standards. The energy needed for potable water treatment is typically included in the "Water Treatment" segment of the water use cycle.

> Prior studies varied with respect to where they recorded ***energy used to "create" water supplies***, such as for desalted and recycled water. The decision as to where in the water use cycle the energy

Prior studies varied with respect to where they may have accounted for energy required for desalination and recycled water. Some included the treatment energy needed to convert unusable water resources to usable supplies under the first segment of the water use cycle, "Collection & Conveyance." Others included energy used in desalination in Water Treatment because of the treatment technologies applied to create the water supply.

Study 2 uses the former definition: i.e., desalination and advanced water treatment both increase usable water supplies. They are therefore being categorized as wholesale water supplies under the first segment of the water use cycle. "Water Treatment" is reserved for treating wholesale supplies to drinking water standards prior to distributing these supplies to retail potable water end uses.

The decision as to where in the water use cycle to consider the energy used for these types of treatment is not particularly important, as long as it is treated consistently within the analytical framework in which it is being evaluated and provided it is not double counted.

Supply

A "water supply" is defined as water that is ready to be conveyed to a beneficial end use, can be cost-effectively treated to the quality needed to serve its intended end use(s) within existing technologies, and can be cost-effectively delivered and used. Energy drivers for the supply segment of California's water cycle vary significantly with the location and quality of the water supply source. The primary sources of water supply in California are: surface water, groundwater, desalted water and recycled water.

- *Surface water* is an above-ground water resource that is ready to be conveyed. Typically, little to no energy is required to "make" surface water into a supply.

- *Groundwater* is transformed from unusable water stored in underground aquifers into usable water supplies when it is pumped to the surface and available for conveyance. The amount of energy needed to pump groundwater varies with the volume to be pumped, the depth from which the groundwater must be pumped, and pump and motor efficiency. Other factors may contribute to the energy intensity of groundwater pumping. For example, changes in water table elevation and clogged well screens can cause groundwater pumps to run less efficiently, increasing the amount of energy needed to pump groundwater at any particular location. In addition, the quality of the source groundwater may require treatment before it can be deemed a usable water supply. There is significant variability in the energy intensity of groundwater from one site or source to another.

> The energy intensity of recycled water is deemed to be the ***incremental energy*** needed to convert treated wastewater effluent to the quality needed to apply the water to an approved reuse. Recycled water is thus a relatively low energy intensity supply, since most of the energy needed to treat the wastewater to the level required by regulation for safe discharge is counted as Wastewater Treatment energy.

- *Recycled water* refers to water supply created by treating wastewater effluent to the quality required by public health and safety regulations before it can be applied to an approved reuse. Energy used for wastewater treatment is typically recorded in that segment of the water use cycle. The energy intensity of recycled water is therefore typically deemed equivalent to the *incremental energy* needed to treat wastewater effluent to a quality higher than that required by the State Water Resources Control Board (SWRCB) for safe discharge. In many areas, wastewater is already required to be treated to tertiary standards. Tertiary treated water needs little further treatment to be applied to non-potable uses. As a consequence, recycled water is typically considered a low energy intensity supply option.

- *Desalination* converts non-usable water sources into usable water supplies by removing excess salts and minerals. The energy intensity of desalted water depends primarily on the volume of the water being desalted, the quality (i.e., saltiness) of the source water supply, and the technology(s) used to desalt the water.

    - *Brackish water* contains moderate quantities of soluble salts and minerals that render the water supply unusable for most purposes. Brackish water can be desalted to create usable water supplies.

    - *Ocean or seawater* contains very high quantities of salts and minerals that make the water unusable. Ocean or seawater desalination requires significant amounts of energy to convert these very salty water resources to usable supplies. Extensive research is being conducted globally to reduce the energy intensity of seawater desalination, which is deemed to be a vital hedge against drought and a valuable water resource option in parched areas throughout the world that have few other water supply options.

Conveyance

Energy requirements for the conveyance segment of California's water use cycle vary based on the volume of water being transported, and the distance and elevations over which the water must be conveyed. The three primary wholesale water conveyance systems are the State Water Project, the Central Valley Project, and the Colorado River Aqueduct. Other major systems that transfer water across hydrologic regions include the Los Angeles Aqueduct and San Francisco's Hetch Hetchy system, both of which are gravity fed. Most of the very large conveyance facilities are open channel canals.

Although the major facilities are concrete lined, many of the secondary conveyance facilities are unlined channels. Friction losses of an unlined canal are higher than those of lined canals, requiring higher head delivered from pumping to offset losses. Water losses due to seepage are also greater in unlined canals.

Figure 2-1. California's Major Water Systems

Source: California Water Plan Update, Bulletin 160-98, 1998

Water losses in the conveyance system come in two forms: seepage and evaporation. While seepage through unlined canals or aging and cracked concrete-lined canals results in recharge of groundwater aquifers, the energy intensity of pumping that groundwater is an accumulation of the original pumping in the conveyance segment and the additional pumping to create supply from a groundwater source. Evaporation in the conveyance segment varies based on temperature and humidity. California's southeastern desert area has the highest losses from evaporation.

2.1.2 Treatment

Energy requirements for the water treatment segment of California's water cycle are determined by treatment plant configurations, system processes, the number of times the water is treated, and the types of water disinfection technologies used. Environmental policy, source water quality, treatment technology, and losses all affect the amount of energy required for treatment.

Over the past decade, more stringent drinking water quality regulations were adopted that required reconfiguring water treatment systems, processes and technologies. In particular, energy hungry disinfection technologies such as reverse osmosis, ozonation, and ultraviolet treatment have replaced traditional very low-energy chemical disinfection processes that are now known to create carcinogenic "disinfection by-products." In addition to switching to higher energy intensity processes and technologies, some systems treat water more than once, at multiple stages of the water treatment process, to ensure effective destruction of bacterial pathogens.

> New energy-intensive disinfection technologies such as ***reverse osmosis***, ***ozonation,*** and ***ultraviolet light arrays*** help to reduce carcinogens in treated water. Some systems treat water more than once (***multi-stage treatment***) to ensure destruction of harmful pathogens. These factors have increased the energy intensity of the water treatment segment of the water use cycle.

Four primary types of advanced treatment technologies (ATT) are most commonly used:

- Microfiltration
- Reverse Osmosis
- Ozone Systems
- Ultra Violet (UV) Systems

2.1.2.1 Microfiltration

Microfiltration is the process of filtering water with a micron sized porous filter that effectively removes particles, sediment, algae and large bacteria. The quality of the source water determines the amount of energy used by the system.

2.1.2.2 Reverse Osmosis

Reverse osmosis (RO) systems use high pressure feed pumps to pass water through semi-permeable membranes. As in other treatment technologies, source water quality is a major determinant of energy intensity.

2.1.2.3 Ozonation

Ozonation is the process of infusing water with ozone, a highly reactive gas consisting of three oxygen atoms (O_3). Ozone is an unstable molecule that gives up one atom of oxygen, providing a powerful oxidizing agent that is toxic to most waterborne organisms. In addition to disinfecting water, the oxidation process reacts with metals to create insoluble metal oxides that can then be removed from water through filtration.

2.1.2.4 Ultra-violet Disinfection

Ultraviolet (UV) disinfection entails passing water through a UV light source. In this manner, UV energy is absorbed by the reproductive mechanisms of bacteria and viruses, destroying their ability to reproduce.

2.1.3 Distribution

Water distribution systems transport water from treatment plants to end users of potable water supplies. Most energy used in the distribution system is for pumping. The primary energy drivers in this segment of the system are water losses and the drivers of pumping energy: volume, distance, pressure, and elevation.

Distribution energy may include delivery of both potable and non-potable water supplies (e.g., untreated surface water and recycled water). Public health and safety regulations require that potable and non-potable water supplies be kept separate and delivered by entirely separate pipelines.

Pumps are used throughout the distribution system to move water through the system and maintain system pressure. Topography, system size, system age, and volume are all energy drivers for the distribution segment of the water use cycle.

> The ***energy intensity of recycled water distribution*** tends to be higher than water distribution because it usually needs to be transported from the point of wastewater discharge to higher elevations where the

Recycled water distribution systems have the same energy drivers as potable water systems. However, the energy intensity of recycled water distribution systems is often higher than potable systems. Treated wastewater effluent, the primary source of recycled water, is usually available at lower elevations where wastewater collection systems used gravity to minimize energy costs. Therefore, although recycled water typically requires little incremental energy to transform wastewater effluent into a usable non-potable water supply, it typically requires more energy than potable water supplies to deliver it to approved uses.

The determination as to which water supply option is least energy intensive should be based on the sum of energy requirements along all segments of the water use cycle – from collection and conveyance, through water treatment and distribution. The energy intensity of a recycled water supply should include both components – the amount of incremental energy needed to treat wastewater effluent to the level of water quality needed to reuse that water, plus the amount of energy needed to deliver that water to approved uses - when comparing its costs and benefits to other supply options. This concept is described in more detail in Chapter 5, Recommendations.

2.1.4 Wastewater Treatment

Wastewater treatment energy varies with plant capacity, treatment technology(s) and regulatory discharge standards.

There are three discharge standards of wastewater treatment: primary, secondary, and tertiary. Tertiary discharge has the most stringent requirements and, in turn, has the highest energy intensity.

Energy requirements of the wastewater discharge segment of California's water cycle depend on the amount of pumping required. As with pumping in distribution energy, the primary determinants of wastewater pumping are a function of volume, distance, and elevation.

2.2 Criteria for Selection of Representative Water & Wastewater Agencies

The primary challenge in Study 2 is to select a "representative" sample of water and wastewater agencies that will be studied to inform the CPUC about ranges of energy intensities observed in the state's water and wastewater systems and functions. As noted earlier, there are thousands of water and wastewater systems in California. In addition, the water-energy nexus is an emerging area of study for which data are not readily available in the form needed to effectively inform policymaking.

In considering alternative sampling approaches, the Study Team looked to the CPUC's intent in commissioning this study. In particular, the purpose of the study is ultimately to provide input to the CPUC's policy deliberations as to (1) whether embedded energy in water should be recognized for purposes of participation in the state's regulated energy efficiency programs, and (2) if so, how such embedded energy should be measured and recognized.

The CPUC's Decision 07-12-050, Appendix B, directed that data should be collected "… from the four major types of water agencies in California: Wholesalers, retailers, wastewater, and irrigation districts …" The study plan suggested focusing on retail water agencies, wastewater agencies and irrigation districts for the following reasons:

- The Study Team collected a considerable amount of information about the state's largest wholesale water and conveyance systems during Study 1.

- Study 2 work plan includes assessing the energy intensity of the marginal water supply that will be displaced by water conservation. In many cases, the energy intensity of the avoided marginal water supply will include conveyance energy.

- Water conveyance energy requirements tend to be fairly constant from one hour to the next. Typically, the quantity of water to be delivered is scheduled in advance; and although there may be one pipeline change during the day, the flows often are fairly constant for most of the day. In fact, the Metropolitan Water District of Southern California explained that deliveries via the Colorado Aqueduct are often scheduled at a constant flow rate 24 hours per day, over a 7-8 month period.24

Therefore, the Study Team determined that it would be most cost-effective to focus Study 2 on the primary data gaps - agricultural water use patterns, and retail urban water and wastewater systems - with the understanding that Study 1 will provide conveyance energy from the state's largest wholesale urban water systems and agricultural irrigators.

To develop the list of primary water-related energy drivers and the resultant stratified sampling criteria, the Study Team conferred with California water and wastewater agencies directly and through their primary industry associations in California.

2.2.1 Selection Criteria

Below is a list of the primary characteristics that the Study Team identified as important to include in the sample of participating agencies. Key issues and primary determinants of energy intensity are also discussed.

- Types of water agencies

    a. Urban: Water and/or Wastewater

    b. Agricultural: Irrigation

    Energy drivers are similar for similar types of water or wastewater agencies and system functions.

- Geographic regions

The North and Central Coast, Central Valley, Southland, and Desert regions of California have distinctly different climates, topography, geology, and other factors that determine their water supply resources and portfolio characteristics.

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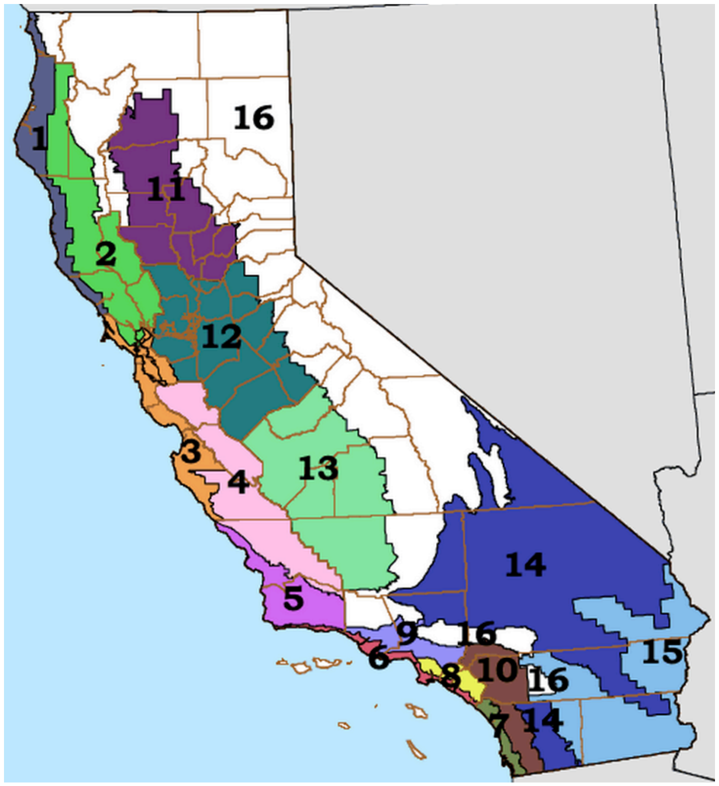
[24] Interview with Jon Lambeck, Manager of Power Resources, Metropolitan Water District of Southern California, on January 13th, 2010.

Table 2-2. Typical Water Resource Portfolios for the Four Geographic Regions

Geographic Region	Local Water Supplies	Imported Water Supplies
North & Central Coast	A mix of surface water supplies, groundwater (interest in desalination growing)	Typically surface water supplies from northern California
Central Valley	Largely surface water from northern and central California, delivered via the State Aqueduct	Typically surface water supplies from northern California
Southland	A mix of surface water supplies, groundwater, and desalination	Typically surface water supplies from northern and central California plus Colorado River imports
Desert	Largely groundwater (sometimes brackish, requiring desalination)	Typically surface water supplies from northern and central California plus Colorado River imports

The California Energy Commission (CEC) divides California into 16 climate zones. The California Department of Water Resources (DWR) divides the state into 10 hydrologic regions. The CEC climate zones and DWR hydrologic zones are not contiguous.

Figure 2-2. CEC Climate Zones (Right) vs. DWR Hydrologic Zones (Left)



Instead of selecting water and wastewater agencies by climate and hydrologic zones, the Study Team grouped water agencies by similar water resource portfolios. Since variations of climate and hydrology are reflected in the types and quantities of different water resources that are available in each region, this approach enables testing more water-related energy drivers with fewer agencies.

Types of Water Resources

More than ninety-nine percent (99 percent) of California's water supply is met from four types of water resources: surface, groundwater, desalination (brackish and seawater), and recycled.[25] Surface and groundwater account for most of this water (about 98 percent). Each geographic region included water agencies that collectively represent all of these types of water resources.

Treatment Technologies

EPRI's 2002 studies on the energy use of water and wastewater agencies nationwide[26] observed that the energy intensity of wastewater treatment processes tended to be relatively uniform, irrespective of geography. The primary drivers of energy intensity of wastewater treatment are typically (a) the level of treatment conducted (primary, secondary, or tertiary), (b) the quality of the wastewater to be treated, and (c) the types of technologies employed in the treatment processes.

Distribution Energy

Distribution energy is significantly impacted by topology. As noted previously, distribution energy is well understood from an engineering perspective to be a function of volume, pressure, elevation and distance. Flat, moderate, and hilly topographies were included in the sample set.

Energy Utility Service Area

Since the ultimate objective of this study is to evaluate the energy efficiency potential of embedded energy in water for IOU programs, the sampling strategy sought to identify a comprehensive set of the primary types of water-related energy relationships in each IOU service area.

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[25] The 2005 California Water Plan Update cited 500,000 AF/year of recycled water (Volume 2, p.16-2) and 79,000 AF/year of desalted water (Volume 2, p.6-1).
[26] Water and Sustainability: U.S. Electricity Consumption for Water Supply and Treatment - The Next Half Century; Electric Power Research Institute (EPRI)
March 2002

2.2.2 Selection Worksheet

The Study Team developed a structured matrix that facilitated identifying candidate agencies for inclusion in Study 2 that achieved sample goals. The draft matrix was vetted with key water and wastewater industry stakeholders and their associations to assure that the selected agencies, in combination with Study 1, met the goal of representing at least 90 percent of the primary types of water-related energy consumption within the water and wastewater sectors.

Table 2-3. Structured Matrix for Sample Selection, Water Agencies

Distribution of Targeted Water Agencies with High, Medium & Low Energy Intensities	Geographic Region				Types of Water Resources					Treatment Technology(s)			Distribution System Topology			Energy Utility Service Area			
	Coast	Central Valley	South Coast	Desert	Surface Water	Groundwater	Desal, Brackish	Desal, Seawater	Recycled Water	Reverse Osmosis	Ozone	UV	Flat	Moderate	Hilly	PG&E	SCE	SDG&E	SCG
Types of Candidate Urban Water Agencies: • Retailer • City • Water District • Utilities District • Water Company • Regional Water District																			
Types of Candidate Agricultural Water Agencies: • Agricultural District • Rural District • Irrigation District																			

As candidate water agencies were identified, the matrix was populated to enable quickly identifying which of the targeted sample characteristics had been achieved (a) in each geographic region, and (b) for each IOU, vs. those for which viable candidates were still being sought.

Similarly, the below matrix was used to identify candidate wastewater agencies.

Table 2-4. Structured Matrix for Sample Selection, Wastewater Agencies

Distribution of Targeted Wastewater Agencies with High, Medium & Low Energy Intensities	Geographic Region				Types of Water Resources					Treatment Technologies					Distribution Energy			Energy Utility Service Area			
	Central Coast	Central Valley	South Coast	Desert	Surface Water	Groundwater	Desal, Brackish	Desal, Seawater	Recycled Water	Secondary	Tertiary	Reverse Osmosis	Ozone	UV	Flat	Moderate	Hilly	PG&E	SCE	SDG&E	SCG
Sanitation District																					
Utilities District																					
County Sanitation District																					
City																					

2.3 Selected Representative Agencies

After conferring with water and wastewater agencies and their industry associations, thirty-four (34) agencies were targeted for participation in Study 2, with the recognition that some agencies may not agree to participate while others may not be able to provide the requested data. The Study Team hoped to obtain participation of 25 of the targeted agencies.

Note that targeted participating agencies could not represent all water-energy characteristics in every region or in every IOU service area.

Brackish desalination, for example, is typically used to create usable water supplies from otherwise unusable brackish groundwater. Brackish groundwater typically occurs at inland locations. Seawater desalination, on the other hand, uses water from the ocean. Consequently, seawater desalination will be found along the coast.

In addition, not all water treatment technologies are found in every geographic region or IOU service area.

The objective in targeting these particular agencies was to obtain as much data as possible about the primary types of water-energy relationships that exist within each of the four geographic regions and the four IOU service areas. The Study Team relied upon input from California's water sector to identify the optimal mix of water and wastewater agencies that could provide those insights.

The following two maps (Figures 2-3 and 2-4) illustrate the service area boundaries of the targeted participants in Study 2. The targeted distribution of water-energy characteristics that guided selection of representative water agencies are depicted in sections 2.3.1 through 2.3.4 by the 4 geographic regions. Section 2.3.5 summarizes the targeted characteristics by region.

