Report Group D – D14.01

Water-Energy Calculator 2.0 Project Report

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Executive Summary

Background

Extracting, moving, treating, and using water requires a substantial amount of energy, especially in California where large amounts of water are moved over long distances and steep terrain. As a result, saving water through water-efficiency measures also saves energy and can help investor-owned energy utilities (IOUs) meet energy-efficiency and greenhouse-gas-reduction goals.

Beginning in 2013, the California Public Utilities Commission (CPUC) engaged Navigant Consulting, Inc. and GEI Consultants (the Navigant team) to develop a cost-effectiveness framework for analyzing demand-side programs aimed at saving water and energy, along with a set of models and calculators to estimate three water-related benefits:

- the avoided embedded IOU energy in water,
- the avoided capacity cost of water, and
- the environmental benefits of reduced water use.

With Decision 15-09-023, the CPUC adopted two tools developed by the Navigant team to quantify the benefits of water-saving programs: the Avoided Water Capacity Cost Model (also referred to as the Water Tool) and the Water-Energy Calculator (hereafter referred to as W-E Calculator 1.0). The Water Tool estimates the avoided capacity cost of water, which is an input into the W-E Calculator 1.0. The W-E Calculator 1.0 estimates the embedded IOU energy savings of water-conservation measures, as well as the IOU avoided embedded energy cost.

A year of using the W-E Calculator 1.0 yielded new insights about its utility and function, and in Decision 16-12-047, the CPUC directed the four major investor-owned utilities (IOUs) to create a Plan of Action to update the W-E Calculator 1.0. Decision 17-12-010 approved the unopposed Plan of Action and closed Rulemaking 13-12-011.

Project Goals and Objectives

The CPUC tasked the Pacific Institute and SBW Consulting Team with developing a new, simpler Water-Energy Calculator (hereafter referred to as W-E Calculator 2.0). In pursuit of this goal, the Pacific Institute and SBW Consulting Team had three primary objectives:

- Engage stakeholders to identify key issues and concerns to inform changes to the W-E Calculator 1.0,
- Update the W-E Calculator 1.0 to create the W-E Calculator 2.0, in accordance with Decision 17-12-010, the Water Energy Joint Utility Plan of Action, and input received through stakeholder engagement, and

- Develop readable and accessible documentation for the W-E Calculator 2.0 that can be easily understood by a nontechnical audience and provide a help desk and recorded training session.

Key Enhancements for the W-E Calculator 2.0

Key enhancements to the functionality and utility of the W-E Calculator 2.0 were identified based on a detailed review of the W-E Calculator 1.0 and related documents and interviews with stakeholders. These are summarized in Table 1.

Table 1: Summary of Key Enhancements for the W-E Calculator 2.0

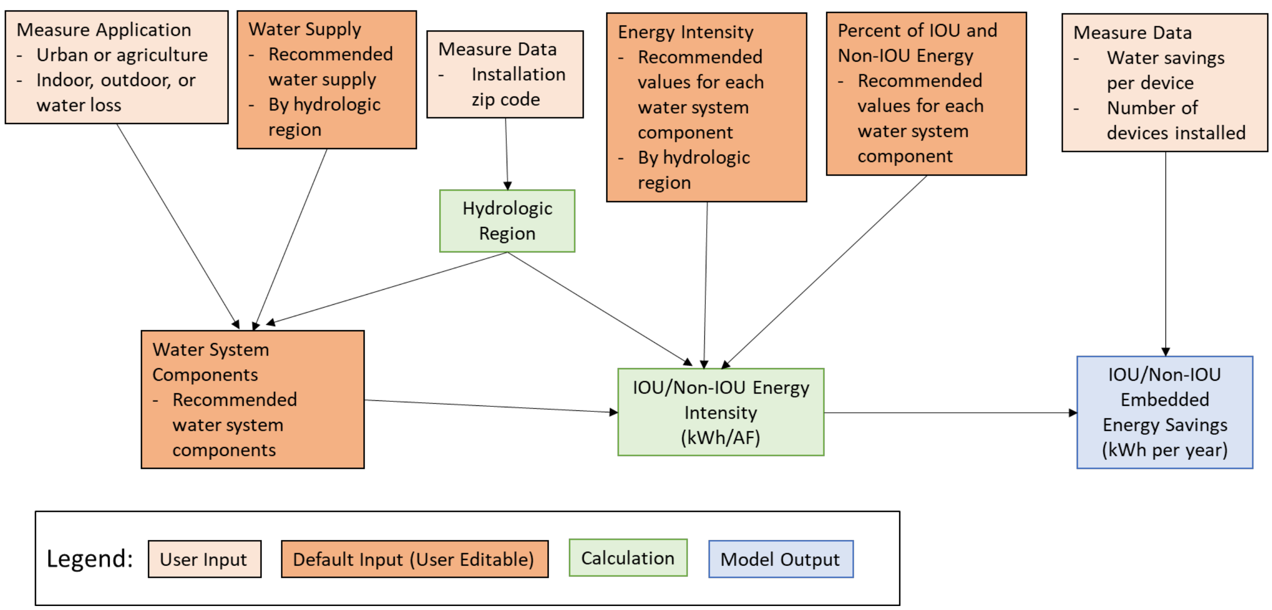
Simplify the calculator
Remove cost-effectiveness calculations
Determine whether to use avoided/marginal water supply when calculating embedded energy savings
Enhance the calculator functionality
Allow user to easily modify the resource balance year
Allow user to specify terrain to determine distribution energy requirements
Allow user to modify default selections and values for extraction, conveyance, water treatment, water distribution, and wastewater systems
Allow for inclusion of water efficiency measures for distribution system leaks
Allow user to select trucked water as a marginal water source (if appropriate)
Provide user a mechanism for identifying the hydrologic region associated with a measure
Review model default values and update as needed
Ensure integration with other CPUC tools
Ensure model inputs are consistent with DEER, eTRM, and work papers
Ensure model outputs are consistent with CEDARS report structure
Ensure model outputs are consistent with CET
Expand education and outreach
Develop easy-to-read user's manual
Provide a recorded training session
Conduct presentations to promote opportunities for water-energy partnerships

Water-Energy Calculator 2.0

The W-E Calculator 2.0 is specifically designed to estimate the investor-owned utility (IOU) and non-IOU embedded energy savings that result from water-efficiency measures. The embedded energy savings can be entered directly into the California Energy Data and Reporting System

(CEDARS) to count those savings toward their energy-efficiency goals and for cost-effectiveness evaluations using the Cost Effectiveness Tool (CET). We and the CPUC identified a short-term and long-term solution to expeditiously integrate the embedded energy savings into CEDARS.

Figure 1 illustrates the underlying methodology used in the W-E Calculator 2.0 to estimate embedded energy savings. Fundamentally, the W-E Calculator 2.0 estimates embedded energy savings by multiplying the annual water savings of an efficiency measure by the energy intensity of relevant water-system components. The energy intensities of the water-system components depend on several factors, including the source of the water saved and its geographic location. Defaults are provided throughout the model; however, the user can adjust these defaults as appropriate for the measures evaluated.



This is a simplified version of the underlying conceptual framework for the W-E Calculator. Although not depicted here, the installation year, measure life, and resource-balance year determine whether the marginal or historical water-supply mix are used to estimate embedded energy savings. This is described in more detail in sections 3.4 and 3.4.

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

Comparison of the W-E Calculator 1.0 and 2.0

In this section, we compare the embedded energy savings for a water-efficiency measure, as estimated using the two versions of the W-E Calculator. In this example, the measure is installed in 2021 and saves 10,000 gallons of water annually. We used the default values for the resource balance year (2016), marginal water supply (non-potable recycled water), and water-system components.

Table 2 provides the IOU embedded energy savings averaged across the state's ten hydrologic regions. IOU embedded energy savings for all sectors and water use types are higher with the W-E Calculator 2.0 than with the W-E Calculator 1.0. Compared to the W-E Calculator 1.0, IOU embedded energy savings in the W-E Calculator 2.0 are 226% higher for an urban outdoor water efficiency measure, 142% higher for an urban indoor water efficiency measure, and 245% higher for an agricultural outdoor water efficiency measure. Across the three water use types for the urban and agricultural sectors, the IOU embedded energy savings are 183% higher in the W-E Calculator 2.0. This is because the W-E Calculator 2.0 uses non-potable recycled water as the marginal water supply for each hydrologic region, whereas the W-E Calculator 1.0 bases embedded energy savings on the historical water supply mix for each hydrologic region. The historical water supply mix is less energy intensive than the marginal water supply in all but the South Coast region and less reliant on electricity from IOUs across the state.

Table 2: Comparison of IOU Embedded Energy Savings, in kWh, from the W-E Calculator 1.0 and 2.0.

Sector	Water Use Type	IOU Embedded Energy Savings (kWh per 10,000 gallons)		Percent Difference
		W-E Calculator 1.0	W-E Calculator 2.0	
Urban	Outdoor	10.06	32.82	226%
Urban	Indoor	22.51	54.42	142%
Agriculture	Outdoor	8.00	27.60	245%
Average		**13.52**	**38.28**	**183%**

Based on an efficiency measure installed in 2021 that saves 10,000 gallons annually and the default values for the resource balance year (2016), marginal water supply (non-potable recycled water), and water-system components.

Recommendations

The following recommendations for further improvements to the W-E Calculator 2.0 and its implementation can help the state to better estimate embedded energy savings and realize the full potential of water-efficiency measures to reduce statewide energy use and greenhouse-gas emissions.

- **Evaluate the default marginal water supply and revise as appropriate.**

The W-E Calculator 2.0 follows D.15-09-23 in its use of the long-run marginal water supply to estimate embedded energy savings. Like its predecessor, it uses non-potable recycled water as the default marginal water supply for each of the California's ten hydrologic regions and allows the user to adjust this default assumption according to local circumstances. New regulations, along with changing technologies and practices, suggest that reviewing the default marginal water supply may be warranted. We recommend that the CPUC evaluate whether it is appropriate to modify the default marginal water supply for each hydrologic region for urban and agricultural water use.

- **Evaluate whether to use a resource balance year (RBY), and if so, select an appropriate year.**

Consistent with D.15-09-23, the W-E Calculator 2.0 uses 2016 as the RBY and allows the user to easily alter this default value. Using 2016 as the RBY recognizes that traditional water sources across California are overallocated, and there is pressure to reduce water withdrawals from these sources by developing new, mostly local, water supplies. As a result, water savings from water-efficiency measures reduce the need to develop new sources of supply, suggesting that we are “in marginal territory.” Moreover, there was no immediately available process by which to revise the RBY, and no new analysis indicating that a different year should be selected. We recommend that the CPUC evaluate whether to continue using a RBY, or to eliminate it, as has been done for energy efficiency analyses. If use of a RBY is maintained, we recommend that the CPUC conduct an evaluation to determine the appropriate year.

- **Consider updating the Water Tool to include as a non-energy benefit in Total System Benefit (TSB) analyses and to evaluate whether to incorporate water-related environmental benefits.**

The W-E Calculator 2.0 does not include a cost-effectiveness analysis. Rather, such analyses are done within the CET. The CET allows including non-energy benefits in TSB analyses, and thus the avoided cost of adding water capacity could be added to those analyses. While it was beyond the scope of this work to revise the Water Tool, we recommend that the CPUC consider updating the Water Tool and its underlying assumptions. We also recommend evaluating environmental benefits associated with reduce water usage and incorporating them as non-energy benefits as appropriate.

- **Review calculator default assumptions every five years and update as needed, consistent with the frequency of updates for key water-planning documents.**

Regularly updating the W-E Calculator 2.0 will help ensure that the default assumptions reflect current water policies and practices. Ultimately, this will improve the accuracy of assessments of embedded energy savings. We recommend reviewing the default assumptions every five years and updating them as needed. This is consistent with the frequency of updates for key water-planning documents.

- **Implement the long-term solution identified for integrating embedded energy savings into CET analyses.**

The stakeholder interviews identified two key issues: (1) cost-effectiveness analyses did not include embedded energy savings, and (2) IOUs were unable to claim credit for these savings toward their energy efficiency goals. While revising the water-energy calculator, we worked closely with CPUC to develop a short-term and long-term solution for integrating embedded energy savings into CET analyses. The short-term solution will be available immediately to PAs. However, the long-term solution will require changes to the structure and calculations within the CET, as identified in Appendix B. We recommend that the CPUC implement the long-term solution for integrating embedded energy savings into CET analyses as soon as is practicable so that PAs and CPUC can better determine the role of embedded energy savings in meeting energy-efficiency goals and promote greater investment in cost-effective water-efficiency measures that save energy.

