CALMAC Study ID CPU0035.01
Volume 15 of 15
Appendix N

Embedded Energy in Water Studies
Study 1: Statewide and Regional Water-Energy Relationship

Prepared by
GEI Consultants/Navigant Consulting, Inc.

Prepared for the
California Public Utilities Commission
Energy Division

Managed by
California Institute for Energy and Environment

August 31, 2010

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

N.1 Introduction

In 2005, to estimate the amount of water-related energy consumed in California, staff of the California Energy Commission (CEC) relied on available data that included:

- Energy consumption data reported by electricity sellers required to report annual sales by Standard Industrial Code (SIC) or North American Industry Classification System (NAICS) building codes (hereafter referred to as "SIC/NAICS")

- Anecdotal information from water and wastewater treatment plant operators

- Input from other state agencies

These data although illustrative, were not definitive for the purpose of quantifying electricity used by the water sector. CEC staff then attempted to organize that data in a manner that facilitated allocating water-related energy to the various segments of the water use cycle. All end uses of energy were included in that process - i.e.:

1. Energy used by water and wastewater agencies themselves in the conduct of their respective missions. Water and wastewater operations include (a) production, collection, conveyance, treatment and delivery of potable water; (b) collection, transport, treatment and disposal of wastewater; and (c) additional treatment and delivery of recycled water.

2. Other end uses were comprised of both agricultural and urban pumping, heating and other energy uses needed to support end uses of water, including residential, commercial and industrial indoor and outdoor water uses. Agricultural uses of water (irrigation pumping and potentially other uses) were also included.

The fundamental problem in comparing these data to Studies 1 and 2 is that the CEC's database contains information about electricity sales, while Studies 1 and 2 focus on electricity requirements by California water and wastewater agencies. (Natural gas was included in the scope of the studies but most water-related natural gas is used for heating; little natural gas consumption is used by the water sector itself.) While it seems logical that there should be a reasonable correlation between these two data sets, the amount of electricity sales reported by

SIC/NAICS does not accurately report the nature of the energy end use for the following reasons related to how data is categorized:[1]

1. ***Inconsistent application of SIC/NAICS codes***. Organizations assign these codes differently. Even within any particular organization, individuals assign these codes differently.

    a. Although there is a specific code for wastewater treatment agencies, the NAICS database reported that only 1,926 organizations nationwide use the code 221320 Sewage Treatment Facilities.[2] Meanwhile, the Water Environment Research Foundation (WERF) reports that there are 16,583 public wastewater treatment facilities in the U.S.[3] There are many potential causes for this inconsistency:

        i. Many cities have their own sewage treatment agencies. The California Association of Sanitation Agencies has 123 members. In fact, CEC staff observed that some reporting entities considered municipal water and wastewater systems as "governmental" functions and included energy use for these types of uses under that category.

        ii. CEC staff also observed that significant quantities of energy are classified to "Transportation and Utilities" (SIC Code 49). This general category may include both potable and wastewater energy uses for both the urban and agricultural sectors.

    b. NAICS code 221310 "Water Supply and Irrigation Systems" can be used for water supply, treatment, distribution, irrigation, etc. However, energy used for agricultural pumping is sometimes reported to a specific farming code by crop. CEC staff also noted that energy used for "water pumping" often gets lumped together, whether for conveyance of supplies or for agricultural pumping.

    The assignment of SIC/NAICS codes is made by individual staff, including the meter installer; the customer service representative that creates the new meter record and assigns a tariff code for billing purposes; and the engineer that approved the electric service design and capacity. Of necessity, judgment is applied by many different types of staff when assigning codes, creating many opportunities for inconsistent classifications.

2. ***A single energy meter may serve multiple end uses***. Meters that serve multiple purposes may be coded to any one of the purposes or to a very broad generic category. Further,

[1] Interview with Lorraine White, Senior Energy Specialist, California Energy Commission, March 2, 2009.
[2] North American Industry Classification System website as of May 9, 2010: http://www.naics.com/naics22.htm
[3] Water Environment Research Foundation "FACT Sheet," Wastewater Sludge: A New Resource for Alternative Energy and Resource Recovery," http://www.werf.org/.

there are inconsistencies as to which codes are used for ancillary systems that support primary functions.

a. Energy used in the administrative headquarters of a large regional water agency may be classified to "Water", "Commercial", "Industrial", "Governmental", or something else entirely.

b. A farming facility may have been classified as "Crops", "Livestock", or "Irrigation Water Pumping." A particular farm could in fact have some component of all three classes (grow some crops, raise some animals and irrigate some land); but most customer billing systems require that the metered electric load be classified to a single end use description.

