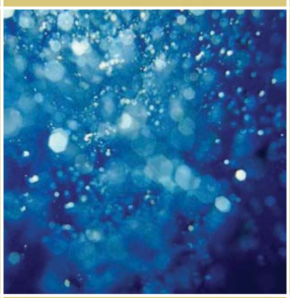

# Embedded Energy in Water Studies

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

## Final Work Plan


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For the
California Public Utilities Commission
Energy Division

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# 1 Executive Summary

In its Decision 07-12-050, the California Public Utilities Commission (CPUC) approved a portfolio of pilot projects and activities that were designed to work in concert to increase understanding about the relationship of California's energy and water resources and infrastructure. The portfolio includes several studies intended to build the databases, models, and tools needed to facilitate decisions about whether energy efficiency programs designed to save energy by saving water – i.e., through avoidance of upstream energy consumption "embedded" in water and avoided downstream energy consumption related to the treatment of wastewater - were cost-effective from the perspective of California's investor-owned energy utilities and their ratepayers.

The CPUC engaged the California Institute for Energy and Environment (CIEE) to conduct three studies to support the CPUC's deliberations:

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

This document describes the work plan for Study 2.

The goal of Study 2 is to characterize and quantify the relationships between water and energy use by water and wastewater agencies, and to determine the range of magnitudes and key drivers of embedded energy in water. As used herein, "water" includes both potable water and wastewater.

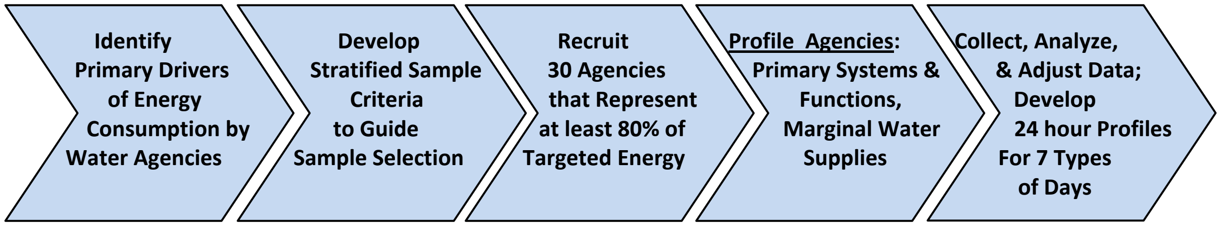
The Study Team anticipates the following types of data challenges:

- There are thousands of water and wastewater agencies in California. As a consequence, a blanket data request would not be feasible. In addition, in the Study Team's experience, this type of approach will result in inconsistent data that cannot be directly used – significant work would be required to interview the respondents and adjust the data to some common basis before the data could be used for statistical or analytical purposes.

- Since water-energy is a new area of study, few water and wastewater agencies are likely to have the types of data needed for this study in the form and at the levels needed. For example, some agencies may have hourly data for some functions; but few (if any) water or wastewater agencies are likely to have all of the data we will be seeking. Consequently, data will need to be adjusted, and in some cases, extrapolated or interpolated, to develop the data sets that can be employed to produce the hourly load profiles that are the end goal of Study 2.

Optimally, Study 2 will produce the types and ranges of energy intensity for the wide variety of types of water agencies, systems and functions that are needed to facilitate the CPUC's deliberations about the magnitude of energy "embedded" in water, and the viability of water-energy efficiency programs. The data from Study 2 will also inform the CPUC's revision of its water-energy calculator.

The Study Team developed the approach in the following diagram to manage the data collection and analytical processes to achieve the needed results.




To develop the list of primary water-related energy drivers and the resultant stratified sampling criteria, the Study Team will confer with California water and wastewater agencies directly and through their primary industry associations in California. National industry associations that may have complementary study efforts will also be included.

The primary drivers of energy consumption help to establish the criteria for the stratified sample, which will then be used to select water and wastewater agency participants for this study. The Study Team will engage the assistance of the industry associations and policy leaders to help recruit the targeted study participants.

Recruitment is a very important step. While there are thousands of water and wastewater agencies in California, the study scope, budget and timeline will only allow studying the energy intensities of 30 agencies. The targeted participants will be selected on the basis of "best fit" with the study needs and objectives. For optimal results, the Study Team will need to rely on assistance from the CPUC, CIEE, CEC, water and wastewater industry associations, and the California leading agencies to encourage the targeted agencies to support the study.

During the data collection process, the Study Team will first profile the participating agency to map its primary systems and functions, and to understand the key drivers of energy consumption by each. The scope of Study 2 includes identifying the marginal source of water supply and associated embedded energy that would be avoided by water conservation. The Study Team is presently conducting similar work for a joint power authority comprised of fifteen wholesale water agencies. About one-third of the agencies have the data in the format needed. Engineering and professional judgment is needed to adjust the data for the other two-thirds to the level that can be used to develop 24 hour load profiles. The Study Team anticipates a need to apply similar techniques to adjust data provided by the thirty water agencies participating in this study.

The final step of Study 2 is to develop 24-hour energy load profiles for seven types of days:

- Winter high daily water demand (amount and demand day)
- Winter average daily water demand (amount and demand day)
- Winter low daily water demand (amount and demand day)
- Summer high daily water demand (amount and demand day)
- Summer average daily water demand (amount and demand day)
- Summer low daily water demand (amount and demand day)
- Summer demand during utility peak energy demand day (amount and demand day)

The water agency and 24-hour energy load profiles will provide input to the CPUC's deliberations about the potential inclusion of water measures in the state's energy efficiency portfolio. The 24-hour energy load profiles will also provide input to revisions of the CPUC's water-energy calculator.

In order to maximize knowledge about the state's water-energy relationship, the Study Team plans to coordinate selection of participants in this study with other complementary study efforts, such as that being conducted by ECONorthwest for the measurement and evaluation of the portfolio of water-energy pilots approved by the CPUC in December 2007. Specifically, the Study Team will consider selecting water and wastewater agencies that are not being studied by ECONorthwest so as to expand the database of water-energy knowledge. In addition, the Study Team will coordinate selection of water and wastewater agencies with the third study, "End Use Water Demand Profiles," in the event that there may be an incremental benefit to being able to match the energy intensity of specific water and wastewater agency participants in Study 2 with the detailed end use water studies being developed by Aquacraft for Study 3.

# 2 Introduction

In 2005, the California Energy Commission found that water-related energy consumption and demand account for a significant portion of the state's energy requirements. This finding launched a series of initiatives related to increasing understanding and quantifying the interdependencies of water and energy resources and infrastructure in California.

On behalf of the California Public Utilities Commission (CPUC), the California Institute for Energy and Environment (CIEE) engaged the team of GEI Consultants (GEI) and Navigant Consulting (NCI) (collectively, the "Study Team") to conduct two studies to increase understanding of the relationship between California's energy and water resources and infrastructure. The CPUC Decision, CPUC D. 07-12-050 (December 21, 2007) ordered and approved the projects. The link to the decision and the overall CPUC Embedded Energy in Water proceeding is: http://docs.cpuc.ca.gov/published/proceedings/A0701024.htmhttp://docs.cpuc.ca.gov/published/proceedings/A0701024.htm.

The overarching reason to start this and other related studies is to determine how much energy can be saved via implementing water conservation measures:

> *"We intend these studies to provide the information basis for a meaningful* ex-post *assessment following the completing of the pilots to inform the Commission in determining whether future embedded energy in water programs should be added to the energy efficiency portfolio." CPUC D. 07-12-050 December 20, 2007 Pg. 81*
>
> *"These studies should provide the missing link between water use changes and energy use changes that is required to evaluate utility water savings proposals. Combining the results of these studies with the information on measure water use reductions will allow the Commission to use the results of the water-energy pilot activity to redirect future water-energy energy efficiency portfolio additions towards water agencies or components of the water system that are likely to have the largest energy savings, and measures that provide cost effective energy savings. "CPUC D. 07-12-050 December 20, 2007 Pg. 82/83.*

In its December 21, 2007 decision, the CPUC authorized a portfolio of pilot projects to be conducted by the investor owned energy utilities in conjunction with water and wastewater agencies. The CPUC also provided direction as to the work needed to effectively evaluate the pilot projects performance. In addition, the CPUC directed the conduct of two additional foundational studies that would provide additional information needed for the CPUC to address issues related to the cost effectiveness of energy savings through water savings (CPUC Decision 07-12-050 December 20, 2007 Pg. 99):

1. A Statewide/Regional Water-Energy Relationship Study designed to establish the relationship between annual climate and hydrology variation, regional and statewide water demand variations and statewide energy use by the water system, and

2. A Water Agency/Function Component Study which includes a redefined Load Profile Study designed to establish detailed annual and daily profiles for energy use as a function of water delivery

requirements for a full range of local, regional, state and federal water agencies within the California water system.