- **Expand partnerships between energy PAs and water utilities to realize greater water and energy savings and help the state to meet its water, energy, and greenhouse-gas goals.**

Spang et al. (2018) found that water efficiency can achieve significant electricity and greenhouse-gas (GHG) savings at costs competitive with existing energy-efficiency programs. This suggests that partnerships between energy PAs and water utilities could benefit ratepayers and also help the state realize water, energy, and greenhouse-gas goals. This is especially important as the state faces another severe drought and climate impacts are intensifying. We recommend that the CPUC proactively expand partnerships between energy PAs and water utilities across California. Additionally, we recommend that the CPUC facilitate partnerships explicitly between water and energy IOUs, both of which are regulated by the CPUC.

1 Introduction

1.1 Water-Energy Nexus

Extracting, moving, treating, and using water requires a substantial amount of energy, especially in California where large amounts of water are moved over long distances and steep terrain. In a landmark 2005 study, the California Energy Commission (CEC) found that water accounted for nearly 20% of California's electricity consumption and one-third of its non-power-plant natural-gas consumption.[1]

Water-related energy is often divided into two categories:

- **Direct energy**, sometimes referred to as end-use energy, is the energy used on the customer side of the meter by, for example, reducing on-site pumping and hot-water usage.
- **Embedded energy** is the energy used to extract, convey, treat, and distribute water to end users, and energy used to collect and transport wastewater for treatment prior to safe discharge of the effluent in accordance with regulations.

As a result, water-efficiency measures also save energy and can help investor-owned energy utilities (IOUs) meet energy-efficiency and greenhouse-gas-reduction goals. Energy utilities in California often refer to water-efficiency measures as Water-Energy Nexus (WEN) measures. These measures can be implemented in residential, commercial, industrial, and agricultural settings and include, for example, low-flow showerheads, efficient clothes washers, high-efficiency toilets, weather-based irrigation controllers, turf removal, drip irrigation, and dry-vacuum pumps.

As with energy use, water-related energy savings that occur on the customer side of the meter are referred to as "direct energy savings," and those energy savings that occur upstream and downstream of the customer are referred to as "embedded energy savings."

1.2 Water-Energy Proceedings

Water-related energy use in California has been of interest to the California Public Utilities Commission (CPUC) since the mid-2000s. In 2005 and again in 2010, the CPUC's Water Action Plan emphasized the importance of water and energy efficiency. In Decision 07-12-050, the CPUC authorized three "embedded energy in water studies" and numerous pilot projects to study the savings potential of programs targeting embedded energy in water.

With Decision 12-05-015, the CPUC directed staff to develop a robust record of strategies to overcome barriers to the adoption and deployment of programs aimed at improving water-energy-nexus efficiency, including methods for calculating the energy savings and cost-

[1] California Energy Commission, November 2005, "California's Water-Energy Relationship," Final Staff Report CEC700-2005-011-SF.

effectiveness of water-efficiency measures, issues associated with the joint funding and implementation of water-energy programs, and the development of an updated water-energy cost-effectiveness calculator. In response to this directive, staff created a workplan to address water-energy-nexus issues. They also presented a proposed cost-effectiveness framework that would help evaluate water-energy-efficiency projects and programs. Finally, staff formed a Project Coordination Group for Water Energy Cost-Effectiveness (PCG) to allow industry stakeholders to provide input and assistance on a framework to analyze water-energy programs.

A petition from the Division of Ratepayer Advocates prompted the CPUC to open Rulemaking 13-12-011. The purpose of this rulemaking was to explore how best to "develop more robust methodologies for measuring the embedded energy savings from energy efficiency and conservation measures in the water sector, and for determining the cost-effectiveness of these projects."[2] This would inform whether and how such programs should be cofunded by the energy IOUs and the water sector—both privately owned water utilities regulated by the CPUC and public water and wastewater agencies—as well as how program costs should be allocated.

Beginning in 2013, the CPUC engaged Navigant Consulting, Inc. and GEI Consultants (the Navigant team) to develop a cost-effectiveness framework for analyzing demand-side programs aimed at saving water and energy. Through this effort, the Navigant team developed a set of models and calculators for estimating three water-related benefits:

- the avoided embedded IOU energy in water,
- the avoided capacity cost of water, and
- the environmental benefits of reduced water use.

With Decision 15-09-023, the CPUC adopted two tools to quantify the benefits of water-saving programs: the Avoided Water Capacity Cost Model (also referred to as the Water Tool) and the Water-Energy Calculator (hereafter referred to as W-E Calculator 1.0). The Water Tool estimates the avoided capacity cost of water, which is an input into the W-E Calculator 1.0. The W-E Calculator 1.0 estimates the embedded IOU energy savings of water-conservation measures, as well as the IOU avoided embedded energy cost.

A year of using the W-E Calculator 1.0 yielded new insights about its utility and function, and in Decision 16-12-047, the CPUC directed the four major investor-owned utilities (IOUs)—Southern California Edison Company (SCE), San Diego Gas & Electric Company (SDG&E), Southern California Gas Company (SoCal Gas), and Pacific Gas and Electric Company (PG&E) (collectively referred to as the Joint IOUs)—to create a Plan of Action to update the W-E Calculator 1.0 and to file it with the CPUC. Specifically, the Plan of Action was to address how best to:

> "(a) create, and incorporate into the Water-Energy Calculator, a greenhouse gas emissions reductions value for water-energy nexus energy efficiency measures; (b) connect the Water-Energy Calculator with the commonly-used E3 energy efficiency program calculator and the

[2] D.13-12-11 at 2.

Database for Energy Efficient Resources; (c) within 6 months of the completion of Southern California Gas Company's natural gas study, incorporate into the Water-Energy Calculator a value representing the natural gas embedded in the water system."[3]

The Plan of Action submitted by the Joint IOUs in August 2017 described the options for addressing each issue identified in Decision 16-12-047, as well as next steps required to implement the recommended changes. The CPUC's Energy Division previously met with representatives of the Joint IOUs in January 2017 to discuss the Energy Division's "Recommendations for Water Energy Calculator Update," and these recommendations were incorporated into the Plan of Action. Decision 17-12-010 approved the unopposed Plan of Action and closed Rulemaking 13-12-011.

1.3 Project Goals and Objectives

The Pacific Institute and SBW Consulting Team was asked to develop a new, simpler Water-Energy Calculator (hereafter referred to as W-E Calculator 2.0). In pursuit of this goal, we had three primary objectives:

- Engage stakeholders to identify key issues and concerns to inform changes to the W-E Calculator 1.0,
- Update the W-E Calculator 1.0 to create the W-E Calculator 2.0, in accordance with Decision 17-12-010, the Water Energy Joint Utility Plan of Action, and input received through stakeholder engagement, and
- Develop readable and accessible documentation for the W-E Calculator 2.0 that can be easily understood by a nontechnical audience and provide a help desk and recorded training session.

1.4 Structure of the Report

The remainder of this report describes the methodology and supporting documentation for the W-E Calculator 2.0. Section 2 summarizes the key enhancements identified by reviewing the W-E Calculator 1.0 and related documents and interviewing stakeholder. Section 3 describes the underlying methodology for the W-E Calculator 2.0, as well as basic elements of that methodology. Section 4 compares the outputs of the W-E Calculator 2.0 with those of its predecessor. Section 5 offers recommendations for next steps. The Appendices provide stakeholder interview questions, the short- and long-term solutions for integrating embedded energy savings into the California Energy Data and Reporting System (CEDARS), and the W-E Calculator 2.0 user manual.

[3] D.16-12-047 at 50.

2 Key Enhancements for the W-E Calculator 2.0

This section summarizes the key enhancements identified to improve the functionality and utility of the W-E Calculator 2.0 based on a detailed review of the W-E Calculator 1.0 and related documents prepared by and/or submitted to the CPUC and interviews with stakeholders.

2.1 Document Review

We compiled a list of documents to review related to the development and use of the W-E Calculator 1.0 and submitted this list to CPUC Energy Division staff for review for additional suggestions. Table 3 lists all the documents reviewed to identify opportunities to improve the utility and functionality of the calculator.

Table 3: Documents Reviewed for the W-E Calculator Updates

Author(s) (Organization)	Date	Title
CPUC	2013	Rulemaking R.13-12-011
Morgenstern & Younghein (CPUC)	3/21/2013	Energy Division Staff Proposal for a Water/Energy Cost-Effectiveness Framework
McDonald et al. (Navigant)	10/7/2014	Water/Energy Cost-Effectiveness Analysis, Final Report
Commissioner Sandoval (CPUC)	4/27/2015	Order Instituting Rulemaking into Policies to Promote a Partnership Framework between Energy Investor-Owned Utilities and Water Sector to Promote Water-Energy Nexus Programs; Rulemaking 13-12-011, Assigned commissioner's amended scoping memorandum and ruling
CPUC, Navigant, GEI Consulting Engineers and Scientists	9/1/2015	Avoided Water Capacity Cost Model, Draft V1.04
CPUC	9/25/2015	Decision 15-09-023 September 17, 2015, Before the Public Utilities Commission of the State of California, Rulemaking 13-12-011
CPUC	2/1/2016	Water-Energy Calculator Draft: Version 1.05
Jill Kjellsson (PG&E)	4/6/2016	W-E Calculator 2.0 Workshop: Experience Implementing the W-E Calculator
Athena Besa (SDG&E) and Carlo Gavina (SCG)	4/6/2016	Water Energy Nexus Calculator 2.0 Workshop
Elise Torres (TURN)	4/6/2016	R. 13-12-011: Track 3 Water Energy Nexus Calculator 2.0 Workshop
Water Energy Innovations, Inc. and RMS Energy Consulting, LLC	4/17/2017	Implementation of the California Public Utilities Commission's Water-Energy Calculator: Issues and Opportunities
RMS Energy Consulting, LLC	4/18/2017	WEN Calculator Usage Reconsideration
San Diego Gas & Electric	4/21/2017	Work Paper WPSDGEWEN001 Revision 0, Water Energy Nexus Measures

Author(s) (Organization)	Date	Title
Water Energy Innovations, Inc.	7/5/17	Natural Gas Intensity of Water
CPUC	8/14/2017	Water Energy Nexus Cost Calculator Plan of Action
CPUC	12/14/2017	Decision 17-12-010
The Climate Registry	6/1/2019	Water-Energy GHG Metrics Guidance for Water Managers in Southern California, V2.0

Documents are listed in chronological order.

2.2 Interviews

We interviewed 22 stakeholders, including representatives from energy IOUs, water-energy experts, and CPUC staff and consultants between April and July 2020 (listed in Table 4). The interviews focused on identifying issues with the W-E Calculator 1.0 and, more broadly, with implementing water-energy-nexus measures. CPUC staff reviewed the interview questions, which are provided in Appendix A. We altered some questions slightly based on the stakeholder's area of interest and expertise. We sent the questions to all interviewees in advance of the call. We conducted the interviews by phone and videoconference, and each lasted approximately one hour.

Table 4: List of Representatives and Organizations Interviewed

Name	Organization/Company
Amy Reardon	California Public Utilities Commission
Peter Biermayer	California Public Utilities Commission
Eric Merkt	Consultant
Bob Ramirez	DNV GL
Kerri-Ann Richard	DNV GL (formerly Energy & Resource Solutions)
Amul Sathe	Guidehouse (formerly Navigant Consulting, Inc.)
Kristin Landry	Guidehouse (formerly Navigant Consulting, Inc.)
Scott Fable	Pacific Gas and Electric
Mary Anderson	Pacific Gas and Electric
Martin Vu	RMS Energy Consulting, LLC
Angela Crowley	RMS Energy Consulting, LLC
Athena Besa	San Diego Gas and Electric
Sandra Williams	San Diego Gas and Electric
Jennifer Scheuerell	Sound Data Management, LLC
Ryan Bullard	Southern California Edison
Brandon Sanders	Southern California Edison
Erin Brooks	Southern California Gas Company

Name	Organization/Company
Paul Deang	Southern California Gas Company
Carlo Gavina	Southern California Gas Company
Chelsea Hasenauer	The Climate Registry
Kendra Olmos	UC Davis, Center for Water-Energy Efficiency
Laurie Park	Water Energy Innovations, Inc.

2.3 Summary of Findings

The documents reviewed and the interviews provided key insights on implementing water-energy programs and use of the W-E Calculator 1.0. We found that energy IOUs' water-energy-efficiency programs were primarily focused on hot-water savings. Energy IOUs were partnering with water utilities for some of these programs, including those for hot-water measures and for custom programs at the water utilities' facilities. The programs selected were largely limited to those measures described in work papers. Energy-efficiency programs were shifting toward third-party implementation, and the impact of this shift on water-energy programs was not known.

Further, we found that energy IOUs were using the W-E Calculator 1.0 to estimate the embedded energy savings from their water-energy-nexus programs. Some were also using it to evaluate potential savings from proposed standards and codes. While embedded energy savings are reported to the CPUC for informational purposes, these savings are not currently being credited toward IOU efficiency goals. Additionally, the embedded energy savings are not integrated into evaluations of measure cost effectiveness because the Cost-Effectiveness Tool (CET) is not currently designed to receive those inputs.