Figure 2-3. Targeted Agencies in Northern California

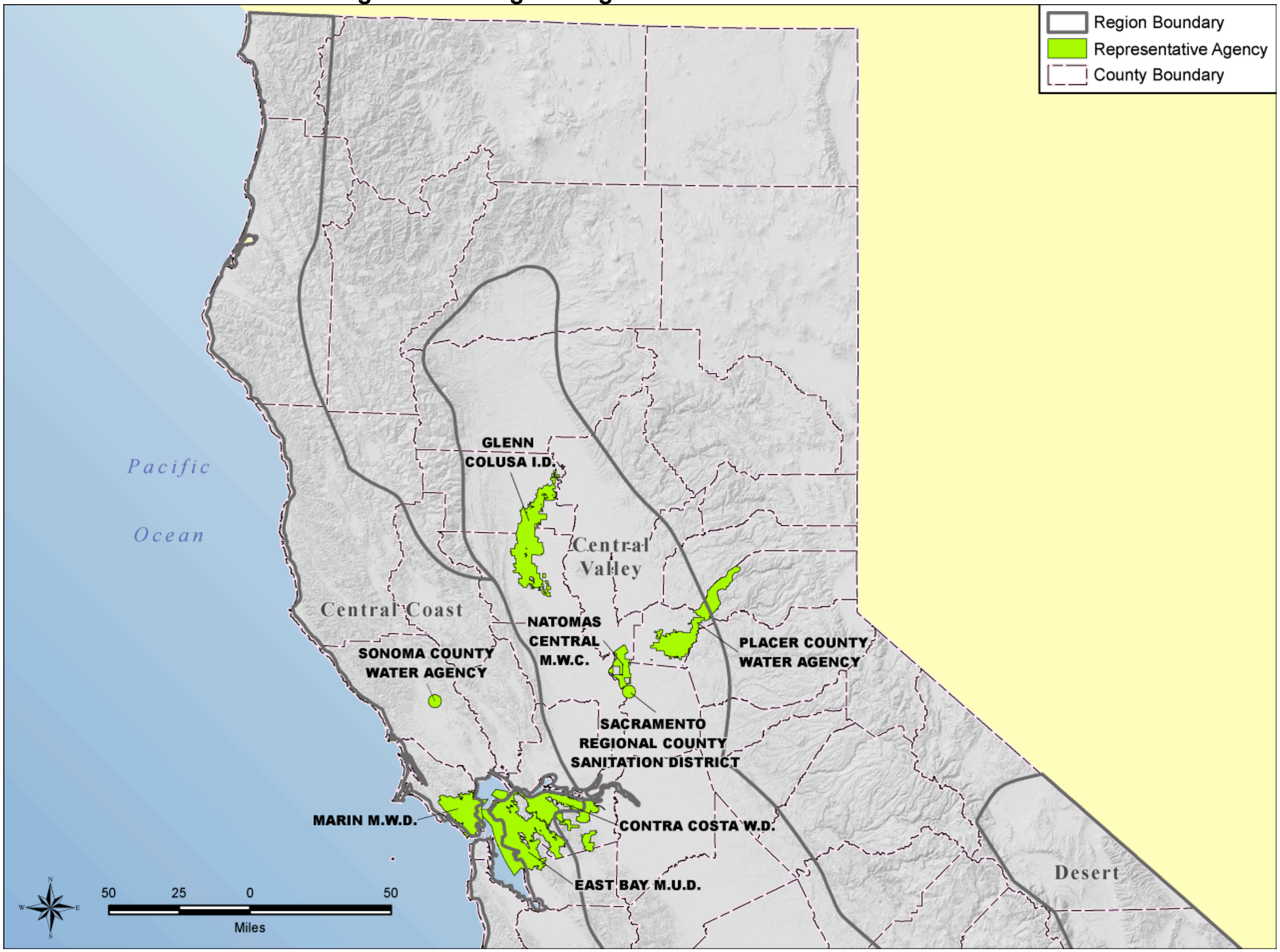
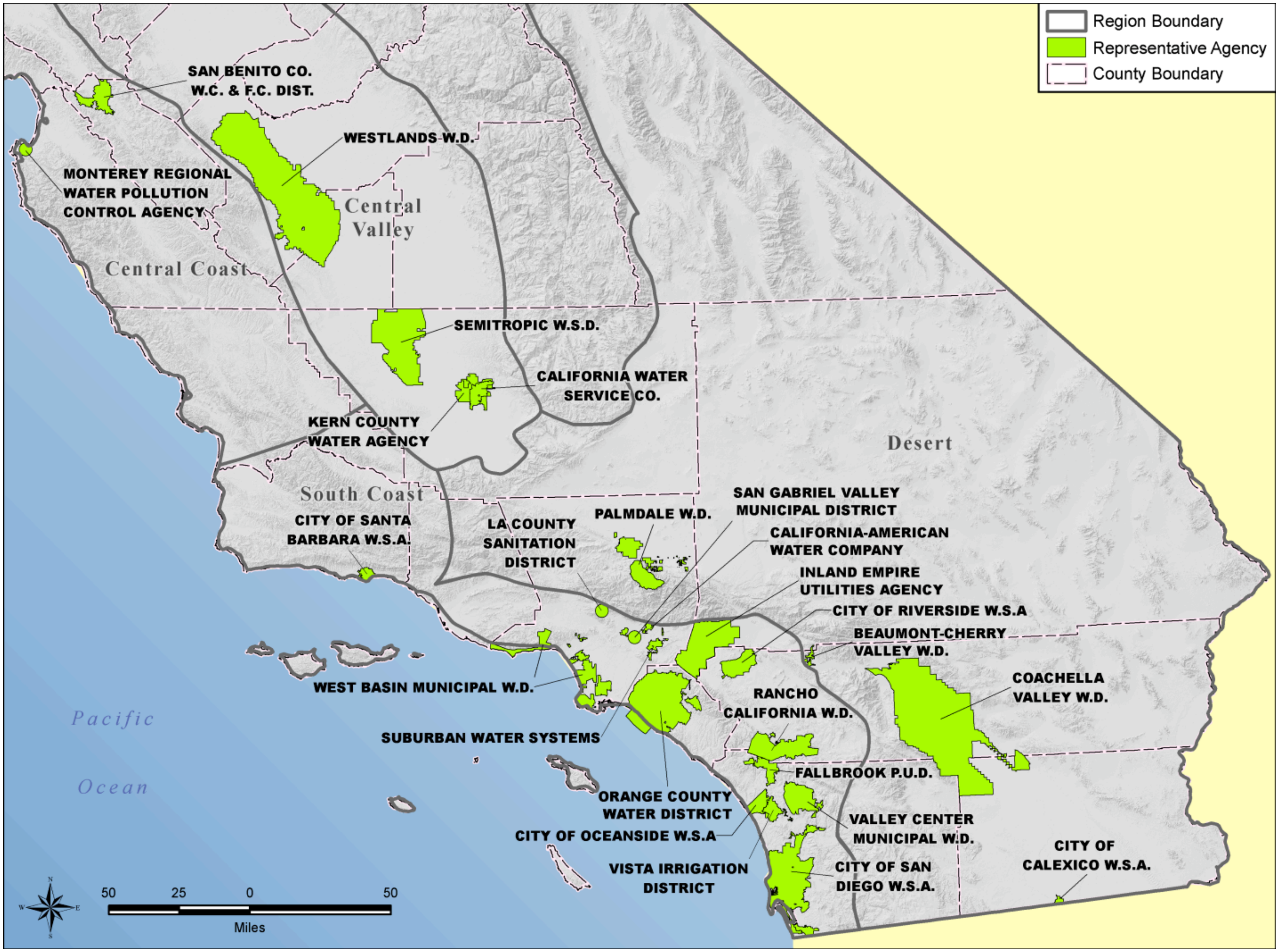


Figure 2-4. Targeted Agencies in Southern California



2.3.1 Region: Northern & Central Coast

Water-Energy Characteristics of Targeted Representative Agencies

Table 2-5. Distribution of Water-Energy Characteristics of Targeted Agencies in Northern & Central Coastal Regions

Agency Name	Energy Provider		Water Sector		Agency Type			Water Supply					Water Treatment				WW Treatment		Distribution Topography		
	ELEC	GAS	AG	URB	W	WW	RW	SW	GW	BD	SD	RW	CL	RO	O3	UV	2nd	3rd	FLAT	MOD	HILL
CAL-AM	PG&E			X	X			X	X				X								
CCWD	PG&E			X	X		X	X	X			X	X		X		X	X			X
EBMUD	PG&E			X	X	X	X	X	X			X			X		X	X			X
MMWD	PG&E			X	X	X		X				X	X								X
MRWPCA	PG&E		X	X		X	X					X	X				X	X		X	
SBCWD	PG&E		X	X	X			X	X				X							X	
SCWA	PG&E			X	X	X	X	X				X	X				X	X		X	
SJWC	PG&E			X	X			X	X				X						X		

Abbreviations:

AGENCY NAME

CAL-AM	California American Water Co.
CCWD	Contra Costa Water District
EBMUD	East Bay Municipal Utility District
MMWD	Marin Municipal Water District
MRWPCA	Monterey Regional Water Pollution Control Agency
SBCWD	San Benito County Water District
SCWA	Sonoma County Water Agency
SJWC	San Jose Water Company

ENERGY PROVIDER

IID	Imperial Irrigation District
PG&E	Pacific Gas & Electric Co.
RPU	Riverside Public Utilities
SCE	Southern California Edison Co.
SCG	Southern California Gas Co.
SDG&E	San Diego Gas & Electric Co.
SMUD	Sacramento Municipal Utility District

WATER SECTOR

AG	Agricultural Water
URB	Urban Water &/or Wastewater

AGENCY TYPE

W	**Water**
WW	**Wastewater**
RW	**Recycled Water**

WATER SUPPLY

SW	**Surface Water**
GW	**Groundwater**
BD	**Brackish Desalination**
SD	**Seawater Desalination**
RW	**Recycled Water**

WATER TREATMENT

CL	Chlorination
RO	Reverse Osmosis
O3	Ozonation
UV	Ultraviolet

WASTEWATER TREATMENT

2nd	Secondary
3rd	Tertiary

DISTRIBUTION SYSTEM TOPOGRAPHY

FLAT	Relatively flat topography
MOD	Moderate or mixed elevations
HILL	Relatively hilly topography

2.3.2 Region: Central Valley

Water-Energy Characteristics of Targeted Representative Agencies

Table 2-6. Distribution of Water-Energy Characteristics of Targeted Agencies in Central Valley Region

Agency Name	Energy Provider		Water Sector		Agency Type			Water Supply					Water Treatment				WW Treatment		Distribution Topography		
	ELEC	GAS	AG	URB	W	WW	RW	SW	GW	BD	SD	RW	CL	RO	O3	UV	2nd	3rd	FLAT	MOD	HILL
CALW-B	PG&E			X	X			X	X					X						X	
GCID	PG&E		X		X			X	X										X		
KCWA	PG&E		X		X			X	X										X		
Natomas	SMUD	PG&E	X	X	X			X	X										X		
PCWA	PG&E		X	X	X			X					X								X
SRCSD	SMUD	PG&E		X		X	X										X	X			
SWSD	PG&E		X		X			X	X										X		
WWD	PG&E		X		X			X	X										X		

Abbreviations:

AGENCY NAME

CALW-B California Water Co., Bakersfield
GCID Glen Colusa Irrigation District
KCWA Kern County Water Agency
Natomas Natomas Mutual Water Co.
PCWA Placer County Water Agency
SRCSD Sacramento Regional County Sanitary District
SWSD Semitropic Water Storage District
WWD Westlands Water District

ENERGY PROVIDER

IID Imperial Irrigation District
PG&E Pacific Gas & Electric Co.
RPU Riverside Public Utilities
SCE Southern California Edison Co.
SCG Southern California Gas Co.
SDG&E San Diego Gas & Electric Co.
SMUD Sacramento Municipal Utility District

WATER SECTOR

AG Agricultural Water
URB Urban Water &/or Wastewater

AGENCY TYPE

W **Water**
WW **Wastewater**
RW **Recycled Water**

WATER SUPPLY

SW **Surface Water**
GW **Groundwater**
BD **Brackish Desalination**
SD **Seawater Desalination**
RW **Recycled Water**

WATER TREATMENT

CL Chlorination
RO Reverse Osmosis
O3 Ozonation
UV Ultraviolet

WASTEWATER TREATMENT

2nd Secondary
3rd Tertiary

DISTRIBUTION SYSTEM TOPOGRAPHY

FLAT Relatively flat topography
MOD Moderate or mixed elevations
HILL Relatively hilly topography

2.3.3 Region: Southland

Water-Energy Characteristics of Targeted Representative Agencies

Table 2-7. Distribution of Water-Energy Characteristics of Targeted Agencies in Southland Region

Agency Name	Energy Provider		Water Sector		Agency Type			Water Supply					Water Treatment				WW Treatment		Distribution Topography		
	ELEC	GAS	AG	URB	W	WW	RW	SW	GW	BD	SD	RW	CL	RO	O3	UV	2nd	3rd	FLAT	MOD	HILL
City SD	SDG&E		X	X	X	X	X	X	X			X	X				X	X		X	
City SB	SCE	SCG		X	X	X	X	X	X		X	X	X	X			X	X		X	
FPUD	SDG&E		X	X	X	X	X	X				X						X			X
IEUA	SCE	SCG	X	X	X	X	X	X	X	X		X						X	X	X	
LACSD	SCE	SCG		X		X	X					X	X				X	X		X	
RPU	RPU	SCG		X	X	X	X	X	X			X	X				X	X		X	
Ocean	SDG&E			X	X	X	X	X		X		X								X	
OCWD	SCE	SCG		X	X	X	X	X	X			X	X	X		X	X	X	X		
RCWD	SCE	SCG	X	X	X	X	X	X	X			X	X	X			X	X			X
SGWCo	SCE	SCG			X																
Suburban	SCE	SCG		X	X			X	X												
Valley	SDG&E		X		X	X	X	X				X					X				X
Vista ID	SDG&E		X	X	X		X	X				X						X		X	
WBMWD	SCE	SCG		X	X		X			X	X	X	X	X	X	X		X	X		

Abbreviations:

AGENCY NAME

City SD City of San Diego
City SB City of Santa Barbara
FPUD Fallbrook Public Utilities District
IEUA Inland Empire Utilities Agency
LACSD Los Angeles County Sanitation Dist.
RPU Riverside Public Utilities
Ocean City of Oceanside
OCWD Orange County Water District
RCWD Rancho California Water District
SGWCo San Gabriel Water Company
Suburban Suburban Water Systems
Valley Valley Center Water District
Vista ID Vista Irrigation District
WBMWD West Basin Municipal Water District

ENERGY PROVIDER

IID Imperial Irrigation District
PG&E Pacific Gas & Electric Co.
RPU Riverside Public Utilities
SCE Southern California Edison Co.
SCG Southern California Gas Co.
SDG&E San Diego Gas & Electric Co.
SMUD Sacramento Municipal Utility District

WATER SECTOR

AG Agricultural Water
URB Urban Water &/or Wastewater

AGENCY TYPE

W Water
WW Wastewater
RW Recycled Water

WATER SUPPLY

SW Surface Water
GW Groundwater
BD Brackish Desalination
SD Seawater Desalination
RW Recycled Water

WATER TREATMENT

CL Chlorination
RO Reverse Osmosis
O3 Ozonation
UV Ultraviolet

WASTEWATER TREATMENT

2nd Secondary
3rd Tertiary

DISTRIBUTION SYSTEM TOPOGRAPHY

FLAT Relatively flat topography
MOD Moderate or mixed elevations
HILL Relatively hilly topography

2.3.4 Region: Desert

Water-Energy Characteristics of Targeted Representative Agencies

Table 2-8. Distribution of Water-Energy Characteristics of Targeted Agencies in Desert Region

Agency Name	Energy Provider		Water Sector		Agency Type			Water Supply					Water Treatment				WW Treatment		Distribution Topography		
	ELEC	GAS	AG	URB	W	WW	RW	SW	GW	BD	SD	RW	CL	RO	O3	UV	2nd	3rd	FLAT	MOD	HILL
Beaumont	SCE	SCG		X	X	X	X	X	X			X	X			X		X		X	
Calexico	IID	SCG		X	X	X		X					X			X	X		X		
Coachella	IID	SCG	X	X	X	X	X	X	X			X	X				X	X	X		
Palmdale	SCE	SCG		X	X	X		X	X				X				X				

Abbreviations:

AGENCY NAME

Beaumont Beaumont Cherry Valley Water District
Calexico City of Calexico
Coachella Coachella Valley Water District
Palmdale Palmdale Water District

ENERGY PROVIDER

IID Imperial Irrigation District
PG&E Pacific Gas & Electric Co.
RPU Riverside Public Utilities
SCE Southern California Edison Co.
SCG Southern California Gas Co.
SDG&E San Diego Gas & Electric Co.
SMUD Sacramento Municipal Utility District

WATER SECTOR

AG Agricultural Water
URB Urban Water &/or Wastewater

AGENCY TYPE

W **Water**
WW **Wastewater**
RW **Recycled Water**

WATER SUPPLY

SW **Surface Water**
GW **Groundwater**
BD **Brackish Desalination**
SD **Seawater Desalination**
RW **Recycled Water**

WATER TREATMENT

CL Chlorination
RO Reverse Osmosis
O3 Ozonation
UV Ultraviolet

WASTEWATER TREATMENT

2nd Secondary
3rd Tertiary

DISTRIBUTION SYSTEM TOPOGRAPHY

FLAT Relatively flat topography
MOD Moderate or mixed elevations
HILL Relatively hilly topography

2.3.5 Regional Distribution of Targeted Water-Energy Characteristics

Table 2-9. Distribution of Water-Energy Characteristics of Targeted Agencies by Region

Region	Energy Provider		Water Sector		Agency Type			Water Supply					Water Treatment				WW Treatment		Distribution Topography		
	ELEC	GAS	AG	URB	W	WW	RW	SW	GW	BD	SD	RW	CL	RO	O3	UV	2nd	3rd	FLAT	MOD	HILL
No. & Central Coast	PG&E		X	X	X	X	X	X	X			X	X		X		X	X	X	X	X
Central Valley	PG&E, SMUD		X	X	X			X	X				X	X					X	X	
South-land	SCE, SSCG, SDG&E		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Desert	IID, SCE, SCG		X	X	X	X	X	X	X			X	X			X	X	X	X	X	

3 Water & Wastewater Agency Profiles

3.1 Introduction

3.1.1 Water & Wastewater Agencies That Participated in Study 2

Not all of the targeted agencies were able to provide the requested water and energy data prior to completion of this study. Twenty-two agencies did provide sufficient data. Profiles for each of these agencies are provided in this chapter, organized by geographic region.

Table 3-1. Water & Wastewater Agency Profiles Completed Through Study 2

REGION/AGENCY	PROFILE?	REGION/AGENCY	PROFILE?
CENTRAL & NORTHERN COASTS		**SOUTHLAND**	
California American Water - Monterey	Yes	City of San Diego	In process
Contra Costa Water District	Yes	City of Oceanside	Yes
East Bay Municipal Utility District	Yes	City of Santa Barbara	In process
Marin Municipal Water District	Yes	Inland Empire Utilities Agency	Yes
Monterey Regional Water Pollution Control Agency	Yes	Los Angeles County Sanitation Districts	Yes
San Jose Water Company	Yes	Orange County Sanitation & Water Districts	Yes
Sonoma County Water Agency	Yes	Rancho California Water District	Yes
		San Gabriel Water Company	Yes
CENTRAL VALLEY		Suburban Water Systems	Yes
California Water Co., Bakersfield	In process	Valley Center Water District	Yes
Glen Colusa Irrigation District	Yes	West Basin Municipal Water District	In process
Natomas Mutual Water Company	Yes		
Semitropic Water Storage District	Yes		
Westlands Water District	Yes		
		DESERT	
		Beaumont Cherry Valley Water District	In process
		City of Calexico	Yes
		Coachella Valley Water District	Yes

Many of the agencies contacted by the Study Team have indicated that they are short staffed, dealing with lay-offs, furloughs, and budget cuts as results of the current economic conditions. Some agencies chose to participate despite reductions in resources, but indicated that they would participate to a less involved extent than requested.

For some agencies, electrical data could be collected directly from the utility service provider with their permission through a third party authorization agreement between the agency, the utility, and the Study Team. The ability of the Study Team to use investor-owned utility (IOU) data reduces demands on participants' time and resulted in a positive decision to participate in some cases. Each agency maintains data in different ways and therefore an initial discussion on data needs versus data available between the Study Team and each agency was required. Additionally, not all agencies had all of the data required for the study so additional cooperation was required of the participants to discuss data adjustments.

3.1.2 Structure and Content of Detailed Agency Profiles

Detailed water-energy profiles were compiled for participating water and wastewater agencies. The profiles are provided in Appendix B. In addition to the summary level water-energy characteristics highlighted in the summary profiles, the detailed profiles contain the following types of information:

- Description of primary functional components and key energy drivers by system and sub-segment of the water use cycle.
- The results of the Study 2 analyses. The detailed profiles contain:
    - Total energy consumption during calendar year 2008 (the test year)
    - Average energy intensity by meter, facility and facility type (e.g., type of process, resource and/or functional water or wastewater system component)
    - Twenty-four (24) hour energy load profiles for the requested seven types of days[27]
    - Marginal water supplies: short-term (less than 1 year) and long-term (greater than 1 year)[28]
    - The estimated energy intensity of each marginal water supply

[27] The 24 hour load profiles prepared through Study 2 relied upon metered energy data wherever possible. As a consequence, the profiles include both energy and demand, where "demand" is the peak demand measured in kilowatts recorded and billed in accordance with the respective electric service providers' tariffs. The CPUC uses another definition for "peak demand" that needed to be separately computed by WELP. A description of the difference between "billed demand" and the CPUC's computation of "system demand" is provided at the end of this Section 3.1.

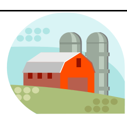
[28] Marginal water supplies were identified through review of 2005 Urban Water Management Plans and interviews with agency management and staff.

The WELP Tool contains all of the data collected and compiled for the 22 agencies at the meter, facility, functional component, and/or system level. WELP's reporting capabilities far exceed the needs of Study 2, with the ability to produce hundreds of daily reports and graphs of 24-hour energy consumption by meter and by facility. This flexibility was programmed into WELP to enable the CPUC and its water-energy stakeholders to maximize the utility of this extensive data collection effort beyond that which was needed for Study 2.

Each detailed agency profile has a "water-energy snapshot" that summarizes its most important water-energy characteristics on one page. The snapshots are included in this chapter, organized by geographic region.

Icons are used to quickly identify the types of agencies and their primary water and wastewater functions.

Table 3-2. Agency Profile Icons

Symbol	Type of Agency/Functions	Description
	Water	The agency provides potable water to its customers. The water is either imported as treated water or treated by the agency.
	Recycled Water	The agency produces and provides recycled water to customers. Agencies that only purchase recycled water but do not produce it themselves are not included.
	Waste Water	The agency collects, treats, and disposes of wastewater.
	Urban	The agency serves an urban customer base by providing them with water or wastewater services. If the agency is a wholesaler, this symbol indicates the type of retail customers served by the agencies contractors
	Agricultural	The agency serves an agricultural customer base by providing them with water for irrigation purposes
	Local Wholesaler	The agency acts as a local wholesaler of water. They may sell treated or raw water to other agencies for use. Agencies may also make retail sales to some customers.

Each detailed profile contains eight sections: background information, water sources, marginal water supply, water demand, system infrastructure and operations, sub-regions, energy profiles, and current infrastructure-related efficiency projects.

Table 3-3. Content in Agency Profiles

Profile Section	Description of Content
Background Information	Agency service area characteristics and demographics, including temperature, precipitation, current and projected population, number of customers and notable trends
Water Sources	Water resource portfolio
Marginal Water Supply	Short and long-term marginal water supplies
Water Demand	Current and projected water demand
System Infrastructure & Operations	Physical system configuration: types of facilities by segment of the water use cycle, system-wide operations strategies, and planned changes that may impact energy requirements
Sub-Regions	Description of sub-regions within the agency's service area, if any
Energy Profiles	Results of Study 2 analyses: • Energy intensity by facility type and primary system • 24 hour load profiles for the 7 representative days
Current Infrastructure Related Energy Efficiency Projects	Current or planned energy efficiency projects (e.g., pump efficiency upgrades, pipeline replacements, canal lining, etc.)

3.1.3 Development of Twenty Four Hour Water-Energy Profiles

The Study 2 scope of work required development of "Energy Use Profile(s) (kWh and MMBTU by hour)."[29] The scope of work did not specify the methodology for developing those 24 hour load profiles. (Note that very few agencies used natural gas. Consequently, this section focuses solely on issues related to profiling electricity demand.)

As noted earlier, the Study Team relied on energy bill meters as its primary source of data for developing the participating agencies' water-energy load profiles. Such meters are installed in a manner that allows recording energy use at the level of detail needed to properly assess rates in accordance with approved energy provider tariffs.