This is the second of the two foundational studies authorized by the CPUC in December 2007. The title of this study is the California Public Utilities Commission – (CPUC) – California Institute for Energy and Environment (CIEE) Study 2, Water Agency and Function Component Study and Embedded Energy-Water Load Profiles. The cost of the study will be $768,216.

The data, analytical methods and findings from this study will be coordinated with, and provided to other CPUC studies that are being performed in parallel. These include the measurement and evaluation study being conducted by ECONorthwest for the water-energy pilots that were approved by the CPUC in its Decision 07-12-050, and a third study being conducted by CIEE and its consultant, Aquacraft, on behalf of the CPUC to develop time-of-use water use profiles for various types of water uses. All of these studies will also provide input to the revision of the CPUC's water-energy calculator.

## 2.1 Background and Purpose

The CPUC is seeking additional information to facilitate its deliberations as to whether energy embedded in water should be included in California's energy efficiency portfolio. One of the key missing inputs is a strong understanding of the range of energy intensities of water and wastewater agencies' systems and functions. The CPUC therefore directed that a study be conducted that will 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. (CPUC Decision 07-12-050 December 20, 2007, Appendix B, Pgs. 5-6)

In its December 2007 decision, the CPUC directed that historic data be collected from a sampling of "representative" water agencies. These agencies should represent the range of possible energy intensities (high, average and low) from the four primary types of California water agencies (wholesalers, retailers, wastewater, and irrigation districts). (CPUC Decision 07-12-050 December 20, 2007, Appendix B, Pg. 6) From these data, profiles for seven types of water days would be developed to enable understanding the energy intensity of each type: high, average and low water days for each of winter and summer seasons, and the utility peak energy demand day. (CPUC Decision 07-12-050 December 20, 2007, Appendix B, Pg. 7) Twenty four hour energy load profiles will then be developed for each of the 7 types of days for each of the selected "representative" water agencies.

The overarching goal of this study (California Public Utilities Commission (CPUC) – California Institute for Energy and Environment (CIEE) Embedded Energy in Water Study 2: Water Agency and Function Component Study and Embedded Energy-Water Load Profiles) is *to increase understanding of the relationship of energy and water/wastewater systems at the individual water agency/functional level*. The primary outcome of this study is a range of energy intensities of the primary water systems and operational functions in the water use cycle. In addition, this study will develop load shapes for specified water systems and functions.

The objective of these studies is to characterize and quantify the relationships between water and energy use and determine the range of magnitudes and key drivers of embedded energy in water. (Note: As used herein, "water" includes both potable water and wastewater.)

The purpose of this document is to describe the planned study approach that will achieve the CPUC's goals and the rationale underlying this draft work plan so that we can obtain input from interested and knowledgeable water and energy stakeholders.

# 3 Study Challenges

This study has several significant data collection challenges.

## 3.1 Large Number of Water and Wastewater Agencies

There are thousands of water and wastewater agencies in California.

- 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) and about 140 are investor-owned water utilities that are regulated by the CPUC. 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.

In the Study Team's experience, even with the support of water industry associations and senior managers of some agencies and excluding the 6,600 public water systems serving populations less than 5,000, it is unlikely that the Study Team will be able to obtain the needed data from more than about 30% of the targeted agencies.

## 3.2 Data Availability and Consistency

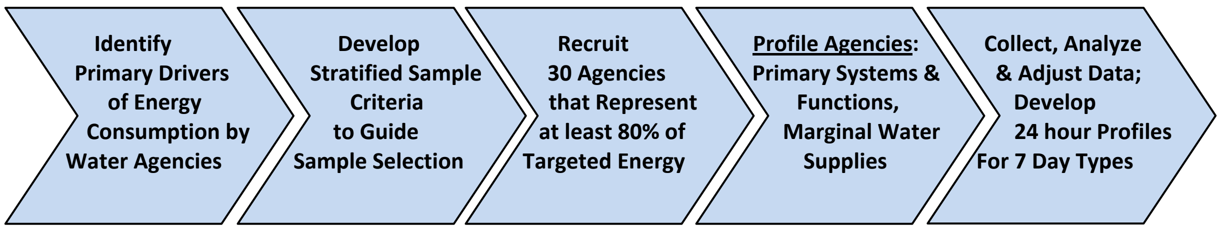
One of the study's most significant challenges is the lack of consistent data. The study of California's water and energy interdependencies is a relatively recent area of focus. Presently, data is not captured at the levels that would lend themselves readily to effective analysis of these interdependencies.

As an example, GEI and NCI are presently working with the 15 members of the Power and Water Resources Pooling Authority (PWRPA) to evaluate their water-energy interdependencies. This study is being undertaken to determine the coincidence of energy use by primary system and function among the members. Surveys, inventories, and analyses to date show that about one-third of the PWRPA members have good energy information by function, by time of day, and by season. The remaining two-thirds of the members have significant data gaps that require applying professional engineering judgment to estimate and synthesize data. A stratification approach will allow focusing on data collection from a smaller, but carefully targeted group of representative water agencies within a framework that allows generalizing the results to water agencies with similar characteristics.

Since much of the data collection for the two study components (e.g. Water Agency and Function and Energy-Water Load Profiles) are common, the Study Team believes that it would be more efficient to combine the data selection for these components into a single effort. The approach to integrating these two parts is described under the discussion of specific work to be accomplished by task, below.

# 4 Recommended Approach

The Study Team developed the below approach to manage the data collection and analytical processes to achieve the needed results.




## 4.1 Selection and Recruitment of Water Agencies

The most critical aspect of this study is identifying the optimal mix of water and wastewater agencies, irrigation districts, and other types of water purveyors that are deemed "representative" of the state's water-energy intensities, *and* that have sufficient data at the levels needed to compute energy intensities by primary resource, system, and subsystem. This level of data collection and analysis is deemed important to informing California's policymakers about the nature, type, and breadth of magnitude of California's water-energy relationships.

To successfully achieve the study's goals, the Study Team recommends a stratified sampling approach that will target detailed study of a sample of thirty (30) "representative" water agencies and systems that collectively depict the range of primary types of water-energy interdependencies needed to develop a strong understanding of energy "embedded" in California's water resources. For purposes of this study, "representative" means that the selected agencies collectively comprise at least 80% of the most important types of water-energy relationships in California's water resources.[1]
To develop the list of primary water-related energy drivers and the resultant stratified sampling criteria, the Study Team will confer with California water and wastewater agencies directly and through their primary industry associations in California. National industry associations that may have complementary study efforts will also be included.

- Targeted water industry associations include but are not limited to: the Association of California Water Agencies (ACWA), the California Association of Sanitation Agencies (CASA), the California Water Association (CWA), the California Urban Water Association (CUWA), the California Urban Water Conservation Council (CUWCC), and the Water Reuse Authority.
- In addition, the American Waterworks Association's Research Foundation (Awwa-RF), the Electric Power Research Institute (EPRI), Lawrence Berkeley National Laboratory's Water Energy Technology Team (WETT), the New York State Energy Research Development Authority (NYSERDA), the U.S. Department of Energy's Energy-Water Nexus Team, the U.S. Environmental Protection Agency's WaterSense Program, the Water Environment Research

[1] As noted before, "water" includes water used for both agricultural and urban purposes, and for wastewater.

Foundation (WERF), and other similar organizations that have commenced studies related to water-energy will be consulted.

- The Study Team will also confer with the Water-Energy Advisory Committee for the California Sustainability Alliance that conducted a study about "The Role of Recycled Water in Energy Efficiency and Greenhouse Gas Reduction".

The primary drivers of energy consumption help to establish the structure for the stratified sample, which will then be used to select water and wastewater agency participants for this study. The Study Team will engage the assistance of the industry associations and policy leaders to help recruit the targeted study participants.

## 4.2 Sample Criteria

The relationship of energy to pumping (volume, lift, friction, etc.) is well understood. Consequently, while pumping energy will be captured through the sampled agencies, the primary focus of sample characteristics will be on primary drivers of energy for targeted system functions.

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

| Agency | Type [1] | Region [2] | Water Resources [3] | Water Treatment [4] | Wastewater Trtmt [5] | Recycled Water [6] | Distribution [7] |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

[1] Primary types of agencies:

a. Urban: Water and/or Wastewater

b. Agricultural: Irrigation

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 …" We suggest instead focusing on the three primary types of agencies above, for the following reasons:

- As noted previously, the study budget and timelines will only allow collecting data from thirty water and wastewater agencies.
- We will be collecting a considerable amount of information about the state's largest wholesale water and conveyance systems during Study 1.
- In addition, also as noted previously, our 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.
- Further, conveyance energy tends to not fluctuate substantially on an hourly basis. 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.

We therefore feel it would be advantageous to focus the Study 2 efforts on the primary data gaps: agricultural water use patterns, and retail urban water and wastewater systems.