Finally, the documents reviewed and the interviews identified several opportunities for improving the utility and function of the calculator. These are described in more detail in sections 2.3.1 and 2.3.4. Table 5 summarizes the key enhancements for the W-E Calculator 2.0 based on the opportunities identified.

Table 5: Summary of Key Enhancements for the W-E Calculator 2.0

Simplify the calculator
Remove cost-effectiveness calculations
Determine whether to use avoided/marginal water supply when calculating embedded energy savings
Enhance the calculator functionality
Allow user to easily modify the resource balance year
Allow user to specify terrain to determine distribution energy requirements

	Allow user to modify default selections and values for extraction, conveyance, water treatment, water distribution, and wastewater systems
	Allow for inclusion of water efficiency measures for distribution system leaks
	Allow user to select trucked water as a marginal water source (if appropriate)
	Provide user a mechanism for identifying the hydrologic region associated with a measure
	Review model default values and update as needed
Ensure integration with other CPUC tools	
	Ensure model inputs are consistent with DEER, eTRM, and work papers
	Ensure model outputs are consistent with CEDARS report structure
	Ensure model outputs are consistent with CET
Expand education and outreach	
	Develop easy-to-read user's manual
	Provide a recorded training session
	Conduct presentations to promote opportunities for water-energy partnerships

2.3.1 W-E Calculator 1.0 Errors

Both the interviews and literature review uncovered several errors in the W-E Calculator 1.0, including a few issues with the default selections and values for various water-system components. For example, while Decision 15-09-023 specified that users can change default selections for various water-system components, the W-E Calculator 1.0 only allowed the user to change the default selection for water supply but not for water treatment, distribution, or wastewater collection and treatment. Likewise, the W-E Calculator 1.0 erroneously assumes that the embedded energy requirements for the distribution of non-potable recycled water are the same as those for potable water.

Other errors related to implementing key features. For example, while there was a placeholder for entering natural-gas energy intensity of all water-system components, the calculator did not use those values when calculating embedded energy savings or avoided embedded energy cost. Likewise, the urban-runoff function of the model allowed the user to account for embedded energy attributable to capturing and treating runoff from outdoor irrigation in combined sewers. However, this function overestimated embedded energy savings because it assumed that all the water saved (rather than some fraction of it) would have gone to the sewer system and been treated to secondary standards. Finally, several issues related to the resource balance year, suggesting that the calculator did not appropriately integrate marginal supply into calculations of embedded energy savings.

2.3.2 Calculator Functionality

The W-E Calculator 1.0 is an Excel-based tool that most users found easy to use. The most common feedback from the interviews was that outputs should be consistent with inputs needed for other CPUC tools, including the CET and CEDARS. Additionally, several components of the W-E Calculator 1.0 could be removed to provide a more streamlined calculator. For example, the Plan of Action and Decision 17-12-010 recommended that greenhouse-gas emissions not be included because they are already integrated into other models. Likewise, some interviewees suggested that avoided water and wastewater-utility cost and the water-related environmental benefits could be removed because they do not use these components regularly and do not need them for advancing water-energy-efficiency programs. Others, however, suggested that avoided water-capacity cost and environmental benefits could be captured as non-energy benefits in other CPUC tools.

The literature review and interviews identified several components that could be added or improved to enhance the functionality of the calculator. The opinions of stakeholders varied on the potential addition of default natural-gas values. While this feature would increase the model functionality, it would not likely be used because natural-gas use by water and wastewater systems is small and declining. Finally, interviewees identified several other features that could improve the model functionality, such as:

- providing simple menus for users to select water-system components, energy-intensity values, resource balance year, and terrain,
- providing an energy intensity value for trucked water,
- adding a GIS overlay of IOU service territories and hydrologic regions, and
- adding a water-use designation that captures water savings opportunities from reducing leaks in the water distribution system.

2.3.3 CPUC Policies and Procedures

The interviews and literature review revealed where additional clarity and guidance are needed on CPUC policies and procedures. For example, there was some confusion about whether embedded energy savings can be credited toward energy-efficiency goals. Some were also unclear whether and what type of justification was needed to depart from the default selections (e.g., changing the marginal supply from non-potable recycled water to imported water) or from the default values (e.g., changing the energy intensity for treatment of non-potable recycled water from 607 to 800 kWh per acre-foot). Finally, there were several technical questions about how to handle areas that fall into multiple hydrologic regions or how to select an appropriate resource balance year.

2.3.4 Education and Outreach

The interviews identified the need for a comprehensive user manual and additional user support for the calculator. Because the calculator is designed for energy IOUs and their Program Administrators (PAs), several stakeholders noted that the user manual should be written for an audience that may not be familiar with water terminology. Though the tool was primarily designed for energy IOUs and PAs, using it to further partnerships with water suppliers might be possible.

3 Water-Energy Calculator 2.0

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—calculations of the avoided embedded energy cost, the avoided water-capacity cost, and all cost-effectiveness functionalities have been removed. The W-E Calculator 2.0 provides an estimate of the embedded energy savings (in kWh), which can be entered directly into the California Energy Data and Reporting System (CEDARS) for cost-effectiveness evaluations using the Cost Effectiveness Tool (CET).

3.1 General Approach

Fundamentally, the W-E Calculator 2.0 estimates embedded energy savings by multiplying the annual water savings of an efficiency measure by the energy intensity of relevant water-system components. The energy intensities of the water-system components depend on several factors, including the source of the water saved and its geographic location. The calculator provides many default inputs, which the user can adjust as appropriate for the measures evaluated.

Figure 2 illustrates the underlying methodology used in the W-E Calculator 2.0. Calculating embedded energy savings follows these four steps:

The user enters basic information about the measure(s) being evaluated. This includes the installation year, annual water savings per device, number of devices installed, measure application, measure life, and the zip code where the measure was installed. The zip code determines the hydrologic region for the analysis.

Based on the hydrologic region, the calculator provides a default marginal water supply that represents the source of the water saved,[4] which the user can adjust as needed. The water supply selected, combined with the measure application,[5] determine the water-system components[6] included in the analysis.

Based on the hydrologic region and marginal supply, the calculator provides default energy-intensity values (in kilowatt-hours per acre-foot) for each water-system component included in the analysis. The calculator also provides default values for the percent of the energy provided by an IOU. The user can adjust default values as appropriate for the measures included in the analysis. However, per D.15-09-023, when PAs use non-default values, they must prove that those values are reasonable in all documents submitted to CPUC.

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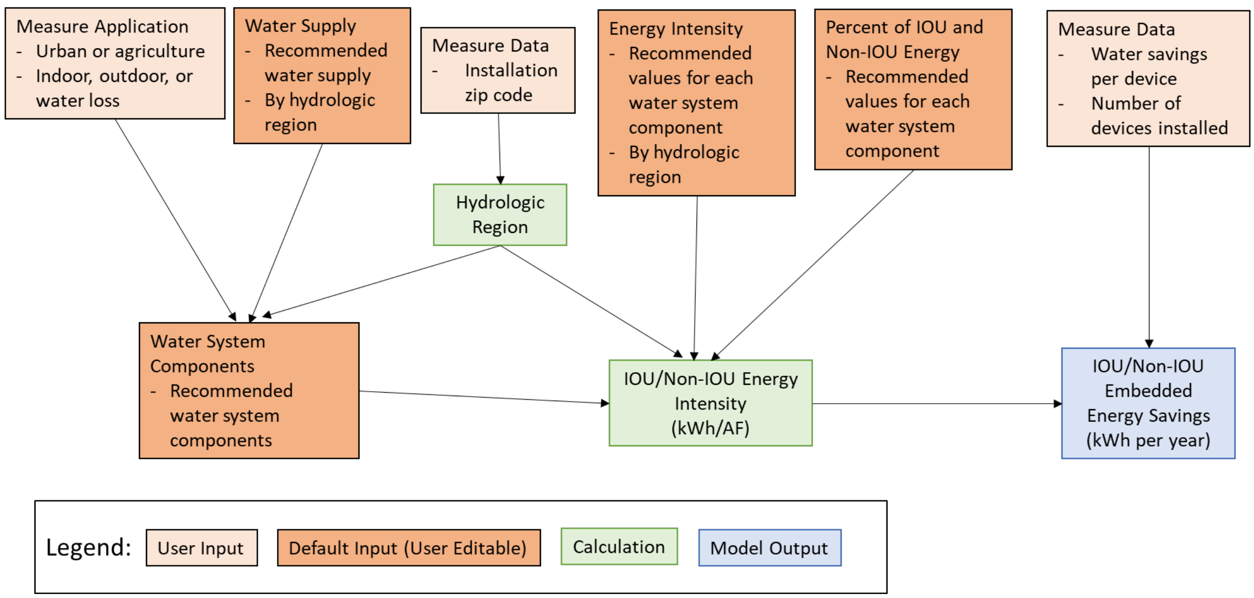
4 As described in section 3.4.1, a default marginal supply of non-potable recycled water, i.e., wastewater treated to tertiary, unrestricted standards, is assumed for all hydrologic regions in California.

5 The measure application indicates whether the measure is applied in an urban or agricultural setting and whether it reduces indoor water use, outdoor water use, or losses in the water distribution system.

6 Water-system components include water extraction and conveyance, water treatment, water distribution, wastewater collection, and wastewater treatment.

The calculator estimates the total embedded energy savings (including IOU and non-IOU energy, in kWh) by multiplying annual water savings by the sum of the energy-intensity values of the water-system components. It then estimates IOU embedded energy savings by multiplying the annual water savings by the sum of the product of the water-system-component energy-intensity value and the fraction of IOU energy for each component. Subtracting IOU embedded energy savings from the total embedded energy savings yields the non-IOU portion of embedded energy savings.



This is a simplified version of the underlying conceptual framework for the W-E Calculator. Although not depicted here, the installation year, measure life, and resource-balance year determine whether the marginal or historical water-supply mix are used to estimate embedded energy savings. This is described in more detail in sections 3.4 and 3.4.

Figure 2: Conceptual Framework of the W-E Calculator 2.0

3.2 Relationship with Other CPUC Tools

The W-E Calculator 2.0 allows PAs to estimate embedded energy savings associated with water-efficiency measures. Integrating embedded energy savings into CEDARS allows the PAs to count those savings toward their energy-efficiency goals and to incorporate them into cost-effectiveness evaluations. Integrating the embedded energy savings expeditiously, however, requires a short-term and a long-term solution, which we summarize here. Appendix B contains additional detail on these approaches.

Figure 3 shows the short-term solution for integrating embedded energy savings into CEDARS. Here, the W-E Calculator 2.0 was run using default assumptions to estimate embedded energy intensities (in units of kWh per 1,000 gallons, or kWh/kgal). Dividing the number of gallons saved by a measure by 1,000 (to put the water savings in kgal) and multiplying the result by the embedded energy intensity yields the embedded energy savings. The eTRM automatically adds the embedded energy savings to the direct energy savings of the measure (per D.17-12-010). By entering the combined value, along with other site-specific savings values, into the CET, it can calculate the measure's cost-effectiveness. PAs can also use the combined value when submitting a claim for this measure. This approach is only suitable for measures that use the default marginal water supply, i.e., recycled non-potable water. Only under the long-term solution can PAs claim measures that use a non-default marginal supply, so they must wait until that solution is implemented. Additionally, per D.15-09-023, where PAs depart from default values, they must show that the departure is reasonable in all documents submitted to the CPUC.

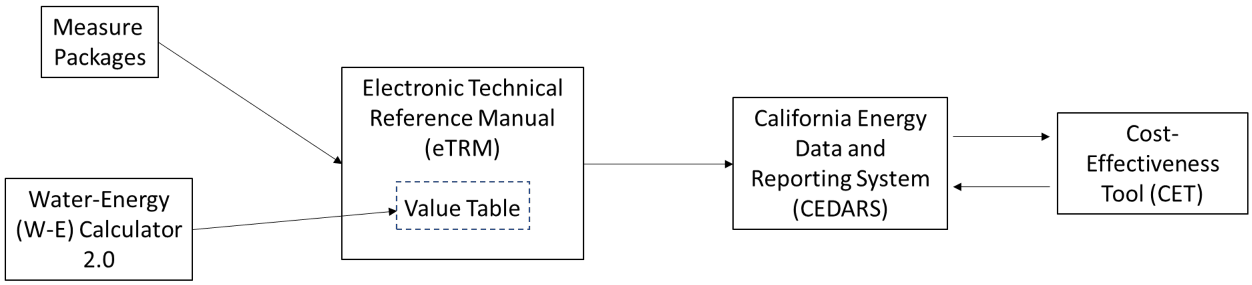


Figure 3: Short-term Relationship Between the W-E Calculator 2.0, eTRM, CEDARS, and CET

Figure 4 shows the long-term solution for integrating embedded energy savings into CEDARS. Here, PAs will use the new CET functionality to enter the direct energy savings and IOU embedded energy savings separately into the CET through CEDARS. The direct energy savings will be calculated using the measure-package methodology. The IOU embedded-water-energy savings will be calculated following the same methodology as used in the short-term solution, but this value will be stored independently within the eTRM and CEDARS to facilitate reporting and cost-effectiveness calculations. The PA will still receive the same credit for both the direct and embedded energy savings as they received using the short-term solution, but for accounting purposes the two types of savings will be entered into the CET and claims separately. Once finalized by the CPUC, this will replace the short-term solution.