Four primary types of energy meters were relied upon to develop the 24 hour energy use profiles:

Table 3.4. Types of Electricity Meter Data Used in Study 2

Type of Electric Meter	Description	Type of Data Collected						
		Total kWh	TOU		Intervals (<= Hourly)		SCADA (<Hourly)	
			kWh	kW	kWh	kW	kWh	kW
Energy	Energy consumed during meter read interval	X						
Time-of-Use (TOU)	Energy by TOU Bucket	X	X					
	Energy & Demand by TOU Bucket	X	X	X				
Interval Meters	Average Demand during a specified interval within an hour (1 minute, 5 minutes, 15 minutes, etc.)	X			X	X		
SCADA Data	Detailed Data (could be any interval defined by the Agency)	X					X	X

[29] CPUC Decision 07-12-050, p.6.

- ***Energy Meters*** – These are meters that record the total amount of electricity used by the connected load during the meter read interval (i.e., between the current read date and the last read date). The meter read interval typically depends on the route of the meter reader assigned to capture that data, and seldom corresponds to a calendar month.

- ***Time-of-Use (TOU) Meters*** – These meters collect the amount of electricity used during certain times of the day into time-of-use "buckets." For example, the person installing the meter sets the meter to record all electricity used during on-peak hours of each day to the "on-peak" bucket. Electricity used during partial-peak and off-peak periods is similarly captured into separate buckets. In this manner, the energy provider is able to charge different rates ($/kWhr) for electricity used during different times of the day, as determined by the applicable tariff. Some TOU meters just capture buckets of electricity used during the meter read interval by TOU bucket; others also separately capture the maximum amount of electricity used during any hour within the TOU bucket. Total energy is computed by adding up all of the energy recorded in the respective buckets.

- ***Interval Meters*** – Interval meters record the average amount of electricity demand consumed over a specified interval within one hour. The interval depends on the level of detail that the energy provider wants to capture. Average demand during the specified interval is then multiplied by the number of intervals within an hour, to obtain total kWh consumed during that hour. The peak demand during that hour is typically the maximum kW recorded among all of the intervals within that hour.

- ***SCADA[30] Data*** – Some of the agencies were able to provide real-time data from their SCADA systems. The granularity and type of SCADA data depends on the needs of the water or wastewater agency collecting the data. Precise data at intervals of seconds was not needed for Study 2, so the Study Team requested hourly data wherever the SCADA systems were able to provide it in this form.

As described in Chapter 1, the WELP Tool was developed to streamline the process of compiling water-energy load profiles from these many disparate types of data and formats. One of the major functions of WELP is to distribute energy consumption and demand in accordance with water operations data. For example:

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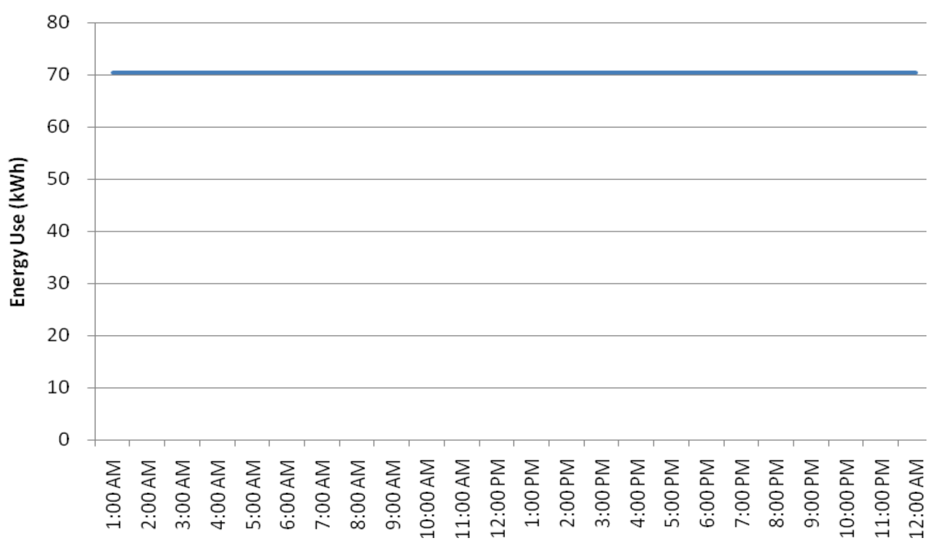
[30] Supervisory Control and Data Acquisition (SCADA) is a term used to describe computerized systems that collect and analyze real time data for a variety of purposes. Water and wastewater agencies often have SCADA systems to automate the monitoring and control of water and wastewater treatment processes and functions.

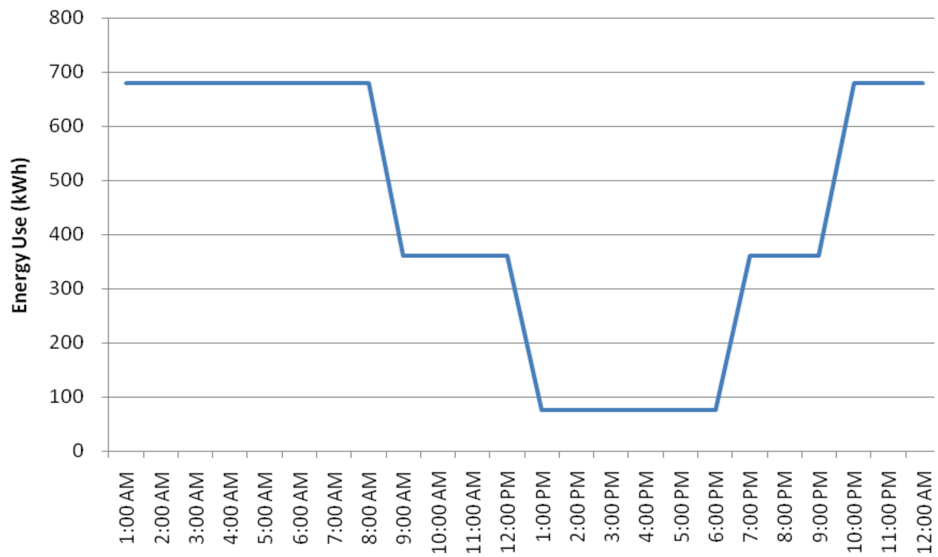
- ***Energy Meters*** provide total energy (kWh) consumed by a load over the meter read interval, typically 30 or more days. Energy meters thus do not provide enough granularity to determine a 24 hour energy use profile. Wherever available, water operations data with more granularity was matched to the energy meter data to distribute the energy over the period of time. Some water data was available on a daily basis, others by calendar month or another reporting interval. Seldom was hourly water operations data available. Consequently, energy consumption from energy meters tends to have little discernible difference over any 24 hour period. This is typically not a problem because energy meters are usually used to meter small loads. Consequently, the sum of energy consumption from energy meters accounts for a small portion of a water agency's water-energy profile.

Figure 3-1. Illustration of the 24 Hour Load Profile Produced by Energy Meters



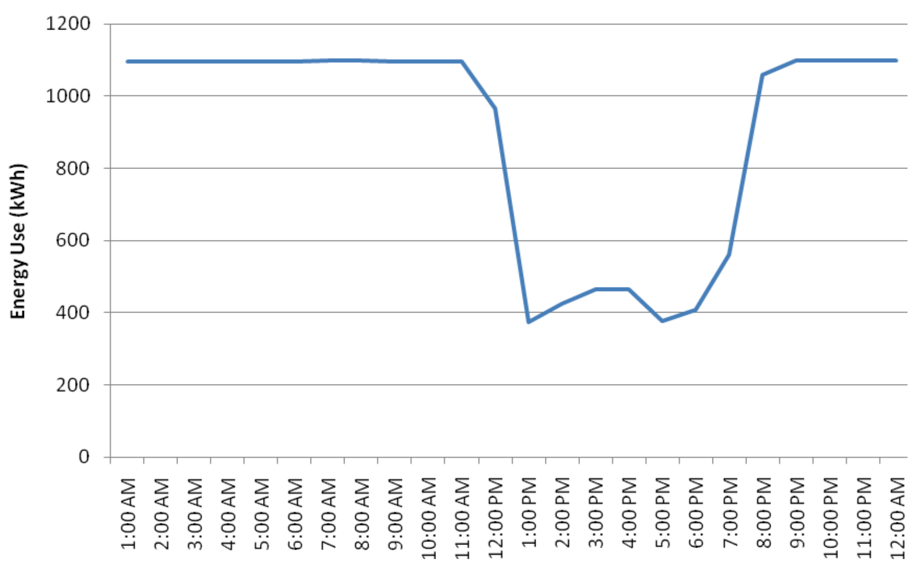
- ***TOU Meters*** also do not provide 24 hour energy data. They do, however, capture energy by TOU buckets. TOU data was matched to water operations data for that meter wherever possible in an attempt to achieve more granularity of the 24 hour load profile. Typically, however, as can be seen in Figure 3-2, the 24 hour load profile developed with TOU data tends to follow the TOU buckets, the best level of granularity available for those loads.

Figure 3-2. Illustration of the 24 Hour Load Profile Produced by TOU Meters



- ***Interval*** provide the best information for purposes of developing 24 hour load profiles. Since these types of meters are typically used only for very large loads, or to meter the variability in significant loads that cannot be easily scheduled or predicted, these typically account for a significant portion of an agency's total energy requirements.

Figure 3-3. Illustration of the 24 Hour Load Profile Produced by Interval Meters

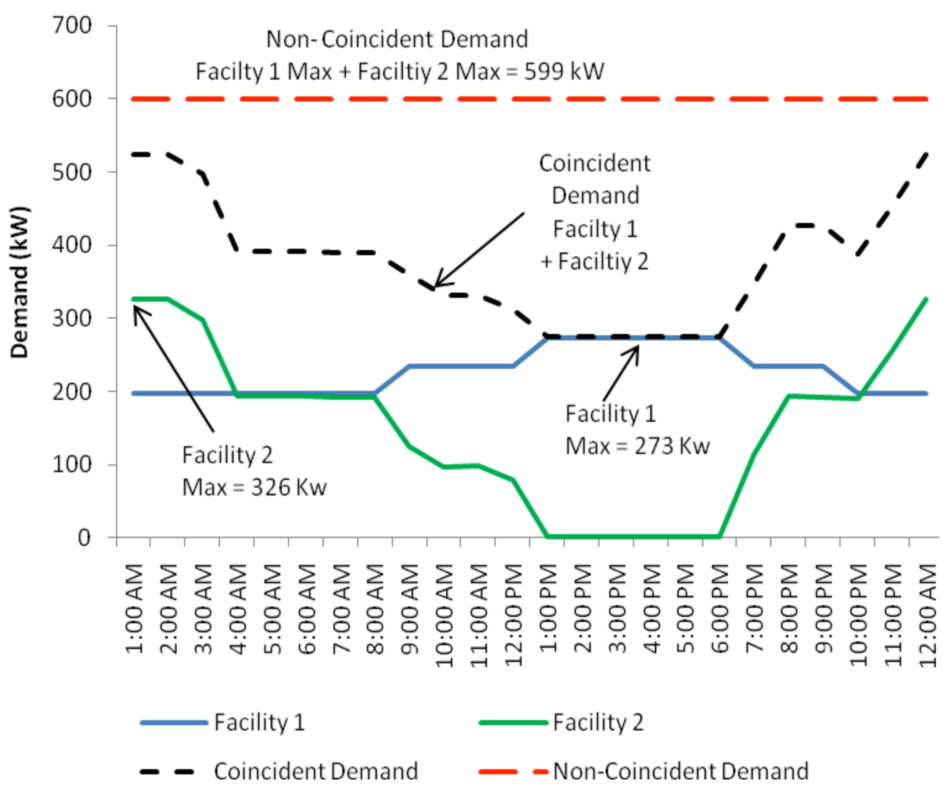


3.1.4 Peak Demand for Billing vs. Electric System Planning Purposes

Electric tariffs often assess charges for both energy (i.e., the total amount of electricity used during any particular period, measures in kilowatt hours) and demand (i.e., the maximum amount of electricity used during any hour within a billing period). In preparing the energy use profiles, the Study Team applied this structure to show the hourly energy profile for individual systems and functional components within a water or wastewater agency. The Study Team also showed the amount of billed demand above the hourly energy consumption data.

In viewing these profiles, it is important to realize that the peak demand shown on these 24 hour load profiles is likely overstated wherever data were compiled from two or more meters. Billed demand is intended to represent the maximum amount of electric capacity an electric service provider would need to provide in order to meet the electricity requirements of that metered load. In real life applications, however, the time at which the maximum amount of electricity required by one metered load does not necessarily coincide with the time the maximum amount is used by another. As a consequence, the actual amount of electric capacity needed to serve two or more meters is seldom equivalent to the sum of their individual maximum, or peak demands.

Figure 3-4. Illustration of Concurrent vs. Non-Concurrent Demand



Note: This graph illustrates coincident and non-coincident demand using two facilities with hourly data. However, the overstatement of non-coincident demand is most likely to occur with two (or more) facilities for which we only have monthly data. The actual peak demand of two different facilities could occur on two different days of the month.

Utilities use a planning concept known as “concurrent peak demand” to represent the likely maximum demand of multiple loads. Without hourly meter data from every load, the Study Team had no basis for adjusting the sum of the maximum demands for multiple meters to a presumed “concurrent peak.” Therefore, the peak demand shown for the agency profiles are created by stacking the sum of the maximum peak demands of every meter included in the study.

While the approach of stacking the maximum demand of the individual meters is consistent with the basis for assessing electricity charges, billed demand is not equivalent to “system peak demand” as applied by the CPUC in its energy efficiency programs.

In 2006, the CPUC adopted a definition for evaluating the impact of efficiency programs and measures on peak system demand. The definition relied upon the Database for Energy Efficient Resources (DEER) method of assessing the average grid-level impact of any measure between the hours of 2:00pm and 5:00pm on three consecutive weekdays, one of which is the weekday with the hottest temperature of the year. DEER identifies those three contiguous peak electric demand days for each of the 16 California climate zones, based on the weather data sets developed for the California Title 24 Building Energy Efficiency Standards.

During the course of this study, the Technical Working Group requested that the Study Team identify the average of these nine hours for each agency studied. The Study Team agreed to include a function in WELP that computes rolling averages for these three hours on every group of three consecutive weekdays. In this manner, the CPUC and its stakeholders can query the database and obtain these data at the meter, facility type, functional component, and/or agency levels.

3.2 Agency Water-Energy Load Profiles

The agency-level water-energy snapshots are provided in the following sections by geographic region.

3.2.1 Northern and Central Coast Agencies

Of the agencies targeted for this region, sufficient water-energy data was received from 7 water and wastewater agencies:

- California American Water – Monterey District
- Contra Costa Water District
- East Bay Municipal Utility District – Water
- Marin Municipal Water District
- Monterey Regional Water Pollution Control Agency
- San Jose Water Company

- Sonoma County Water Agency

The coastal region had no significant change to the overall coverage in the representative sample criteria.

Summaries of the water-energy characteristics of each agency studied are provided on the following pages. Detailed water-energy profiles of each agency studied are provided in Appendix B.

Table 3-5. California American Water – Monterey District

Primary function	Urban Water		
Segments of Water Use Cycle	Supply, Treatment, Distribution		
Hydrologic Region	Coastal	**DEER Climate Zone**	3
Quantity of water	Produced: 9.7 MGD Groundwater Produced: 3.3 MGD	Distributed: 13.0 MGD	
Number of Customers (2009)	Total: 125,000 population served	**Service Area Size**	N/A
Distinguishing Characteristics	CALAM supplies retail potable water to 19 areas in Monterey, utilizing local rainfall and groundwater for supply. Topography generally moderate to hilly terrain. Existing water supplies consist of local surface water and groundwater which are fully allocated and increases in supply are not expected in the short-term.		
Key Energy Drivers	• Water Supply - significant energy is used for groundwater pumping. • Water Treatment – conventional treatment technologies are used to treat local surface water.		
Water/Wastewater Treatment Technology	Carmel Valley Water Treatment Plant: Conventional Treatment		
Water Resources	Surface Water: 75%, Groundwater: 22%, Other: 3%		
Marginal Water Supply and Energy Intensity (kWh/MG)	Short-term: Local Surface Water (3,546-6,666) Long-term: Recycled water, recovered water, desalinated water (31-12,272)		
Energy Service Provider	PG&E		
Observed Energy Intensities (kWh/MG)	**Segment**	**Lower Range**	**Upper Range**
	Groundwater	2,099	2,514
	Water Treatment	3,546	6,666

Table 3-6. Contra Costa Water District

<table>
<tr><td>Primary functions</td><td colspan="3">Urban Water, Local wholesale and retail</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Supply, treatment, distribution</td></tr>
<tr><td>Hydrologic Region</td><td>San Francisco and San Joaquin</td><td>DEER Climate Zone</td><td>2</td></tr>
<tr><td>Quantity of Water</td><td colspan="3">Treated by Agency: 32.7 MGD (Ave for 2008)
Total Distributed: 105 MGD (Ave for 2008)</td></tr>
<tr><td>Number of Customers (2008)</td><td>Population: 550,000
Total Connections: 89,191
Residential: 84,229
Commercial: 3,145
Other: 1,817</td><td>Service Area Size</td><td>137,127 Sq miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">Contra Costa Water District’s (CCWD) location in the Sacramento-San Joaquin Delta provides access to supplies from the Sacramento and San Joaquin Rivers and their tributaries. The district obtains water primarily from CVP at two locations. Water must be pumped out of the delta to reach customers at higher elevations. CCWD owns and operates Los Vaqueros Reservoir using it to control water quality and for seasonal storage.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="3">• Water Conveyance – pumping plants are required to lift water from the Delta up to the Contra Costa Canal and Los Vaqueros Reservoir at a higher elevation
• Water Treatment – Two treatment plants using chlorination and ozone to treat water for CCWD customers
• Water Distribution – Water is pumped to the eight-pressure zones with an elevation difference of over 450 feet</td></tr>
<tr><td>Water Treatment Technologies</td><td colspan="3">Bollman Water Treatment Plant: coagulation, flocculation, sedimentation, ozone, filtration, and disinfection
Randall-Bold Water Treatment Plant: pre-ozone, coagulation, flocculation, sedimentation, filtration, post-ozone, and disinfection</td></tr>
<tr><td>Water Resources (2005)</td><td colspan="3">CVP: 82.9%
Surface Water: 12.1%
Groundwater: 1.4%
Recycled Water: 3.6%</td></tr>
<tr><td>Marginal Water Supplies and Energy Intensity (kWh/MG)</td><td colspan="3">Short-term: CVP Water (1,743-2,914)
Long-term: Conservation measures, surface water transfers, regional desalination partnership, recycled water (1,743-12,276)</td></tr>
<tr><td>Energy Service Providers</td><td colspan="3">PG&E, CVP, MID</td></tr>
<tr><td rowspan="4">Observed Energy Intensities (kWh/Mgal)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Raw Water Conveyance</td><td>848</td><td>1,704</td></tr>
<tr><td>Water Treatment</td><td>895</td><td>1,210</td></tr>
<tr><td>Water Distribution</td><td>688</td><td>1,524</td></tr>
</table>

Table 3-7. East Bay Municipal Utility District – Water

<table>
<tr><td>Primary functions</td><td colspan="3">Urban Water, Wastewater</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Supply, Treatment, Distribution, Recycled Water Production</td></tr>
<tr><td>Hydrologic Region</td><td>Coastal</td><td>DEER Climate Zone</td><td>3 and 12</td></tr>
<tr><td>Quantity of Water</td><td colspan="3">Treated and Distributed: 200 MGD (average for 2008)</td></tr>
<tr><td>Number of Customers (2005)</td><td>Total: 391,216
Residential: 363,980
Commercial: 17,231
Industrial: 2,578
Institutional: 3,892
Irrigation: 3,535</td><td>Service Area Size</td><td>325 Sq miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">EBMUD supplies water and provides wastewater treatment for parts of Alameda and Contra Costa counties. Water is conveyed via gravity from the Mokelumne River (Pardee Dam) via gravity fed pipelines to EBMUD's service territory. Water is treated at one of 5 water treatment plants before being distributed. Geographically, the western portion of the service area is characterized by a plain that extends from Richmond to Hayward and from the shore of the Bay inland up into the Oakland/Berkeley Hills that rise to about 1,900 feet above sea level.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="3">• Water Conveyance – Most water flow by gravity to EBMUD with some use of pumps to supplement flows, energy use depends on reservoir levels , water demands, rainfall and operations
• Water Treatment- Two water treatment plants use conventional technologies and utilize ozone disinfection. Three treatment plants use inline direct filtration.
• Water Distribution – Booster pumps are needed to distribute water to customer at elevations above about 250 feet</td></tr>
<tr><td>Water Treatment Technologies</td><td colspan="3">Upper San Leandro and Sobrante (Water): Aeration, Coagulation, Flocculation, Sedimentation, Filtration, Disinfection, Ozonation, Flouridation, Corrosion Control
Orinda, Laffayette, and Walnut Creek (Water): Coagulation, Filtration, Disinfection, Flouridation, Corrosion Control</td></tr>
<tr><td>Water Resources</td><td colspan="3">Imported Surface Water: 90%, Local Runoff: 10%</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">Short-term – Surface Water (145 – 906)
Long-term – Groundwater storage, Desalination (1,051 – 12,276)</td></tr>
<tr><td>Energy Service Provider</td><td colspan="3">PG&E</td></tr>
<tr><td rowspan="4">Observed Energy Intensities (kWh/MG)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Raw Water Conveyance</td><td>10</td><td>597</td></tr>
<tr><td>Water Treatment</td><td>135</td><td>310</td></tr>
<tr><td>Water Distribution</td><td>319</td><td>699</td></tr>
</table>