[2] Geographic regions (4: Central Coast, Central Valley, South Coast, Desert) will significantly impact the relative energy intensities of water resource portfolios of both urban and agricultural water purveyors.

Retail Water Agencies that provide Potable Water

There are many similarities in the types of water resources and energy intensity characteristics of those resources within each hydrologic region. The four selected geographic regions, while not directly contiguous with the hydrologic regions, represent the spectrum of expected resource mixes, with a fairly consistent set of local water resources and imported supplies represented in each region.

**Table 4-1. Illustrative Water Resource Portfolios for the Four Geographic Regions**

| Geographic Region | Local Water Supplies | Imported Water Supplies |
|---|---|---|
| Central Coast | A mix of surface water supplies, groundwater (interest in desalination growing) | Typically some surface water supplies from Northern California |
| Central Valley | Largely surface water from Northern and Central California; 25% groundwater | Typically surface water supplies from Northern California |
| South Coast | A mix of surface water supplies, groundwater, with recycling and desalination | Typically a mix of surface water supplies from Northern and Central California, and Colorado River imports |
| Desert | Largely groundwater (sometimes brackish, requiring desalination) | Typically a mix of surface water supplies from Northern and Central California, and Colorado River imports |

Grouping water agencies by similar water resource portfolios thus enables testing more water system characteristics with fewer agencies. We recommend this approach for the following reasons:

- The California Energy Commission and Building Climate Zones used for energy efficiency measures, like DEER (Database for Energy Efficient Resources), are not as applicable to water.
- The limit of 30 water and wastewater agencies makes it impossible to create a stratified sample that represents at least 80% of the targeted system characteristics *and* also represents each of the 16 climate zones.
- Geographic information will be collected and reported, thus preserving the opportunity for subsequent analysis using alternative regional groupings, including CEC Climate Zones, if desired.

Wastewater Treatment Agencies

Prior studies such as the Electric Power Research Institute (EPRI's) 2003 studies on the energy use of water and wastewater agencies nationwide indicate that the energy intensity of wastewater treatment processes is 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.

We believe there is sufficient evidence that geography and/or climate are not as significant as energy drivers of wastewater treatment as level of treatment, quality of wastewater, and treatment processes and technologies. For this reason, we are reluctant to allocate too many slots of the thirty agencies to wastewater treatment. (Three would be needed if one wastewater agency is selected for each investor owned utility (IOU's) service area; nine would be needed if it is deemed necessary to select one of each type of wastewater agency – primary, secondary and tertiary – from each IOU's service area. We use three IOU service areas, with the simplifying assumption that Southern California Gas Company's service area is nearly contiguous with that of Southern California Edison.)

The below maps illustrate the differences among the various types of regional classifications:

- California's Electric Service Areas
- California's Major Water Systems
- The CEC Climate Zones