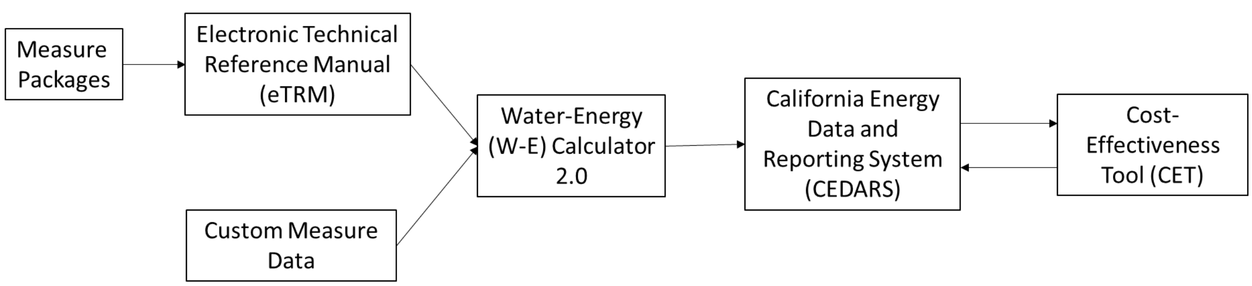


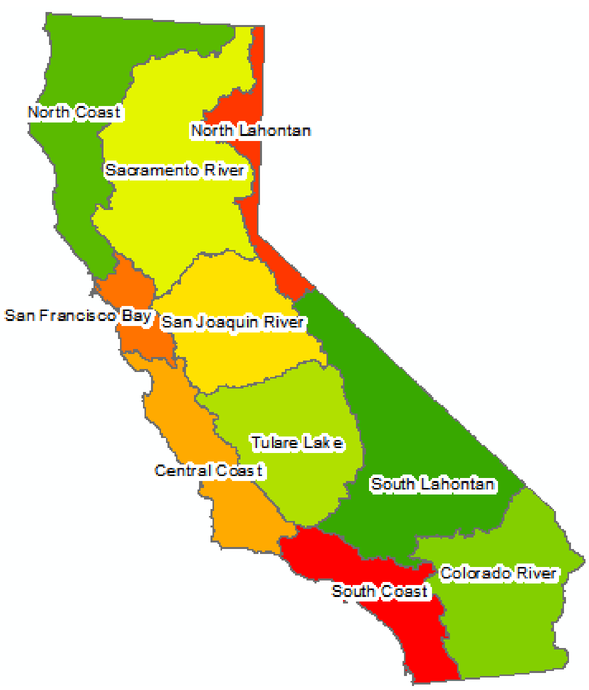
Figure 4: Long-term Relationship Between the W-E Calculator 2.0, eTRM, CEDARS, and CET

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 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 total water-related energy savings. CEDARS then interfaces with the CET to determine the measure's cost effectiveness.

Previously, PAs have been required to report water savings on CEDARS. As a policy matter, PAs were also able to claim savings towards their energy efficiency goals on WEN measures using W-E Calculator 1.0. However, there was confusion about whether and how to do this, as the CPUC had not created a clear mechanism to serve that function.

3.3 Regional Analysis

The available water supplies and their associated energy intensities vary across California. To account for this variability, the W-E Calculator 2.0 operates at a regional level, using the ten hydrologic regions of the California Department of Water Resources (DWR). These ten hydrologic regions (Figure 5) generally correspond to the state's major water-drainage basins: North Coast (NC), North Lahontan (NL), Sacramento River (SR), San Francisco Bay (SF), Central Coast (CC), San Joaquin River (SJ), Tulare Lake (TL), South Coast (SC), South Lahontan (SL), and Colorado River (CR). This is consistent with the approach taken in the W-E Calculator 1.0, as well as CPUC Decision D.15-09-23.[7]



Source: https://indicators.ucdavis.edu/water/regions

Figure 5: California's Ten Hydrologic Regions

[7] Decision (D.) 15-09-23, at 28.

The W-E Calculator 2.0 uses zip code as the common locator, consistent with how energy-efficiency measures are assigned to climate zones within cost-effectiveness evaluations. We conducted an analysis in GIS to assign each zip code to a hydrologic region. Where a zip code straddled two or more hydrologic regions, we followed a "majority rules" approach, assigning the zip code to the hydrologic region that contained the largest area of the zip code. This approach is consistent with how evaluators assign energy-efficiency measures to climate zones and reduces the complexity within the eTRM for deemed measures. The W-E Calculator 2.0 automatically selects the hydrologic region based on the user-entered installation zip code.

3.4 Marginal Water Supply and Historical Water Supply Mix

3.4.1 Marginal Water Supply

The marginal water supply represents the next unit of water supply that would need to be developed within a region to meet demand in the absence of water conservation and efficiency. When developing the W-E Calculator 1.0, the Navigant team consulted publicly available documents, including state and regional planning studies, and consulted with experts and stakeholders to identify the long-run marginal supply in each of California's ten hydrologic regions. Based on this consultation, the Navigant team identified a proxy marginal supply of non-potable recycled water, i.e., wastewater treated to tertiary, unrestricted standards, for all hydrologic regions in California. According to McDonald et al. (2014):

> "Using recycled wastewater as the default proxy marginal supply is reasonable for several reasons. All regions currently are developing and have available recycled water supplies. Although the predominant use of these supplies currently is irrigation, these supplies are approved for numerous other uses. Many utilities include recycled wastewater as a key element of their future supply portfolios. Recycled water is a more conservative supply option than ocean water, which addresses concerns raised by some stakeholders who question the availability of treated ocean supplies to more inland coastal agencies. Lastly, recycling of wastewater is consistent with the SWRCB goals, which encourage water agencies to significantly increase development and use of these supplies.
>
> When recycled water is used for non-potable end uses, it can displace potable or raw water that was previously serving that end use. The displaced potable water can be used to increase supply available to potable end uses; the displaced raw water could be treated further for potable uses. Thus, developing a recycled water supply can still increase the amount of supply available for potable end uses."

CPUC D.15-09-23 supported use of the long-run marginal supply in the W-E Calculator 1.0. The decision stated that "It is the margin—the next water resource we do not have to develop or procure—that matters, and so the W-E calculator correctly considers costs for the marginal supply (e.g., recycled water) rather than average supply."[8] D.15-09-23 further notes that while users can override the default marginal supply to reflect local circumstances, they should continue to use values for a marginal supply rather than for historical or existing supplies.[9]

Additionally, D.15-09-023 supports the calculator's use of the long-run marginal supply, rather than the short-run marginal supply, for several reasons. "The first is that data on short-run supplies remain hard to come by. The second is that imports continue to involve much energy that is not from jurisdictional energy companies. A third is that short-run supply options can vary enormously in cost from period to period, and from place to place."[10]

The W-E Calculator 2.0 follows D.15-09-23 in its use of the long-run marginal water supply to estimate embedded energy savings. Like its predecessor, the W-E Calculator 2.0 uses non-potable recycled water as the default marginal water supply for each of the ten hydrologic regions and allows the user to adjust the default according to local circumstances. As described in section 3.6.2 and 3.6.3, the energy intensities of water treatment and of distribution for non-potable recycled water does not vary regionally and a single value is used for each of the state's ten hydrologic region.

3.4.2 Historical Water Supply Mix

To plan for and manage water supplies over time, water suppliers evaluate their available supplies using a portfolio approach. The water-supply portfolio for the state varies across time and space, and each hydrologic region has a unique mix of water supplies available, ranging from imported water sources like the Colorado River to more local sources like groundwater. While the type of water supplies available within a hydrologic region is subject to little interannual availability, the *amount* of water available from each supply often changes from year to year due to weather and other factors. Table 6 provides a short description of the various water supply options in California.

Table 6: Description of Water Supplies Options in California

Water Supply	Description
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	Water diverted from the Colorado River by the Metropolitan Water District of Southern California.

8 Decision (D.) 15-09-23, at 23.

9 Decision (D.) 15-09-23, at 24.

10 Decision (D.) 15-09-23, at 25.

Water Supply	Description
Groundwater	Water beneath the Earth's surface in soil pore space and in the fractures of rock formations.
Local Surface Water	Water delivered by local water agencies and individuals. It includes direct deliveries of water from stream flows, as well as local water storage facilities.
Local Imported Water	Water transferred by local agencies from other regions of the state.
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.
Seawater	Water from the ocean, typically with a salinity between 33 and 37 parts per thousand (ppt)
State Water Project	A collection of canals, pipelines, reservoirs, and hydroelectric power facilities that extends more than 700 miles and is managed by the California Department of Water Resources.

As described in section 3.45, if a measure is installed before the resource balance year (RBY), the W-E Calculator 2.0 uses the historical water-supply mix for each hydrologic region to estimate the "historical" embedded energy savings. Table 7 shows the historical water-supply mix for each hydrologic region based on water-balance data from the California Department of Water Resources' 2018 Water Plan Update for the ten-year period preceding the Resource Balance Year of 2016, i.e., 2006 to 2015. The DWR data, however, does not differentiate between potable and non-potable recycled water. We used data reported in the 2015 Urban Water Management Plans to differentiate between these types of recycled water

Table 7: 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%	0.47%	4.14%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%
Recycled Water (Potable)	0.0%	0.0%	0.03%	0.36%	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 Surface Water	96.4%	21.1%	2.2%	4.5%	54.3%	41.1%	16.9%	76.4%	15.9%	0.1%
Local Imported Water	0.1%	35.7%	0.0%	4.4%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%
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 and Other Federal Deliveries	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 DWR 2018 and Table 6.4 of DWR 2015.

3.5 Resource Balance Year

The RBY is the year in which new capacity will be required to meet water demand. Consistent with both D.15-09-023 and the Water-Energy Calculator 1.0, the W-E Calculator 2.0 uses 2016 as the default RBY.[11] Using 2016 as the RBY recognizes that traditional surface water and groundwater sources across California are overallocated, and there is no excess capacity within these systems. Rather, there is tremendous pressure to reduce water withdrawals from existing surface water and groundwater sources by developing new, mostly local, water supplies. As a result, water savings from water-efficiency measures reduce the need to develop new sources of supply, suggesting that we are "in marginal territory." Moreover, there is currently no process to revise the RBY, and no new analysis indicates that a different year should be selected.

According to D.15-09-23, however, the user can select a different RBY "to account for a particular water supplier's planning, resource, and other needs."[12] Accordingly, the W-E Calculator 2.0 lets the user override the default RBY and select a year up through 2050.

Within the W-E Calculator 2.0, the RBY determines whether the embedded energy savings are based on the marginal water supply or the historical water-supply mix. 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 from a water-efficiency measure occur both before and after the RBY, the calculator uses the historical embedded energy savings for the years preceding the RBY and the marginal embedded energy savings for the RBY and subsequent years. Summing the annual embedded energy savings and dividing by the measure life yields an annualized embedded energy savings.

3.6 Energy Intensity of Water-System Components

The W-E Calculator 2.0 estimates embedded energy savings and does *not* include direct energy savings, which are accounted for in other CPUC tools. Within the calculator, embedded energy is divided into five major water-system components:

- Water extraction and conveyance
- Water treatment
- Water distribution
- Wastewater collection

[11] Decision (D.) 15-09-23, at 27.

[12] Decision (D.) 15-09-23, at 27.

- Wastewater treatment

We developed energy intensity values for each water-system component after reviewing the literature comprehensively. We identified 12 studies with energy intensity estimates relevant for California water systems. If a study contained a single energy intensity value, we used that value for the study. If a study contained more than one energy intensity value, we calculated an average value for the study. If we found multiple studies for a water-system component, the default energy intensity estimate was averaged across the studies. If sufficient data was available and the energy intensity value varied by region, we provided default energy intensity values for each hydrologic region. Otherwise, we provided a single statewide default energy intensity value. We describe the major water-system component categories and data sources for the default energy intensity values in more detail below.

3.6.1 Water Extraction and Conveyance

Water extraction and conveyance refer to the transport of untreated or partially treated water from its source through aqueducts, canals, and pipelines to a water-treatment facility, or directly to an end user that uses untreated water. The energy required to extract and convey depends on the distance and net elevation it has to travel and the efficiency of the pumping system.