Table 3-8. Marin Municipal Water District

Primary functions	Urban Water, Recycled Water		
Segments of Water Use Cycle	Supply, Treatment, Distribution, Recycled Water Production		
Hydrologic Regions	San Francisco	**DEER Climate Zones**	3 and 12
Quantity of Water	Treated: 29 MGD (average) Distributed: 34.1 MGD (average)	Recycled: 0.91 MGD (during summer months only, no production in winter)	
Number of Customers (2005)	Total: 64,588 Residential: 59,422 Other: 5,166	**Service Area Size**	147 Sq miles
Distinguishing Characteristics	The Marin Municipal Water District (MMWD) in the eastern corridor of Marin County covers approximately 147 square miles and serves a population of approximately 190,000. MMWD manages several local reservoirs for its supply in addition to imports from Sonoma County Water Agency. MMWD serves an area with hilly terrain; about 90% of the water must be pumped at least once before it reaches customers.		
Key Energy Drivers	• Water Supply – Many reservoirs are at high elevations, though varying operations cause a large range in energy use • Treatment – Treatment is required at two treatment plants for all local surface water • Water Distribution – Significant energy is used to pump water through the hilly terrain		
Water and Wastewater Treatment Technologies	Bon Tempe and San Geronimo Treatment Plants (Water): coagulation, sedimentation, filtration, and chloramines Ignacio Treatment Facility (Water): quality monitoring, chemical addition Recycled Water Facility: filtration, tertiary treatment		
2008 Water Resources	73% Local Surface Water, 25% Imported, 2% Recycled		
Marginal Water Supply and Energy Intensity (kWh/MG)	Short-term: Local Surface Supply (456 - 1,435) Long-term: Recycled Water, Additional Russian River Supply, Desalination (1,953 – 12,276)		
Energy Service Provider	PG&E		
Observed Energy Intensities (kWh/MG)	**Segment**	**Lower Range**	**Upper Range**
	Raw Water Pumps	9	480
	Water Treatment	105	322
	Water Distribution	352	633
	Recycled Water Treatment	984	1,262
	Recycled Water Distribution	969	1,304

Table 3-9. Monterey Regional Water Pollution Control Agency

Primary functions	Urban Wastewater, Recycled Water Production, Agricultural Supply		
Segments of Water Use Cycle	Wastewater Treatment, Recycled Water Production, Recycle Water Distribution,		
Hydrologic Region	Coastal	**DEER Climate Zone**	3
Quantity of wastewater	21 MGD Average Flow Secondarily Treated	Recycled: 29.6 MGD Permitted Capacity	
Number of Customers	Total Population: Approximately 266,000	**Service Area Size**	Not Available
Distinguishing Characteristics	Monterey Regional Water Pollution Control Agency (MRWPCA) member communities include Pacific Grove, Monterey, Del Rey Oaks, Seaside, Sand City, Fort Ord, Marina, Castroville, Moss Landing, Boronda, Salinas and some unincorporated areas in northern Monterey County. Wastewater is treated at one regional plant that provides some recycled water while discharging the rest into the ocean. The recycling operations provide irrigation water to 12,000 acres of food-chain crop farmland near Castroville.		
Key Energy Drivers	• Wastewater Treatment – treatment to secondary levels and discharges 2 miles into Monterey Bay (by permit). • Recycled Water Distribution – multiple pump stations move water through 45 miles of distribution piping to reach recycled water customers		
Wastewater Treatment Technology	Regional Wastewater Treatment Plant (Wastewater): Primary Treatment, Secondary treatment, Tertiary treatment and chlorination		
Water Resources	N/A - wastewater only		
Marginal Water Supply and Energy Intensity (kWh/MG)	N/A - wastewater only		
Energy Service Provider	PG&E		
Observed Energy Intensities (kWh/MG)	**Segment**	**Lower Range**	**Upper Range**
	Wastewater Treatment	1,422	1,994
	Wastewater Pumps	243	333

Table 3-10. San Jose Water Company

<table>
<tr><td>Primary functions</td><td colspan="3">Potable Water, Urban</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Supply, Treatment, Distribution</td></tr>
<tr><td>Hydrologic Region</td><td>San Francisco Bay</td><td>DEER Climate Zone</td><td>4</td></tr>
<tr><td>Quantity of Water</td><td colspan="3">Treated by Agency: 6.56 MGD (Ave. for 2008); 10.79 MGD (5-year avg.)
Total Distributed: 134 MGD (Ave. for 2008); 132.6 MGD (5-year avg.)</td></tr>
<tr><td>Number of Customers</td><td>2005 Total: 214,774
Residential: 193,106
Commercial: 19,626
Other: 2,042</td><td>Service Area Size</td><td>138 square miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">SJWC supplies retail potable water to a single distribution system with sixty pressure zones in the communities of San Jose, Los Gatos, Saratoga, Campbell, Cupertino and Monte Sereno. SJWC has three sources of water (groundwater, local surface water and wholesale treated water purchased from the Santa Clara Valley Water District). Each zone is served by at least two sources of water. The topography is characterized by a valley floor, which slopes northward to San Francisco Bay, surrounded by two mountain ranges. SJWC serves customers in both the valley and the foothills.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="3">The majority of energy is consumed by supply and distribution facilities
• Water Supply – Significant energy is used for groundwater pumping
• Water Treatment – Local surface water requires treatment at one of two plants
• Water Distribution – Majority of system is fed by gravity, with booster pumps replenishing tanks at night</td></tr>
<tr><td>Water Treatment Technologies</td><td colspan="3">Montevina Plant : Direct Filtration, with sodium hypochlorite disinfectant
Saratoga Plant : Microfiltration, with sodium hypochlorite disinfectant</td></tr>
<tr><td>Water Resources</td><td colspan="3">2008 Supply Distribution: 49% Imported, 46% Groundwater, 5% Local Surface Water.</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">Each zone is served by at least two sources of supply.
Short-term: Increase groundwater pumping. (1452- 1866)
Long-term: Increase groundwater well capacity. (1452-1866)</td></tr>
<tr><td>Energy Service Provider</td><td colspan="3">PG&E</td></tr>
<tr><td rowspan="6">Observed Energy Intensities (kWh/MG)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Groundwater Pump</td><td>1,452</td><td>1,866</td></tr>
<tr><td>Booster Pump (large zone)</td><td>589</td><td>1,104</td></tr>
<tr><td>Water Treatment</td><td>167</td><td>515</td></tr>
<tr><td>Raw Water Pump</td><td>10</td><td>444</td></tr>
<tr><td>Pressure System Pump</td><td>1,587</td><td>2,724</td></tr>
</table>

Table 3-11. Sonoma County Water Agency

<table>
<tr><td>Primary functions</td><td colspan="3">Urban Water, Agricultural Water, Urban Wastewater, Local Wholesale</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Supply, Distribution, Wastewater Treatment, Recycled Water Production</td></tr>
<tr><td>Hydrologic Region</td><td>North Coast</td><td>DEER Climate Zone</td><td>2</td></tr>
<tr><td>Quantity of water and wastewater (2005)</td><td colspan="3">Surface Water Diversions: 49 MGD
Groundwater Produced: 3.5 MGD
Wastewater Treated: 5.1 MGD
Recycled: <5.1 MGD</td></tr>
<tr><td>Number of Customers (2005)</td><td>Total: 13
Water Contractors: 8
Other: 5</td><td>Service Area Size</td><td>N/A</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">The Sonoma County Water Agency (SCWA) distributes Russian River water and groundwater to its water contractors and other customers. SCWA's service area covers a large part of Sonoma County, as well as the northern portion of Marin County. SCWA operates two recycled water facilities owned by local sanitation districts. The recycled water is not considered supply for SCWA, but is used to offset demand by its contractors.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="3">• Water Supply – Water is pumped from beneath the Russian River, water is naturally filtered removing the need for treatment.
• Water Conveyance- Significant energy is used by system booster pump stations. Topography varies but is generally hilly.
• Recycled Water Deliveries – pumping is required to deliver treated recycled water</td></tr>
<tr><td>Wastewater Treatment Technologies</td><td colspan="3">Sonoma Valley County Sanitation District (Wastewater): Secondary treatment, tertiary treatment</td></tr>
<tr><td>Water Resources (2008)</td><td colspan="3">Surface Water Diversions: 93%, Agency Produced Groundwater: 7%</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">Short-term: Russian River Diversions (1,728-1,975)
Long-term: Conservation, recycled water, and enhanced local supplies. (unknown - 3,466)</td></tr>
<tr><td>Energy Service Provider</td><td colspan="3">PWRPA, PG&E</td></tr>
<tr><td rowspan="6">Observed Energy Intensities (kWh/MGal)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Groundwater Pumps</td><td>1,728</td><td>1,975</td></tr>
<tr><td>Booster Pumps</td><td>273</td><td>610</td></tr>
<tr><td>Wastewater Treatment</td><td>1,812</td><td>4,941</td></tr>
<tr><td>Waste Water Pumps</td><td>2</td><td>2</td></tr>
<tr><td>Recycled Water Pumps</td><td>210</td><td>509</td></tr>
</table>

3.2.2 Central Valley Agencies

Of the agencies targeted for this region, sufficient water-energy data was received from 4 water and wastewater agencies:

- Glenn-Colusa Irrigation District
- Natomas Central Mutual Water Company
- Semitropic Water Storage District
- Westlands Water District

The 4 agencies who have agreed to participate in the Central Valley represent the major water system features in the Central Valley. They are agricultural water retailers, which are representative of the water agency types in this region, and therefore water treatment in this region is not prominent. The Central Valley region had no wastewater treatment agency in the final sampling. The Study Team has found that the energy intensity associated with wastewater treatment systems is not as influenced by the region as water systems and is satisfied with the statewide wastewater treatment agency representation for the study. In addition, a hilly distribution is not expected in the Central Valley region where the topography is typically flat.

Summaries of the water-energy characteristics of each agency studied are provided on the following pages. Detailed water-energy profiles of each agency studied are provided in Appendix B.

Table 3-12. Glenn-Colusa Irrigation District

Primary functions	Agricultural Water		
Segments of Water Use Cycle	Supply, Distribution		
Hydrologic Regions	Sacramento River	**DEER Climate Zone**	11
Quantity of water	Maximum Contracted: 736.5 MGD Non-Contract Water Right: 163.1 MGD	Recaptured: 0.138 MGD	
Number of Customers	Land Owners: 1,076 Tenant Water Users: 300	**Service Area Size**	273.4 Square miles
Distinguishing Characteristics	GCID is located in the central portion of the Sacramento Valley on the west side of the Sacramento River and is the largest irrigation district in the Sacramento Valley, encompassing approximately 273.4 square miles (175,000 acres), with rice as the predominant crop. The service area extends from northeastern Glenn County near Hamilton City to south of Williams in Colusa County. District boundaries also encompass the communities of Willows and Maxwell. GCID operates an aggressive recapture program that includes groundwater seepage and tailwater runoff from cultivated fields.		
Key Energy Drivers	• Water Supply – Energy is used to pump water into GCID's main canal. Groundwater pumping account for a small portion of energy use. • Recaptured Water Deliveries – Energy is used by pump systems that recapture water.		
Water/Wastewater Treatment Technology	N/A – no treatment is needed as all deliveries are raw water		
Water Resources	At maximum supply: 100% Local Surface Water		
Marginal Water Supply and Energy Intensity (kWh/MG)	Short-term: Current local surface water (65-155) Long-term: Increasing drain water reuse, conjunctive use programs, Groundwater (27-188)		
Energy Service Provider	PG&E, PWRPA		
Observed Energy Intensities (kWh/MG)	**Segment**	**Lower Range**	**Upper Range**
	Booster Pumps (Main Pump)	39	116
	Raw Water Conveyance (Relift)	27	39

Table 3-13. Natomas Central Mutual Water Company

<table>
<tr><td>Primary function</td><td colspan="3">Agricultural Water</td></tr>
<tr><td>Segment of Water Use Cycle</td><td colspan="3">Supply</td></tr>
<tr><td>Hydrologic Region</td><td>Sacramento River</td><td>DEER Climate Zone</td><td>12 (64%) and 11 (36%)</td></tr>
<tr><td>Quantity of water (2008)</td><td>Diversions: 51 MGD</td><td colspan="2">Wholesaled: 8.9 MGD
Recycled: 31 MGD</td></tr>
<tr><td>Number of Customers</td><td>Total: 280</td><td>Service Area Size</td><td>51.9 Sq miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">The Company’s service area includes the Sacramento Municipal Airport and several residential developments, which are proposed in response to continued growth within and adjacent to the Sacramento area. NCMWC has three main pump stations located on the Sacramento River. The Company also diverts water from the Natomas Cross Channel, which is located along the northern boundary of the Company. Diversion waters from the Cross Channel subsequently flow from north to south, and water diverted from the Sacramento River generally flow from west to east or south.</td></tr>
<tr><td>Key Energy Driver(s)</td><td colspan="3">The majority of the NCMWC’s energy is used by pumping plants. NCMWC owns groundwater wells, but they are rarely used for water supply.
• Water Supply- 6 pump stations divert agricultural water
• Recycled Water Deliveries – A recirculation system consists of 30 pumping stations</td></tr>
<tr><td>Water/Wastewater Treatment Technology</td><td colspan="3">N/A – no treatment performed</td></tr>
<tr><td>Water Resources</td><td colspan="3">Maximum Base Supply: 98,200 AF, Maximum CVP: 22,000 AF, Recirculated Tailwater: 35,000 AF</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">Short-term: Groundwater, recaptured tailwater, and surplus Project Water (0 – 576)
Long-term: Conjunctive Use Programs, Conservation and Reuse (2 -12)</td></tr>
<tr><td>Energy Service Provider</td><td colspan="3">PG&E</td></tr>
<tr><td rowspan="2">Observed Energy Intensities</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Raw Water Pump</td><td>2 kWh/Mgal</td><td>12 kWh/Mgal</td></tr>
</table>

Table 3-14. Semitropic Water Storage District

Primary function	Agricultural Water		
Segment of Water Use Cycle	Supply		
Hydrologic Region	Central Valley	**DEER Climate Zone**	13
Quantity of water	Banked: 700,000 AF		
Number of Customers	Total: 300	**Service Area Size**	345 Sq miles
Distinguishing Characteristics	Semitropic Water Storage District is located between the State Water Project and the Central Valley Project canals. This makes Semitropic's location ideal for groundwater storage and banking for many agencies in southern and central California. The area hosts eight or nine underground water storage and recovery facilities, including two of the largest in the world — the Semitropic Water Storage Bank and the Kern Water Bank. Semitropic owns 6.67 percent of the Kern Water Bank.		
Key Energy Drivers	All energy use is for groundwater pumping		
Water/Wastewater Treatment Technology	N/A – no treatment performed		
Water Resources	In wet years, participating banking partners deliver their surplus water to Semitropic: Antelope Valley Water Bank: 23.3%, Semitropic's Contribution to SRWBA: 14.0%, Uncommitted (Used by all Customers): 5.7%, Not Available Until SRWBA has Committed: 7.0%, Rampage Vineyard (Reserved): 0.8%, Poso Creek Water Company: 2.8%, MWD-SC: 16.3%, Santa Clara Valley WD: 16.3%, Alameda County WD: 7.0%, Newhall Land and Farming Company: 2.6%, San Diego County Water Authority: 1.4%, Zone 7 Water Agency: 3.0%.		
Marginal Water Supply and Energy Intensity (kWh/MG)	Short-term: Temporary water-service connections, water-pricing initiatives, connection of landowner wells to Semitropic's main conveyance system, interconnection of facilities with neighboring districts, purchase and importation of available water supplies, and implementation of the Semitropic Groundwater Banking Project. (2,079 – 2,574) Long-term: Groundwater Banking Project Expansion and additional banking partners. (2,079 – 2,574)		
Energy Service Provider	PG&E		
Observed Energy Intensities	**Segment**	**Lower Range**	**Upper Range**
	Groundwater	790 kWh/Mgal	1,261 kWh/Mgal

Table 3-15. Westlands Water District

Primary function	Agricultural Water		
Segment of Water Use Cycle	Supply		
Hydrologic Region	Tulare Lake	**DEER Climate Zone**	13
Quantity of water (2008)	Contracted: 296 MGD Pumped: 410 MGD		
Number of Customers	Total: 600 family owned farms	**Service Area Size**	937.5 Sq miles
Distinguishing Characteristics	Westlands Water District (WWD) provides water to agricultural customers, and drainage service to those lands that need it. Most of the land east of the San Luis Canal (SLC) slopes from elevation 320 to 160 feet and has gravity service from the SLC. Small recirculating pumping plants at the headworks of each of the gravity laterals pressurize the laterals serving lands adjacent to the SLC which are too high in elevation to be served through the gravity laterals. The land lying west of the SLC is at higher elevations than the SLC and is served by pumping from the SLC and gravity from the Coalinga Canal.		
Key Energy Drivers	• Water Supply- significant energy is used to pump groundwater • Water Conveyance- Pumps divert water from the San Luis Canal • Water Distribution – Energy is used to pump water to Priority Area II which is at higher elevations than the San Luis Canal		
Water/Wastewater Treatment Technology	N/A – no treatment required		
Water Resources (2008)	CVP Allocations: 33.9%, Groundwater: 46.9%, Water User Acquired: 8.7%, Water Transfers: 10.5%		
Marginal Water Supply and Energy Intensity (kWh/MG)	Short-term: Increased CVP allocations, water transfers, conjunctive use, San Joaquin and King River flood flows. (1,313 – 2,530) Long-term: Increased surface water and/or imported water supplies. (1,313 – 2,530)		
Energy Service Provider	PG&E, PWRPA, CVP (temporary diversions)		
Observed Energy Intensities (kWh/MG)	**Segment**	**Lower Range**	**Upper Range**
	Groundwater	1,571	2,530
	Raw Water Pumps	1,044	1,341

3.2.3 Southland Agencies

Of the agencies targeted for this region, sufficient water-energy data was received from 9 water and wastewater agencies:

- Inland Empire Utilities Agency
- Los Angeles County Sanitation Districts
- City of Oceanside
- Orange County Sanitation District
- Orange County Water District
- Rancho California Water District
- San Gabriel Valley Water Company
- Suburban Water Systems
- Valley Center Municipal Water District

The Southland region had no significant change to the representation of the sample criteria in that region between targeted and final sampling.

Summaries of the water-energy characteristics of each agency studied are provided on the following pages. Detailed water-energy profiles of each agency studied are provided in Appendix B.

Table 3-16. Inland Empire Utilities Agency

<table>
<tr><td>Primary functions</td><td colspan="4">Wholesale, Wastewater, Recycled Water, Urban Potable Water</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="4">Supply, Water Treatment, Wastewater Treatment, Recycled Water Production</td></tr>
<tr><td>Hydrologic Region</td><td colspan="2">South Coast</td><td>DEER Climate Zone</td><td>10</td></tr>
<tr><td>Quantity of Water and Wastewater (2005)</td><td colspan="2">Total Water Supplied: 64.4 MGD
Recycled Water Supplied: 7.2 MGD[a]</td><td colspan="2">Wastewater Treated: 60 MGD</td></tr>
<tr><td>Number of Customers (2005)</td><td colspan="2">Retail Water Agencies: 8
Wastewater Contracts: 7</td><td>Service Area Size</td><td>242 Sq miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="4">Inland Empire Utilities Agency (IEUA) is a municipal water District that delivers supplementary, imported, and recycled water within its service area as well as provides regional wastewater treatment services with domestic and industrial disposal systems and energy/production and composting facilities. IEUA is a member agency of MWD and imports water for distribution to its customers. Water supply is supplemented by recycled water and brackish water desalination.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="4">• Wastewater Treatment- Water is treated to tertiary standards
• Recycled Water Deliveries – recycled water distribution pumps are required to deliver water to customers.
• Water Treatment – brackish water desalination using reverse osmosis consumes significant energy</td></tr>
<tr><td>Water/Wastewater Treatment Technologies</td><td colspan="4">Carbon Canyon, Regional Plant (RP) #1, #4, #5 (Recycled Water): Preliminary, primary, secondary, tertiary (see “System Infrastructure and Operations” section for more details
Regional Solids Plant #2 (biosolids handling) and RP #1: Thickening; dewatering; anaerobic digestion; biosolids conditioning.
Chino Desalter (owned by Chino Desalting Authority) - Reverse Osmosis</td></tr>
<tr><td>Water Resources</td><td colspan="2">MWD Imports: 25%, IEUA
Recycled Water: 3%
Brackish Desalination: 2%</td><td colspan="2">Groundwater (Non-IEUA): 63%
Local Surface Water (Non-IEUA): 7%</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="4">Short-term: Recycled Water (752-914)
Long-term: Recycled Water, Brackish Water Desalination (752- 3,945)</td></tr>
<tr><td>Energy Service Provider</td><td colspan="4">SCE, SCG</td></tr>
<tr><td rowspan="8">Observed Energy Intensities (kWh/MG)</td><td colspan="2">Segment</td><td>Lower Value</td><td>Upper Value</td></tr>
<tr><td colspan="2">Wastewater Collection</td><td>44</td><td>44</td></tr>
<tr><td colspan="2">Recycled Water Production Total</td><td>2,103</td><td>2,122</td></tr>
<tr><td colspan="2">Primary Treatment</td><td>454</td><td>462</td></tr>
<tr><td colspan="2">Secondary Treatment</td><td>1,207</td><td>1,220</td></tr>
<tr><td colspan="2">Tertiary Treatment</td><td>125</td><td>126</td></tr>
<tr><td colspan="2">Recycled Water Distribution</td><td>752</td><td>914</td></tr>
<tr><td colspan="2">Brackish Water Desalination</td><td>3,819</td><td>3,945</td></tr>
</table>

a) Rapid growth in recycled water use has occurred since 2005. Production in 2009 ranges from 21-45 MGD.

