Water-Energy Calculator 2.0 User's Guide

Submitted to **California Public Utility Commission**
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September 29, 2021

ENERGY + WATER + EFFICIENCY

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1 Introduction

This user's guide provides basic information and guidance on using the Water-Energy (W-E) Calculator 2.0. The *Overview* section provides an overview of the methodology and conceptual framework underlying the W-E Calculator 2.0 and describes its relationship with other CPUC tools. The *Step-by-Step Instructions* section explains how to use the W-E Calculator 2.0.

2 Overview

The W-E Calculator 2.0 estimates the investor-owned utility (IOU) and non-IOU embedded-energy savings that result from water-efficiency measures. Compared to the previous version, the W-E Calculator 2.0 is simpler and focuses on embedded-energy savings. As such, calculations of the avoided embedded-energy cost, the avoided water-capacity cost, and all cost-effectiveness functionalities have been removed. Instead, the tool estimates the embedded-energy savings (in kWh) that can be entered directly into the California Energy Data and Reporting System (CEDARS) for integration into the Cost-Effectiveness Tool (CET) for cost-effectiveness evaluations.

2.1 Methodology

Fundamentally, the model estimates embedded-energy savings by multiplying the annual water savings of an efficiency measure by the energy intensity of wastewater and/or water, in kilowatt-hours per acre-foot, or kWh/AF. Determining energy intensity, however, requires assumptions about, for example, the water supply, the water-system components, the associated energy intensity of each component, and the amount of IOU and non-IOU energy required.

Figure 1 illustrates the underlying methodology used in the W-E Calculator 2.0 to estimate IOU and non-IOU embedded-energy savings. Calculating the embedded-energy savings begins with the user entering basic information about the measure(s) being evaluated. This includes basic measure data (e.g., installation year and annual water savings), measure application, and the zip code where the measure is installed. The zip code determines the hydrologic region and the associated default marginal water supply. The marginal supply and the measure application determine the appropriate water-system components (e.g., extraction and conveyance, treatment, distribution, wastewater collection. and wastewater treatment) included in the calculations. The energy intensity (in kWh/AF) of each water-system component is multiplied by the percent of the energy provided by an IOU to produce an IOU and non-IOU energy intensity (in kWh/AF). Annual water savings for the measure are then multiplied by the energy intensity values for each relevant water-system component, and then summed across system components to estimate the IOU and non-IOU embedded-energy savings (in kWh).

The final project report will include a more detailed description of the underlying methodology.