Table 8 provides the default energy intensity values for extraction and conveyance of each water supply and hydrologic region. Based on Wilkinson (2007), we estimate that the energy required to pump seawater from the ocean to the desalination facility is 197 kWh per acre-foot. The energy intensity of extraction and conveyance for groundwater are based on values for each hydrologic region reported in Klein (2005), GEI Consultants/Navigant (2010a and 2010b), Plappally (2012), and Liu et al. (2017).

We provide default energy intensity values for the state's major interbasin water transfers, including the State Water Project, Central Valley Project, and Colorado River Aqueduct; local imported water; and local surface water. For interbasin water transfers, we use the energy intensity values for the furthest delivery point within a given hydrologic region. If there are multiple branches of a project within the same region, we calculate a volume-weighted average energy intensity across the delivery points in the region. In addition, we compute a net value of energy required by subtracting the average hydropower generation per unit of water volume on any conveyance project from the energy intensity. We drew the default energy intensity values for interbasin water transfers, local imports, and local surface water from EPRI (2002), Klein (2005), GEI Consultants/Navigant (2010a and 2010b), Cooley et al. (2012), Tarroja et al. (2014), Liu et al. (2017), and Stokes-Draut et al. (2017).

Table 8: 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	197	197	197	197	197	197	197	197	197	197

Component	NC	SF	CC	SC	SR	SJ	TL	NL	SL	CR
Brackish Desalination -Groundwater Pumping	383	491	506	697	294	301	347	381	401	532
Brackish Desalination - Local Surface Water	89	89	89	89	89	89	89	89	89	89
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
Recycled Water (Potable) – Groundwater Pumping	383	491	506	697	294	301	347	381	401	532
Recycled Water (Potable) – Local Surface Water	89	89	89	89	89	89	89	89	89	89
Local Surface Water	89	89	89	89	89	89	89	89	89	89
Local Imported Water	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: EPRI 2002, Klein et al. 2005, Wilkinson 2007, GEI Consultants/Navigant Consulting 2010a, GEI Consultants/Navigant Consulting 2010b, Cooley et al. 2012, Plappally 2012, Tarroja et al. 2014, Liu et al. 2017, and Stokes-Draut et al. 2017

We assumed that that the energy intensity of extraction and conveyance for brackish desalination is the same as for groundwater because most brackish water is drawn from groundwater basins; however, the user can select "local surface water" if the brackish water is drawn from a local surface water body.

The energy intensity of extraction and conveyance for non-potable recycled water is the energy required to transport the partially-treated wastewater to the recycled-water treatment facility. Based on estimates in Stokes-Draut et al. (2017), the default energy intensity of extraction and conveyance for non-potable recycled water is 107 kWh per acre-foot.

Currently in California, recycled water for potable applications must be stored temporarily in either a groundwater aquifer or a reservoir (surface-water augmentation), which serves as an environmental buffer, before the water is conveyed to a conventional drinking-water treatment plant and distributed to the end user. Currently, most potable recycled water in California is temporarily stored in a groundwater aquifer. Therefore, the default energy intensity of extraction and conveyance for potable recycled water is the same as for groundwater extraction and conveyance; however, the user can select "local surface water" if the recycled water is temporarily stored in a surface water reservoir rather than in a groundwater aquifer.

3.6.2 Water Treatment

Water treatment refers to processes and technologies that treat water before it is distributed to the end user. The energy required depends on the quality of the source water, the level of treatment appropriate for the end use, and the technology used to treat the water.

Table 9 provides default energy intensity values of water treatment for each of the major water sources and treatment technologies included in the calculator. Modern seawater-desalination facilities typically rely on reverse osmosis to remove the salts, with an estimated default energy intensity of 4,497 kWh per acre-foot based on Klein (2005), GEI Consultants/Navigant (2010a), Cooley et al. (2012), Tarroja et al. (2014), Tidwell et al. (2014), Liu et al. (2017), and Stokes-Draut et al. (2017). Brackish water is, by definition, less saline than seawater and thus requires less energy to treat. Based on Klein (2005), GEI Consultants/Navigant (2010a and 2010b), Cooley et al. (2012), Liu et al. (2017), and Stokes-Draut et al. (2017), the default energy intensity for desalination of brackish water is 1,407 kWh per acre-foot. Geography does not drive the energy requirements for water treatment, and as a result, the energy intensity of water treatment does not vary by hydrologic region.

Table 9: 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: EPRI 2002, Klein et al. 2005, GEI Consultants/Navigant Consulting 2010a, GEI Consultants/Navigant Consulting 2010b, Cooley et al. 2012, Tarroja et al. 2014, Tidwell et al. 2014, Liu et al. 2017, and Stokes-Draut et al. 2017.

Treating conventional drinking water is a multistage process that includes physical filtration and chemical disinfection. Based on EPRI (2002), Klein (2005), GEI Consultants/Navigant (2010b), Cooley et al. (2012), Tarroja et al. (2014), Liu et al. (2017), and Stokes-Draut et al. (2017), the default energy intensity for treating conventional drinking water is 205 kWh per acre-foot. In some instances, such as for some groundwater, only chlorination is required, and the default energy intensity is 63 kWh per acre-foot

The energy required to treat non-potable recycled water includes the incremental energy required to bring treated wastewater to recycled-water standards appropriate for non-potable uses. Based on Cooley et al. (2012), GEI Consultants/Navigant (2010b), and Stokes-Draut et al. (2017), the energy intensity of non-potable reuse is 607 kWh per acre-foot.

For potable recycled water, partially treated wastewater is first subject to treatment (typically membrane treatment) and then temporarily stored in a groundwater aquifer or surface reservoir before use. In an urban setting, the water would be withdrawn from temporary storage and conveyed to a water treatment plant, where it would be treated a second time to drinking water standards before distribution to customers. While potable reuse is uncommon in an agricultural setting, in theory, the water withdrawn from temporary storage would not be subject to additional treatment before use. Based on Cooley et al. (2012), GEI Consultants/Navigant (2010a and 2010b), Tarroja et al. (2014), and Stokes-Draut et al. (2017), the default energy intensity of membrane treatment is 1,066 kWh per acre-foot, and we use this value as the default for potable reuse treatment in an agricultural setting. The default energy intensity for potable recycled water in an urban setting is equal to the sum of the energy intensity of membrane treatment (1,066 kWh per acre-foot) and conventional treatment (205 kWh per acre-foot), or 1,272 kWh per acre-foot.

3.6.3 Water Distribution

Water distribution is the transport of treated water, both potable and non-potable, to the end user. Like water conveyance, the energy intensity depends on the distance and net elevation traveled and pump efficiency.

Table 10 summarizes the default energy intensity values for distributing water in different terrains and for different supply types. The default energy intensity of potable water distribution in an urban water system with flat, moderate, and hilly terrain is 18, 163, and 318 kWh per acre-foot, respectively (MacDonald et al.2014). In the W-E Calculator 2.0, we assigned a default topography (flat, moderate, or hilly) to each hydrologic region based on GEI Consultants/Navigant (2010b) and MacDonald et al. (2014). However, the user can override these defaults to select a different topography, as needed. The default energy intensity for distributing water in an agricultural setting varies by hydrologic region and is based on GEI Consultants/Navigant (2010b).

The energy required to distribute non-potable recycled water may be higher than for potable water. This is because the recycled-water facility is usually located at or near the wastewater-treatment facilities, which are typically located at the lowest point of the service area. Based on Klein (2005), GEI Consultants/Navigant (2010b), Cooley et al. (2012), and Tidwell et al. (2014) and Liu et al. (2017), the default energy intensity for distributing non-potable recycled water is 416 kWh per acre-foot. This data was drawn from urban settings and was only applied to those areas.

Table 10: 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: Klein et al. 2005, GEI Consultants/Navigant Consulting 2010b, Cooley et al. 2012, McDonald et al. 2014, Tidwell et al. 2014, and Liu et al. 2017.

3.6.4 Wastewater Collection and Treatment

Wastewater collection is the movement of untreated wastewater from the end user to a wastewater collection facility. The energy required depends on the distance, elevation, and pump efficiency. Wastewater treatment is the treatment required to bring wastewater to discharge standards. The energy required depends on the level of treatment, the technology employed, and the efficiency of the pumps used to move wastewater throughout the treatment facility.

Secondary treatment of wastewater involves primary treatment, which is largely a physical filtration process, followed by biological disinfection. This is the most common level of wastewater treatment in California (California State Water Resources Control Board 2021) and is consequently the default wastewater treatment type in the W-E Calculator 2.0.

Table 11 summarizes default energy intensity values for collecting and treating wastewater. Based on Klein et al. (2005), Cooley et al. (2012), and GEI Consultants/Navigant (2010b), the default energy intensity for collecting wastewater is 72 kWh per acre-foot. Based on EPRI (2002), Klein et al. (2005), GEI Consultants/Navigant (2010b), Cooley et al. (2012), Tarroja et al. (2014), Tidwell et al. (2014), and Liu et al. (2017), the default energy intensity value for secondary treatment is 654 kWh per acre-foot. Some wastewater is subject to tertiary treatment, with a default energy intensity value of 999 kWh/AF based on Klein et al. (2005), GEI Consultants/Navigant (2010b), and Cooley et al. (2012).

Table 11: 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: EPRI 2002, Klein et al. 2005, GEI Consultants/Navigant Consulting 2010b, Cooley et al. 2012, Tarroja et al. 2014, Tidwell et al. 2014, and Liu et al. 2017.

3.6.5 IOU Energy Intensity of Water-System Components

Water systems may be powered by energy from an IOU or from another energy source. Consequently, IOUs may not be able to claim credit for all embedded energy savings. In the W-E Calculator 1.0, the Navigant team developed estimates of the statewide average fraction of energy supplied by an IOU for each water-system component (MacDonald et al. 2014). These estimates, shown in Table 12, were based on data derived from the Water Energy Load Profiling Tool, as augmented by the Pacific Institute for use in the CPUC Water-Energy Pilot Evaluations. Limited data was available, and it was not possible to develop more detailed estimates, such as for each IOU. Additionally, no other data was readily available to update them, so the W-E Calculator 2.0 also uses the values shown in Table 12.

Table 12: 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 Surface Water	0.27
	Local Imported Water	0.27
	Colorado River	0
	Central Valley Project	0
	State Water Project	0
Water Treatment		0.94
Water Distribution		0.95
Wastewater Collection		0.97
Wastewater Treatment		0.97

Data Source: McDonald et al. 2014

3.7 Water-System Components by Sector

The W-E Calculator 2.0 requires the user to specify whether the measure applies to the urban or agricultural sector. This determines which water-system components are included in the analysis.

3.7.1 Urban Sector

In the urban sector, water for indoor use is subject to water extraction and conveyance, water treatment, water distribution, wastewater collection, and wastewater treatment. So, when the user selects "urban" for the measure-application sector and "indoor" for the water-use type, the calculator provides default assumptions for each of those water-system components. By contrast, water for outdoor uses and water losses during distribution are only subject to water extraction and conveyance, water treatment, and water distribution, so default assumptions apply only to those components.

3.7.2 Agricultural Sector

In most cases, water for agricultural applications is not subject to water treatment, i.e., raw water, and the wastewater is not collected or treated prior to discharge. Thus, when the user selects "agriculture" for the measure-application sector, default assumptions are only provided for water extraction and conveyance, water treatment (when the marginal water supply is recycled water or desalination), and water distribution. Defaults are not provided for water treatment (when the marginal supply is not recycled water or desalination), wastewater collection, and wastewater treatment. However, the user can override this and provide energy-intensity values for these water-system components if appropriate.

In some instances, especially in an agricultural or industrial setting, the end user may extract water from a groundwater aquifer or nearby stream for their own use. In these instances, the estimates of on-site direct energy savings may include embedded energy savings so be sure to avoid double counting these savings.

4 Comparison of the Water-Energy Calculator 1.0 and 2.0

This section compares the estimated embedded energy savings from the W-E Calculator 1.0 and 2.0. We analyze a water-efficiency measure installed in 2021 that saves 10,000 gallons of water per year, using the default values for the RBY, the marginal water supply, and the water-system components.

Table 13 compares the estimated embedded energy savings for a water-efficiency measure targeting urban outdoor water use or leaks in the water distribution system. W-E Calculator 2.0 estimates that IOU and total embedded energy savings are 32.82 kWh and 34.68 kWh, respectively, for each of the state’s ten hydrologic regions. IOU embedded energy savings are lower in W-E Calculator 1.0 across all hydrologic regions. Total embedded energy savings are lower in all but the South Coast hydrologic region. Across all hydrologic regions, IOU and total embedded energy savings are 226% and 81%, respectively, higher in the W-E Calculator 2.0 than in the W-E Calculator 1.0 for this test case.