3. ***Loads connected to energy meters can change over time***. SIC/NAICS codes may not be updated to reflect these changes.

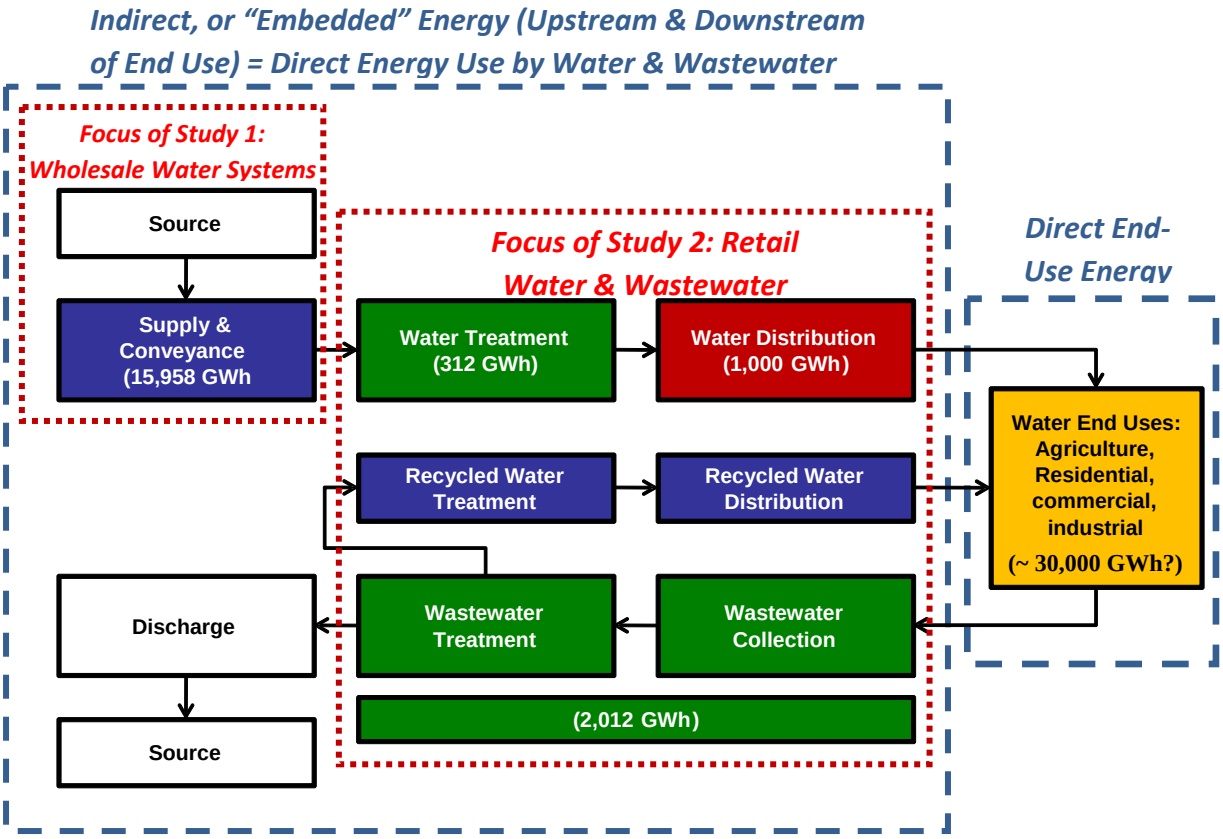
CEC staff that manage the state's database of energy consumption by SIC/NAICS observed that electricity sellers vary as to how they report water-related energy consumption. There were too many inconsistencies and unknowns to enable reclassifying these data to segments of the water use cycle.