**Figure 4-1. California Electric Utility Service Areas**

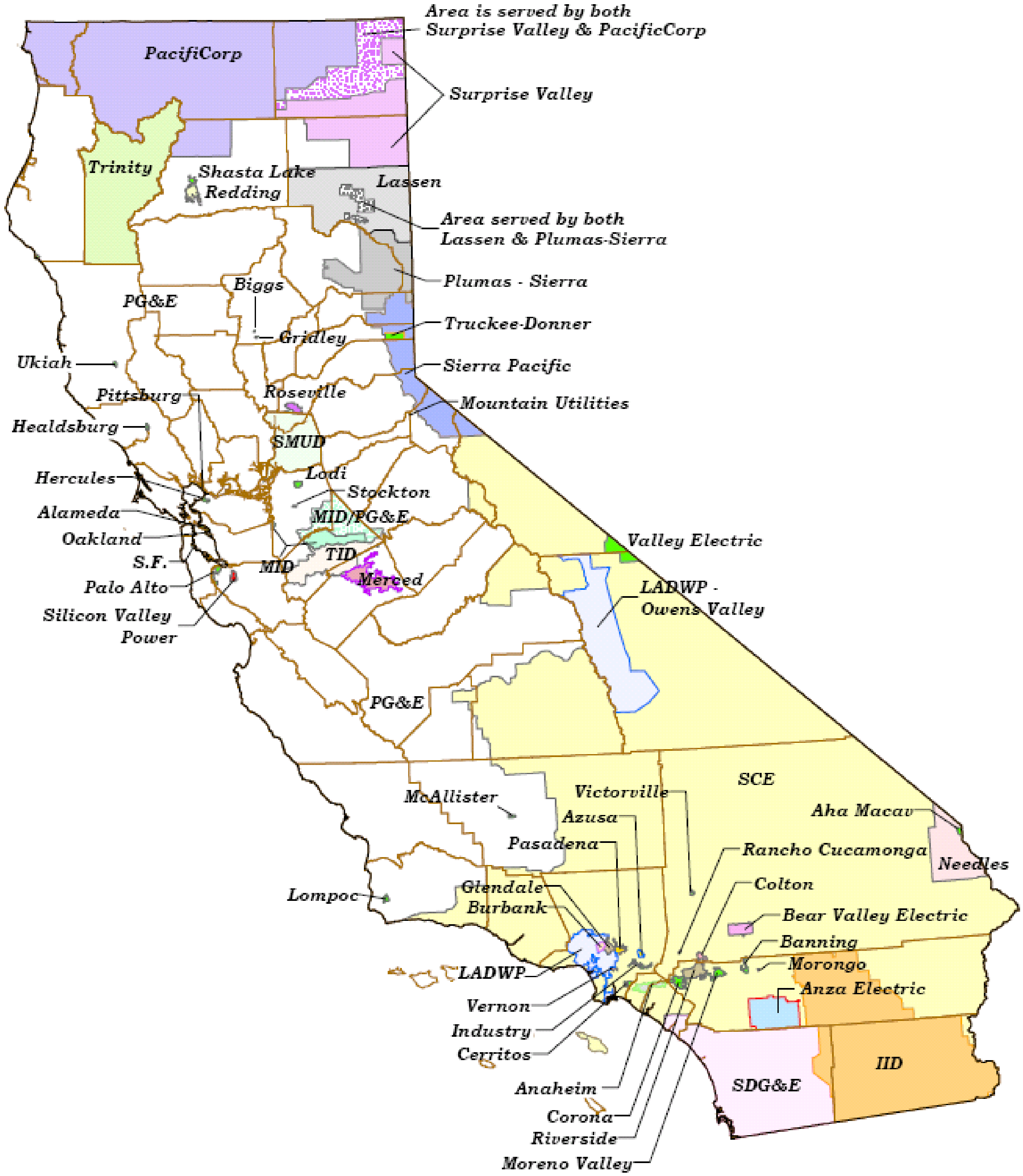


**Figure 4- 2. California's Major Water Systems**

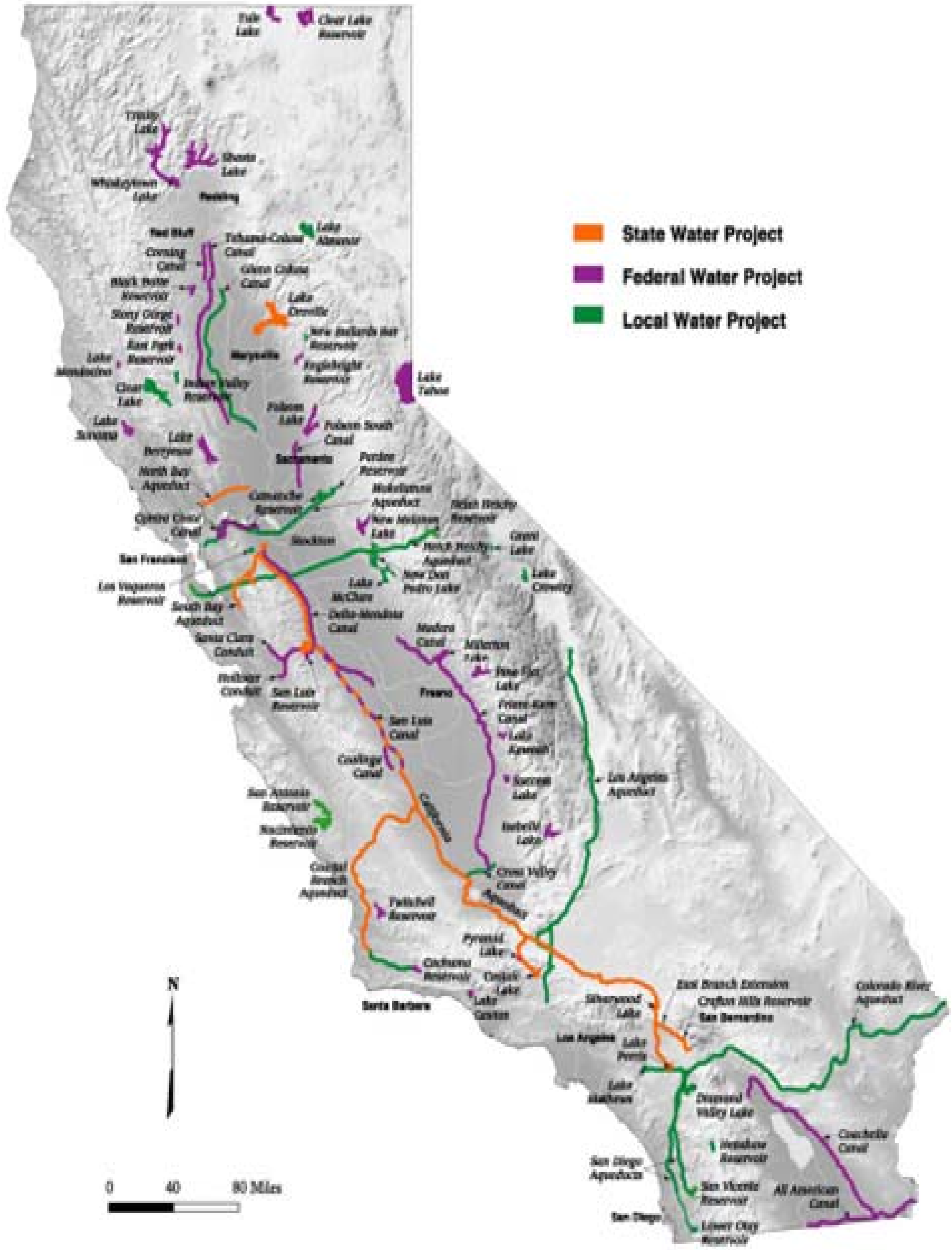
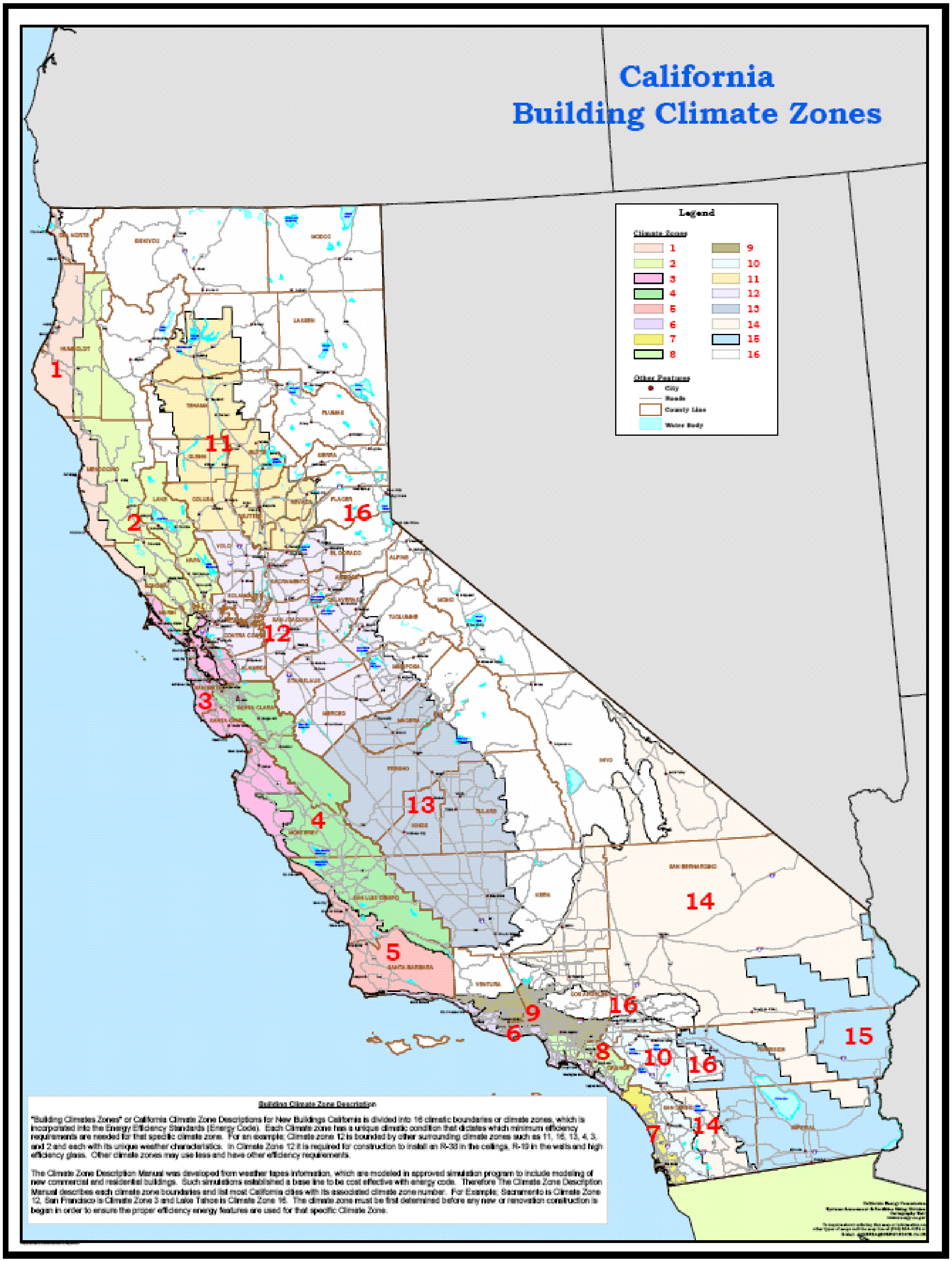


**Figure 4-3. California Building Climate Zones**



[3] The primary types of water resources to be captured within the portfolio are surface, groundwater, and desalination (brackish and ocean). Surface and groundwater (including desalinated brackish groundwater) account for 99.6 % of California's water supplies. Seawater desalination will also be identified wherever it is encountered in a water agency's resource portfolio because of its important role as California's likely long-term marginal supply and its very high energy intensity.

[4] The energy intensity of water treatment is increasing, with the combined challenges of increased contamination of surface and groundwater sources; increasing evidence that prior water treatment approaches resulted in disinfection by-products, some of which are known carcinogens; and more stringent water quality regulations as a result. More disinfection is needed. Disinfection technologies are increasing in energy intensity, and some systems disinfect their water at multiple points in the treatment and delivery processes. The sample set should include chlorination, ultraviolet, ozonation, and reverse osmosis. It would also be beneficial to capture at least one agency that applies multi-stage disinfection.

[5] There are three major types of wastewater treatment: primary, secondary, and tertiary. At least one secondary and one tertiary treatment plant should be included in this study. Since the number of primary treatment plants has decreased substantially due to increasing concerns about public health and safety, studying primary treatment plants is not as useful for purposes of this study. As noted under item [2] above, studies performed by EPRI indicated that the energy intensity of wastewater treatment processes were fairly uniform throughout the U.S., irrespective of geography and climate. The level of treatment and types of technologies and processes, however, are deemed significant drivers of energy intensity. It might also be useful to identify wastewater treatment plants that receive very different types of wastewater quality (e.g., urban vs. rural-agricultural wastewater).

[6] The types of recycled water energy intensity to be included in the sample include water reclamation plant(s) that treat wastewater effluent to higher levels needed to meet the water quality requirements for approved non-potable use, and energy used to distribute recycled water to end users. For purposes of this study, there is no apparent reason why distribution energy for recycled water should be studied separately from distribution of potable water – it is all pumping energy that is dependent primarily on volume, pressure, topology and distance. For that reason, we recommend including 2-3 recycled water systems in the sample set, with the objectives of (a) investigating differences in the energy intensity of recycled water produced from different qualities of wastewater (e.g., primary, secondary or tertiary), and (b) documenting the energy intensity of recycled water distribution.

[7] 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 should be included in the sample set.

## 4.3 Recruitment

Recruitment is a very important step. While there are thousands of water and wastewater agencies in California, the study scope, budget and timeline will only allow studying the energy intensities of 30 agencies. The targeted participants will therefore be carefully selected on the basis of "best fit" with the study needs and objectives, with the additional goal of complementing studies being conducted by others such as ECONorthwest and Aquacraft.