Table 13: Comparison of Embedded Energy Savings for a Water-Efficiency Measure Targeting Urban Outdoor Water Use and Leaks in the Water-Distribution System (kWh/10,000 gal)

Hydrologic Region	W-E Calculator 1.0		W-E Calculator 2.0	
	IOU Embedded Energy Savings	Total Embedded Energy Savings	IOU Embedded Energy Savings	Total Embedded Energy Savings
San Francisco	14.68	21.26	32.82	34.68
Central Coast	13.30	20.77	32.82	34.68
South Coast	13.49	59.43	32.82	34.68
Sacramento River	6.77	7.83	32.82	34.68
San Joaquin	7.32	9.10	32.82	34.68
Tulare Lake	7.51	12.24	32.82	34.68
North Lahontan	8.23	9.30	32.82	34.68
South Lahontan	12.14	30.69	32.82	34.68
Colorado River	6.27	9.07	32.82	34.68
North Coast	10.86	12.20	32.82	34.68
Average	**10.06**	**19.19**	**32.82**	**34.68**

Table 14 compares embedded energy estimates for a water-efficiency measure targeting urban indoor water use. W-E Calculator 2.0 estimates IOU and total embedded energy savings are 54.42 kWh and 56.95 kWh, respectively, for each of the state’s ten hydrologic regions. These savings are higher than in Table 13 because they include the embedded energy savings from reductions in wastewater collection and treatment. IOU embedded energy savings in the W-E

Calculator 1.0 are lower across all hydrologic regions. Similarly, total embedded energy savings are lower in all but the South Coast hydrologic region. Across all hydrologic regions, IOU and total embedded energy savings for a water-efficiency measure targeting urban indoor water use are 142% and 78%, respectively, higher in the W-E Calculator 2.0 than in the W-E Calculator 1.0.

The results shown in Table 13 and Table 14 are due to several factors. First, W-E Calculator 2.0 uses non-potable recycled water as the marginal water supply for each hydrologic region, and the available data indicate that the energy intensity of non-potable recycled water does not vary across the state. W-E Calculator 1.0, by contrast, bases the embedded energy savings on the historical water-supply mix for each hydrologic region. The historical water-supply mix is less energy intensive than the marginal water supply in all but the South Coast region and relies less on electricity from IOUs across all hydrologic regions.

Table 14: Comparison of Embedded Energy Savings for a Water-Efficiency Measure Targeting *Urban Indoor* Water Use (kWh/10,000 gallons)

Hydrologic Region	W-E Calculator 1.0		W-E Calculator 2.0	
	IOU Embedded Energy Savings	Total Embedded Energy Savings	IOU Embedded Energy Savings	Total Embedded Energy Savings
San Francisco	27.13	34.10	54.42	56.95
Central Coast	25.75	33.60	54.42	56.95
South Coast	25.94	72.26	54.42	56.95
Sacramento River	19.22	20.67	54.42	56.95
San Joaquin	19.77	21.93	54.42	56.95
Tulare Lake	19.96	25.07	54.42	56.95
North Lahontan	20.68	22.13	54.42	56.95
South Lahontan	24.59	43.52	54.42	56.95
Colorado River	18.72	21.91	54.42	56.95
North Coast	23.31	25.04	54.42	56.95
Average	**22.51**	**32.02**	**54.42**	**56.95**

Table 15 compares estimates of embedded energy savings for a water-efficiency measure targeting agricultural water use. In the W-E Calculator 2.0, embedded energy savings are subject to some regional variation due to differences in the energy intensity of distributing water to the end user. IOU embedded energy savings across all hydrologic regions average 27.60 kWh, ranging from a low of 21.26 kWh in the San Joaquin and Sacramento River regions to a high of 34.92 kWh in the South Coast and Colorado River regions. By comparison, IOU embedded energy savings in the W-E Calculator 1.0 are lower, averaging 8.00 kWh across all regions. Across all regions, IOU and total embedded energy savings for water-efficiency measures targeting outdoor agricultural water use are 245% and 72%, respectively, higher in the W-E

Calculator 2.0 than in the W-E Calculator 1.0. As with the urban analysis, these differences are driven by use of the marginal water supply in the W-E Calculator 2.0 and the historical water supply portfolio in the W-E Calculator 1.0.

Table 15: Comparison of Embedded Energy Estimates for a Water-Efficiency Measure Targeting Agricultural Outdoor Water Use (kWh/10,000 gallons)

Hydrologic Region	W-E Calculator 1.0		W-E Calculator 2.0	
	IOU Embedded Energy Savings	Total Embedded Energy Savings	IOU Embedded Energy Savings	Total Embedded Energy Savings
San Francisco	11.44	17.82	24.89	26.33
Central Coast	12.70	20.13	24.89	26.33
South Coast	11.08	56.86	34.92	36.88
Sacramento River	4.26	5.16	21.26	22.50
San Joaquin	5.39	7.05	21.26	22.50
Tulare Lake	5.85	10.47	32.03	33.84
North Lahontan	6.38	7.33	24.89	26.33
South Lahontan	11.22	29.71	32.03	33.84
Colorado River	2.93	5.52	34.92	36.88
North Coast	8.73	9.94	24.89	26.33
Average	**8.00**	**17.00**	**27.60**	**29.18**

5 Recommendations

The following recommendations for further improvements to the W-E Calculator 2.0 and its implementation can help the state to better estimate embedded energy savings and realize the full potential of water efficiency measures to reduce statewide energy use and greenhouse gas emissions.

- **Evaluate the default marginal water supply and revise as appropriate.**

  The W-E Calculator 2.0 follows D.15-09-23 in its use of the long-run marginal water supply, rather than the average water supply, to estimate embedded energy savings. Like its predecessor, the W-E Calculator 2.0 uses non-potable recycled water as the default marginal water supply for each of the California's ten hydrologic regions and lets the user adjust this default assumption according to local circumstances. This marginal water supply was selected in 2014 after a review of planning documents and consultation with stakeholders across the state.

  New regulations, along with changing technologies and practices, suggest that reviewing the default marginal water supply may be warranted. For example, the State Water Resources Control Board is developing uniform water recycling criteria for direct potable reuse on or before December 31, 2023; once adopted, these regulations are likely to generate greater investment in this water-supply option among urban water suppliers in California and may be the marginal water supply. Similarly, implementing the Sustainable Groundwater Management Act (SGMA) will necessitate reducing groundwater pumping in some parts of the state over the next several decades, especially among agricultural users in the San Joaquin hydrologic region, suggesting that groundwater may be the marginal water supply in these areas. We recommend that the CPUC evaluate whether it is appropriate to modify the default marginal water supply for each hydrologic region for urban and agricultural water uses.

- **Evaluate whether to use a resource balance year (RBY), and if so, select an appropriate year.**

  In response to stakeholder comments, the Navigant team added a resource balance year to the W-E Calculator 1.0. However, they did not determine the appropriate default resource balance year. Rather, the calculator, which was developed in 2014, adopted the convention used for energy-efficiency analyses at the time and used a default RBY that was two years in the future—2016. D.15-09-23 supported using 2016 as the RBY and allowing the user to change the RBY, as needed.

  Consistent with D.15-09-23, the W-E Calculator 2.0 uses 2016 as the RBY and allows the user to easily alter this default value. Using 2016 as the RBY recognizes that traditional water sources across California are overallocated, and there is pressure to reduce water withdrawals from these sources by developing new, mostly local, water supplies. As a result, water savings from water-efficiency measures reduce the need to develop new sources of supply, suggesting that we are "in marginal territory." Moreover, there was no immediately available process by which to revise the RBY, and no new analysis indicating that a different year should be selected. We recommend that the CPUC evaluate whether to continue using a RBY, or to eliminate it, as has been done for energy efficiency analyses. If use of a RBY is maintained, we recommend that the CPUC conduct an evaluation to determine the appropriate year.

- **Consider updating the Water Tool to include as a non-energy benefit in TSB analyses and to evaluate whether to incorporate water-related environmental benefits.**

  The W-E Calculator 1.0 included a cost-effectiveness analysis, and as part of that analysis, the Navigant team also developed the Water Capacity Avoided Cost Tool (also referred to as the Water Tool). The primary output of the Water Tool is the annual avoided cost of capacity, which is the level annualized payment that would be required for an additional unit of capacity.

  The W-E Calculator 2.0 does not include a cost-effectiveness analysis. Rather, such analyses are done within the CET. The CET allows including non-energy benefits in TSB analyses, and thus the avoided cost of adding water capacity could be added to those analyses. While it was beyond the scope of this work to revise the Water Tool, we recommend that the CPUC consider updating the Water Tool. We also recommend evaluating environmental benefits associated with reduced water usage and incorporating them as non-energy benefits.

- **Review calculator default assumptions every five years and update as needed, consistent with the frequency of updates for key water-planning documents.**

  Regularly updating the W-E Calculator 2.0 will help ensure that the default assumptions reflect current water policies and practices. Ultimately, this will improve the accuracy of assessments of embedded energy savings. We recommend reviewing the default assumptions every five years and updating them as needed. This is consistent with the frequency of updates for key water planning documents. For example, water suppliers update Urban Water Management Plans every five years, in years ending in 0 and 5. Additionally, the State Water Plan is also updated every five years, in years ending in 3 and 8.

- **Implement the long-term solution identified for integrating embedded energy savings into CET analyses.**

  The stakeholder interviews identified two key issues: (1) cost-effectiveness analyses did not include embedded energy savings, and (2) IOUs were unable to claim credit for these savings toward their energy efficiency goals. While revising the water-energy calculator, we worked closely with CPUC to develop a short-term and long-term solution for integrating embedded energy savings into CET analyses. The short-term solution will be available immediately to PAs. However, the long-term solution will require changes to the structure and calculations within the CET, as identified in Appendix B. We recommend that the CPUC implement the long-term solution for integrating embedded energy savings into CET analyses as soon as is practicable so that PAs and CPUC can better determine the role of embedded energy savings in meeting energy efficiency goals and promote greater investment in cost-effective water-efficiency measures that save energy.

- **Expand partnerships between energy PAs and water utilities to realize greater water and energy savings and help the state to meet its water, energy, and greenhouse-gas goals.**

  Spang et al. (2018) found that water efficiency can achieve significant electricity and GHG savings at costs competitive with existing energy efficiency programs. This suggests that partnerships between energy PAs and water utilities could benefit ratepayers and help the state realize water, energy, and greenhouse-gas goals. This is especially important as the state faces another severe drought and climate impacts are intensifying. We recommend that the CPUC proactively expand partnerships between energy PAs and water utilities across California, for example, through statewide organizations like the California Water-Efficiency Partnership or regional organizations like the Metropolitan Water District of Southern California or Bay Area Regional Energy Network (BayREN). Additionally, we recommend that the CPUC facilitate partnerships explicitly between water and energy IOUs, both of which are regulated by the CPUC.

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Appendices

A. Interview Questions

We conducted interviews with energy utilities, consultants, and researchers, covering water-energy savings and the W-E Calculator. We developed separate questions for energy utilities and for consultants and researchers.

A.1 Interview Questions for Energy Utilities

General Questions about Water-Energy Savings Estimates

Do you currently have any water measures in your energy efficiency programs?

- If yes,
  - Which measures are included?
  - What were some of the challenges you encountered when integrating these measures into your programs?
  - Is there anything that would help you to include more of these measures into your programs?
- If no,
  - Why not?
  - Is there anything that would help you to include more of these measures into your programs?

Have you estimated the energy savings from water efficiency measures?

- If no, why not?
- If yes,
  - Did you evaluate the direct energy savings (aka hot water savings), the embedded energy savings (e.g., the energy associated with treating and transporting water/wastewater), or both?
  - For what purpose did you use these estimates, e.g., programmatic planning or site estimates for specific projects?
  - Did you get credit for the embedded and/or direct energy savings toward meeting your energy efficiency goals?
  - Did this evaluation change your investment decision?
  - What methods and tools did you use to estimate the embedded energy savings, e.g., the Water-Energy Calculator?

Specific Questions About the Water-Energy Calculator (W-E Calculator)

How familiar are you with the Water-Energy Calculator (W-E Calculator)?

Did you participate in the development of the W-E Calculator, e.g., attending workshops or providing comments? If so, how?

Have you used the W-E Calculator? (For reference, the calculator and user guide are available here: https://www.cpuc.ca.gov/nexus_calculator/)

If no,

Why not?

What tools would be useful for integrating energy benefits into efficiency investments?

If yes,

Why did you use the W-E Calculator?

What was your general impression of the W-E Calculator?

Did you use the default values in the W-E Calculator?

Did you use the water and wastewater utility cost test? If so, for what purpose?

What outputs from the W-E Calculator were of greatest interest? Which were least of interest?

Were you confident in the results provided by the W-E Calculator?

What changes to the W-E Calculator do you think are necessary? Of these, what is of greatest importance? What would be of lesser importance?

How could the outputs from the W-E Calculator be better integrated into existing CPUC calculation tools?