Table 3-17. Los Angeles County Sanitation Districts

<table>
<tr><td>Primary functions</td><td colspan="4">Urban Wastewater, Recycled Water</td></tr>
<tr><td>Segment of Water Use Cycle</td><td colspan="4">Wastewater Treatment</td></tr>
<tr><td>Hydrologic Region</td><td>Southland</td><td colspan="2">DEER Climate Zone</td><td>9</td></tr>
<tr><td>Quantity of wastewater</td><td>Treated: 480 MGD</td><td colspan="3">Recycled: 170 MGD</td></tr>
<tr><td>Number of Customers</td><td>24 Independent Special Districts</td><td colspan="2">Service Area Size</td><td>820 Sq miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="4">The Sanitation Districts convey and treat approximately 480 MGD, 170 MGD of which are available for reuse. Three active sanitary landfills handle approximately 18,000 tons per day (tpd), of which 15,000 tpd are disposed (approximately forty percent of the County-wide disposal capacity) and 3,000 tpd are recycled. The agency also operates four landfill energy recovery facilities, two recycle centers, and three transfer/materials recovery facilities, and participates in the operation of two refuse-to-energy facilities.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="4">• Wastewater Collection – Lift stations are required for wastewater collection
• Wastewater Treatment – Considerable energy is used by the treatment plants
• Recycled Water Deliveries – Energy is used to recharge groundwater or to deliver water for a variety of applications</td></tr>
<tr><td>Wastewater Treatment Technologies</td><td colspan="4">Long Beach WRP, Los Coyotes WRP, San Jose Creek WRP, Whittier Narrows WRP, and Saugus WRP (Wastewater): Primary, secondary, tertiary, reclamation
Pomona WRP (Recycled Water): Primary, secondary, tertiary, reclamation
Joint Water Pollution Control Plant (Wastewater): Primary, secondary, solids processing
La Cañada WRP (Wastewater): Extended aeration secondary, reclamation
Valencia WRP (Wastewater): Primary, secondary, tertiary, reclamation, solids processing
Lancaster WRP (Wastewater): Primary and secondary treatment (aerated oxidation ponds), solids processing, membrane bioreactors, UV disinfection, reclamation
Palmdale WRP (Wastewater): Primary and secondary treatment (aerated oxidation ponds), solids processing, reclamation</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="4">N/A</td></tr>
<tr><td>Energy Service Providers</td><td colspan="4">SCE, SCG</td></tr>
<tr><td rowspan="3">Observed Energy Intensities (kWh/MG)</td><td>Segment</td><td>Lower Range</td><td colspan="2">Upper Range</td></tr>
<tr><td>Wastewater Treatment</td><td>1104</td><td colspan="2">1446</td></tr>
<tr><td>Wastewater Pumps</td><td>205</td><td colspan="2">400</td></tr>
</table>

Table 3-18. City of Oceanside

Primary functions	Urban Water, Urban Wastewater, Recycled Water		
Segments of Water Use Cycle	Supply, Treatment, Distribution, Wastewater Treatment, Recycled Water Production		
Hydrologic Region	South Coast	**DEER Climate Zone**	7
Quantity of water/ wastewater (2008 Total)	Water Treated: 7,233 MG Water Distributed: 7,777 MG Waste Water Treated: 5,354 MG	Desalting Facility 679 MG Pumped 543 MG Produced	
Number of Customers	Total Water: 43,574 (2005)	**Service Area Size**	42 Sq miles
Distinguishing Characteristics	The City of Oceanside supplies retail potable water primarily to the City of Oceanside. Distribution topography is moderate. Oceanside treats brackish water from the Mission Basin at its Mission Basin Desalting Facility which accounts for about 7% of the city's water supply. The city reclaims wastewater at the San Luis Rey Wastewater Treatment Plant and uses it to irrigate the Oceanside Municipal Golf Course.		
Key Energy Drivers	• Water Supply & Treatment - Mission Basin Desalting Facility uses significant energy to treat brackish ground water from the Mission Basin. • Wastewater Treatment - aeration blowers and effluent pumps are reported to be the greatest energy consumers on the wastewater side. • Wastewater Treatment - centrifuges at the San Luis Rey WWTP.		
Water/Wastewater Treatment Technologies	Weese Filtration Plant: filtration/chlorine Mission Basin Desalting Facility: Reverse Osmosis San Luis Rey Wastewater Treatment Plant: tertiary, water reclamation plant La Salina Wastewater Treatment Plant: secondary		
Water Resources	The city purchases about 93% of its water from the San Diego County Water Authority who imports water from MWD. About 7% of Oceanside's water supply is groundwater from the Mission Basin.		
Marginal Water Supply and Energy Intensity (kWh/MG)	Short-Term: Imported water from SDCWA (6,785 - 6,912) Long-Term: Purchase additional imported water, expansion of the Weese Filtration Plant, add more wells to increase groundwater supply, currently have a pilot seawater desalination project, purchase water from the proposed Carlsbad Ocean Desalination project.(43 – 12,276)		
Energy Service Provider	SDG&E		
Observed Energy Intensities (kWh/Mgal)	**Segment**	**Lower Range**	**Upper Range**
	Groundwater/Desalination	1,117	2,009
	Water Treatment	43	86
	Water Distribution	134	247
	Wastewater Treatment	1,062	1,105
	Wastewater Lift Stations	383	497

Table 3-19. Orange County Sanitation District

<table>
<tr><td>Primary functions</td><td colspan="3">Urban Wastewater</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Wastewater Treatment</td></tr>
<tr><td>Hydrologic Region</td><td>South Coast</td><td>DEER Climate Zone</td><td>6 and 8</td></tr>
<tr><td>Quantity of wastewater</td><td colspan="3">Treated: 230 MGD (typical daily treatment)</td></tr>
<tr><td>Number of Customers</td><td>Total: 911,152
Residential/Commercial: 910,637
Industrial: 515</td><td>Service Area Size</td><td>471 Sq miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">The Orange County Sanitation District (OCSD) treats wastewater from customers in Orange County. OCWD operates two treatment plants. Most of the treated effluent is combined and pumped through a five-mile, 10-foot diameter, ocean outfall pipe. Some secondary effluent is pumped to the Orange County Water District (OCWD) where it enters the Advanced Water Purification Facility (AWPF) and is recycled for groundwater recharge operations. OCSD and OCWD jointly built the AWFP.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="3">• Wastewater Collection – A flat collection area and treatment plants located near the ocean require little collection energy use
• Wastewater Treatment- Significant energy is used by the OCSD’s two wastewater treatment plants</td></tr>
<tr><td>Water/Wastewater Treatment Technologies</td><td colspan="3">Reclamation Plant No. 1 (Wastewater): Primary treatment, secondary treatment
Treatment Plant No. 2 (Wastewater): Primary treatment, secondary treatment</td></tr>
<tr><td>Wastewater Sources</td><td colspan="3">80% Residential, 20% Non-Residential</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">N/A</td></tr>
<tr><td>Energy Service Providers</td><td colspan="3">SCE, SCG</td></tr>
<tr><td rowspan="3">Observed Energy Intensities (kWh/MGal)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Wastewater Collection</td><td>3</td><td>6</td></tr>
<tr><td>Wastewater Treatment</td><td>1,120</td><td>1,314</td></tr>
</table>

Table 3-20. Orange County Water District

<table>
<tr><td>Primary functions</td><td colspan="3">Raw Water, Wholesale (Urban), Recycled Water</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Supply, Recycled Water Treatment, Groundwater Recharge</td></tr>
<tr><td>Hydrologic Region</td><td>South Coast</td><td>DEER Climate Zones</td><td>6 and 8</td></tr>
<tr><td>Quantity of Water (2008)</td><td colspan="3">Groundwater Demand by Member Agencies: 368,000 AF/yr
Total Groundwater Recharge: 258,000 AF/yr
Recycled Water Production: 28,000 AF/yr</td></tr>
<tr><td>Number of Customers</td><td>23 Member Agencies</td><td>Service Area Size</td><td>350 Sq miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">The Orange County Water District (OCWD) manages a groundwater basin covering approximately 350 square miles underlying the north half of Orange County. OCWD supplies recharge water to the basin from local surface water, imported water, and highly treated recycled water from the Groundwater Replenishment (GWR) System Advanced Water Purification Facility (AWPF). The AWPF is one of the most advanced recycled water facilities in the world; constructed in partnership with Orange County Sanitation District. Recycled water is used to replenish the groundwater basin and to maintain a seawater intrusion barrier.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="3">• Water Supply – Water is diverted from the Santa Ana River into recharge ponds with relatively low energy use
• Recycled Water – Significant energy is needed to run Reverse Osmosis and Microfiltration systems in the AWPF
• Recycled Water Distribution – significant energy is needed to inject water into the ground and pump it to recharge basins</td></tr>
<tr><td>Wastewater/Recycled Water Treatment Technologies</td><td colspan="3">Groundwater Replenishment System (Recycled Water): Microfiltration, Reverse Osmosis, Ultraviolet Light with Hydrogen Peroxide (Advanced Oxidation)</td></tr>
<tr><td>Water Resources</td><td colspan="3">Santa Ana River, Santiago Creek, imported water from various sources (including MWD via MWDOC), storm flows, secondary treated wastewater effluent from Orange County Sanitation District</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">Short-term: Local Surface Water (30)
Long-Term: Recycled water (additional capacity to be built at the GWR system) and Storm Water (additional capture and percolation facilities) (4,105 – 4,893)</td></tr>
<tr><td>Energy Service Providers</td><td colspan="3">SCE, SCG, City of Anaheim</td></tr>
<tr><td rowspan="7">Observed Energy Intensities (kWh/MG)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Recycled Water Treatment*</td><td>3,161</td><td>3,771</td></tr>
<tr><td>Microfiltration</td><td>756</td><td>839</td></tr>
<tr><td>Reverse Osmosis</td><td>1,483</td><td>1,784</td></tr>
<tr><td>UV light Treatment</td><td>288</td><td>336</td></tr>
<tr><td>Seawater Intrusion Barrier</td><td>575</td><td>668</td></tr>
<tr><td>Recycled Water Transport</td><td>944</td><td>1,122</td></tr>
</table>

Table 3-21. Rancho California Water District

<table>
<tr><td>Primary functions</td><td colspan="3">Urban Water, Agricultural Water, Urban Wastewater</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Supply, Distribution, Wastewater Treatment, Recycled Water Production</td></tr>
<tr><td>Hydrologic Region</td><td>South Coast</td><td>DEER Climate Zone</td><td>10</td></tr>
<tr><td>Quantity of water (or wastewater)</td><td>Water Distributed: 69.5 MGD</td><td colspan="2">Recycled: 3.25 MGD
Pumped: 22.7 MGD</td></tr>
<tr><td>Number of Customers (2008)</td><td>Total: 41,986
Domestic: 36,069
AG-Domestic: 710
Agricultural: 970
Others: 4,237
Sewer: 17,407</td><td>Service Area Size</td><td>154.7 Sq miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">RCWD is a local, independent Special District, providing retail potable water and wastewater collection and treatment to its customers in Temecula, Murrieta, and unincorporated areas southwest of Riverside County. Topography is hilly with elevations ranging from 900 to 1,200 feet above sea level at the valley floor. RCWD pumps water to a maximum elevation of 2,850 feet for some pressure zones in its service area. In the surrounding foothills, the elevations range from 1,200 to 2,900 feet above sea level, with slopes often greater than 20%.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="3">• Water Supply – significant energy is used by groundwater pumps to pump water from wells.
• Water Distribution – Water is pumped to five pressure zones with an elevation difference of up to nearly 2000 ft.
• Wastewater Treatment- Energy is used to treat wastewater to tertiary levels for reuse.</td></tr>
<tr><td>Water/Wastewater Treatment Technologies</td><td colspan="3">Santa Rosa Water Reclamation Facility (Recycled Water): microfiltration, reverse osmosis, tertiary treatment
Temecula Valley Regional Water Reclamation Facility (operated by RCWD): microfiltration, reverse osmosis, tertiary treatment</td></tr>
<tr><td>Water Resources</td><td colspan="3">25-40% Groundwater, 60-70% Imported Water, <5% Recycled Water</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">Short-term: Imported water (7,377 - 7,499)
Long-term: increased recycled water projects (using microfiltration and reverse osmosis), increased groundwater recharge, increased imported water through existing turnouts (1,971 – 3,436)</td></tr>
<tr><td>Energy Service Provider</td><td colspan="3">SCE</td></tr>
<tr><td rowspan="4">Observed Energy Intensities (kWh/MG)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Groundwater</td><td>1,971</td><td>2,324</td></tr>
<tr><td>Water Distribution</td><td>1,166</td><td>1,423</td></tr>
<tr><td>Recycled Water</td><td>992</td><td>1,292</td></tr>
</table>

Table 3-22. San Gabriel Valley Water Company

<table>
<tr><td>Primary functions</td><td colspan="3">Urban Water, Recycled Water Production</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Supply, Treatment</td></tr>
<tr><td>Hydrologic Region</td><td>Southland</td><td>DEER Climate Zone</td><td>9</td></tr>
<tr><td>Quantity of Water</td><td colspan="3">Distributed: 46,146.4 acre-ft (groundwater distributed)</td></tr>
<tr><td>Number of Customers</td><td>Fontana: 42,000 connections
Los Angeles: 48,000 connections</td><td>Service Area Size</td><td>N/A</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">The San Gabriel Valley Water Company (SGVWC) produces, distributes, and sells water an urban area east of Los Angeles. It consists of two divisions: the Fontana and Los Angeles Divisions. The Los Angeles Division has 3 systems and 16 pressure zones. Pumping plan elevations range from 101 to 1,215 feet.</td></tr>
<tr><td>Key Energy Driver(s)</td><td colspan="3">• Groundwater Pumping: significant energy is used for groundwater pumping
• Distribution: energy is used for booster pumps and raw water pumps</td></tr>
<tr><td>Water/Wastewater Treatment Technologies</td><td colspan="3">Sandhill Surface Water Treatment Plant (Water):
The Fontana Division has a LEED certified energy efficient surface water treatment plant; began operation in December of 2008.</td></tr>
<tr><td>Water Resources</td><td colspan="3">SGVWC's water resources include groundwater, surface water, and purchased water.</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">Short-term: increase groundwater pumping, purchase water (1,989-6064)
Long-Term: increase storage, increase imported water (30 – 6,064)</td></tr>
<tr><td>Energy Service Provider</td><td colspan="3">SCE</td></tr>
<tr><td rowspan="4">Observed Energy Intensities (kWh/MG)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Groundwater</td><td>1,989</td><td>3,014</td></tr>
<tr><td>Booster Pumps</td><td>37</td><td>141</td></tr>
<tr><td>Raw Water Pumps</td><td>5</td><td>104</td></tr>
</table>

Table 3-23. Suburban Water Systems

<table>
<tr><td>Primary function</td><td colspan="3">Urban Water</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Supply, Distribution</td></tr>
<tr><td>Hydrologic Region</td><td>South Coast</td><td>DEER Climate Zone</td><td>9</td></tr>
<tr><td>Quantity of water (2008)</td><td colspan="3">Produced: 1.78 MGD
Distributed: 50.71 MGD</td></tr>
<tr><td>Number of Customers (2005)</td><td>Total: 74,700 connections
Residential: 54,202
Commercial: 14,851
Industrial: 1,165
Public Agencies: 4,482</td><td>Service Area Size</td><td>41.7 Sq miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">SWS meets most of its demand with groundwater. The SWS service area is currently divided into two main Districts: the San Jose Hills District, and the Whittier/La Mirada District. The San Jose Hills District is divided into five (5) operational service areas. The Whittier/La Mirada District is divided into four (4) operational service areas.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="3">• Water Supply – Energy is used to pump water from wells in the service area.
• Water Treatment – The energy use for the addition of sodium hypochlorate for disinfection of groundwater at wells is negligible.
• Water Distribution – A significant amount of energy is used by booster pumps.</td></tr>
<tr><td>Water/Wastewater Treatment Technology</td><td colspan="3">Plant 409 W-3 and Plant 410 W-1 (Central Basin): SWS adds sodium hypochlorate for disinfection.
Plant 121 W-1, Plant 142 W-2, Plant 151 W-2, Plant 147 W-3, Plant 201 W-4, Plant 201 W-5, Plant 201 W-7, Plant 201 W-8, Plant 201 W-9, Plant 201 W-10 (Main San Gabriel Basin): SWS adds sodium hypochlorate for disinfection.</td></tr>
<tr><td>Water Resources</td><td colspan="3">Groundwater: 66.25%, Surface Water (CIC): 6.59%, Imported Water (Metropolitan Water District (MWD)): 10.33%, Purchased From Other Agencies: 16.82%</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">Short-term: SWS has multiple interconnections with other water agencies to supplement groundwater supply and for emergency transfers. (30 – 7,499)
Long-term: A groundwater treatment facility has been constructed to provide an average annual supply of about 11,300 acre-feet. SWS will receive about 8,200 acre-feet per year of fully treated water that will be used to supplement existing sources of supply. (1,104 – 1,619)</td></tr>
<tr><td>Energy Service Provider</td><td colspan="3">SCE, SCG</td></tr>
<tr><td rowspan="3">Observed Energy Intensities (kWh/MG)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Groundwater</td><td>1,254</td><td>1,619</td></tr>
<tr><td>Water Distribution</td><td>801</td><td>1,081</td></tr>
</table>

Table 3-24. Valley Center Municipal Water District

<table>
<tr><td>Primary functions</td><td colspan="3">Agricultural Water, Wastewater</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Distribution, Recycled Water Production</td></tr>
<tr><td>Hydrologic Region</td><td>Southland</td><td>DEER Climate Zone</td><td>10</td></tr>
<tr><td>Quantity of water (2005)</td><td>Wastewater Treated: 0.41 MGD
Water Distributed: 12,416 MGD</td><td colspan="2">Recycled: 0.05 MGD</td></tr>
<tr><td>Number of Customers</td><td>Water: 8,593
Wastewater: 2,750</td><td>Service Area Size</td><td>100 Sq miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">VCMWD retails treated imported water to its service area. The topography is hilly, and energy intensive pumping is required to distribute water to customers. VCMWD does not treat any of its imported supply.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="3">The majority of energy is consumed by supply and distribution facilities:
• Water Distribution - pumping to distribute over hilly topography.
• Wastewater Treatment - small wastewater treatment plants contribute to energy consumption, but were not included in this analysis.</td></tr>
<tr><td>Water/Wastewater Treatment Technologies</td><td colspan="3">Water Treatment: VCMWD provides back-up chlorination as needed.
Lower Moosa Canyon Water Reclamation Facility: advanced secondary, water reclamation plant
Woods Valley Ranch Water Reclamation Facility: tertiary, water reclamation plant</td></tr>
<tr><td>Water Resources</td><td colspan="3">2008 Supply Distribution: 99% Imported, 1% Reclaimed</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">Short-term: Lake Turner Emergency Water (6912)
Long-term: increased imports, seawater desalination (Carlsbad). (6912 – 12,279)</td></tr>
<tr><td>Energy Service Provider</td><td colspan="3">SGD&E</td></tr>
<tr><td rowspan="3">Observed Energy Intensities (kWh/MG)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Booster Pumps</td><td>846</td><td>1,772</td></tr>
<tr><td>Pressure System Pumps (Water Distribution)</td><td>347</td><td>432</td></tr>
</table>

3.2.4 Desert Agencies

Of the 4 agencies targeted for this region, sufficient water-energy data was received from 2 water and wastewater agencies:

- City of Calexico
- Coachella Valley Water District

The Desert region had no change to the overall coverage of the sample criteria in the region between targeted and final sampling.

Summaries of the water-energy characteristics of each agency studied are provided on the following pages. Detailed water-energy profiles of each agency studied are provided in Appendix B.

Table 3-25. City of Calexico

<table>
<tr><td>Primary functions</td><td colspan="3">Urban Potable Water, Urban Wastewater</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Treatment, Distribution</td></tr>
<tr><td>Hydrologic Region</td><td>Colorado River</td><td>DEER Climate Zone</td><td>15</td></tr>
<tr><td>Quantity of Water and Wastewater (2008)</td><td colspan="3">Water Treated: 5.9 MGD (yearly average)
Wastewater Treated: 2.8 MGD (yearly average)</td></tr>
<tr><td>Number of Customers (2005)</td><td>Total: 6,710
Residential: 6,184
Commercial: 523
Industrial: 3</td><td>Service Area Size</td><td>N/A</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">The City of Calexico’s sole supply of water is imported from the Colorado River via the Imperial Irrigation District's (IID) All American Canal. Local surface sources are limited in availability and groundwater is often of poor quality. Treated water is supplied to a relatively flat service area. Wastewater is treated by the city and flows into the New River eventually ending up in the Salton Sea.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="3">• Water Treatment – Conventional treatment technologies are employed
• Water Distribution – A relatively flat service area requires low distribution energy
• Wastewater Treatment – Secondary treatment and UV light treatment are utilized</td></tr>
<tr><td>Water/Wastewater Treatment Technologies</td><td colspan="3">Calexico Water Treatment Plant (Water): Blending, clarifiers, coagulation/flocculation/filtration
Calexico Wastewater Treatment Plant (Wastewater): Primary/secondary treatment, anaerobic digesters, aeration lagoons, UV disinfection</td></tr>
<tr><td>Water Resources</td><td colspan="3">The City of Calexico depends solely on the Colorado River for surface water inflows, supplied by the Imperial Irrigation District.</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">Short-term: Colorado River via All American Canal (0)
Long-term: Colorado River via All American Canal, Conservation (0)
The city’s geographic location and dependence on the All American Canal present limited options for alternative water sources.</td></tr>
<tr><td>Energy Service Provider</td><td colspan="3">IID Energy</td></tr>
<tr><td rowspan="3">Observed Energy Intensities (kWh/MG)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Water Treatment</td><td>1,114</td><td>1,214</td></tr>
<tr><td>Waste Water Treatment</td><td>3,842</td><td>4,472</td></tr>
</table>

Table 3-26. Coachella Valley Water District

<table>
<tr><td>Primary functions</td><td colspan="3">Urban Water, Agricultural Water, Urban Wastewater</td></tr>
<tr><td>Segments of Water Use Cycle</td><td colspan="3">Supply, Distribution, Treatment</td></tr>
<tr><td>Hydrologic Region</td><td>Colorado River</td><td>DEER Climate Zone</td><td>15</td></tr>
<tr><td>Quantity of Water and Wastewater (2004)</td><td>Distributed: 110.2 MGD
Treated (Wastewater): 18.0 MGD</td><td colspan="2">Recycled: 6.1 MGD</td></tr>
<tr><td>Number of Customers (2004)</td><td>Total: 90,145
Residential: 82,682
Commercial: 3,094
Public: 207
Irrigation: 3,934
Temporary Construction: 228</td><td>Service Area Size</td><td>1,000 Sq miles</td></tr>
<tr><td>Distinguishing Characteristics</td><td colspan="3">Coachella Valley Water District (CVWD) was formed in 1918, to protect and conserve local water sources. CVWD delivers irrigation and domestic water and collects and recycles wastewater. The Coachella Valley lies in the northwestern portion the Salton Trough, which extends from the Gulf of California in Mexico northwesterly to the Cabazon area. The Colorado River enters this trough, and its delta has formed a barrier between the Gulf of California and the Coachella Valley.</td></tr>
<tr><td>Key Energy Drivers</td><td colspan="3">• Water Supply: significant energy is used for groundwater pumping
• Water Distribution: distribution topology is flat and therefore there is little energy required for distribution.
• Wastewater Treatment: significant energy is used for wastewater treatment</td></tr>
<tr><td>Wastewater Treatment Technologies</td><td colspan="3">WRP-1 (Reclamation): Oxidation basin, stabilization basins, evaporation-infiltration basin
WRP-2 (Reclamation): Activated sludge, secondary treatment, oxidation treatment
WRP-4 (Reclamation): Preliminary treatment, chlorination/dechlorination
WRP-7 (Reclamation): Secondary treatment, tertiary treatment
WRP-9 (Reclamation): Secondary treatment
WRP-10 (Reclamation): Secondary treatment, tertiary treatment</td></tr>
<tr><td>Water Resources (2004)</td><td colspan="3">Groundwater: 28.8%, Imported Water: 74.3%, Recycled: 4.3%</td></tr>
<tr><td>Marginal Water Supply and Energy Intensity (kWh/MG)</td><td colspan="3">Short-term: Groundwater (1,970-3,753)
Long-term: Increased groundwater, SWP and CRA, and recycled water supplies, and new supplies from desalinated drain water. (923-9,560)</td></tr>
<tr><td>Energy Service Provider</td><td colspan="3">SCE, IID</td></tr>
<tr><td rowspan="3">Observed Energy Intensities (kWh/MG)</td><td>Segment</td><td>Lower Range</td><td>Upper Range</td></tr>
<tr><td>Groundwater</td><td>1,970</td><td>3,753</td></tr>
<tr><td>Wastewater Treatment</td><td>923</td><td>1,437</td></tr>
</table>

4 Summary of Findings

The over-arching goal of Study 2 was to develop a range of energy intensities for the primary types of water and wastewater functional components. The purpose of developing this range of energy intensities was to determine the types of water and wastewater agency functions in which there is some commonality of energy intensity vs. those that are highly variable.