Despite all of these data imperfections, the CEC's database of statewide energy consumption was the best source of data available in 2005, and it probably still is.[4] So, what is the total amount of energy used in California by the water sector itself? The best answer as of 2006 (CEC 2006) was 12,383 GWh - the sum of urban and agricultural water supply and treatment plus wastewater treatment - about 4.9% of total electricity consumption in California during calendar year 2001. During the course of Study 1, however, the Study Team became aware that the electricity data collected from the nine wholesale water agencies were not exactly the same as that reported in the CEC's energy consumption database that was used to support its estimates of water-related electricity. In addition, it appeared that groundwater energy was significantly understated.

After comparing the sources of differences in the data, the Study Team recommended adjusting the allocation between energy used by the water sector itself and water-related end uses. The results of the Study Team's recommended adjustments are reflected in Figure N-1 below.

[4] California Energy Consumption Database, California Energy Commission's website: http://www.ecdms.energy.ca.gov/

Figure N-1 – Water-Related Electricity Consumption by Segment of the Water Use Cycle[5]



The following discussion describes the bases for these recommended adjustments.

N.2 Analysis

Based on the data collected through Studies 1 and 2, the Study Team believes that the amount of electricity used by the water sector itself is considerably higher than the CEC's original estimates (2005), and also higher than the adjusted numbers (CEC 2006) that were based on very conservative assumptions. Table N-1 below summarizes the differences between the Study Team's estimates and past report. Since water sector energy use establishes the value of energy deemed "embedded" in a unit of avoided water consumption, the energy value of water efficiency measures increases as more electricity consumption is allocated to the water sector itself.

[5] Estimated electricity use by segment of the water use cycle reflects the Study Team's recommended adjustments.

Table N-1: Comparison of Calendar Year 2001 Statewide Water Sector Electricity Use (GWh)

Segment of the Water Use Cycle	CEC Study (2005)	CEC Study (2006)	Study 1	Study 2
Supply	10,742	10,371	15,786	172
Conveyance				
Water Treatment				312
Water Distribution				1,000
Wastewater Treatment	2,012	2,012		2,012
Total Water Sector Electricity Use	12,754	12,383	19,282	
% of Total Statewide Electricity Requirements	5.1%	4.9%	7.7%	
Note: Excludes estimates of electricity consumption for water end uses.				

The adjustments recommended by the Study Team are very conservative. We believe the true amount of electricity used by the state's water sector is more than 8%. The rest of this appendix describes in detail the data and methods used to make the adjustments found in Table N-1.

Table N-2 shows the amount of water-related electricity estimated by the CEC in 2005 and then adjusted in 2006.

Table N-2: 2001 Energy Use by the Water Sector as Reported in Past CEC studies[6]

	CEC 2005 Report	CEC 2006 Report	Description of Energy Consuming Equipment Included in Segment
2001 Water Supply and Treatment (GWh)			
Urban	7,554	7,583	Energy use by pumps (raw surface water, groundwater, distribution) and treatment plants to supply water to urban areas
Agricultural	3,188	2,788	Energy use by SWP, CVP, and WAPA to convey water to Irrigation Districts. Groundwater pump and booster pump energy consumed by Irrigation districts
Subtotal: Water Supply & Treatment	*10,742*	*10,371*	
2001 Water End Uses (GWh)			
Agricultural	7,372	7,372	On-farm (privately owned) groundwater pump and booster pump energy use
Residential	27,887	28,258	Water heating and water cooling appliances. Energy use by appliances that use water (Example: dishwashers and laundry machines)
Commercial			
Industrial			
Subtotal: Water End Uses	*35,259*	*35,630*	
2001 Wastewater Treatment (GWh)			
Wastewater Treatment	2,012	2,012	Energy used by wastewater treatment plants
2001 Total (GWh)			
Total Water-Related Energy Use	48,013		Sum of the energy use above
Total California Energy Use	250,494		All energy use by all end uses in California
Water-Related Energy Use as a Percent of Total California Energy Use	19.2%		

Note that some groundwater pumping energy is included in both the Urban and Agricultural sectors of the Water Supply and Treatment segments, and some also appears under Agricultural Water End Uses. The CEC's 2005 report states that agricultural end use includes 4,499 GWH of energy use by groundwater pumps while the remaining 2,873 GWH is used by booster pumps (water distribution systems).[7] For consistency with classifications along the water use cycle, the amount of energy used for groundwater pumping should be considered "Supply" and the amount of energy used by booster pumps should be classified as "Distribution."