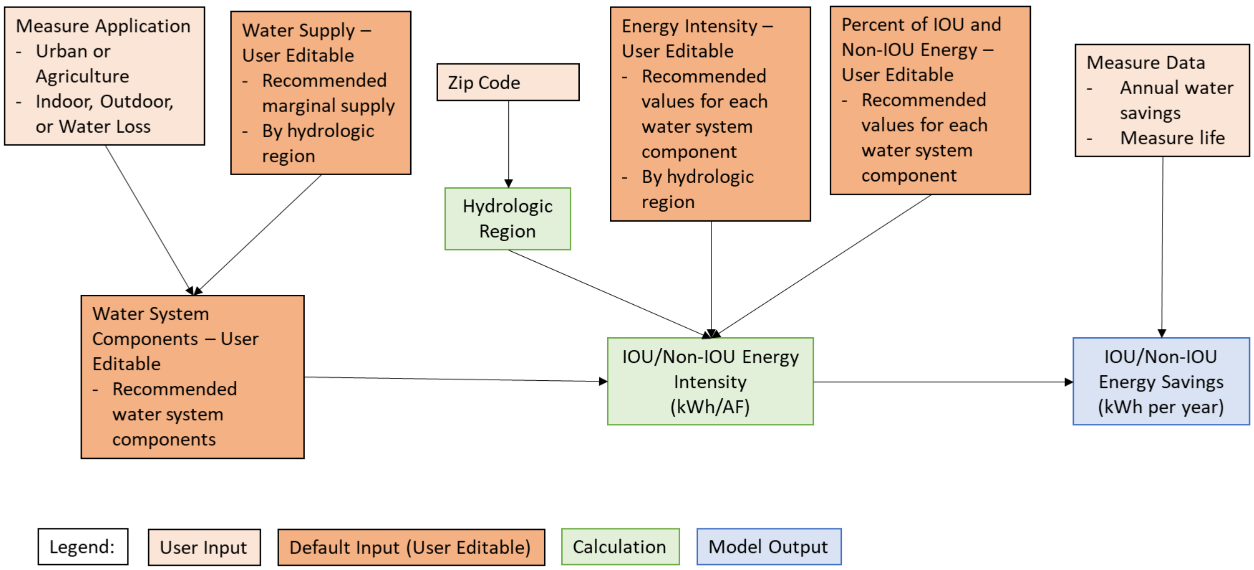


Figure 1: Conceptual Framework of the W-E Calculator 2.0

2.1.1 Water-System Components by Sector

The model requires the user to specify whether the measure is applied to the urban or agricultural sector. Within the urban sector, the user must specify whether the measure reduces indoor water use, outdoor water use, or water losses from the water-distribution system. These specifications determine which water-system components are included in the analysis, and in estimates of default energy intensity. In most cases, the agricultural sector uses water that is not subject to treatment, i.e., raw water, and does not collect or treat wastewater. In the urban sector, indoor water use is subject to extraction and conveyance, treatment, distribution, wastewater collection, and wastewater treatment. By contrast, outdoor water use and water losses in the distribution system are only subject to extraction and conveyance, treatment, and distribution.

2.1.2 Resource Balance Year

Consistent with CPUC directive D. 15-09-023, the default Resource Balance Year (RBY) in the W-E Calculator 2.0 is 2016, although the user can override this default "to account for a particular water supplier's planning, resource, and other needs." Prior to the RBY, the calculator uses the historical water-supply mix to calculate a "historical" embedded-energy savings. In the RBY and beyond, the calculator uses the marginal water supply to calculate a "marginal" embedded-energy savings. If some of the water savings occur prior to the RBY and some after the RBY, then the model estimates the annualized embedded-energy savings.

2.1.3 Regional Analysis

The available water sources and their associated energy intensities can vary across the state, so the W-E Calculator 2.0 operates at a regional level, using the California Department of Water Resources (DWR) hydrologic regions.[1]

While the hydrologic region is the basis of the regional analysis, most users do not know hydrologic region in which a measure was installed. So, the W-E Calculator 2.0 uses zip code as a common locator, consistent with how energy-efficiency measures are assigned to climate zones within cost-effectiveness evaluations. The zip code is assigned to the hydrologic region that represents the largest proportion of the areal extent of the zip code (i.e., a "majority rule"). This simplifying assumption is consistent with how energy-efficiency measures are assigned to climate zones and reduces the complexity within the California's Electronic Technical Reference Manual (eTRM) for deemed measures.

2.2 Relationship with Other CPUC Tools

Figure 2 shows that the inputs and outputs of the W-E Calculator 2.0 are connected to several other CPUC tools. Inputs for selected water-efficiency measures, such as water savings and effective useful life, can be obtained from the eTRM, which serves as a repository for all statewide deemed measures for California. Information for custom measures is not contained with the eTRM, and Program Administrators (PAs) will need to manually add this information into the W-E Calculator.

Outputs of the W-E Calculator 2.0 are consistent with the CEDARS report structure, helping the user to track and report embedded-energy savings to the CPUC. CEDARS processes data as inputs for the CET for cost-effectiveness evaluations and then post processes the CET outputs for filings and claims.

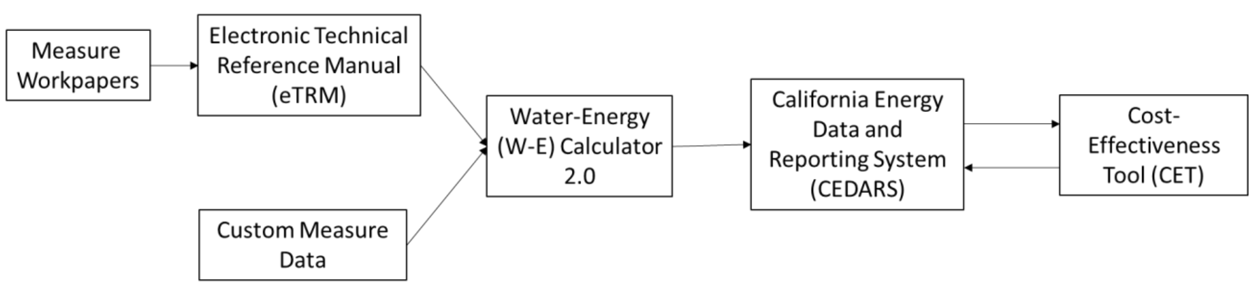


Figure 2: Relationship Between the W-E Calculator 2.0, eTRM, CEDARS, and CET

For example, assume low-flow showerheads were installed in a hotel in San Francisco consistent with the deemed measure "Low-flow Showerhead – Commercial" (SWWH020). The measure's permutations in the eTRM indicate that the annual water savings are 2,979 gallons