In addition, Study 2 developed 24 hour load profiles for the seven day types specified in the CPUC's decision (winter high, low and medium water demand; summer high, low and medium water demand; and the peak demand day for the electricity service provider). Through the WELP Tool, Study 2 also provided the capability of querying the database to identify the average energy requirements for the three specified hours (2:00pm to 5:00pm) over three consecutive weekdays at multiple data levels (meter, facility, type of facility, and for the agency overall). Further, Study 2 identified the short- and long-term marginal supplies for the retail water agencies that participated in this study.

The Study 2 results are summarized here and compared to values computed or estimated through prior studies.

4.1 Energy Intensity by Agency

The scope of work required that the Study Team compute ranges of observed energy intensities for the primary functional components of each participating agency. The results of these computations for each agency are summarized here, grouped by IOU service area.

Table 4-1. Summer and Winter Ranges of Energy Intensity Agencies in PG&E Service Territory

Agency	Segment	Summer Average (kWh/MG)	Winter Average (kWh/MG)	Summer Range (kWh/MG)	Winter Range (kWh/MG)
Cal-Am Monterey	Groundwater	2,437	2,924	2415 - 2481	2099 - 4373
	Water Treatment	3,855	5,623	3546 - 4612	4016 - 6666
Contra Costa Water District	Booster Pumps	1,116	1,000	991 - 1352	688 – 1524
	Raw Water Pumps	1,104	1,213	934 - 1346	625 – 1704
	Water Treatment	1,080	1,039	949 - 1175	895 – 1210
East Bay Municipal Utility District (Water)	Booster Pumps	510	518	499 - 519	319 – 699
	Raw Water Pumps	355	265	10 - 1193	37 – 597
	Water Treatment	272	168	226 - 310	80 – 254
Marin Municipal Water District	Booster Pumps	379	854	352 - 412	415 - 1851
	Raw Water Pumps	399	152	341 - 480	9 - 305
	Recycled Water Pumps	1,050	1,505	969 - 1304	1076 - 1965
	Wastewater Treatment	1,072	2,165	984 - 1262	1225 - 2948
	Water Treatment	134	457	105 - 177	209 - 1045
Monterey Regional Water Pollution Control Agency	Wastewater pumps	256	275	253 - 262	243 - 333
	Wastewater Treatment	1,452	1,622	1422 - 1508	1469 - 1994
Natomas Mutual Water Company	Raw Water Pumps	5	1	2 - 12	0 - 4
San Jose Water Company	Booster Pumps	932	956	779 - 987	605 – 1219
	Groundwater	1,844	1,712	1823 - 1871	1452 – 2098
	Pressure System Pumps	1,780	2,569	1558 - 2273	2039 – 4045
	Raw Water Pumps	15	233	10 - 20	74 – 464
	Water Treatment	220	718	167 - 322	246 - 2220
Semitropic Water Storage District	Groundwater	906	1,019	790 - 1020	817 - 1261

Table 4-2. Summer and Winter Ranges of Energy Intensity Agencies in SCE Service Territory

Agency	Segment	Summer Average (kWh/MG)	Winter Average (kWh/MG)	Summer Range (kWh/MG)	Winter Range (kWh/MG)
Coachella Valley Water District	Groundwater	2,169	2,652	2109 - 2238	1970 - 3753
	Wastewater Treatment	1,178	1,127	1116 - 1239	923 - 1437
Los Angeles County Sanitation District	Wastewater pumps	231	259	224 - 235	205 - 400
	Wastewater Treatment	1,237	1,323	1186 - 1298	1104 - 1446
Orange County Sanitation District	Wastewater pumps	3	4	3 - 3	3 - 6
	Wastewater Treatment	1,146	488	667 - 1314	24 - 734
Orange County Water District	Wastewater Treatment	3,410	3,398	3279 - 3503	3258 - 3525
	Microfiltration	795	837	756 - 839	772 - 949
	Reverse Osmosis	1,579	1,596	1483 - 1784	1285 - 1788
	UV light Treatment	306	330	288 - 336	293 - 399
	Recycled Water Pumps	1,024	796	956 - 1122	458 - 1080
Rancho California	Booster Pumps	1,262	1,321	1166 - 1340	1247 - 1423
	Groundwater	2,144	2,150	2031 - 2258	1971 - 2324
	Wastewater Treatment	1,241	1,153	1192 - 1292	992 - 1241
San Gabriel Water Company	Booster Pumps	82	45	56 - 141	37 - 61
	Groundwater	2,542	2,515	2403 - 2701	1989 - 3014
	Raw Water Pumps	28	40	5 - 53	5 - 104
Suburban Water	Booster Pumps	817	897	801 - 829	835 - 1081
	Groundwater	1,574	1,416	1471 - 1619	1254 - 1490

Table 4-3. Summer and Winter Ranges of Energy Intensity Agencies in SDG&E Service Territory

Agency	Segment	Summer Average (kWh/MG)	Winter Average (kWh/MG)	Summer Range (kWh/MG)	Winter Range (kWh/MG)
Oceanside	Booster Pumps	168	196	134 - 183	164 - 247
	Groundwater	1,824	1,415	1669 - 2009	1117 - 1876
	Wastewater pumps	455	430	432 - 475	383 - 497
	Wastewater Treatment	1,087	1,086	1062 - 1099	1074 - 1105
	Water Treatment	46	66	43 - 47	49 - 86
Valley Center	Booster Pumps	1,357	1,574	1157 - 1772	846 - 3063
	Pressure System Pumps	360	374	347 - 371	350 - 432

Table 4-4. Summer and Winter Ranges of Energy Intensity Agencies in Non-IOU Service Territory

Energy Service Provider	Agency	Segment	Summer Average (kWh/MG)	Winter Average (kWh/MG)	Summer Range (kWh/MG)	Winter Range (kWh/MG)
IID	**City of Calexico**	Wastewater Treatment	4,159	4,178	3842 - 4363	3900 - 4472
		Water Treatment	1,132	1,179	1114 - 1148	1131 - 1214
PWRPA	**Glenn Colusa Irrigation District**	Booster Pumps	48	60	40 - 60	39 - 116
		Raw Water Pumps	36	32	30 - 39	26 - 36
	Sonoma County Water Agency	Booster Pumps	512	337	415 - 610	273 - 496
		Groundwater	1,941	1,825	1887 - 1975	1728 - 1902
		Recycled Water Pumps	351	0	210 - 509	0 - 0
		Wastewater pumps	2	1	2 - 2	0 - 2
		Wastewater Treatment	4,531	3,119	4034 - 4941	1812 - 4117
	Westlands Water District	Groundwater	1,962	1,990	1571 - 2321	1681 - 2530
		Raw Water Pumps	1,108	1,166	1074 - 1146	1044 - 1341

The purpose of computing the energy intensities by water and wastewater functional component is to identify any patterns or comparability in energy intensity ranges that could support development of a proxy for use in estimating the amount of energy embedded in water in each segment of the water use cycle. The next step therefore involved organizing the energy intensity data by functional components, and comparing these with the range of energy intensities estimated by prior studies.

4.2 Energy Intensity by Function and Energy Driver

As noted earlier, data for the Supply and Conveyance segment of the water use cycle was developed through Study 1. Study 2 focused on collecting and compiling water-energy data for water treatment and distribution, and wastewater treatment. In addition, to the extent that data was available through the participating agencies, Study 2 also collected water-energy on groundwater pumping, recycled water production and distribution, and desalination (brackish). Other than a few small pilot projects, there are no seawater desalination plants in operation in California.

Ultimately, the energy intensities of all segments of the water use cycle need to be included to compute the amount of energy embedded in water.

4.2.1 Energy Intensity Data from Wholesale Water Agencies

While Study 2 focuses on the embedded energy in water for retail water and wastewater agencies in the state, many retail water agencies import or purchase water supplies for the major water wholesalers, such as the State Water Project, Central Valley Project, and Metropolitan Water District of Southern California. These wholesalers consume energy to transport, and in some cases treat, the water prior to delivering it to retail agencies. The true energy intensity of water delivered to end users by retail agencies should include any energy intensity associated with wholesale deliveries made to the retail agency.

Table 4-5 below contains the energy intensity of imported water supplies of select Study 2 agencies that import water. The table shows that the total energy intensity values for wholesale water can be significant and span a broad range. If a large percentage of a retail agency's water is obtained from wholesale suppliers, as is the case for some retail agencies, it significantly increases the total energy intensity of water delivered to retail customers.

Table 4-5. Energy Intensity of Wholesale Supply to Retail Agencies

	Wholesale Source 1			Wholesale Source 2		
Retail Agency	Supplier	Approximate Share of Retailer's Total Supply	Source EI (kWh/MG)	Supplier	Approximate Share of Retailer's Total Supply	Source EI (kWh/MG)
Contra Costa Water District	CVP	83%	0			
San Jose Water Company	SCVWD	40%	3380 - 3735			
Westlands Water District	CVP	40%	1313			
Inland Empire Utilities Agency	SWP	25%	8798			
Suburban Water Systems	MWD - Treated	10%	7499			
City of Oceanside	SDCWA - Treated	33%	6912	SDCWA - Raw	55%	6785
Rancho California	MWD - Treated	48%	7499	MWD - Raw	15%	7377
Valley Center MWD	SDCWA - Treated	99%	6912	SDCWA - Raw	1%	6785

Source: Data collected through Studies 1 and 2.

4.2.2 Energy Intensity Data from Retail Water and Wastewater Agencies

Table 4-6 summarizes the range of average energy intensities observed in Study 2 by functional component and geographic region. These ranges were obtained by analyzing the detailed monthly energy intensity results for all the agencies studied. Any disproportionate impacts of data for a few months that seemed atypical of the observed population are moderated by averaging the energy intensities by functional component and by agency. Averages were calculated for both the summer (May-October) and the winter (November- April). The range indicated in Table 4-6 depicts the minimum and maximum of these average energy intensity values (including both summer and winter) across all agencies for each functional component. Table 4-6 then compares this range against the range of observed or estimated energy intensities from previous studies.

Table 4-6. Observed Energy Intensities by System and Functional Component

	Functional Component	Primary Energy Drivers	Energy Intensity From Prior Studies[a]	Range of Energy Intensities Observed in Study 2 (kWh/MG)				
				Northern & Central Coast	Central Valley	Southland	Desert	Statewide
Supply	Local Surface Water	Pumping		152-1,213				152-1,213
	Groundwater	Pumping	537 - 2,272	1,712-2,924	906 - 1,990	1,415-2,552	2,169-2,652	906-2,924
	Brackish Desalination	Treatment	1,240-5,220			1,415-1,824		1,415-1,824
	Recycled Water	Incremental Treatment	300-1,200[b]	1,072-2,165		1,153-3,410		1,072-3,410
	Seawater Desalination	Reverse Osmosis	13,800					
Water Treatment	Coagulation + flocculation + filtration		100-111	134-457		44-66		44-457
	Microfiltration	Removal of Suspended Solids		220-718				220-718
	Removal of Salts, etc.	Reverse Osmosis						
	Disinfection	Ozone		168-272				168-272
		Ultraviolet						
Water Distribution	Booster Pumps	Flat Terrain	1,200-3,000		48-60			48-60
		Moderate Terrain		510-956		45-897		45-956
		Hilly Terrain		379-1,116		1,262-1,574		379-1,574
	Pressure System Pumps			1,780 - 2,569		360 - 374		360 - 2,569
Wastewater Treatment	Wastewater Collection Pumps		140	2-275		3-455		2-455
	Primary + Secondary		955-1,372	1,452-1,622		488-1,146		488-1,622
	Primary + Secondary + Tertiary		1,541	3,119-4,531		1,086-1,323	1,127-1,178	1,086-4,531
	Microfiltration (incremental)	High Pressure Pumping				794 - 836		794 - 836
	Reverse Osmosis (incremental)	High Pressure Pumping				1578 - 1595		1578 - 1595
	UV (incremental)					306 - 330		306 - 330

a) Unless noted source is: *Refining Estimates of Water-Related Energy Use in California*, Table 9. Urban water intensity matrix (kWh/MG), Navigant Consulting, Inc. for the California Energy Commission, CEC-500-2006-118, December 2006, p.25.
b) *The Role of Recycled Water in Energy Efficiency and Greenhouse Gas Reduction.* Navigant Consulting. May 2008.

Several observations can be drawn from the data in Table 4-6:

- Previous estimates of groundwater energy intensity are consistent with Study 2 observations.
- Study 2 observed a larger range of energy intensity in recycled water production than was previously documented.
- Study 2 examined and quantified the differences in energy intensity for distribution systems that varied in terrain, an observation not previously quantified through prior studies.
- For the first time, the energy intensity of microfiltration, reverse osmosis, and ultraviolet light wastewater treatment were separately documented.

While Table 4-6 includes most of the observations made from the data collected in Study 2, some data were excluded as they were deemed not representative of the energy intensity of the indicated functional component. These types of data problems occurred when multiple functions were performed at one facility, and energy data could not be readily disaggregated into the separate functions.

For example, some agencies' water treatment plants contained distribution pumps that were used to pressurize and pump the water into the distribution system. These pumps use a significant amount of energy; their energy use was included in the treatment plant's energy usage. Including these data would distort the amount of energy used for treatment. Consequently, these types of data problems were excluded from the computation of the minimum and maximum energy intensities by functional component.

Table 4-7 indicates the number of agencies that were relied on to provide ranges of energy intensity data by functional component within each energy service provider's territory. The number of agencies shown reflects the adjustments described above.

Table 4-7. Number of Agencies Observed with Each Function

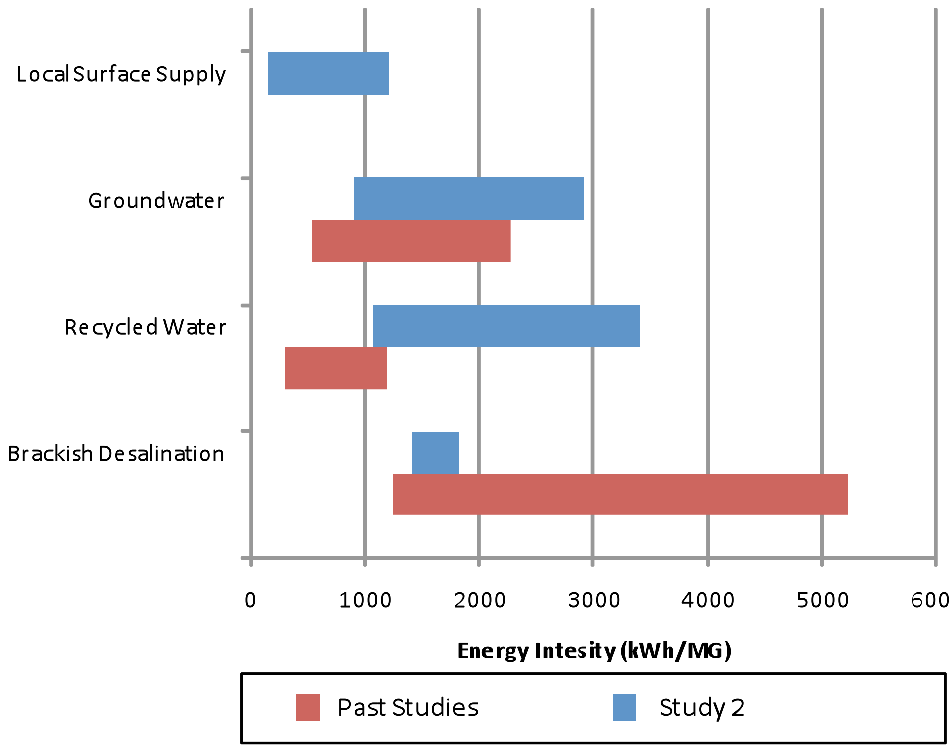
	Number of Agencies with Function					
Functional Component	**IID**	**PG&E**	**PWRPA**	**SCE**	**SDG&E**	**Total**
Raw Water Pumps		5	2	1		8
Groundwater Pumps		3	2	4	1	10
Water Treatment Plants		3			1	4
Booster Pumps		4	2	3	2	11
Pressure System Pumps		1			1	2
Waste Water Pumps		1	1	3	1	6
Wastewater Treatment Plant	1	2	1	9	1	14
Recycled Water Pumps		1	1	2		4

The following sections and figures illustrate the variability in energy intensity by functional component observed through the participating agencies. These figures illustrate energy intensities obtained from previous studies and the statewide range from Study 2 (data from Table 4-2). The sources of the previous studies are those cited in Table 4-2.

4.2.3 Supply

The range of energy intensities for water supplies observed in Study 2 are illustrated in Figure 4-1 below.

Figure 4-1. Statewide Energy Intensity Ranges for Supply



Water from local raw surface supplies was observed to vary from 150 up to 1,200 kWh/MG due to the distinguishing characteristics of each agency. Some, like CCWD, pump large amounts of water to significant elevations resulting in high energy intensities. Other agencies (such as irrigation districts) use pumps to simply divert water from local streams or canals at a low elevation difference, these activities are less energy intensive

The energy intensity for groundwater pumping is primarily dependent on the depth of the water table in the aquifer or the height that water must be pumped. Urban pumping often includes additional water pressure for distribution, while agricultural wells need only to pump water to the ground's surface for irrigation. This would lead one to think that urban groundwater would have a higher energy intensity than agricultural water. This is somewhat reflected in the Study 2 results (Table 4-1). Groundwater energy intensity for agencies in the Central Valley (mostly agricultural wells captured in Study 2) are lower than those observed in other regions (more where mostly urban systems were captured in Study 2.) In general Study 2 results for statewide estimates of groundwater energy intensity are consistent with past studies.

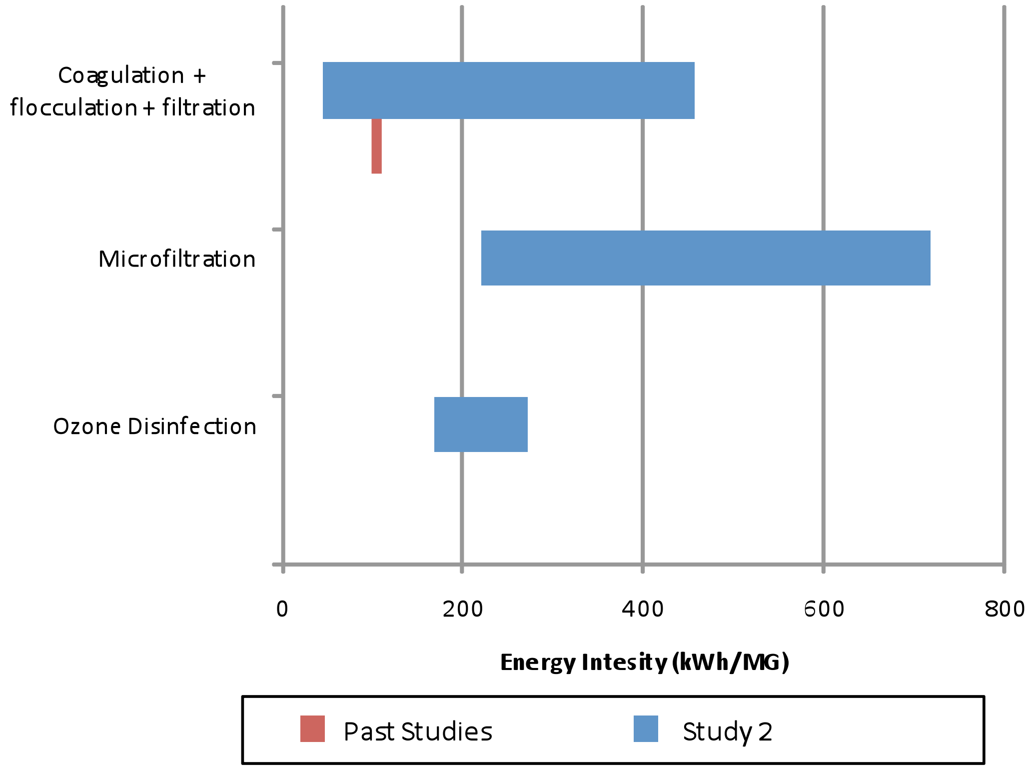
Data on recycled water production collected by Study 2 indicates a large range of possible energy intensities. This is because Study 2 captured a large range of treatment technologies relating to the production of recycled water. The production of tertiary treated water for reuse accounts for the lower range of the energy intensity (approximately 1,150 kWh/MG). The upper range represents advanced recycled water treatment processes (data collected from OCWD) that includes microfiltration, reverse osmosis, and ultraviolet light that produces water that exceeds California drinking water standards.

Data on brackish water desalination was only available from one agency in Study 2. While it may seem Study 2's observation results in a narrower range of energy intensity than previously estimated, the small sample size does not allow us to draw any conclusions. Interviews with agencies operating brackish desalination plants (which primarily use reverse osmosis) indicated that energy requirements vary based on water quality. High concentrations of dissolved salts require higher pressures in reverse osmosis equipment increasing energy intensity.

4.2.4 Treatment

The range of energy intensities for water treatment observed in Study 2 are illustrated in Figure 4-2 below.