Studies 1 and 2 collected data about energy uses by the water and wastewater sectors themselves. To identify the amount of energy that is deemed "embedded in water" – i.e., electricity use by water and wastewater agencies themselves that could be avoided by reducing water consumption - the Study Team removed energy attributable solely to end uses of water and reallocated

[6] CEC 2006, "Table 3. Recommended adjustments to WER Table 1-1, Water-related energy use in California in 2001", p.16 (with subtotals added).

[7] CEC 2005, "Table 1-4: Energy Consumed in Agriculture for Water", p.13.

agricultural groundwater energy to the Supply and Conveyance segment. These adjustments increase the amount of water sector energy use from the 4.9% reported in the CEC's studies, to 6.7% (see Table N-3 below).

Table N-3: 2001 Energy Use by the Water Sector as Reported in Past CEC studies with Study Team Adjustments

	Energy Use[a]	Description of Energy Consuming Equipment Included in Segment
Water Supply and Treatment (GWh)		
Urban	7,583	Energy use by pumps (raw surface water, groundwater, distribution) and treatment plants to supply water to urban areas
Agricultural (Irrigation Districts)	2,788	Energy use by SWP, CVP, and WAPA to convey water to Irrigation Districts. Groundwater pump and booster pump energy consumed by Irrigation districts
Agricultural (On-Farm)	4,499	On-farm (privately owned) groundwater pump energy use
Supply & Treatment Subtotal (GWh)	**14,870**	
Wastewater Treatment	2,012	Energy used by wastewater treatment plants
Total Water-Related Energy Use (GWh)	**16,882**	Sum of the water segments above
Total California Energy Use	250,494	All energy use by all end uses in California
Water-Related Energy Use as a Percent of Total California Energy Use	***6.7%***	

a) Obtained from CEC 2006.

Comparison with Study 1 Data

The CEC's studies used energy consumption data from calendar year 2001. Consequently, the Study Team compared Study 1 estimated electricity use in the Water Supply and Conveyance sector to the totals estimated by the CEC's studies.

Table N-4: Calendar Year 2001 Electricity Consumption by Wholesale Water Agency

Supply & Conveyance Electricity Use	Electricity Sales Reported to CEC (GWh) [a]	Study 1 Data Collected for CY2001			
		Total Energy Use (GWh)	In-Conduit Energy Production (GWh)	Net Energy Use (GWh)	Source(s)
State Water Project (SWP)	6,349	6,352	1,933	4,420	Bulletin 132, DWR
Central Valley Project (CVP)	1,595	833	0.85	832	Data from USBR
Colorado River Aqueduct (CRA)	2,484	2,483	0	2,483	Data from MWD staff
Metropolitan Water District of Southern California (MWD)	0	0	363	-363	Data from MWD staff
Santa Clara Valley Water District (SCVWD)	0	36	0	36	Data from SCVWD
San Francisco Public Utilities Commission (SFPUC)	0	14	0	14	Data from and interviews with SFPUC
Modesto Irrigation District (MID)	89	0	0	0	Data from MID
San Diego County Water Authority (SDCWA)	0	0	0	0	Data from and interviews with SDCWA
Los Angeles Department of Water and Power (LADWP)	181	0	0	0	Data from LADWP
Urban & Agricultural Groundwater	**unknown**	**6,068**	**0**	**6,068**	**Estimated by Study 1**
Total	**14,870[b]**	**15,786[c]**	**2,297**	**13,469**	

a) Electricity sales values for individual suppliers taken from http://www.ecdms.energy.ca.gov/
b) Number obtained from "Supply & Treatment Subtotal" in Table N-3 and includes Supply & Conveyance, Water Treatment and Water Distribution.
c) This estimate was computed by the Study Team and only includes Supply & Conveyance.