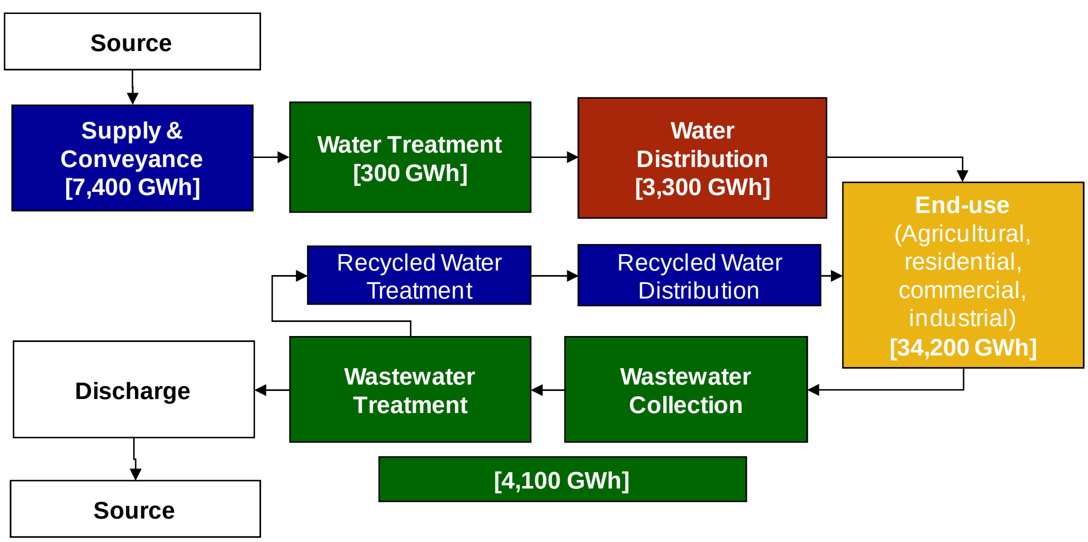
For optimal results, the Study Team will need to rely on assistance from the CPUC, CIEE, CEC, water and wastewater industry associations, and the California leading agencies to encourage the targeted agencies to support the study.

## 4.4 Data Collection, Analysis & Load Profiling

During the data collection process, the Study Team will first profile the participating agency to map its primary systems and functions, and to understand the key drivers of energy consumption by each. The Study Team is presently conducting similar work for a joint power authority comprised of fifteen wholesale water agencies. About one-third of the agencies have the data in the format needed. Engineering and professional judgment is needed to adjust the data for the other two-thirds to the level that can be used to develop 24 hour load profiles. The Study Team anticipates a need to apply similar techniques to adjust data provided by the thirty water agencies participating in this study. Some water and wastewater agencies that participate in this study may not have retained detailed records of their energy use. In those cases, the Study Team will request that the participating agencies authorize their respective IOU energy utilities to provide the needed energy data to the Study Team.

The following distribution of energy consumption by segment of the water-use cycle will be used as a guideline for determining the relative importance of the types of urban water and wastewater system characteristics.

**Figure 4-4. Distribution of Energy Consumption by Segment of Water-Use Cycle[2]**




[2] "Refining Estimates of Water-Related Energy Use in California", Navigant Consulting for the California Energy Commission Public Interest Energy Research division (PIER), CEC-500-2006-118, 2006.

As can be seen from the above figure, nearly 50% of water-related energy consumption (excluding end use) is related to water supply and conveyance. About 27% is related to wastewater collection and treatment, and 22% to water distribution. Note that although water treatment accounts for only 2% of all energy used by water and wastewater treatment agencies, as noted previously it is also potentially an area of high load growth due to changes in disinfection regulations, processes and technologies."

Data for the 30 selected agencies will be collected by segment of the water use cycle (and, if sufficient data exists) by primary systems and subsystems. Marginal water supply source(s) is also an important consideration in developing the sample of representative agencies since prior studies indicate the largest variance in energy intensity occurs in the water supply segment of the water use cycle.

**Table 4-2. Range of Energy Intensities for Water Use Cycle Segments[3]**

| | Range of Energy Intensity (kWh/MG) | |
|---|---|---|
| **Water-Use Cycle Segments** | **Low** | **High** |
| Water Supply and Conveyance | 0 | 14,000 |
| Water Treatment | 100 | 16,000 |
| Water Distribution | 700 | 1,200 |
| Wastewater Collection and Treatment | 1,100 | 4,600 |
| Wastewater Discharge | 0 | 400 |
| Recycled Water Treatment and Distribution | 400 | 1,200 |

Consequently, the scope of work will also include identifying the amount of embedded energy that could be saved by each water agency by avoiding consumption of one unit of its marginal water resource.[4]

[3] "California's Water-Energy Relationship", California Energy Commission, CEC-700-2005-011-SF, Table 1-2, p.9 [ http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF ]

[4] I.e., saving water to save embedded energy, where the amount of energy saved is deemed embodied in the agency's marginal supply – the last unit needed to meet it water demand.

# 5 Study Plan

The tasks to accomplish this project are described below.

## 5.1 Task 1: Project Kickoff Meeting

The Study Team will participate in a project kickoff meeting with CIEE and CPUC. **(*COMPLETED*)**

## 5.2 Task 2: Prepare Draft and Final Study Plans

The purpose of this task is to develop a Draft Study Plan that describes the work to be conducted. (***DRAFT STUDY PLAN IN PROGRESS.***)

- The Study Team will prepare a Draft Study Plan for review by CIEE and CPUC staff and consultants and update as necessary.
- The approved Draft Study Plan will be presented by the Study Team at a Stakeholder (Public) Workshop for public review and comment.
- Public comments will be reviewed by the CPUC, CIEE, and the Study Team to determine what, if any, changes should be made to the Draft Study Plan in order to successfully achieve the study objectives.
- Upon agreement with CIEE and CPUC, the Study Team will issue the Final Study Plan.

## 5.3 Task 3: Conduct Literature Review

A literature review will be conducted of energy intensities (kWh and MMBTU/Mg Water) and water industry energy load profiles to determine what information is available. An understanding of the current state of knowledge and information will help refine the study steps in collection and compilation of data, and help build upon what information currently exists.

- The Study Team will compile a list of authoritative documents and data sets with which it is familiar and bring to the Public Workshop with a request that stakeholders supplement the list of documents and data.
- The Study Team will then review these documents and data, and potentially also identify additional documents and data through internet research and stakeholder interviews.
- The Study Team will summarize the state of current knowledge about energy intensities and water industry energy load profiles in an Interim Report.

Following is a *preliminary illustrative list* of some of the primary reports and data sources that will be reviewed and may be relied upon for this study.

***General References on California's Water-Energy Intensity***

- California Energy Commission, 2005, "Integrated Energy Policy Report" and "California's Water-Energy Relationship" [ http://www.energy.ca.gov/2005publications/CEC-700-2005-011/CEC-700-2005-011-SF.PDF ]

- Dr. Robert Wilkinson, "Methodology for Analysis of The Energy Intensity of California's Water Systems, and an Assessment of Multiple Potential Benefits Through Integrated Water-Energy Efficiency Measures", Exploratory Research Project, Ernest Orlando Lawrence Berkeley Laboratory, California Institute for Energy Efficiency, 2000 [ http://www.es.ucsb.edu/faculty/wilkinson.pdfs/Wilkinson_EWRPT01%20DOC.pdf ]
- Ronnie Cohen, Barry Nelson and Gary Wolff, NRDC and Pacific Institute, "Energy Down the Drain: The Hidden Costs of California's Water Supply," 2004 [ http://www.nrdc.org/water/conservation/edrain/contents.asp ]
- The Pacific Institute, prepared for the California Energy Commission, CEC-500-2005-031, Sacramento, CA, "Quantifying the Potential Air Quality Impacts from Electric Demand Embedded in Water Management Choices," 2005 [ http://www.energy.ca.gov/pier/final_project_reports/CEC-500-2005-031.html ]

***General References on California's Water Systems and Resources***

- California Department of Water Resources Bulletin 160, California Water Plan [ http://www.waterplan.water.ca.gov/cwpu2009/ae/index.cfm]

***Sources of Data About Retail Water & Wastewater Systems (Design, Capacity, Resources, Operations)***

- Individual water agencies' Urban Water Management Plans (required to be conducted at least once every 5 years – most filed plans in 2005 for the following 25 years)
- Interviews with participating water and wastewater agencies' planning, engineering and operations managers and review of system drawings, specifications, and operations plans and protocols
- Electric Power Research Institute (EPRI), 2002, "Water & Sustainability (Volume IV): U.S. Electricity Consumption for Water Supply & Treatment – The Next Half Century" [Topical Report 1006787]
- Lon House, prepared for Demand Response Research Center, Lawrence Berkeley National Laboratory, "Water Supply Related Electricity Demand in California," LBNL-62041, December 2006 [ http://drrc.lbl.gov/drrc-pubsall.html ]
- Green Buildings Studio, Santa Rosa, CA, "Supply and Demand Side Water-Energy Efficiency Opportunities," 2007
- California Sustainability Alliance, "The Role of Recycled Water in Energy Efficiency and Greenhouse Gas Reduction", 2008, [ http://www.sustainca.org/files/FINAL%20RECYCLED%20WATER%20MAY%202%202008a.pdf ]
- Navigant Consulting for the California Energy Commission Public Interest Energy Research division (PIER), "Refining Estimates of Water-Related Energy Use in California", December 2006, CEC-500-2006-118 [ http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF ]
- Santa Clara Valley Water District, "From Watts to Water - Climate Change Response through Saving Water, Saving Energy, and Reducing Air Pollution", [ http://www.valleywater.org/conservation/media/Documents/WUE%20Water%20Energy%20Report.pdf ]

- Dr. Blain Reely, Efficiency Analysts International, P. O. Box 11896 Tucson, Arizona. 85734 (various California water-energy studies).
- Utilities & Sustainabilty Task Force (USTF), "Energy–Water Snapshot, San Mateo County", 2006 [ http://www.recycleworks.org/co2/USTFwaterenergyreport.pdf ]

## 5.4 Task 4: Select Representative Water Agencies for Sampling

The study will select 30 representative water agencies, based on the information collected in the previous Task and in consultation with the three major water trade groups in California. A stratified sample approach will be used to achieve a closer match between the agencies selected for detailed study and the population that they are selected to represent.