Figure 4-2. Statewide Energy Intensity Ranges for Water Treatment



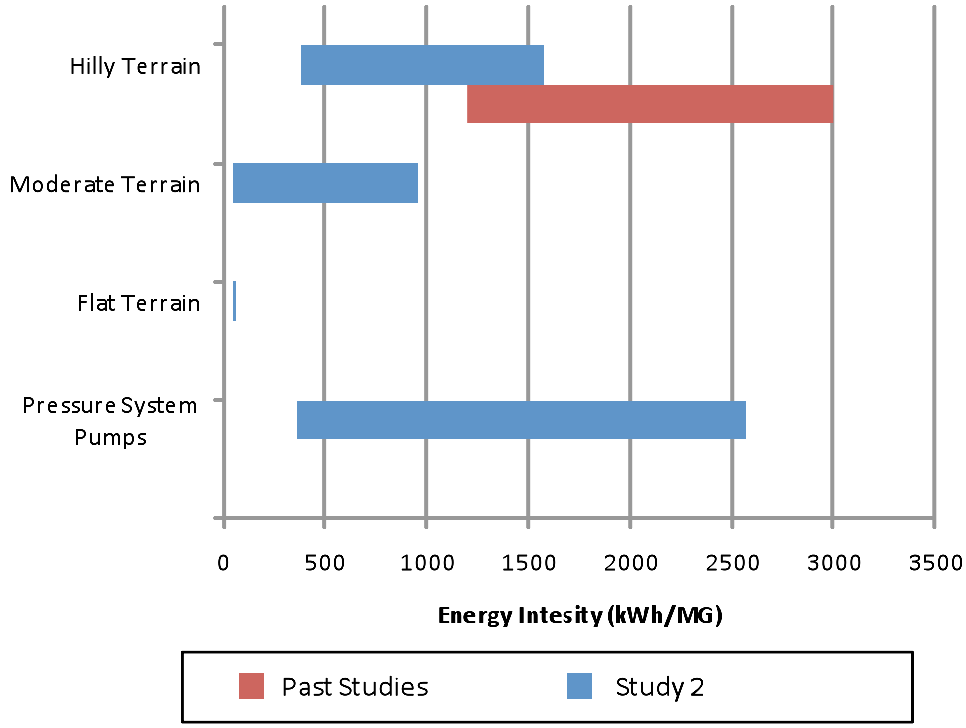
Study 2 observed a larger range of energy intensity than previously estimated for traditional water treatment technologies (the combination of coagulation, flocculation, and filtration as primary processes.) Several plants were removed from this analysis as the Study Team was aware that multiple functions were performed at the plant and were contributing to artificially high treatment energy intensity. It is possible that we were not informed of other functions in the remaining plants, which could be an explanation for the high upper range.

Study 2 additionally included water treatment facilities that use microfiltration and ozone treatment in addition to traditional technologies. Of these two advanced treatment processes, Study 2 observed higher energy intensities for plants utilizing microfiltration. Microfiltration requires additional and higher pressure pumping than that which normally occurs at a treatment plant leading to higher energy intensity. The additional use of ozone disinfection along with traditional treatment technologies does not seem to significantly affect treatment energy intensity. The observed energy intensity of plants utilizing ozone falls within the range of those plants not utilizing ozone as observed by Study 2.

4.2.5 Distribution

The range of energy intensities for distribution systems observed in Study 2 are illustrated in Figure 4-3 below.

Figure 4-3. Statewide Energy Intensity Ranges for Distribution Systems



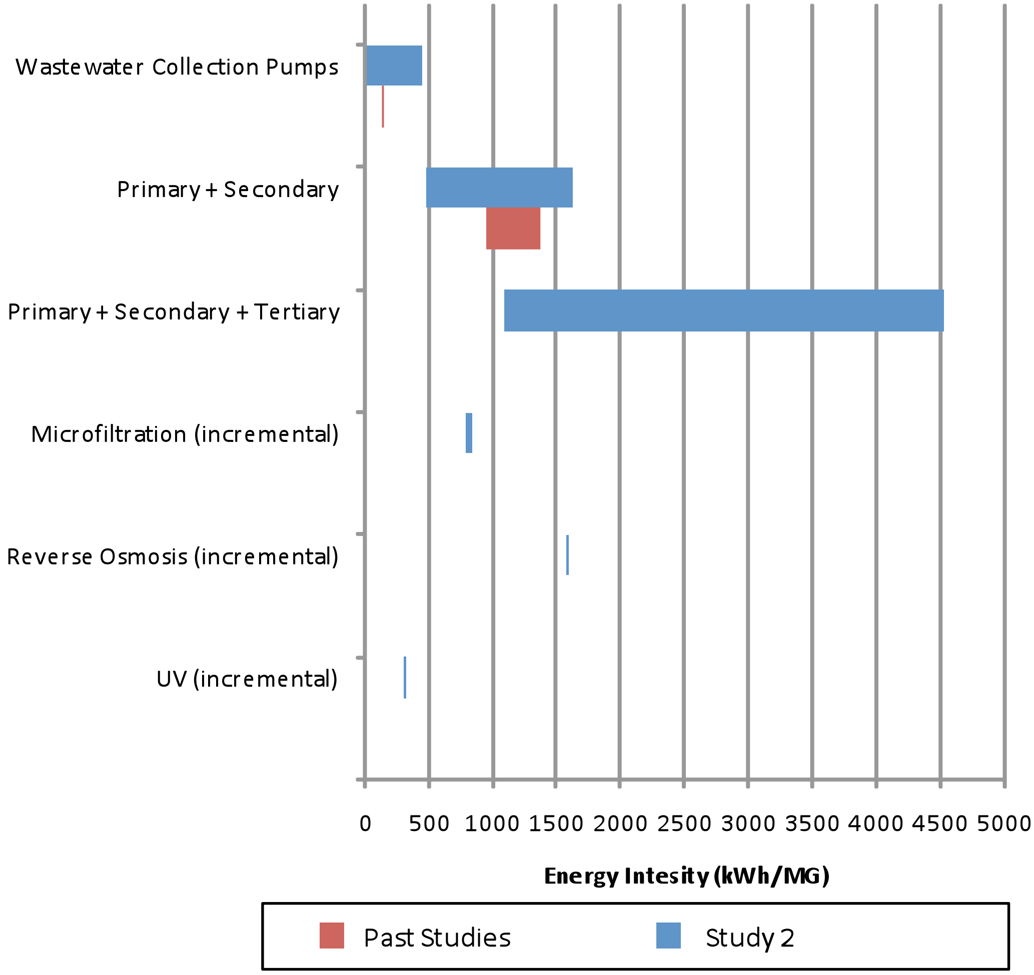
Study 2 observed and quantified the differences in energy intensity for distribution systems that served varying terrain. Previous studies estimated that distribution energy intensities varied from 1,200 – 3,000 kWh/MG. Study 2 did not observe any systems with energy intensities as high as 3,000 (though such systems may certainly exist). Distribution systems in hilly areas such as were observed to range from about 400 to 1500 kWh/MG. On the other hand, distribution systems in flat terrain such as those found in the Central Valley can be less than 100 kWh/MG.

For a few agencies, pressure-regulating pumps are needed. Those are pumps which maintain a pressure in the distribution pipes. Like booster pumps, which supply water to higher elevation zones within the service area, their energy use and energy intensities are dependent on the terrain and layout of the agency's service area. In some cases, they add a substantial energy requirement to the agency's profile, anywhere from 300 to 2,500 kWh/MG.

4.2.6 Wastewater Collection and Treatment

The range of energy intensities for water treatment observed in Study 2 is illustrated in Figure 4-4 below.

Figure 4-4. Statewide Energy Intensity Ranges for Wastewater Treatment



Energy intensity for wastewater collection pumps ranged from near 0 to 450 kWh/MG. The actual value depended on an agency's service area terrain and treatment plant location. Wastewater treatment plants are often located at a lower elevation than the treated water service area so that wastewater can flow via gravity to the plant, requiring few pumps and little energy use (energy intensity near 0 kWh/MG). However, not all systems can be designed this way. For some coastal communities in Southern California, significant wastewater pumping is required, resulting in higher energy intensities.

Study 2 observed facilities that treat wastewater to both secondary and tertiary effluent. Study 2 observed previous estimates of energy intensity requirements for secondary treatment are relatively consistent with data collected. Tertiary treatment plants were observed to have a wide range of energy intensities.

For the first time, Study 2 documented the incremental energy intensity of three advanced wastewater treatment technologies using data collected from OCWD. Of these technologies (microfiltration, reverse osmosis, and UV light treatment), Study 2 observed reverse osmosis required the highest energy intensity as it requires significant pressure generated by pumps.

4.3 Energy Intensity by IOU

Figure 4-5 illustrates the energy intensity ranges of each component by IOU. These ranges were obtained by including only those Study 2 water agencies served by each IOU. While the Study Team attempted to capture a broad range of agency times from each IOU service territory, some functional components were not represented in all three IOU service territories (Table 4-2).

Figure 4-5. Energy Intensity Range by Functional Component for Each IOU (kWh/MG)

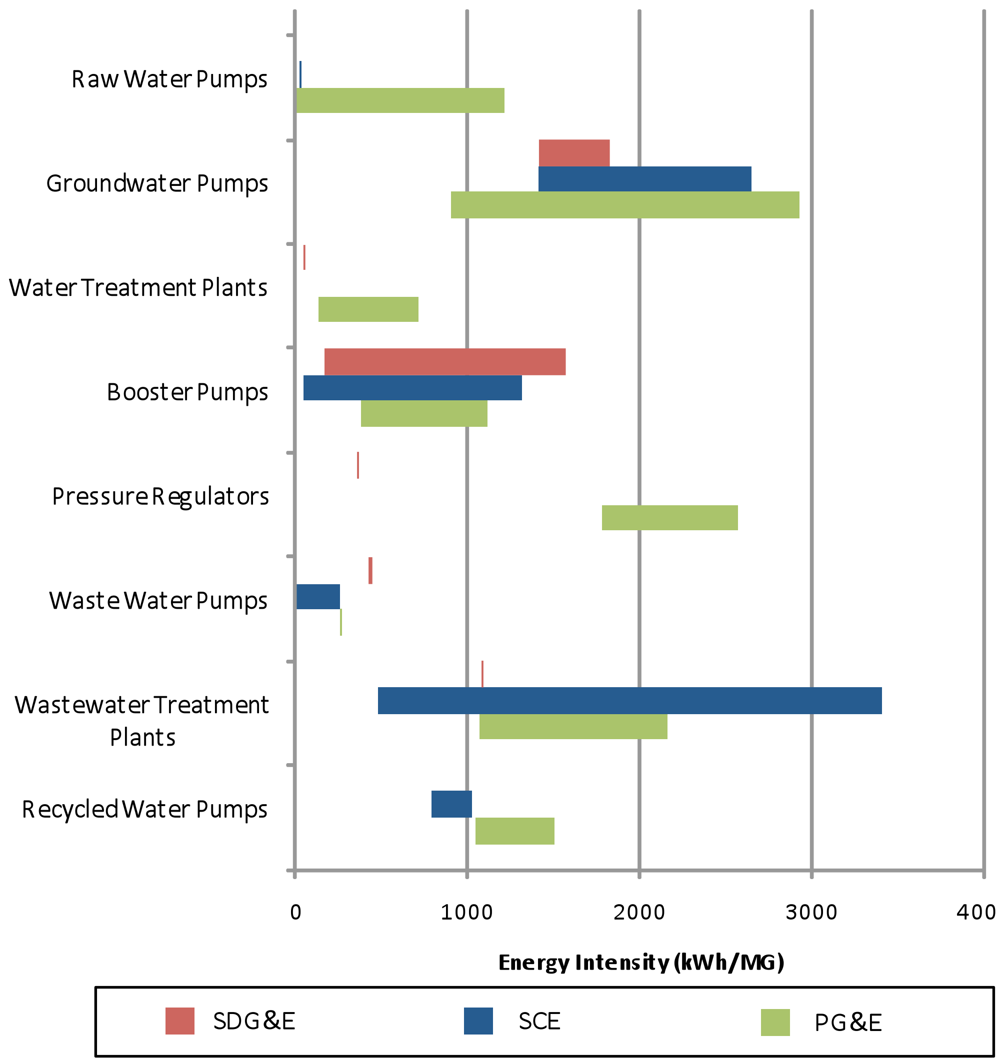


Figure 4-5 illustrates the range over the entire year. The Study Team also tabulated seasonal average energy intensities (Table 4-8).

Table 4-8. Summer and Winter Ranges of Energy Intensity for Each IOU (kWh/MG)

	PG&E		SCE		SDG&E	
	Range of Summer Averages	Range of Winter Averages	Range of Summer Averages	Range of Winter Averages	Range of Summer Averages	Range of Winter Averages
Raw Water Pumps	5 - 1104	1 - 1213	28	40	-	-
Groundwater Pumps	906 - 2437	1019 - 2924	1574 - 2542	1416 - 2652	1824	1415
Filter Plants	134 - 272	168 - 718	-	-	46	66
Booster Pumps	379 - 1116	518 - 1000	82 - 1262	45 - 1321	168 - 1357	196 - 1574
Pressure Regulators	1780	2569	-	-	360	374
Waste Water Pumps	256 - 256	275 - 275	3 - 231	4 - 259	455	430
Wastewater Treatment Plant	1072 - 1452	1622 - 2165	1146 - 3410	488 - 3398	1087	1086
Recycled Water Pumps	1050	1505	1024	796	-	-

Raw water pump energy intensity at the retail water agency level varies significantly in PG&E's service territory. Retail agencies in northern California that convey their own raw water do so over a variety of terrain (flat, over hills, or all downhill) that result in this large variation. In SCE and SDG&E's service territory, however, fewer retail agencies participating in Study 2 convey raw water; and when they do, the energy intensity is low. This is because there are vast networks of raw water transport systems operated by wholesalers that deliver water to retail water agencies, eliminating most of the need for raw water transport at the retail level.

Groundwater energy intensity falls within the same range across all three IOUs and was observed to take on a variety of values. This is due to the varying depth to which each retail agency must pump. While difference geographic areas will have different groundwater depths, differences in each IOU service territory cannot be discerned with certainty given Study 2's observations.

Data from water treatment plants were mostly collected from retail agencies in PG&E's service territory. Treatment in SCE and SDG&E's service territories was not as well covered. Retail water agencies in Southern California purchase a significant amount of treated water from wholesalers (such as Metropolitan Water District of Southern California) and use significant amounts of groundwater that requires less treatment.

Observed energy intensities of distribution systems (booster pumps) were fairly consistent across all three IOUs. Booster pump energy intensity varies by terrain (as previously illustrated in Figure 4-3) and each IOU service territory contains a variety of terrain from flat to hilly. Pressure system pumps (part of the distribution system) were only observed in two agencies each in different IOU service territories. No conclusions can be drawn regarding pressure system pumps.

Wastewater collection pumps were observed in each IOU service territory and some variation can be observed. Pumps observed in PG&E territory had a wide range of energy intensities, from near zero to 450 kWh/MG. As mentioned previously, the actual value depends largely on the juxtaposition of the wastewater treatment plant to the area it serves. When wastewater plants are downhill from is collection area, energy intensity tends to be low.

Wastewater pump energy intensities observed in SCE and SDG&E territories were higher than in PG&E territory. Many of the participating agencies in SCE or SDG&E's service areas serve coastal areas or hilly regions. These regions are more likely to have large populations located at the same elevation or lower than the wastewater treatment plants, requiring more pumps to be used and higher wastewater collection energy intensities. However, other wastewater agencies in these areas may well have lower energy intensities for wastewater collection.

Wastewater treatment plants were observed in each IOU service territory with most located in PG&E and SCE. Little difference was observed between the energy intensity ranges of the two territories. SCE's territory does have a higher value for the upper range; however, this is due to one advanced recycled water facility operated by OCWD that treats wastewater well beyond typical requirements. Treatment plants in each service territory treat water to either secondary or tertiary using similar technologies. Thus the ranges of energy intensities for wastewater treatment appear independent of service territory.

Recycled water distribution pump energy intensity (similar to booster pumps) varies by agency and terrain. Observed ranges for PG&E and SCE do not overlap; however, this may simply be due to the limited sample size.

4.4 Total Energy Use

Study 2 collected annual energy and flow data from 21 retail water and wastewater agencies across the state for the calendar year 2008.[31] These 21 agencies collectively consumed 1,376 GWh of electricity during CY2008. Additional details of which utility supplied this energy and what it was used for can be found in Figures 4-6 through 4-9.

These 21 agencies delivered about 3.5 million acre feet of water (raw water, potable water, and wastewater) in CY2008. Of this, 340,000 AF was treated at water treatment plants, 940,000 AF treated at wastewater treatment plants, and the rest needed no treatment (supplied by groundwater, supplied as raw water, or imported from other agencies as treated water).

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[31] Another agency, the 22nd agency, provided a snapshot of its operations but did not provide full data for calendar year 2008.

4.5 Energy Intensity of Marginal Supplies

The water-energy load profiles include identification of the short- and long-term marginal water supplies and their associated energy intensities for each water agency that participated in this study. For purposes of comparison, these data are summarized in Table 4-9. A description of the marginal supplies is included in each agency's profile in Appendix B.

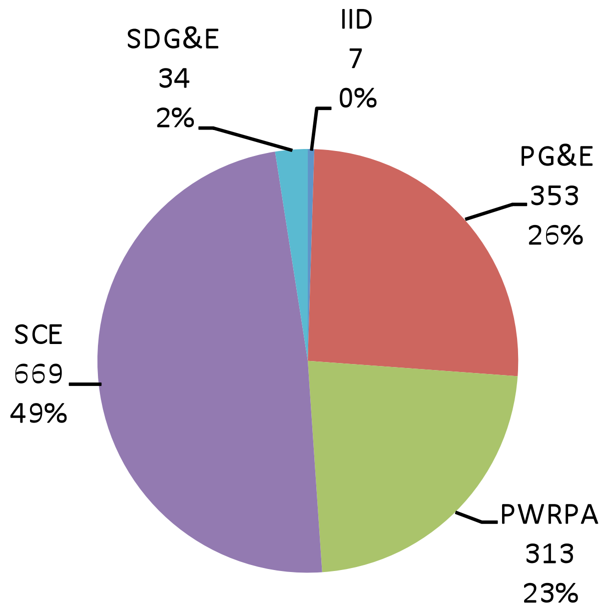
Table 4-9. Energy Intensity of Marginal Supplies

Water Agency/District	Ag	Urban	Marginal Supplies											Planning	Supply & Convey		Treatment		Total EI, Marginal Supply			Notes
			Surf	GW	CO	CVP	SWP	Impt	Recy	Recov	D-Br	D-Sea	Xfrs	Horizon	Low	High	Low	High	Low	High	Trt Incl?	
Calexico, City of		X			X									Short	0	0	1,114	1,214	1,114	1,214	Y	CO River via IID + treatment
					X									Long	0	0	1,114	1,214	1,114	1,214	Y	
Cal-Am, Monterey		X	X											Short	0	0	3,546	6,666	3,546	6,666	Y	Low is recycled; high is desal
			X						X	X		X		Long	1,422	12,276	0	0	1,422	12,276	Y	
Coachella	X	X		X										Short	1,970	3,753	0	0	1,970	3,753	Y	Ag uses raw water; urban water includes treatment
				X	X		X		X		X		X	Long	923	9,560	0	0	923	9,560	Y	
Contra Costa		X				X								Short	848	1,704	895	1,210	1,743	2,914	Y	Low is treated surface water pumping; high is desal
									X			X	X	Long	1,743	12,276	0	0	1,743	12,276	Y	
East Bay MUD		X	X											Short	10	597	135	310	145	907	Y	Low is treated surface water; high is desal
				X								X		Long	1,051	12,276	0	0	1,051	12,276	Y	
Glenn-Colusa	X		X											Short	65	155	0	0	65	155	n/a	Ag uses raw water
			X	X						X				Long	27	188	0	0	27	188	n/a	
Inland Empire		X							X					Short	0	0	0	0	0	0	n/a	Wastewater treated to tertiary; recycled water = 0
									X		X			Long	0	3,945	0	0	0	3,945	Y	
Los Angeles Sanitation		X	N/A (Wastewater Treatment Only)																			
Marin Municipal		X	X											Short	9	480	105	322	114	802	Y	Low is treated surface water; high is desal
			X						X			X		Long	984	12,276	0	0	984	12,276	Y	
Monterey Regional	X	X	N/A (Wastewater Treatment Only)																			
Natomas Central	X			X		X								Short	0	576	0	0	0	576	n/a	Ag uses raw water
										X				Long	0	0	0	0	0	0	n/a	
Oceanside, City of		X						X						Short	6,785	6,826	43	86	6,828	6,912	Y	Low is treated imports; high is desal
														Long	1,117	12,276	0	0	1,117	12,276	Y	

Table 4-9. Energy Intensity of Marginal Supplies (continued)

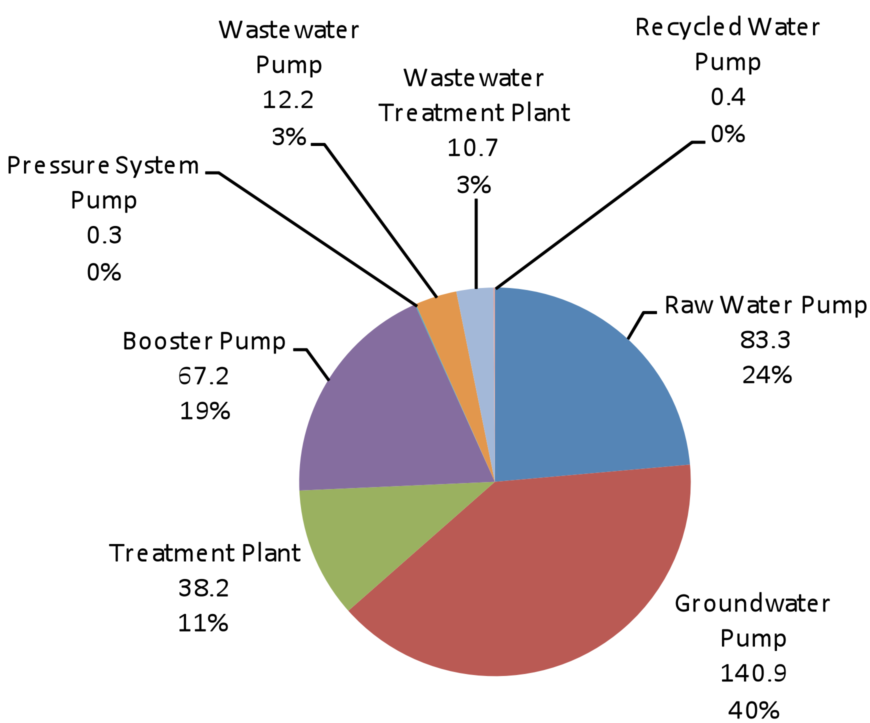
Water Agency/District	Ag	Urban	Marginal Supplies											Planning	Supply & Convey		Treatment		Total EI, Marginal Supply			Notes
			Surf	GW	CO	CVP	SWP	Impt	Recy	Recov	D-Br	D-Sea	Xfrs	Horizon	Low	High	Low	High	Low	High	Trt Incl?	
Orange County San.	X	X	N/A (Wastewater Treatment Only)																			
Orange County WD		X	X											Short	30	0	0	0	30	0	n/a	Local surface water does not require treatment. Long-term, low EI is recycled water; high is imported.
								X	X					Long	0	7,418	3,161	n/a	3,161	7,418	Y	
Rancho California WD	X	X						X						Short	7,377	7,499	0	0	7,377	7,499	Y	Low is groundwater; high is imported treated water
				X										Long	1,971	3,436	0	0	1,971	3,436	Y	
San Gabriel Valley		X		X				X						Short	1,989	6,064	134	713	2,123	6,777	Y	Low is groundwater; high is imported treated water
			X											Long	6,064	6,094	134	713	6,198	6,807	Y	
San Jose		X		X				X						Short	1,452	3,735	0	0	1,452	3,735	n/a	Groundwater does not need treatment; high is treated imported water
				X										Long	1,452	1,871	0	0	1,452	1,871	n/a	
Semitropic	X			X		X	X							Short	790	2,574	0	0	790	2,574	n/a	Groundwater banking
				X		X	X							Long	790	2,574	0	0	790	2,574	n/a	
Sonoma County	X	X	X											Short	1,728	1,975	0	0	1,728	1,975	Y	Minimal treatment needed; high is recycled water
			X						X					Long	3,466	3,466	0	0	3,466	3,466	Y	
Suburban		X	X					X						Short	30	7,377	122	122	152	7,499	Y	High is treated imports; groundwater & recycled do not need additional treatment
				X					X					Long	1,104	1,619	0	0	1,104	1,619	n/a	
Valley Center	X							X						Short	6,912	6,912	0	0	6,912	6,912	n/a	Ag uses raw water
								X				X		Long	6,912	12,276	0	0	6,912	12,276	n/a	
Westlands	X			X		X								Short	1,313	2,530	0	0	1,313	2,530	n/a	Ag uses raw water
				X		X								Long	1,313	2,530	0	0	1,313	2,530	n/a	