1 https://atlas-dwr.opendata.arcgis.com/datasets/2a572a181e094020bdaeb5203162de15_0/explore

per showerhead. The water savings, along with the measure life, can be entered into the W-E Calculator 2.0. The default water supply and energy intensity for the SF Bay hydrologic region produce an estimated annual IOU embedded-energy savings of 16.2 kWh per showerhead. The embedded-energy savings can then be entered into CEDARS alongside the claimed direct energy savings to get the water-related energy savings. CEDARS then interfaces with the CET to determine the measure's cost effectiveness.

3 Step-by-Step Instructions

3.1 Getting Started

The W-E Calculator 2.0 opens to the **Information** tab, shown in Figure 3. This tab describes the purpose of the tool, as well as its uses and limitations. Scroll down the page to find instructions on how to use the model and a legend for tab colors and cell formatting. After reviewing the **Information** tab, select the **Measure Inputs** tab to begin entering information about the water-efficiency measures to be evaluated.

3.2 Model Inputs

Model inputs are entered on two tabs: **Measure Inputs** and **Water System Inputs**.

3.2.1 Measure Inputs Tab

On the **Measure Inputs** tab, describe the project and use the drop-down list to identify the electric IOU within whose service area the measure(s) is installed (Figure 4).

Scroll down to enter basic information about the measure(s) to be evaluated. For each measure, enter the measure name and the zip code where it was installed. Based on the zip code provided, the hydrologic region is automatically filled in. For each measure evaluated, enter the measure-installation year, measure life, sector (i.e., urban or agriculture), type of measure evaluated (i.e., indoor, outdoor, or system leaks), and annual water savings. Annual water savings should be based on the savings for one measure, e.g., a single low-flow showerhead. Use the drop-down lists to specify Installation Zip Code, Installation Year, Sector, and Measure Type.

(Draft) Water Energy Calculator 2.0

Version 2.0.1

Overview

This calculator was developed for the California Public Utilities Commission by Pacific Institute and SBW Consulting to help estimate the embedded energy savings associated with various water efficiency/conservation measures. The tool allows users to define up to twenty water efficiency measures according to the water demand profile, water sector, water use, and other parameters. Additional information regarding methodology and data sources can be found in the accompanying report. The previous version of this tool was developed by Navigant in 2014.

Uses and Limitations

Outputs are estimates based on regional data for California. This tool will not be representative for other states.

Embedded energy savings are estimates; actual embedded energy savings will vary based on site-specific conditions.

Instructions

1. Fill in measure information on the "Input" tab.
2. Review default assumptions and edit values as necessary. Any values that differ from default values will be appended with an asterisk (*).
3. Results are updated automatically. Detailed calculations can be reviewed on the Calculations sheet.