- The Study Team will compile a matrix of water agency attributes that cover the range of those found in California's water supply and treatment agencies. This matrix of characteristics will guide the choice of specific agencies to be sampled and ensure that the sampling covers the full data range.
- The Study Team will draft an initial list of possible agencies to be sampled for energy intensity information.
- The Study Team will engage the assistance of the three water industry associations named in the RFP: the Association of California Water Agencies (ACWA), the California Association of Sanitation Agencies (CASA) and the California Water Association (CWA) as well as industry associations, key water and energy stakeholders, water and wastewater agencies already participating in the California Sustainability Alliance (the Alliance), the Alliance's Water-Energy Advisory Committee,[5] and other knowledgeable water industry stakeholders to identify the primary drivers of energy use by the water sector and to review, comment on, and suggest changes to the draft agency sampling list. The list of select representative water and/or wastewater agencies should exemplify characteristics of primary drivers of energy use by the water sector.
- The Study Team will summarize the key energy drivers, sampling criteria and recommended agency sample list in a memorandum report.

As noted in Chapter 4 Recommended Approach, the Study Team recommends selecting 30 water and wastewater agencies that collectively represent the following primary sample characteristics:

[5] The California Sustainability Alliance conducted a study, "The Role of Recycled Water in Energy Efficiency and Greenhouse Gas Reduction", that identified the build-up of energy use in several southern California water agencies' systems. The Alliance's Water-Energy Committee is comprised of senior managers of California water and wastewater agencies, the California Department of Water Resources, and the California Energy Commission.

**Table 5-1. Sample Criteria**

| Primary Characteristics | Sample Criteria | Preliminary Sample Objectives |
|---|---|---|
| [1] Type | Water, Wastewater, Agricultural Irrigation | There will be multiple agencies of each type, determined in conjunction with the below criteria. |
| [2] Region | Central Coast, Central Valley, South Coast, Desert | At least one water and agricultural agency from each region. Geographic region is not a major determinant of the energy intensity of wastewater treatment. |
| [3] Water Resources | Surface Water, Groundwater, Desalinated Brackish Groundwater, Desalinated Seawater | Water agencies representing portfolios of water resource types in each region and each IOU service area. |
| [4] Water Treatment | Disinfection Types: Chloramination, Ultraviolet, Ozonation | One of each disinfection technology and at least one water agency employing multi-stage disinfection (two or more technologies at two or more steps in the water treatment process) |
| [5] Wastewater Treatment | Primary, Secondary, Tertiary | At least one each of secondary & tertiary; may also include one primary, but not a high priority. May also be beneficial to evaluate different energy intensities of different types of wastewater streams, e.g., urban vs. rural/agricultural. |
| [6] Recycled Water | Reclaimed from Primary, Secondary or Tertiary Treated Wastewater | At least one each of recycled water from reclaimed primary, secondary and tertiary treated water. Geographic region is not a primary determinant of energy intensity. However, the location of the recycled water facility from qualified end uses may be informative. |
| [7] Distribution | Flat, Moderate, Hilly Topologies | At least one retail water distribution system representing each of flat, moderate and hilly topologies. IOU service area is not relevant to the key energy drivers of volume, pressure, elevation and distance. |

* Note: An individual sample agency may represent more than one sample criteria and sample objective.

## 5.5 Task 5: Develop Embedded Energy and Load Profiles

The Study Team will collect historical water supply and related energy use by operational function for each of the representative agencies determined in Task 4. The Study Team will coordinate, where possible, with other parallel studies being preformed by the CPUC.

- The Study Team will contact each representative agency and request water demand, deliveries, and associated energy consumption data. This information will be collected seven types of days for each representative water agency. The seven types of days are:
  - Winter high daily water demand (amount and demand day)
  - Winter average daily water demand (amount and demand day)
  - Winter low daily water demand (amount and demand day)
  - Summer high daily water demand (amount and demand day)
  - Summer average daily water demand (amount and demand day)
  - Summer low daily water demand (amount and demand day)
  - Summer demand during utility peak energy demand day (amount and demand day)

  The Study Team expects the water agency data will look similar to the following charts with the results of the seven types of days being reported similar to the matrix below (Note Figure 5-1 for water use is at a monthly level and Figure 5-2, displaying power, is at a daily time level).