Is there anything else you think we should keep in mind when updating the W-E Calculator?

Who else should we talk to at your organization or elsewhere?

A.2 Interview Questions for Consultants and Researchers

General Questions Water-Energy Programs

Are you familiar with the energy efficiency program offerings? If yes,

What types of water efficiency measures are being integrated into these programs (e.g., cold water measures, hot water measures, or both)?

What are the challenges with integrating water efficiency measures into these programs?

What would help to integrate more measures into these programs?

Are there any policy issues that need to be addressed to better integrate water measures into energy efficiency programs?

Are you familiar with energy efficiency program evaluations? If yes,

- to what extent are direct energy savings (aka hot water savings) being estimated? embedded energy savings (e.g., the energy associated with treating and transporting water/wastewater)?
- Are they using the Water-Energy Calculator for these evaluations, or are they using other methods?
- For what purpose are these estimates used, e.g., programmatic planning or site estimates for specific projects?
- What are some of the barriers for estimating embedded energy savings?
- Are the energy IOUs getting credit for the embedded and direct energy savings toward meeting energy efficiency goals?

Specific questions about the Water-Energy Calculator (W-E Calculator)

Use of the W-E Calculator

For what purpose(s) have you used the W-E Calculator?

Did you integrate environmental benefits into your cost calculations?

Did you use the water and wastewater utility cost test? If so, for what purpose?

What changes to the W-E Calculator would improve its usability?

Model Defaults

What marginal supply and energy intensity estimates are the energy IOUs using? Default values or other values?

What are the issues and concerns with the model defaults?

Outputs

What outputs are most important?

What outputs are of least interest or even unnecessary?

Were you confident in the results provided by the W-E Calculator? Why or why not?

How could the W-E Calculator outputs be better integrated into existing CPUC tools?

Can or should the W-E Calculator and its outputs be used for other purposes?

Other questions or concerns

Is there anything else you think we should keep in mind when updating the W-E Calculator?

Who else should we talk to?

B. Short- and Long-term Solutions for Integrating Embedded Energy Savings into CEDARS

On 20 December 2021, the California Public Utilities Commission (CPUC) published the final version of the Water-Energy Calculator 2.0 (W-E Calculator 2.0). The W-E Calculator 2.0 replaces the first version of the Water-Energy Calculator, and Program Administrators (PAs) will use its values going forward to calculate the embedded energy savings of Water-Energy Nexus (WEN) measures. PAs can now use the embedded energy savings from these WEN measures to claim incentives and they will count towards PAs' energy-efficiency goals.

The two solutions described below detail how PAs will calculate the embedded energy savings using the California electronic Technical Reference Manual (eTRM).

Short-term Solution

Until the CPUC implements the long-term solution, existing and new WEN-measure packages will use the following method to calculate the embedded energy savings produced by a water-efficiency measure and add it to the direct (site) energy savings generated by that measure.

The measure or measure update will add the energy-intensity values in Table 16 to eTRM. The embedded energy savings for the measure will be the result of dividing the number of gallons saved by the measure by 1000 and multiplying that result by the "Total IOU Embedded Water Energy Intensity" value in Table 16, based on whether the measure is an indoor or outdoor measure. For IOUs, the embedded-water-energy intensity is 5.44 kWh/kgal for indoor measures, and 3.28 kWh/kgal for outdoor measures. Once the embedded energy savings have been calculated, they will be automatically added in eTRM to the direct energy savings of the measure (per D.17-12-010). That combined value, along with other site-specific savings values, will then be input into the Cost-Effectiveness Tool (CET) through California Energy and Data Reporting System (CEDARS) to calculate the measure's cost effectiveness. Program Administrators (PAs) will also use the combined value if they submit a claim for this measure.

As the embedded energy savings are present regardless of whether the measure uses hot or cold water, the total annual water savings including both hot and cold water will be multiplied by the appropriate "Total IOU Embedded Water Energy Intensity" value in Table 16. The calculation of direct energy savings will be unchanged.

This approach is only suitable for measures that use the default marginal water supply—recycled water (non-potable). PAs may claim measures that use a different marginal supply only if they use the long-term solution, and thus must wait until that solution is implemented. Additionally, per D.15-09-023, where PAs depart from default values, they must show that the departure is reasonable in all documents submitted to CPUC.

Table 16: Embedded Water Energy Intensities

Climate Zone	Sector	Water Use Type	Marginal Supply	Total IOU Embedded Water Energy Intensity (kWh/kgal)	Total Non-IOU Embedded Water Energy Intensity (kWh/kgal)
Any	Urban	Indoor	Recycled Water (Non-Potable)	5.44	0.25
Any	Urban	Outdoor	Recycled Water (Non-Potable)	3.28	0.19

Long-term Solution

Once CPUC finalizes this solution, it will replace the short-term solution for the measure. When the CPUC informs the relevant PAs of this transition, the PAs will create a Measure Log Entry that includes a Measure Package Plan (MPP). The MPP will describe the administrative change to the measure package that will incorporate the long-term solution used to calculate the total energy savings as well as when the change will take effect. This administrative change will not trigger a new version of the measure package since impacts (including savings, cost, and measure life) have not changed. It is expected that total energy savings will be broken out in this long-term approach so that direct energy savings can be distinguished from IOU embedded-water-energy savings and stored separately in permutation data fields.

The measure or measure update will use the new CET functionality to accept the direct energy savings and IOU embedded energy savings separately into the CET. The direct energy savings will be calculated using the measure-package methodology. The IOU embedded-water-energy savings will be calculated following the same methodology described in the short-term solution but will be stored independently within the eTRM to facilitate reporting and cost-effectiveness calculations. The PA will still receive the same credit for both the direct and embedded energy savings as they received using the short-term solution, but for accounting purposes, the two types of savings will be entered into the CET separately through CEDARS.

C. User's Manual

This appendix contains the User's Guide for the Water-Energy Calculator 2.0

Water-Energy Calculator 2.0 User's Guide

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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, a tool intended to help Project Administrators (PAs) calculate the embedded energy savings of water-efficiency measures. The *Overview* section describes the basic methodological framework underlying the calculator and its relationship to other California Public Utilities Commission (CPUC) tools. The *Step-by-Step Instructions* section provides detailed instructions on how to use the calculator. The *Appendices* provide the short- and long-term solutions for integrating embedded energy savings into the California Energy Data and Reporting System (CEDARS), as well as the default values used in the calculator. More detailed information about the W-E Calculator 2.0 can be found in the final project report on the CPUC's Water-Energy Nexus homepage.

2 Overview

Extracting, moving, treating, and using water requires a substantial amount of energy, especially in California where large amounts of water are pumped over long distances and steep terrain. As a result, water-efficiency measures that save water also save energy and can help investor-owned energy utilities (IOUs) meet energy-efficiency and greenhouse-gas-reduction goals. Water-efficiency measures can be implemented in residential, commercial, industrial, and agricultural settings and include, for example, low-flow showerheads, efficient clothes washers, high-efficiency toilets, weather-based irrigation controllers, turf removal, drip irrigation, and dry-vacuum pumps. Existing water efficiency measures, sometimes referred to as Water-Energy Nexus (WEN) measures, and their related information can be found in the electronic Technical Reference Manual (eTRM).

Water-related energy is often divided into two categories.

- **Direct energy** is the energy used on the customer side of the meter by, for example, reducing on-site pumping and hot water usage. These energy savings are also sometimes referred to as end-use energy savings.
- **Embedded energy** is the energy used to extract, convey, treat, and distribute water to end users, and energy used to collect and transport wastewater for treatment prior to safe discharge of the effluent in accordance with regulations.

Historically, energy-efficiency tools only accounted for the direct energy savings associated with reduced water use. In 2015, the CPUC approved use of the Water-Energy Calculator 1.0 to estimate embedded energy savings associated with water-efficiency measures so that these savings could be incorporated into evaluations of measure cost effectiveness.

Like its predecessor, the W-E Calculator 2.0 estimates the embedded energy savings (in kWh) of water-efficiency measures. However, while the previous calculator also estimated the avoided embedded energy cost and the avoided water-capacity cost, all cost-effectiveness functions have been removed from the W-E Calculator 2.0. Instead, the estimated embedded energy savings from the W-E Calculator 2.0 can be entered into CEDARS for cost-effectiveness evaluations using the Cost Effectiveness Tool (CET).

2.1 Methodology

Fundamentally, the W-E Calculator 2.0 estimates embedded energy savings by multiplying the annual water savings of an efficiency measure by the energy intensity of relevant water-system components. The energy intensities of the water-system components depend on several factors, including the source of the water saved and its geographic location. Defaults are provided throughout the model; however, the user can adjust these defaults as appropriate for the measures evaluated.

Figure 1 illustrates the underlying methodology used in the W-E Calculator 2.0 to estimate embedded energy savings. Calculating embedded energy savings follows these four steps:

1. The user enters basic information about the measure(s) being evaluated. This includes the installation year, annual water savings per device, number of devices installed, measure application, and the zip code where the measure was installed. The zip code determines the hydrologic region for the analysis.
2. Based on the hydrologic region, the calculator provides a default marginal water supply that represents the source of the water saved.[1] The default can be adjusted as needed. The water supply selected, combined with the measure application,[2] determine the water-system components[3] included in the analysis.
3. Based on the hydrologic region and marginal supply, the calculator provides default energy-intensity values (in kilowatt-hours per acre-foot) for each water-system component included in the analysis. The calculator also provides default values for the percent of the energy provided by an IOU. The default values can be adjusted as appropriate for the measures included in the analysis. However, per D.15-09-023, where PAs depart from default values, they bear the burden of proving the departure is reasonable in all documents submitted to CPUC staff.
4. The calculator estimates the total embedded energy savings (including IOU and non-IOU energy, in kWh) by multiplying annual water savings by the sum of the energy-intensity values of the water-system components. It then estimates IOU embedded energy savings by multiplying the annual water savings by the sum of the product of the water-system-component energy-intensity value and the fraction of IOU energy for each component.

---

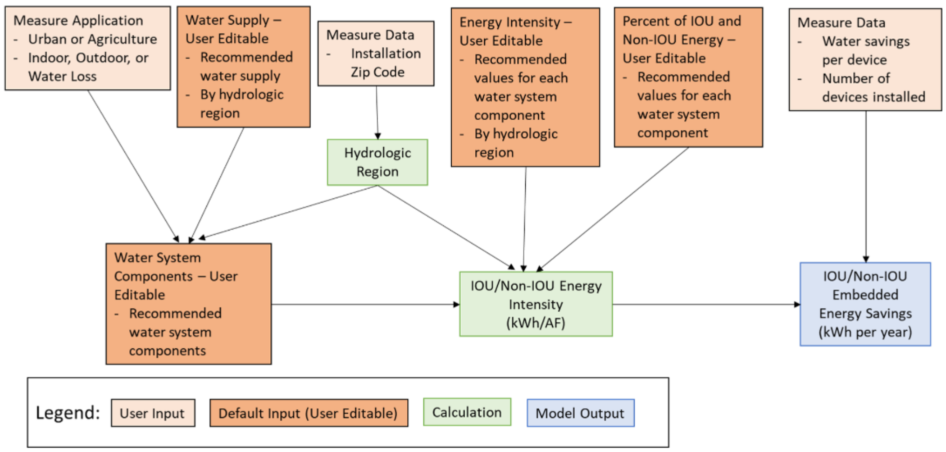
[1] As described in Section 2.1.4, a default marginal supply of non-potable recycled water, i.e., wastewater treated to tertiary, unrestricted standards, is assumed for all hydrologic regions in California.

[2] The measure application indicates whether the measure is applied in an urban or agricultural setting and whether it reduces indoor water use, outdoor water use, or losses in the water distribution system.

[3] Water-system components include water extraction and conveyance, water treatment, water distribution, wastewater collection, and wastewater treatment.

Subtracting IOU embedded energy savings from the total embedded energy savings yields the non-IOU portion of embedded energy savings.

The project report includes a more detailed description of the underlying methodology and default assumptions provided in the calculator.



This is a simplified version of the underlying conceptual framework for the W-E Calculator. Although not depicted here, the installation year, measure life, and resource-balance year determine whether the marginal or historical water-supply mix are used to estimate embedded energy savings. This is described in more detail in sections 2.1.3, 2.1.4, and 2.1.5.