Legend

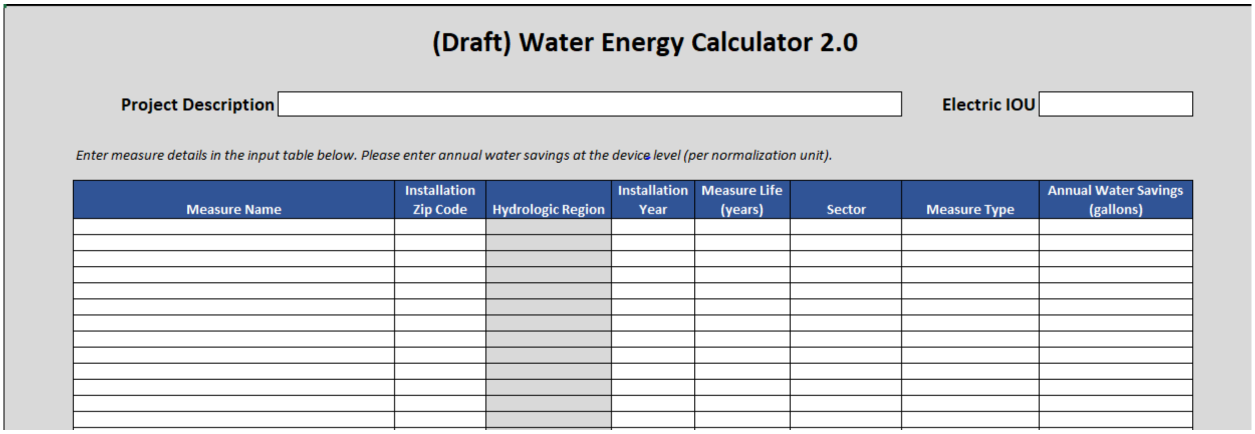
Tab Colors

User Guidance and Information
User Input Required
Model Outputs
Data and Default Assumptions
Reference Material

Cell Formatting

User Input
Autofilled or Calculated Values
Default Value (Autofilled)
User Override

Figure 3: The Information Tab



(Draft) Water Energy Calculator 2.0

Project Description | **Electric IOU**

Enter measure details in the input table below. Please enter annual water savings at the device level (per normalization unit).

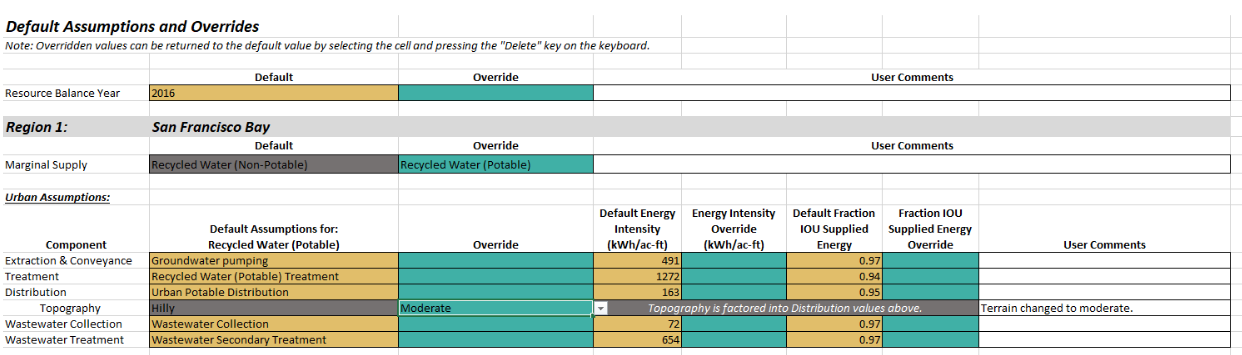
Measure Name	Installation Zip Code	Hydrologic Region	Installation Year	Measure Life (years)	Sector	Measure Type	Annual Water Savings (gallons)

Figure 4: The Measure Inputs Tab

3.2.2 Water System Inputs Tab

On the **Water System Inputs** tab, identify the marginal water supply for the hydrologic regions identified on the **Measure Inputs** tab (Figure 5). Defaults are provided for the marginal water supply and each water-system component based on the marginal water supply, sector, and measure type. Default values are also provided for the energy intensity of each of the water-system components and the fraction of embedded energy provided by an IOU. You can override the default selections, as appropriate for the measures evaluated. The Appendix contains the default values and data sources for water-system components, the historical water-supply mix, and the fraction of embedded energy provided by an IOU.

For the example shown in Figure 5, the user overrode the default marginal water supply for the San Francisco Bay hydrologic region and selected potable recycled water as the marginal supply. Additionally, the user overrode the distribution-system topography, selecting a moderate terrain.



Default Assumptions and Overrides

Note: Overridden values can be returned to the default value by selecting the cell and pressing the "Delete" key on the keyboard.

	Default	Override	User Comments
Resource Balance Year	2016		

Region 1: ***San Francisco Bay***

	Default	Override	User Comments
Marginal Supply	Recycled Water (Non-Potable)	Recycled Water (Potable)	

Urban Assumptions:

Component	Default Assumptions for: Recycled Water (Potable)	Override	Default Energy Intensity (kWh/ac-ft)	Energy Intensity Override (kWh/ac-ft)	Default Fraction IOU Supplied Energy	Fraction IOU Supplied Energy Override	User Comments
Extraction & Conveyance	Groundwater pumping		491		0.97		
Treatment	Recycled Water (Potable) Treatment		1272		0.94		
Distribution	Urban Potable Distribution		163		0.95		
Topography	Hilly	Moderate	*Topography is factored into Distribution values above.*				Terrain changed to moderate.
Wastewater Collection	Wastewater Collection		72		0.97		
Wastewater Treatment	Wastewater Secondary Treatment		654		0.97		

Figure 5: The Water System Inputs Tab

After you enter information on the **Measure Inputs** and **Water System Inputs** tabs, the **Calculations** and **Output Table** tabs are automatically populated; there is no need to press "Enter" or a "Run" button.