**Figure 5-1. Pumped Groundwater for Sample Central Valley Irrigation District**

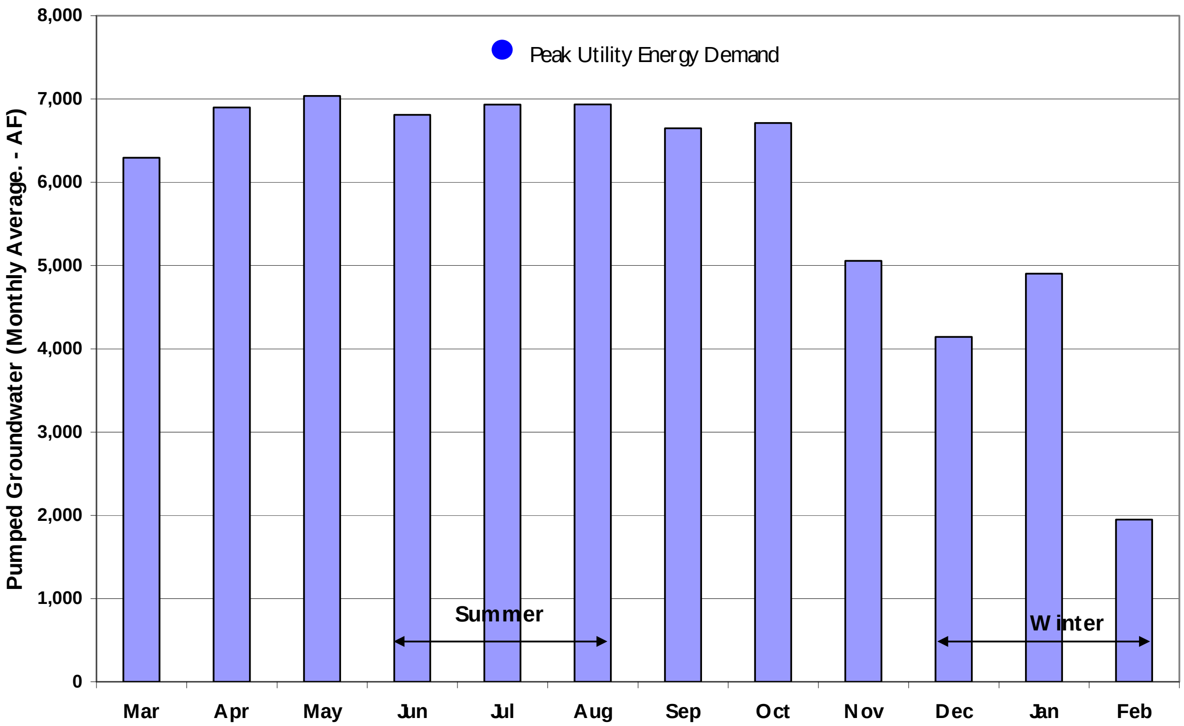



**Figure 5-2. Daily Power Use to Pump Groundwater**

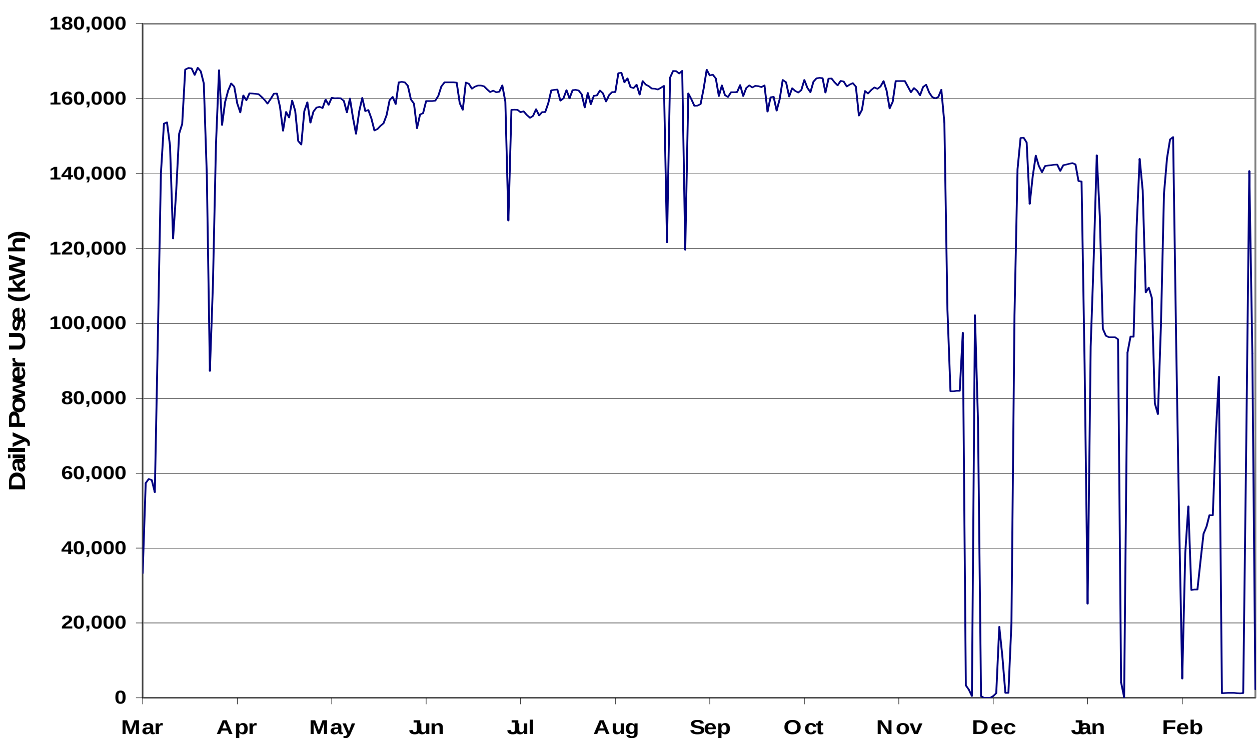


**Table 5-2. Example Results: Sample Central Valley Irrigation District**

| | | | |
|---|---|---|---|
| **Energy Use:** | | | |
| **(kWh)** | **Maximum Daily** | **Average Daily** | **Minimum Daily** |
| **Winter Power** | **6241** | **3356** | **0** |
| **Summer Power** | **6979** | **6633** | **4984** |
| **Summer @ Peak Utility Demand** | **6769** | | |
| **(July 15)** | | | |

- The Study Team will use the data compiled in Task 5a to develop estimates for embedded energy in water (kWh/Mg or MMBTU/Mg) by water agency for both the system and operational components for the seven water type days listed above. The important characteristics and issues related to the energy intensity of their marginal supplies will also be highlighted. Since the marginal supply changes over time, it will be necessary to specify the year for the analysis of the marginal supplies; either the year 2010 or 2012 will be used since any programs or policies arising from this study would be unlikely to take effect prior to 2010. The Urban Water Management Plans of each representative water retailer may need to be reviewed in order to evaluate the analysis of marginal water supplies.

  The following tables show the sample data that would be produced as part of the work effort.

### Table 5-3. Energy Intensity of LADWP's Water Supplies

| Stage | Facility | | Water Type | Annual Production (af/yr) | Energy Intensity (kWh/af) | Annual Energy Usage (MWh) | Principal Energy Supplier |
|---|---|---|---|---|---|---|---|
| **Conveyance** | SWP – West Branch to Castaic Lake/Foothill Feeder Power Plant | | Raw and Treated | 202,500[6] | 2,500 | 506,250 | DWR |
| | Colorado River to Lake Matthews | | Raw | 22,500 | 2,000 | 45,000 | Hoover, Parker Dams (MWD, USBR), SCE |
| | Local Groundwater | | Raw | 92,400 | 0[7] | 0 | LADWP |
| | Los Angeles Aqueduct | | Raw | 320,000 | Net producer | 0 | LADWP |
| **Treatment** | Jensen Treatment Plant | | Potable | 225,000 | 35.1[8] | 6,780[9] | LADWP |
| | Weymouth Treatment Plant | | Potable | | 42.1 | | SCE |
| | Diemer Treatment Plant | | Potable | | 13.2 | | SCE |
| | Los Angeles Aqueduct Treatment Plant | | Potable | 320,000 | 32[10] | 10,930 | LADWP |
| | Groundwater wells | | Potable | 92,400 | 520[11] | 52,269 | LADWP |
| | Recycled Water | Tillman | Tertiary | 71,689[12] | 100 | 12,256 | LADWP |
| | | Glendale | Tertiary | 16,802 | | | LADWP |
| | | Terminal Island | Tertiary | 33,604 | | | LADWP |
| **Distribution** | Potable water supplies, imported and local | | Potable | 637,400 | 387 | 246,674 | LADWP |
| | Recycled Water | Tillman | Tertiary | 71,689 | Data not available | | LADWP |
| | | Glendale | Tertiary | 16,802 | | | LADWP |
| | | Terminal Island | Tertiary | 33,604[13] | | | LADWP |

(Source: Recycled Water Study, 2008)

[6] Based on total average annual deliveries of 225,000 AF from the MWD, typically 90% SWP imports and 10% Colorado River imports.
[7] Energy for pumping and treating groundwater from LADWP's San Fernando Valley Wells is combined and represented in the treatment category.
[8] Data provided by Bill McDonnell (MWD) for the calendar year 2006. The energy use for these facilities includes tertiary treatment *and* other facility energy uses, such as water quality testing, or administrative functions.
[9] Data for the volume treated at each of the treatment plants were not available; this analysis uses an average energy intensity of 30.1 kWh/acre-foot for the three MWD facilities.
[10] The average energy intensity for the three plants, weighted by volume for 2005 is 525 kWh/acre-foot for both secondary and tertiary treatment. At the Terminal Island Treatment Plant, tertiary treatment represented approximately 19% of total energy use. Assuming that the other plants have this distribution of energy use, the incremental energy used to produce tertiary-treated water from secondary-treated water is 100 kWh/AF.
[11] Data provided by LADWP for FY 2005-2006, during which period 48,486 AF were pumped.
[12] In 2004, 2005, and 2006, the Tillman Plant produced 60 to 62 AF annually.
[13] This water is not usable at a tertiary level. Currently about 5 MGD is treated with advanced treatment.