Although the CEC's prior studies netted in-conduit hydropower from estimated energy intensities, total electricity requirements of the state's water systems were reported on a gross basis. The electricity reported by SWP and CRA confirm that these values were not reduced for in-conduit hydropower. The CEC's estimate of 14,870 GWh for Water Supply and Treatment is lower by 916 GWh than the amount of electricity estimated in Study 1 for the Water Supply and Conveyance segment alone. We believe this amount is the minimum difference between the CEC's studies and Study 1. The actual number may be much higher.

Although Study 1 did not collect data from enough water agencies to complete an agency by agency comparison, electricity sales reported by the two largest wholesale water conveyance systems (State Water Project and Colorado River Aqueduct) are consistent with the amounts verified through detailed collection and compilation of water and energy data. As can be seen in Table N-4, the primary difference between prior CEC studies and the current Study 1 is the inclusion of estimated groundwater energy.

In order to compare the results of these studies on an equivalent basis, the amount of electricity used in California for water treatment, distribution, and production of other water supplies would need to be added to Study 1 totals for Supply & Conveyance electricity. This aggregate

comparison is the only comparison possible - a comparison at the function level is not possible because within the Supply and Conveyance segment in the CEC report, energy use by all sub-segments of the water use cycle (such as treatment and distribution) are lumped together in the total energy use for Supply and Conveyance, see Table N-5.

Table N-5: Primary Electricity Uses Within the Supply & Conveyance Segments of the Water Use Cycle

Segment of the Water Use Cycle	CEC Estimated Energy Use[a]	Study 1	Electricity Use
Supply	14,870	TBD	Surface Water Pumping by other water agencies
		6,068	Groundwater Pumping
		TBD	Desalination
		TBD	Recycled Water (incremental treatment, if any, needed to convert wastewater effluent to usable recycled water)
Conveyance		9,718	Wholesale Water Transport (Conveyance)
Treatment		TBD	Water Treatment Plants
Total	**14,870**	**15,786**	

a) As reported by CEC 2006. The CEC's original estimate included all water-sector related electricity consumption except wastewater treatment.

It is important to note that the 6,068 GWh Study 1 estimate for groundwater energy was computed on the basis of average depth to groundwater for each major groundwater basin at the beginning and ending of the water year, with average pump efficiency factors applied. The reallocation of 4,499 GWh from Water End Uses to Supply & Conveyance alone accounts for about 74% of the variance in the Supply and Conveyance segment. Since (a) the Study 1 number is an estimate based on average assumptions, and (b) we know that the energy consumption numbers reported by SIC/NAICS are not reliable, it is difficult to determine whether any additional adjustments should be made. It is likely, for example, that some groundwater energy is included in urban and agricultural supply and conveyance (see Table N-6 below).

Table N-6: Calendar Year 2001 Groundwater Energy

	CEC Estimated Energy Use[a]	Study 1	Types of Electricity Use
Water Supply and Treatment (GWh)			
Urban	Portion of 7,583 GWh	6,068 GWh	Energy use by pumps (raw surface water, groundwater, distribution) and treatment plants to supply water to urban areas
Agricultural (Irrigation Districts)	Portion of 2,788 GWh		Energy use by SWP, CVP, and WAPA to convey water to Irrigation Districts. Groundwater pump and booster pump energy consumed by Irrigation districts
Agricultural (On-Farm)	100% of 4,499 GWh		On-farm (privately owned) groundwater pump energy use
a) As reported by CEC 2006			

Study 1 included collection and compilation of data related to surface and groundwater pumping. As discussed above, the primary sources of data were comprised of (a) monthly water and energy data collected from nine large wholesale water agencies, and (b) computed estimates of groundwater energy. The Study 1 estimate of 15,786 GWh[8] does not yet include any electricity for desalination or incremental treatment needed to convert wastewater effluent to recycled water. It also does not include any estimates for surface water pumping that may be performed by wholesale water agencies other than the nine Study 1 participants. Consequently, if the Study 1 groundwater energy estimate is deemed reasonable, Supply & Conveyance electricity is likely still understated[9]. At a minimum, we should add the amount of energy used for raw water pumping that was collected through Study 2,[10] since there is no overlap of agency data between Studies 1 and 2.

Comparison with Study 2 Data

Study 2 collected energy and flow data from 21[11] retail water and wastewater agencies across the state for calendar year 2008. Total electricity use during CY2008 was 1,376 GWh. Removing groundwater and raw water pumps from this energy figure (to avoid overlap with Study 1 data), these agencies collectively consumed 653 GWh. The Study 2 agencies combined treated 340,000 AF at water treatment plants and 940,000 AF at wastewater treatment plants in CY2008.