3.3 Model Outputs

3.3.1 Calculations Tab

The **Calculations** tab summarizes the input model information, including the measure name, installation zip code, annual water savings, and the marginal supply (Figure 6). Scroll to the right to view information about the historical embedded-energy savings (based on the historical water-supply portfolio), as well as the energy intensity and fraction of energy provided by an IOU for the marginal water supply selected (Figure 7). An asterisk indicates any selection that differs from the default value for the marginal water supply, water-system component, its energy intensity, or the fraction of IOU-supplied energy. You can expand the historical embedded-energy calculations by clicking the "+" sign above column V.

Measure Information										
Measure Name	Installation Zip Code	Installation Year	Measure Life (years)	Sector	Measure Type	Annual Water Savings (gallons)	Annual Water Savings (acre-feet)	Hydrologic Region	Fraction of Zip Code in Hydrologic Region	Marginal Supply
Indoor Leak	94602	2021	10	Urban	Indoor	10,000	0	San Francisco B	100.0%	Recycled Water (Potable)*

Figure 6: The Calculations Tab Showing a Summary of the Measure Information

Historical Energy Calculations			Marginal Energy Calculations					
Historical Energy Savings (Pre-2016)			Extraction & Conveyance			Treatment		
Annual Embedded Energy Savings (kWh)	Annual IOU Embedded Energy Savings (kWh)	Annual Non-IOU Embedded Energy Savings (kWh)	Extraction & Conveyance	Fraction IOU Supplied Energy	Energy Intensity (kWh/ac-ft)	Treatment	Fraction IOU Supplied Energy	Energy Intensity (kWh/ac-ft)
48	40	9	Groundwater pumping	0.97	491	Recycled Water (Potable) Treatment	0.94	1,272

Figure 7: The Calculations Tab Showing the Historical Embedded-Energy Savings and the Water-System Component, Fraction IOU Supplied Energy, and Energy Intensity for Extraction and Conveyance and Treatment for the Marginal Water Supply

Scroll further to the right (Figure 8) to view the marginal and annualized embedded-energy savings. When the measure is installed after the RBY, the annualized energy savings are equal to the marginal energy savings. When the measure is installed before the RBY, the historical embedded-energy savings are used for the years preceding the RBY and the marginal embedded-energy savings are used for the RBY and for subsequent years. The annual embedded-energy savings are then summed and divided by the measure life to produce an annualized embedded-energy savings.

Marginal Energy Savings (Post 2016)			Annualized Savings			
Annual Total Embedded Energy Savings (kWh)	Annual IOU Embedded Energy Savings (kWh)	Annual Non-IOU Embedded Energy Savings (kWh)	Annualized Total Embedded Energy Savings (kWh)	Annualized IOU Embedded Energy Savings (kWh)	Annualized Non-IOU Embedded Energy Savings (kWh)	Warnings
86	82	4	86	82	4	Marginal Energy calculations contain user overrides

Figure 8: The Calculations Tab Showing the Marginal Embedded-Energy Savings and Annualized Embedded-Energy Savings

3.3.2 Output Table Tab

The **Output Table** tab summarizes outputs generated by the W-E Calculator 2.0 (Figure 9). These include the hydrologic region, sector, measure type, gallons saved, the annualized IOU embedded-energy savings, and the annualized non-IOU embedded-energy savings. You can also provide other information about the measure, i.e., the Claim ID, water measure code, the savings profile, and the source description; though these are not used in the W-E Calculator 2.0, you may want to enter this information into CEDARS along with the embedded-energy savings.

ClaimID	WaterMeasCode	SavingsProfile	HydrologicRegion	Sector	WaterUse	Gallons	AnnualizedIOUkWh	AnnualizedNonIOUkWh	SourceDesc
			San Francisco Bay	Urban	Indoor	10,000	78	4	

Figure 9: The Output Table Tab

3.4 Entering Model Outputs into CEDARS

(Add text here once this is known)

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Appendices

Appendix A contains the default values and data sources for water-system components, the historical water-supply mix, and the fraction of embedded energy provided by an IOU.