**Table 5-4. City of San Diego Energy Requirements and Water Summary**

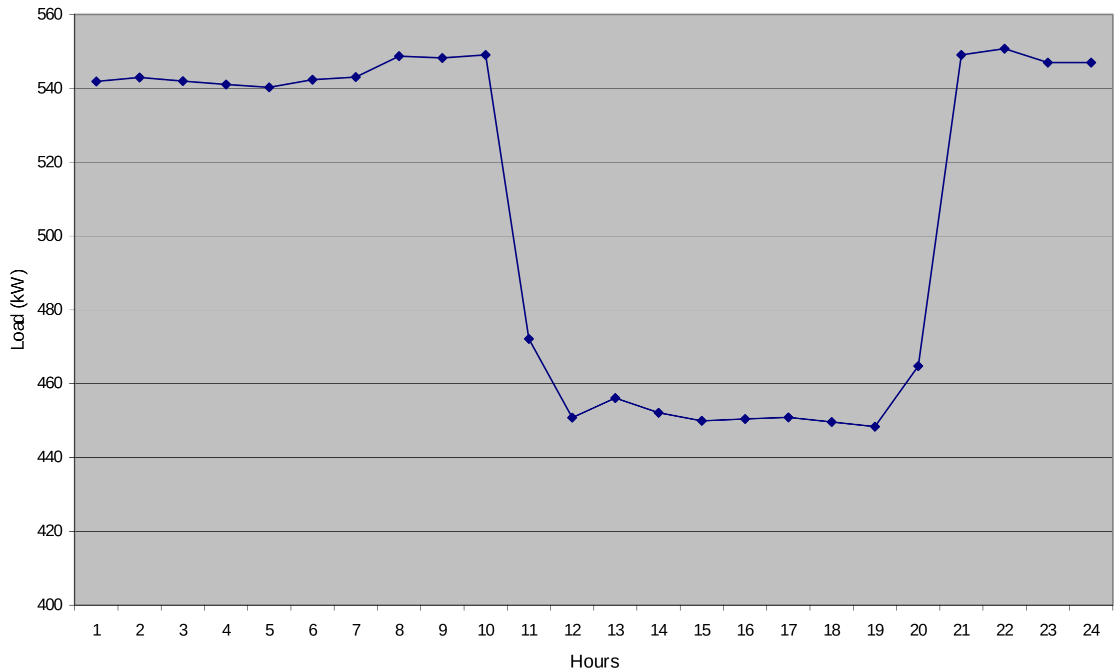
| Facility | Water Type | System Element | Annual Production (af/yr) | Annual Conveyance and Storage (af/yr) | Energy Requirement (kWh/af) | Annual Energy Usage (mWh) | Principal Energy Provider |
|---|---|---|---|---|---|---|---|
| SWP | Raw | Conveyance | 31,000 | n/a | 3,240 | 100,440 | Ca DWR |
| Colorado River | Raw | Conveyance | 173,000 | n/a | 2,000 | 346,000 | WAPA |
| Local Runoff | Raw | Conveyance | 23,000 | n/a | 0 | 0 | SDGE |
| Conveyance to Miramar WTP | Raw | Conveyance | n/a | 93,000 | 175 | 16,280 | SDGE |
| Conveyance to Otay WTP | Raw | Conveyance | n/a | 22,000 | 175 | 3,850 | SDGE |
| Treatment at Miramar WTP | Potable | Treatment (Potable) | 93,000 | n/a | 50 | 4,650 | SDGE |
| Treatment at Otay WTP | Potable | Treatment (Potable) | 22,000 | n/a | 85 | 1,870 | SDGE |
| Transport to North City WRP | Waste | Sewage Collection | n/a | 15,000 | 20 | 300 | SDGE |
| Transport to South Bay WRP | Waste | Sewage Collection | n/a | 9,000 | 10 | 90 | SDGE |
| Treatment to North City WRP | Secondary | Treatment (Recycled) | 25,000 | n/a | 870 | 21,750 | SDGE |
| Treatment to North City WRP | Tertiary | Treatment (Recycled) | 7,600 | n/a | 320 | 2,430 | SDGE |
| Treatment to South Bay WRP | Secondary | Treatment (Recycled) | 9,000 | n/a | 340 | 3,060 | SDGE |
| Treatment to South Bay WRP | Tertiary | Treatment (Recycled) | 7,000 | n/a | 555 | 3,890 | SDGE |
| NCWRP Reclaimed Water Use | Reclaimed | Distribution | n/a | 2,000 | 970 | 1,940 | SDGE |
| SBWRP Reclaimed Water Use | Reclaimed | Distribution | n/a | 2,000 | 470 | 940 | SDGE |
| Conveyance to User | Potable | Distribution | n/a | 115,000 | 280 | 32,200 | SDGE |

(Source: Recycled Water Study, 2008)

Notes:
[1] Data from Water Reuse Study and from City of San Diego.
[2] Power usage associated with conveyance to Otay WTP was assumed equal to conveyance to Miramar WTP.
[3] Energy associated with reclaimed water use is for pumping.
[4] Energy associated with SBWRP Reclaimed water use is estimated from Water Reuse Study, Technical Appendix 7.

The Study Team will develop 24-hourly profiles based on data from simulations, previous studies, and metered data provided by the representative agencies. A water resource loading for each water agency studied will be developed in order to define the portions of their systems that need to be operated to deliver their short run marginal supplies on each of the seven days. The following graph shows the power load shape for a sample irrigation district in the Central Valley.

**Figure 5-3. Sample Central Valley Irrigation District Power Load Shape for July 15**




The energy intensities and load profiles gathered in this task will be organized and summarized in a way that can be accessed and used in modeling or other needs.

## 5.6 Task 6: Develop Range of Energy Intensities for Investor Owned Utility Service Areas

The Study Team will use the data compiled in Task 5 by selecting representative agencies within utility service areas to characterize the range of energy intensities within those service areas. The Study Team will identify key drivers of variances and identify how other agencies within an IOU's service area may operate.

- The Study Team will review and sort representative water agency energy use by IOU, and present the resulting data ranges by IOU and functional component in a memorandum.

## 5.7 Task 7: Prepare Interim Reports and a Draft and Final Technical Report

This Task provides for the writing and production of interim reports for each task as well as the final report that summarizes the work of the previous tasks. An important element of this task is the public review of the draft final report. The final report will be produced shortly after closure of the public review period and in conjunction with CIEE and CPUC staff and consultants.

- Upon completion of Tasks 1-6, the Study Team will compile the Draft Report.
- The Draft Report will be reviewed by CIEE and CPUC staff and consultants, and the Draft Report revised as deemed necessary.

- The Revised Draft Report will be presented and reviewed with water and energy stakeholders at a Public Workshop.
- The Study Team and CIEE and CPUC staff and consultants will collectively review stakeholder/public comments to determine revisions to the report, if any.
- Agreed upon revisions will be incorporated into the Final Technical Report that will be issued by the Study Team and will include pertinent documented datasets.

## 5.8 Study Coordination Efforts with CIEE Water Studies

As noted previously, the data and methods used in this study will be provided to other CPUC studies that are being performed in parallel. These include the measurement and evaluation study being conducted by ECONorthwest for the water-energy pilots that were approved pursuant to the CPUC's Decision 07-12-050 and a third study being conducted by CIEE on behalf of the CPUC with regard to the time-of-use profile of water consumption by various types of water users, agricultural and urban. All of these studies are also being relied upon to provide input to the revision of the CPUC's water-energy calculator.

The Study Team will work closely with the CIEE and their consultants to ensure that the outputs of this research are consistent with what is being developed in the other CIEE studies. The Team will also refine our research plan for this study as needed to provide inputs for the CIEE studies as directed by the CPUC. The Study Team will also coordinate with these other studies to ensure that definitions and data analytical approaches are consistent, to the extent appropriate to the objectives of Study 2. Currently, the CIEE studies are still in the development stage and additional details on how the Embedded Energy in Water Studies will merge with the other CPUC studies and other CPUC efforts will be provided once the CIEE studies are underway.

## 5.9 Study 2 Deliverables

| Deliverable | Due Date |
|---|---|
| 1) Draft Study Plan | *November 1, 2008* |
| 2) Final Study Plan | *January 1, 2009* |
| 3) Interim Report: Literature Review | *January 15, 2009* |
| 4) Memo: Key Energy Drivers | *January 15, 2009* |
| 5) Sampling Stratification Plan:<br>a. Matrix by characteristics<br>b. Criteria for selection<br>c. Recommended sample | *February 1, 2009* |
| 6) Embedded Energy & Load Profiles | *October 1, 2009* |
| 7) Memo: Range by IOU and water system/functional components | *October 1, 2009* |
| 8) Draft Final Report | *November 1, 2009* |
| 9) Final Report | *February 1, 2010* |
| 10) Monthly Reports | *Monthly* |

## 5.10 Study 2 Schedule

| Milestones | Deliverables | Schedule Duration | Month | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan |
| Kickoff Meeting | | 1 day | X | | | | | | | | | | | | | | | |
| Study Plan | Draft Study Plan | 2 weeks | X | | | | | | | | | | | | | | | |
| | Review with CIEE/CPUC | 1 day | X | | | | | | | | | | | | | | | |
| | Stakeholder Review Workshop | 4 weeks | | | X | | | | | | | | | | | | | |
| | Review Public Input w/ CIEE/CPUC | 1 day | | | X | | | | | | | | | | | | | |
| | Final Study Plan | 1 week | | | X | | | | | | | | | | | | | |
| Literature Review | Interim Report | 2 weeks | | | | X | | | | | | | | | | | | |
| Select Representative Water Agencies | Memo: Key Energy Drivers | 2 weeks | | | | X | | | | | | | | | | | | |
| | Sampling Stratification Plan:<br>1 - Matrix by characteristics<br>2 - Criteria for selection<br>3 - Recommended sample | 2 weeks | | | | X | | | | | | | | | | | | |
| Develop Embedded Energy & Load Profiles | Collect water & energy data<br>Develop embedded energy ests.<br>Develop 24 hr load profiles | 32 weeks | | | | | | | | | | | | X | | | | |
| Develop Range by IOU Service Area | Memo: Range by IOU and water system/functional components | 2 days | | | | | | | | | | | | X | | | | |
| Final Report | Draft Final Report | 2 weeks | | | | | | | | | | | | | X | | | |
| | Review with CIEE/CPUC | 1 day | | | | | | | | | | | | | X | | | |
| | Stakeholder Review Workshop | 4 weeks | | | | | | | | | | | | | | X | | |
| | Review Public Input w/ CIEE/CPUC | 1 day | | | | | | | | | | | | | | | X | |
| | Final Report | 2 weeks | | | | | | | | | | | | | | | | X |

**Embedded Energy in Water Studies**

**California Institute for Energy and Environment**

GEI Consultants