[8] See Table N-4. Calendar Year 2001 Electricity Consumption by Wholesale Water Agency.

[9] Note that this analysis only compares data for Calendar Year 2001, since that was the base year used for the CEC's 2005 study and subsequent studies. Consequently, although Study 1 does estimate the electricity impacts of changes in hydrology within each of the state's ten hydrology regions, Study 1 does not estimate the impact of these changes as a percentage of the state's total electric requirements during other test years. This would have required projecting changes in statewide electricity requirements under different types of hydrology, which was beyond the Study 1 scope.

[10] 172.1 GWh; see Figure N-2: Summary of Energy Data Collected from 21 Agencies in Study 2.

[11] The 22nd water agency provided a snapshot of its operations but did not provide full data for calendar year 2008.

Figure N-2: Summary of Energy Data Collected from 21 Agencies in Study 2

Segment	Function	Energy Use (GWh)
Supply & Conveyance	Groundwater	551.7
	Raw Water Pumping	172.1
Treatment	Water Treatment Plants	41.1
Distribution	Booster Pumps	146.8
	Pressure System Pumps	10.6
Subtotal Upstream from End Users		**922**
Wastewater Systems	Wastewater Collection	28.9
	Wastewater Treatment	424.5
Recycled Water Systems	Recycled Water Pumps	1.1
Subtotal Downstream from End Users		**454**
Total Energy Quantified by Study 2 Agencies		**1,376**
Note: The 551.7 GWh for groundwater pumping is presumed included in the Study 1 estimates for groundwater energy.		

Since Study 2 did not collect data for calendar year 2001, it isn't possible to perform a direct correlation of the data collected through Study 2 with the CEC's 2001 electricity estimates. In addition, since the selection of agencies for participation in Study 2 was not based on a statistical sample, there is no basis for extrapolating the Study 2 results to statewide estimates of electricity consumption.

We can, however, compare the quantity of water and wastewater treated by the 21 participating water and wastewater agencies to statewide numbers recorded by DWR in its regional water balances to make some hypotheses and make some recommendations:

Water Treatment. During calendar year 2001, California consumed 8,610,000 AF of water for urban uses.[12] Not all water applied to beneficial uses is treated. For example, depending on the quality, groundwater can often be directly applied to end uses. Study 2 found that 41.1 GWh

[12] DWR Bulletin 160, California Water Balances.

was needed during calendar year 2008 to treat 340,000 AF of water – less than 4% of California's urban water demand for that year.[13] If we conservatively assume that 30% of urban water needed to be treated before it can be used,[14] 2.583 MAF of water would need to be treated. Presuming there is a basis for scaling up the Study 2 sample, 312 GWh would be needed to treat water statewide to serve urban water uses.

Wastewater Treatment. Also during calendar year 2001, California consumed 5,296,000 AF of water for indoor urban uses (residential interior, commercial and industrial).[15] The predominant portion of indoor water uses are discharged to sewers for transport to wastewater treatment plants. Study 2 accounted for 940,000 AF of wastewater treatment (17.7% of the wastewater volume statewide) by 8 large sanitation agencies. This sample of wastewater treatment plants consumed 453 GWh (22% of the total electric consumption reported by the CEC's 2005 study for this segment of the water use cycle). This data reveals Study 2 data collected generally aligns with the CEC data regarding wastewater treatment energy use; thus, there is no basis for adjusting the amount of electricity used for wastewater treatment.

Water & Wastewater Distribution. Both Studies 1 and 2 indicate wide variability in the amount of energy needed to transport water and wastewater. Study 1 provided detailed data about conveyance energy. Study 2 provided additional data about distribution energy. While we have no basis for extrapolating the amount of distribution energy reported through Study 2 to the entire state, we can say that the amount of electricity reported by the CEC's 2005 study for Water Supply & Treatment is understated, since the total amount of electricity requirements identified by Study 1 for the Supply & Conveyance segments alone, exceeded the total amount of electricity use CEC previously estimated (see Table N-5). Data is insufficient to determine how the Study 2 results should be used to estimate statewide electricity use for potable retail water distribution. However, we know that water distribution systems accounted for 157 GWh to serve 4% of the state's urban water demand. As a consequence, we know that a significant adjustment is needed to this segment. Although we have no basis for determining what that adjustment should be, we recommend using 1,000 GWh at this time, as a placeholder.