A. Default Values Used by Water-Energy Calculator 2.0

Table 1: Total Electric Energy Intensity of Extraction and Conveyance for Each Hydrologic Region (kWh/AF)

Component	NC	SF	CC	SC	SR	SJ	TL	NL	SL	CR
Seawater Desalination Conveyance	100	100	100	100	100	100	100	100	100	100
Groundwater Pumping	383	491	506	697	294	301	347	381	401	532
Central Valley Project Conveyance	225	478	696	225	120	327	241	N/A	N/A	N/A
Colorado River Conveyance	N/A	N/A	N/A	2,111	N/A	N/A	N/A	N/A	N/A	116
State Water Project Conveyance	NA	1,062	2,056	3,306	241	527	2,603	NA	3,600	4,000
Recycled Water (Non-Potable) Conveyance	107	107	107	107	107	107	107	107	107	107
Local Deliveries	89	89	89	89	89	89	89	89	89	89
Local Imported Deliveries	89	112	N/A	33	N/A	N/A	N/A	N/A	N/A	N/A

Note: NC = North Coast, SF = San Francisco Bay, CC = Central Coast, SC = South Coast, SR = Sacramento River, SJ = San Joaquin, TL = Tulare Lake, NL = North Lahontan, SL = South Lahontan, CR = Colorado River

Data Sources: Klein et al. 2005, Cooley et al. 2012, GEI Consultants/Navigant Consulting 2010a, GEI Consultants/Navigant Consulting 2010b, Liu et al. 2017, Plappally 2012, Stokes-Draut et al. 2017, and Tarroja et al. 2014

Table 2: Total Electric Energy Intensity of Water Treatment (kWh/AF)

Treatment Technology	Energy Intensity (kWh/AF)
Seawater Desalination	4,497
Brackish Desalination	1,407
Conventional Drinking Water Treatment	205
Chlorination	63
Recycled Water – Urban Potable Treatment	1,272
Recycled Water – Ag Potable Treatment	1,066
Recycled Water - Non-Potable Treatment	607

Data Sources: Klein et al. 2005, Cooley et al. 2012, GEI Consultants/Navigant Consulting 2010a, GEI Consultants/Navigant Consulting 2010b, Stokes-Draut et al. 2017, Tarroja et al. 2014, and Tidwell et al. 2014.

Table 3: Total Electric Energy Intensity of Water Distribution (kWh/AF)

Component	NC	SF	CC	SC	SR	SJ	TL	NL	SL	CR
Urban Potable (Flat)					18	18	18	18		18
Urban Potable (Moderate)	163		163	163					163	
Urban Potable (Hilly)		318								
Recycled Water (Non-Potable)	416	416	416	416	416	416	416	416	416	416
Agriculture	144	144	144	488	19	19	389	144	389	488

Note: Distribution energy intensity for urban potable water was calculated by topography, i.e., flat, moderate, and hilly, and a default topography was assigned to each hydrologic region.

Data Sources: Cooley et al. 2012, Craig et al. 2014, GEI Consultants/Navigant Consulting 2010b, Klein et al. 2005, Liu et al. 2017, and Tidwell et al. 2014.

Table 4: Total Electric Energy Intensity of Wastewater Collection and Treatment (kWh/AF).

Technology	Energy Intensity (kWh/AF)
Wastewater Collection	72
Wastewater Secondary Treatment	654
Wastewater Tertiary Treatment	999

Data Sources: Cooley et al. 2012, EPRI 2002, GEI Consultants/Navigant Consulting 2010b, Klein et al. 2005, Liu et al. 2017, Tarroja et al. 2014, and Tidwell et al. 2014.

Table 5: Fraction of Energy Provided by an IOU for Each Water-Supply Component and Type

Water-Supply Component	Water-Supply Type	Fraction of IOU Energy
Extraction and Conveyance	Seawater	0.94
	Brackish Water	0.94
	Recycled Water (Non-Potable)	0.97
	Recycled Water (Potable)	0.97
	Groundwater	0.59
	Local Deliveries	0.27
	Local Imports	0.27
	Colorado River Deliveries	0
	Central Valley Project Deliveries	0
	State Water Project Deliveries	0
Water Treatment		0.94
Water Distribution		0.95
Wastewater Collection		0.97
Wastewater Treatment		0.97

Data Source: McDonald et al. 2014

Table 6: Water-Supply Mix, 2006-2015, by Hydrologic Region.