Figure 4-6. 2008 Total Energy Use by All Study 2 Agencies by Electric Supplier (GWh)



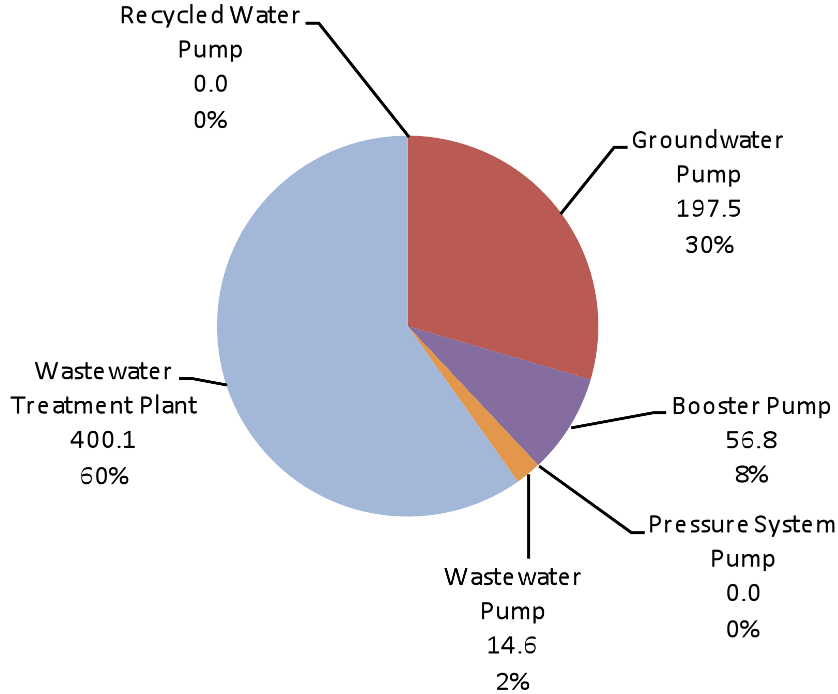
Total: 1,367 GWh

Figure 4-7. 2008 Total Energy Use by Study 2 Agencies in PG&E Service Territory by Function (GWh)



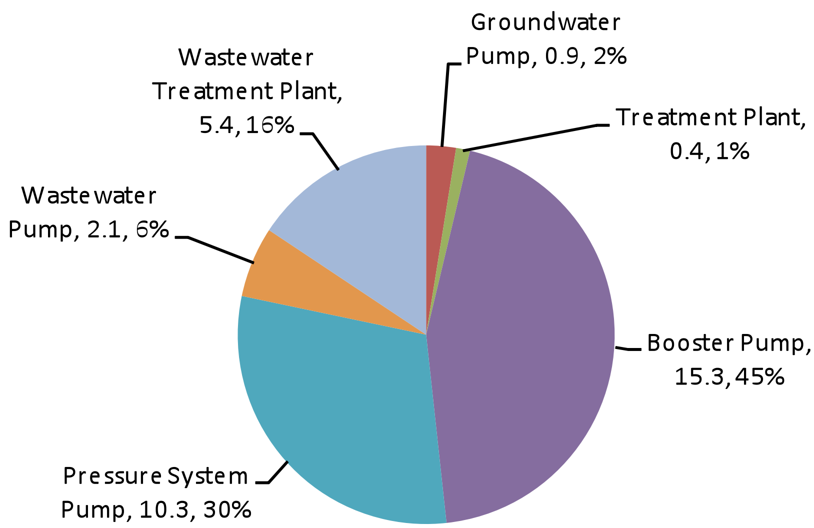
Total: 353 GWh

Figure 4-8. 2008 Total Energy Use by Study 2 Agencies in SCE Service Territory by Function (GWh)



Total: 669 GWh

Figure 4-9. 2008 Total Energy Use by Study 2 Agencies in SDG&E Service Territory by Function (GWh)



Total: 34.3 GWh

5 Recommendations

5.1 Summary

Prior studies relied primarily on the CEC's 2005 and 2006 studies. Studies 1 and 2 are the most extensive data collection and analysis efforts conducted thus far about energy use by California's water sector.

- Study 1 focused on estimating the amount of energy consumed by the Supply and Conveyance segments of the water use cycle. Through that study, detailed water-energy data were collected that also enable estimating the energy intensity of primary wholesale water supplies throughout California.

- Study 2 focused on collecting and compiling detailed water-energy data at the retail water and wastewater agency functional level.

Both studies observed wide variability in the energy intensities of water transportation (conveyance) and delivery (distribution) systems. The amount of energy needed to serve water to any particular customer depends on the distance and elevation over which that water must be transported.

However, Study 2 also observed wide variability among functional components in retail water and wastewater systems. It would be difficult from these data to select a single value as indicative of the "typical" energy intensity of water and wastewater treatment. This may be in part due to the fact that the contribution of key energy drivers to the energy intensity of any particular functional component could not be readily determined from the data that were available. It may also be because each treatment plant is configured uniquely, and there are distinct differences in the key energy drivers in each.

In Chapter 4 Findings, the Study Team documented the range of variance found in the energy intensities observed in the functional components of the participating water and wastewater agencies. There was no clear pattern that could point to a single value to be used as a proxy for any segment of the water use cycle or is sub-segments, nor was there sufficient basis to select proxies by geographic or hydrological region. In fact, while Studies 1 and 2 addressed the questions raised in the respective scopes of work, both pointed to a need for additional data, methods and tools. The types of data, methods and tools identified through these studies are described generally below, along with an illustration of how the data from the two studies can be integrated to compute embedded energy in water.

5.2 Recommendations

Based on the data collected through Studies 1 and 2, the Study Team believes that the amount of electricity used by the water sector is higher than the CEC's conservative estimates in 2005.

In Appendix F, Comparison of Study 1 and Study 2 Findings with Prior Studies, electricity use by the Supply and Conveyance segment alone was shown to exceed the amount of electricity use reported by the CEC for all water sector use (i.e., including water treatment and distribution, wastewater collection and treatment, and recycled water production and distribution). In the absence of better data, the Study Team recommends conservative adjustments which we believe understate the amount of energy embedded in the state's water. These conservative estimates increase water sector electricity use in 2001 from 4.9% to 7.7%. The Study Team does not, however, have a basis for increasing the CEC's estimate that 19.2% of all electricity used in California is in some way related to water, since the increase in water sector use may be a reallocation of electricity counted towards water end use.

The primary significance of these findings is that the value of energy embedded in water is higher than that initially estimated in the CEC's 2005 and 2006 studies. Notably, the estimates developed by the CEC were purposely conservative because the CEC did not want to overstate the potential water-energy relationship.[32] Since water sector energy use establishes the value of energy deemed "embedded" in a unit of water, the energy value of water efficiency measures increases as more electricity consumption is allocated to the water sector itself.

The key recommendations indicated by these studies entail improving the body of water-energy data, methods and tools to enable more accurate measurement of the state's water-energy relationships. In particular, the Study Team recommends the following actions:

- Collect more water-energy data, and with more granularity
- Develop and adopt a methodology for computing the energy embedded in a unit of water
- Quantify water losses throughout the water use cycle

These recommendations are discussed below.

Collect more water-energy data, and with more granularity. Better data is needed about electricity requirements for groundwater and for water and wastewater treatment.

1. <u>Groundwater Energy</u>. Study 1 indicates that groundwater energy is much larger than previously realized. During summer months, electricity used for groundwater exceeds

[32] Interview with Lorraine White, Senior Energy Specialist and Advisor to Commissioner Anthony Eggert, California Energy Commission, May 19, 2010.

the amount of electricity used by the three largest wholesale water systems (SWP, CVP and CRA) combined. Data on the amount of energy used for groundwater pumping is very spotty. Very good data is available in adjudicated basins, very little data is available in other places, where groundwater pumping is not adjudicated. In addition to being a very significant component of embedded energy in water, groundwater energy is important because much of it is provided by the state's IOUs. Unfortunately, how much of it is provided by the IOUs is presently undeterminable from existing data.[33]

2. Treatment Energy. The amount of energy used to treat water and wastewater is typically computed at the plant level. Although engineering studies enable estimating the relative amount of energy needed for different types of treatment technologies, energy meters do not capture data at a level that would facilitate validating those engineering assumptions.

As noted earlier, given the tremendous variability in water conveyance and distribution systems, the energy intensity of water transport and delivery systems need to be computed separately for each water agency.

There are a number of near-term opportunities for significantly improving the state's knowledge about electricity use by the state's water sector:

- Advanced Metering Infrastructure (AMI). The state's IOUs have commenced replacement of existing meters with advanced meters that have the ability to capture real-time energy consumption data. The AMI conversion is expected to be completed within about five years. This existing activity provides a near-term opportunity to significantly improve the state's understanding of its water-energy relationships for no incremental cost – the CPUC need only direct the IOUs to prioritize water sector electricity uses for near-term conversion to AMI.

- The Water-Energy Load Profiling (WELP) Tool developed through Study 2 can be used to develop detailed water-energy load profiles for all water and wastewater agencies in California. Water and wastewater agencies could be required to provide the data needed to develop these detailed water-energy load profiles as a condition for accessing IOU energy incentives. During the conduct of Studies 1 and 2, the Study Team found that water and wastewater agencies cited limited staff time as the greatest obstacle to participation. Water and wastewater agencies dealing with cutbacks in staffing had great difficulty providing the detailed water and energy data that was required by Study 2, in

[33] During the course of this study, members of the Internal Working Group and Study team contacted both water and energy utilities to identify more data about groundwater pumping. Both water and energy sector stakeholders stated that little information is presently available about the amount of energy used to pump groundwater.

particular. Since energy utilities have at least half of the data, a partnership seems logical.

In addition, all of the medium to large-size water and wastewater treatment facilities have SCADA systems that can be set up to monitor and report energy use by functional components, if desired. The state's IOUs could work with water and wastewater agencies to identify opportunities to increase monitoring and reporting of energy use by high priority segments and sub-segments of the water use cycle.

Develop and adopt a methodology for computingenergy embedded in water. Study 2 required collection of the short- and long-run marginal water supplies for participating water agencies. The purpose of this task was to provide a basis for computing the value of energy embedded in water. Study 1 provided much of the data that would be needed to compute the energy embedded in the Supply and Conveyance segment of the water use cycle, while Study 2 focused on collecting data about energy used in water treatment and distribution, wastewater treatment, and incremental treatment (if any) needed to produce usable recycled water.

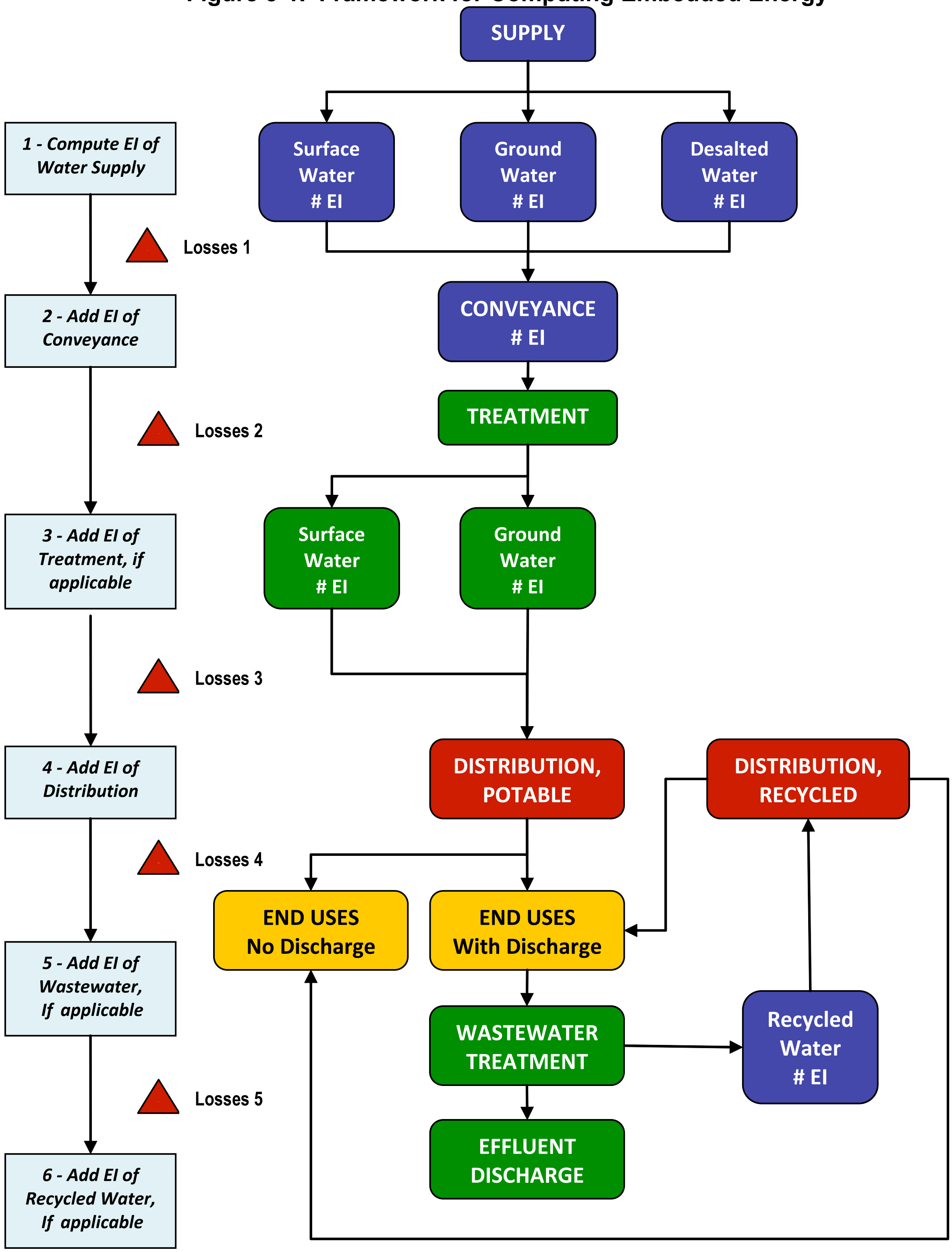
Quantify water losses throughout the water use cycle. Prior studies indicate that losses in the water system are substantial. There is significant variability, depending on the type of facility(s), the climate, and the condition of the system. Reservoirs and aqueducts are open to the atmosphere and thus experience losses due to evaporation. Pipelines have fewer losses due to evaporation but depending on the age, condition and type of materials used, can have significant losses due to leaks. Water system losses have been documented along all segments of the water use cycle. Even newly constructed distribution systems can experience losses of 5%, while mature systems in dense urban areas may experience losses as high as 10-15% or more. All of the energy used along all segments of the water use cycle need to be accounted for in computing embedded energy, including energy that may have been used to transport, treat or deliver water that is lost and not delivered to water end users.

5.3 A Framework for Computing Embedded Energy

Ultimately, the goal of Studies 1 and 2 was to enable selecting values to insert along the segments of the water use cycle to determine the amount of energy embedded in a unit of water. Whether that computation is made at the level of a single agency, a region or statewide is a matter of policy.

The diagram below illustrates the way in which data from Studies 1 and 2 could be integrated in order to compute the amount of energy embedded in a unit of water.

Figure 5-1. Framework for Computing Embedded Energy



The key steps and associated issues that should be considered when computing energy embedded in water, whether at the individual agency level, regionally or statewide, are described below. Losses should be included in the computations. For example, if a particular water supply source starts at 1,000 AF at the beginning of the water use cycle but, after losses, results in delivering 800 AF of water supply to end users, all of the energy used to produce and deliver that water along all segments of the water use cycle, including the missing 200 AF, should be counted. Whether or not this value needs to be separately computed depends on how the energy data are collected and computed at each segment.

1. ***Compute EI of Water Supply***. As discussed in both Studies 1 and 2, nearly 98% of the state's water use by the urban and agricultural sector is met by the two primary sources of water: surface water (67%) and groundwater (31%). The remainder is met by desalted and recycled water supplies. The energy intensity (EI) of each water resource depends on a number of factors, including the quality and location of the water supply.

    - *Surface water* tends to be a relatively low EI resource because it is ready to be applied to beneficial uses.

    - *Groundwater* tends to have a higher EI than surface water because energy is needed to pump water to the surface before it can be used.

    - *Desalted water* may either be pumped from aquifers or drawn from brackish surface water sources, such as the ocean. By definition, water resources are not deemed "water supply" until they are usable. Consequently, brackish water resources must be desalted before they can be considered "water supplies." Typically, the process of desalting water is higher on an average EI basis than groundwater pumping. The amount of energy needed for desalting depends on the quality of the water – the higher the salt content of the water, the more energy is needed to remove the salts. Consequently, seawater desalination is one of the highest EI water resources.

    - *Recycled water* is produced from wastewater effluent. The amount of energy needed to treat wastewater to a quality needed for safe discharge in accordance with public health regulations is accounted for as wastewater treatment energy. The EI of recycled water is thus the amount of incremental energy, if any, needed to treat the effluent to a higher quality as may be needed to serve the targeted beneficial uses.

    Supply Losses (Losses 1): Although losses occur during the process of water production, those losses need not be separately accounted for in the embedded energy computation, since the EI of the water supply is typically already computed net of water supply production losses.

2. ***Add EI of Conveyance***. The EI of conveyance of wholesale water supplies depends on the distance and elevation that the water must traverse. The State Water Project (SWP) provides

an excellent illustration of how conveyance EI varies at each delivery point along the system,[34] with the highest EI occurring at the points after which SWP water must be pushed a total of 3,000 feet over the Tehachapi Mountains.

Conveyance Losses (Losses 2). The state's water conveyance systems transport large volumes of water supply from one region to another. These systems tend to be large diameter pipelines or lined or unlined channels. Conveyance systems tend to have substantial losses through pipeline leaks, aqueduct or canal seepage, and evaporation. The largest systems that transfer water across the state traverse hundreds of miles. Most leaks in underground pipelines go undetected for many years; and even when they are known to leak, the cost of digging up and repairing the pipelines is a significant economic deterrent. The actual magnitude of losses in the state's wholesale water conveyance systems is unknown. More research is needed to quantify these losses.

3. ***Add EI of Water Treatment***. Not all water supplies need treatment. Depending on the quality of the source water supplies and the quality needs of their intended uses, no treatment may be required – for example, to apply some surface or groundwater supplies to agricultural irrigation, or even for potable uses.

   - In the past, high quality water resources may only have been treated with lime (e.g., to remove carbonates that make water "hard" and/or to adjust the pH to reduce corrosion) and then dosed with chlorine to kill bacteria and other micro-organisms. Now that it is known that that chlorine and other chemical disinfectants can cause carcinogenic by-products, other treatment methods are used. The particular treatment technologies and processes needed depend on the end use of the water. Drinking water has the highest requirements, and typically has the highest treatment EI.

   - Reverse osmosis (RO) is used to remove salts and minerals from brackish water. The water produced through RO is already of drinking water quality. The energy used to desalt water is accounted for in the Supply segment of the water use cycle. Consequently, no additional energy is likely needed for desalted water in the Treatment segment.

   Treatment Losses (Losses 3). The volume of treated water produced is always less than the amount of influent. Typically, the EI would be measured as the average energy used to produce the total amount of water treated. More research is needed to quantify these losses

[34] See Chapter 3 in Study 1 for full results on all studied wholesale supplies.

4. ***Add EI of Distribution***. As for Conveyance EI, the primary drivers of Water Distribution EI are distance and elevation. This can vary significantly across agencies and even within an agency's service territory.

   <u>Distribution Losses (Losses 4)</u>. Distribution system losses are highly variable. More research is needed to quantify these losses.

5. ***Add EI of Wastewater***. Not all water end uses are discharged to sewers. Only indoor end uses (and only a percentage of total indoor water use) should include a component for wastewater treatment. Some portion of outdoor water uses may end up in sewers.

   <u>Wastewater Treatment Losses (5)</u>. Water is lost during the solids removal processes of wastewater treatment. This is an important factor to consider especially when the wastewater will then be treated further to produce recycled water. The volume of recycled water produced will be less than the treatment plant influent. More research is needed to quantify these losses.

6. ***Add EI of Recycled Water***. Incremental energy needed to increase the quality of wastewater effluent to standards needed for the intended water reuse is accounted for in the Recycled Water segment of the water use cycle.

Appendix A Literature Review

Appendix B Agency Profiles

Appendix C Database for Retail Agency Water/Energy Loads

Appendix D Glossary

Appendix E Comparison of Study 1 and Study 2 Findings with Prior Studies