N.3 Summary of Findings

Although it is not possible to directly reconcile the results of Studies 1 and 2 with the CEC's estimates, we believe there is sufficient basis for determining that the amount of energy used by the Supply & Conveyance segment of the water use cycle is likely higher than the amount originally estimated by the CEC in 2005. The primary source of the difference is likely attributable to groundwater energy. For consistency, we recommend reallocating 4,499 GWh of electricity from agricultural water end use to Supply & Conveyance. We also recommend increasing Supply & Conveyance electricity by the 172 GWh of raw water pumping identified

[13] Based on treatment operations reported by 7 retail water agencies.
[14] Many surface and groundwater sources do not need much treatment.
[15] DWR Bulletin 160, California Water Balances.

through participating agencies in Study 2. This brings the total amount of electricity for the Supply & Conveyance segment to 15,958 GWh[16], ***before*** accounting for any reallocations of treatment electricity for desalting water or treating wastewater effluent to levels needed to use recycled water.

Table N-7 documents the detailed adjustments that we recommend to the allocated electricity use by the water sector. Note that although we believe certain segments of the water use cycle are understated, we do not have sufficient information to determine that the electricity that is used by the water sector should be reallocated from water end uses or from other energy end uses in the CEC's energy database. Consequently, although we do recommend reallocating electricity use among segments of the water use cycle, we do not have a basis for recommending increasing the 19.2% estimate of water-related electricity as a percentage of the state's total electricity requirements.

[16] Add the 15,786 GWh from Table N-3: Calendar Year 2001 Electricity Consumption by Wholesale Water Agency (Study 1) to 172.1 GWh in raw water pumping (Study 2).

Table N-7: Recommended Adjustments to CEC Estimates of 2001 Statewide Electricity Use by the Water Sector

	CEC 2006 Report	Recommended Adjustments	Adjusted Total	Notes
2001 Water Supply & Treatment (GWh)				
Urban	7,583	+172	7,755	
Agricultural	2,788	n/a	7,287	
Additional Groundwater Pumping (Agricultural)		+4,499		[1]
Additional Supply & Conveyance		+ 916	916	[2]
Additional Water Treatment		+312	312	[3]
Additional Water Distribution		+1,000	1,000	[4]
Subtotal: Water Supply & Treatment	***10,371***	***+6,899***	***17,260***	
2001 Water End Uses (GWh)				
Agricultural	7,372	-4,499	2,873	[1]
Residential	28,258	n/a	28,258	
Commercial				
Industrial				
Other Adjustments to Water End Uses		***unknown***	***unknown***	
Subtotal: Water End Uses	*35,630*	*-4,499*	*31,131*	
2001 Wastewater Treatment				
Wastewater Treatment	2,012	n/a	2012	[5]
2001 Total				
Total Water Sector Electricity Use	***12,383***	***+6,899***	***19,282***	
Total Water-Related Energy Use	48,013		***unknown***	
Total California Energy Use	250,494		250,494	
Percent	19.20%		***unknown***	

Notes:

[1] Transfer 4,499 GWh for agricultural groundwater pumping from water end uses to the Supply & Conveyance segment of the water use cycle.

[2] For conservatism, adjust Supply & Conveyance electricity for the additional 916 GWh verified in CY2001 through data collected from the 9 large wholesale water agencies (see note to Table N-3: Calendar Year 2001 Electricity Consumption by Wholesale Water Agency). This amount is the minimum difference between the CEC's studies and Study 1. The actual number may be much higher.

[3] Estimated Water Treatment electricity assumes that 30% of the total 8,610,000 AF applied to urban uses needs to be treated.

[4] Distribution energy is significantly understated, but there is no reasonable basis to determine how much this should be adjusted. We therefore recommend using 1,000 GWh as a conservative placeholder for now.

[5] No adjustments are recommended to Wastewater Treatment.