Water-Supply Type	NC	SF	CC	SC	SR	SJ	TL	NL	SL	CR
Seawater	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Brackish Water	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Recycled Water (Non-Potable)	0.0%	2.9%	0.5%	4.5%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%
Recycled Water (Potable)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Groundwater	2.1%	20.3%	88.5%	36.9%	21.6%	42.1%	62.8%	23.6%	70.6%	7.8%
Local Deliveries	96.4%	21.1%	2.2%	4.5%	54.3%	41.1%	16.9%	76.4%	15.9%	0.1%
Local Imports	0.1%	35.7%	0.0%	4.4%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%

Water-Supply Type	NC	SF	CC	SC	SR	SJ	TL	NL	SL	CR
Colorado River	0.0%	0.0%	0.0%	26.5%	0.0%	0.0%	0.0%	0.0%	0.0%	89.6%
Central Valley Project	1.4%	11.6%	7.0%	0.0%	23.6%	16.4%	12.9%	0.0%	0.0%	0.0%
State Water Project	0.0%	8.4%	1.8%	23.2%	0.2%	0.3%	7.4%	0.0%	13.4%	2.2%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Note: NC = North Coast, SF = San Francisco Bay, CC = Central Coast, SC = South Coast, SR = Sacramento River, SJ = San Joaquin, TL = Tulare Lake, NL = North Lahontan, SL = South Lahontan, CR = Colorado River

Data Source: Based on data from California Department of Water Resources 2018

Glossary of Terms

Term	Definition
Acre-Foot	The volume of water that would cover one acre to a depth of one foot (equivalent to 325,851 gallons)
Brackish Water	Water with a salinity ranging from 0.5 to 30 parts per thousand (ppt), which exceeds normally acceptable standards for municipal, domestic, and irrigation uses but is less than that of ocean water.
Central Valley Project and Other Federal Deliveries	The delivery of water to Central Valley Project contractors and to other federal water projects.
Colorado River Aqueduct	Water diverted from the Colorado River by the Metropolitan Water District of Southern California.
Desalination	Water treatment process for the removal of salt from water for beneficial use. Source water can be brackish or ocean water.
Distribution	The transport of treated water (both potable and non-potable) to the customer.
Electronic Technical Reference Manual (eTRM)	A statewide repository of California's deemed measures, including supporting values and documentation.
Embedded Energy	The amount of energy consumed in water and wastewater systems to provide water and dispose of wastewater.
Embedded-Energy Savings	The amount of energy that is saved in water and wastewater systems due to reductions in the amount of water that is extracted, conveyed, treated, and delivered as well as the wastewater that is collected, treated, and discharged.
Entergy Intensity	The amount of energy used to extract and convey, treat, and distribute water and to collect and treat wastewater on a per-unit basis, e.g., kilowatt-hours per acre-foot of water (kWh/AF)
Energy Load Profile	The hourly variation in energy use over the course of a day.
Extraction and Conveyance	The transport of untreated or partially treated water from its source through aqueducts, canals, and pipelines to a water treatment facility, or directly to the end user if using untreated water.
Groundwater	Water beneath the Earth's surface in soil pore space and in the fractures of rock formations.
Hydrologic Region	A geographical division of the state based on the local hydrological basins. The Department of Water Resources divides California into ten hydrologic regions, correspond to the state's major water drainage basins.
Local Deliveries	Water delivered by local water agencies and individuals. It includes direct deliveries of water from stream flows, as well as local water storage facilities.

Term	Definition
Local Imports	Water transferred by local agencies from other regions of the state.
Marginal Water Supply	The next increment or unit of water supply developed within a region to meet demand in the absence of water conservation and efficiency.
Measure Life	An estimate of the median number of years that the measure installed will remain in place and operable.
Recycled Water (Non-Potable)	Municipal wastewater that is treated to meet a non-potable beneficial use.
Recycled Water (Potable)	Municipal wastewater that is treated to meet a potable beneficial use.
Resource Balance Year (RBY)	The year in which new capacity will be required to meet water demand.
Water Treatment	Processes and technologies that treat water prior to its distribution to the end user.
Wastewater Collection	Movement of untreated wastewater from the end user to a wastewater treatment facility.
Wastewater Treatment	Application of biological, physical, and/or chemical processes to bring wastewater to discharge standards.