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

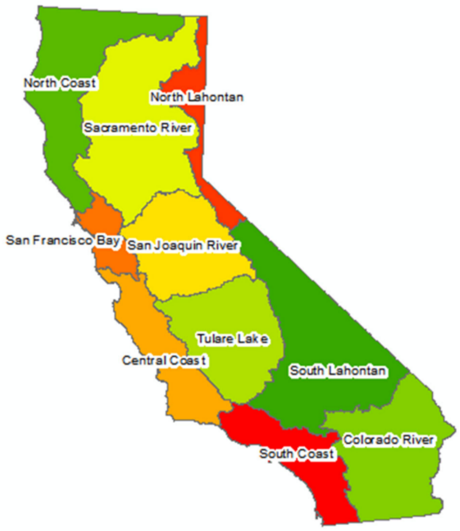
2.1.1 Regional Analysis

The available water supplies and their associated energy intensities can vary across California. To account for this variability, the W-E Calculator 2.0 operates at a regional level, using the ten hydrologic regions of the California Department of Water Resources (DWR). These ten hydrologic regions (Figure 2) generally correspond to the state's major drainage basins. This is consistent with the approach taken in the W-E Calculator 1.0, as well as CPUC Decision D.15-09-23.[4]

The W-E Calculator 2.0 uses zip code as the common locator, consistent with how energy-efficiency measures are assigned to climate zones within cost-effectiveness evaluations. We conducted an analysis in GIS to assign each zip code to a hydrologic region. In cases where a zip code straddled two or more hydrologic regions, we followed a "majority rules" approach, assigning the zip code to the hydrologic region that contained the largest area of the zip code. This approach is consistent with how evaluators assign energy-efficiency measures to climate zones and reduces the complexity within the eTRM for deemed measures. The W-E Calculator

[4] Decision (D.) 15-09-23, at 28.

2.0 contains a look-up function that automatically selects the hydrologic region based on the user-entered installation zip code.



Source: https://indicators.ucdavis.edu/water/regions

Figure 2: California's Ten Hydrologic Regions

2.1.2 Water-System Components by Sector

The W-E Calculator 2.0 requires the user to specify whether the measure applies to the urban or agricultural sector. These specifications determine which water-system components are included in the analysis.

2.1.2.1 Urban Sector

In the urban sector, water for indoor use is subject to water extraction and conveyance, water treatment, water distribution, wastewater collection, and wastewater treatment. So, when the user selects "urban" for the measure-application sector and "indoor" for the water-use type, the calculator provides default assumptions for each of those water-system components. By contrast, water for outdoor uses and water losses in the distribution system are only subject to water extraction and conveyance, water treatment, and water distribution, so default assumptions apply only to these components.

2.1.2.2 Agricultural Sector

In most cases, water for agricultural applications is not subject to water treatment, i.e., raw water, and the wastewater is not collected or treated prior to discharge. Thus, when the user selects "agriculture" for the measure-application sector, default assumptions are only provided for water extraction and conveyance, water treatment (when the marginal water supply is recycled water or desalination), and water distribution. Defaults are not provided for water treatment (when the marginal supply is not recycled water or desalination), wastewater collection, and wastewater treatment; however, the user can override this and provide energy-intensity values for these water-system components if appropriate.

In some instances, especially in an agricultural or industrial setting, the end user may extract water from a groundwater aquifer or nearby stream for their own use. In these instances, the estimates of on-site direct energy savings may include embedded energy savings so be sure to avoid double counting these savings.

2.1.3 Resource Balance Year

The Resource Balance Year represents the year in which new capacity will be required to meet water demand. Consistent with both D.15-09-023 and the Water-Energy Calculator 1.0, the W-E Calculator 2.0 uses 2016 as the default Resource Balance Year (RBY).[5] According to D.15-09-23, however, the user can select a different RBY "to account for a particular water supplier's planning, resource, and other needs."[6] Accordingly, the W-E Calculator 2.0 lets the user override the default RBY and select a year up through 2050.

Within the W-E Calculator 2.0, the RBY determines whether the embedded energy savings are based on the marginal water supply or the historical water-supply mix. 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 from a water-efficiency measure occur both before and after the RBY, the calculator uses the historical embedded energy savings for the years preceding the RBY and the marginal embedded energy savings for the RBY and subsequent years. Summing the annual embedded energy savings and dividing by the measure life yields an annualized embedded energy savings.

2.1.4 Marginal Water Supply

The marginal water supply represents the next unit of water supply that would need to be developed within a region to meet demand in the absence of water conservation and efficiency. In support of the W-E Calculator 1.0, the Navigant team consulted publicly available documents, including state and regional planning studies, and consulted with experts and

[5] Decision (D.) 15-09-23, at 27.
[6] Decision (D.) 15-09-23, at 27.

stakeholders to identify the long-run marginal supply in each of California's ten hydrologic regions. Based on this consultation, the Navigant team identified a proxy marginal supply of non-potable recycled water, i.e., wastewater treated to tertiary, unrestricted standards, for all hydrologic regions in California. According to McDonald et al. (2014):

> "Using recycled wastewater as the default proxy marginal supply is reasonable for several reasons. All regions currently are developing and have available recycled water supplies. Although the predominant use of these supplies currently is irrigation, these supplies are approved for numerous other uses. Many utilities include recycled wastewater as a key element of their future supply portfolios. Recycled water is a more conservative supply option than ocean water, which addresses concerns raised by some stakeholders who question the availability of treated ocean supplies to more inland coastal agencies. Lastly, recycling of wastewater is consistent with the SWRCB goals, which encourage water agencies to significantly increase development and use of these supplies.
>
> When recycled water is used for non-potable end uses, it can displace potable or raw water that was previously serving that end use. The displaced potable water can be used to increase supply available to potable end uses; the displaced raw water could be treated further for potable uses. Thus, developing a recycled water supply can still increase the amount of supply available for potable end uses."

CPUC D.15-09-23 supported use of the long-run marginal supply in the W-E Calculator 1.0. The decision stated that "It is the margin—the next water resource we do not have to develop or procure—that matters, and so the W-E calculator correctly considers costs for the marginal supply (e.g., recycled water) rather than average supply."[7] D.15-09-23 further notes that while the user can override the default marginal supply to reflect local circumstances, the user should continue to use values for a marginal supply rather than for historical or existing supplies.[8]

Additionally, D.15-09-23 supports the calculator's use of the long-run marginal supply, rather than the short-run marginal supply, for several reasons. "The first is that data on short-run supplies remain hard to come by. The second is that imports continue to involve much energy that is not from jurisdictional energy companies. A third is that short-run supply options can vary enormously in cost from period to period, and from place to place."[9]

The W-E Calculator 2.0 follows both the W-E Calculator 1.0 and D.15-09-23 in its use of the long-run marginal water supply. It uses non-potable recycled water as the default marginal water supply for each of the ten hydrologic regions and allows the user to adjust the default according to local circumstances.

7 Decision (D.) 15-09-23, at 23.
8 Decision (D.) 15-09-23, at 24.
9 Decision (D.) 15-09-23, at 25.

2.1.5 Historical Water Supply Mix

To plan for and manage water supplies over time, water suppliers evaluate their available supplies using a portfolio approach. The water-supply portfolio for the state varies across time and space, and each hydrologic region has a unique mix of water supplies available, ranging from imported water sources like the Colorado River to more local sources like groundwater. While the type of water supplies available within a hydrologic region is subject to little interannual availability, the *amount* of water available from each supply often changes from year to year due to weather and other factors.

As described in section 2.1.3, if a measure is installed before the RBY, the W-E Calculator 2.0 uses the historical water-supply mix for each hydrologic region to estimate the "historical" embedded energy savings. The historical supply mix for each hydrologic region was based on water-balance data from the California Department of Water Resources' 2018 Water Plan Update for the ten-year period preceding the Resource Balance Year of 2016, i.e., 2006 to 2015.

2.2 Relationship to Other CPUC Tools

The W-E Calculator 2.0 allows PAs to estimate embedded energy savings associated with water-efficiency measures. Integrating embedded energy savings into CEDARS allows the PAs to count those savings toward their energy-efficiency goals and to incorporate them into cost-effectiveness evaluations. Integrating the embedded energy savings expeditiously, however, requires a short-term and a long-term solution, which we summarize. Appendix A contains additional detail on these approaches.

Figure 3 shows the short-term solution for integrating embedded energy savings into CEDARS. Here, the W-E Calculator 2.0 was run using default assumptions to estimate embedded energy intensities (in units of kWh per 1,000 gallons, or kWh/kgal). Embedded energy savings can then be determined by dividing the number of gallons saved by a measure by 1,000 (to put the water savings in kgal) and multiplying the result by the embedded energy intensity. Within the eTRM, the embedded energy savings are automatically added to the direct energy savings of the measure (per D.17-12-010), You can enter the combined value, along with other site-specific savings values, into the CET to calculate the measure's cost-effectiveness. PAs can also use the combined value if they submit a claim for this measure. This approach is only suitable for measures that use the default marginal water supply, i.e., recycled non-potable water. PAs can only claim measures that do not use the default as their marginal supply using the long-term solution, and so must wait until that solution is implemented. Additionally, per D.15-09-023, where PAs depart from default values, they must show that the departure is reasonable in all documents submitted to CPUC staff.

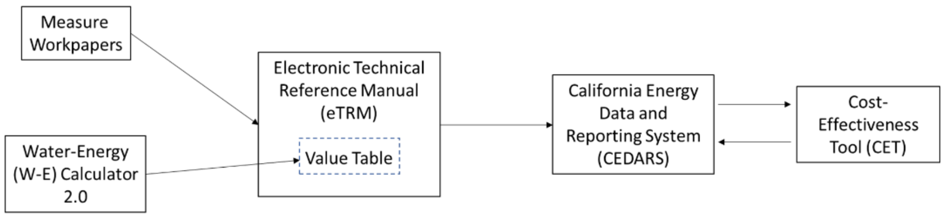


Figure 3: Short-term Relationship Between the W-E Calculator 2.0, eTRM, CEDARS, and CET

Figure 4 shows the long-term solution for integrating embedded energy savings into CEDARS. Here, PAs will use the new CET functionality to enter the direct energy savings and IOU embedded energy savings separately into the CET through CEDARS. The direct energy savings will be calculated using the measure-package methodology. The IOU embedded-water-energy savings will be calculated following the same methodology as used in the short-term solution, but this value will be stored independently within the eTRM and CEDARS to facilitate reporting and cost-effectiveness calculations. The PA will still receive the same credit for both the direct and embedded energy savings as they received using the short-term solution, but for accounting purposes the two types of savings will be entered into the CET and claims separately. Once finalized by the CPUC, this will replace the short-term solution.

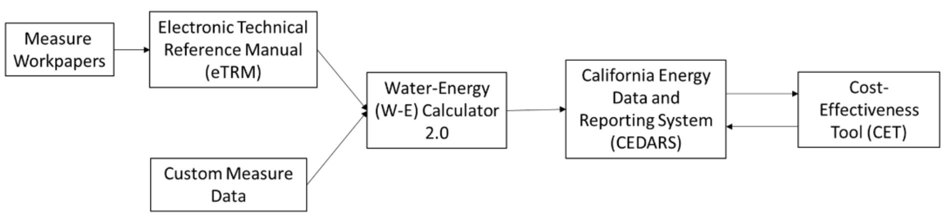


Figure 4: Long-term Relationship Between the W-E Calculator 2.0, eTRM, CEDARS, and CET

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 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 5. 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 calculator 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.

Water-Energy Calculator 2.0

Version 2.0.3

Overview

This tool was developed for the California Public Utilities Commission by Pacific Institute and SBW Consulting to estimate the embedded energy savings associated with water conservation and efficiency measures. Additional information regarding the methodology and data sources can be found in the accompanying report. An earlier version of this tool was developed by Navigant Consulting in 2014.

This tool does not estimate water savings or direct energy savings; rather, it estimates the energy saved due to water efficiency measures that reduce the amount of water extracted, conveyed, treated, and delivered to the customer as well as the wastewater collected, treated, and discharged. As such, it is intended to complement other tools that estimate water savings and direct energy savings and evaluate measure cost effectiveness.

Uses and Limitations

Outputs are estimates based on local and regional data for California. As a result, this tool may not be appropriate for use outside of California.

Embedded energy savings in this tool are only estimates; actual embedded energy savings may vary based on site-specific factors.

Instructions

Please refer to the User Manual for detailed instructions. The following is a quick start guide:

1. Provide measure information on the "Measure Inputs" tab.
2. Review the default assumptions on the "Water System Inputs" tab and adjust as needed. Values that differ from the defaults provided will be appended with an asterisk (*).
3. Results are updated automatically. There is no need to hit a Run or Start button.
4. Detailed calculations are shown on the "Calculations" tab, and a summary is provided on the "Output Table" tab.

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 5: The Information Tab

3.2 Model Inputs

Enter model inputs on the **Measure Inputs** and **Water System Inputs** tabs.

3.2.1 Measure Inputs Tab

On the **Measure Inputs** tab, provide a description of the project (Figure 6). Note that this field is for reference purposes only.

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 installation year, measure life, sector (i.e., urban or agriculture), type of water use evaluated (i.e., indoor, outdoor, or system leaks), annual water savings per device or normalization unit, and the number of devices installed. Based on the annual water savings per device and the number of devices installed, the total annual water savings are automatically filled in. You can enter inputs directly into cells or use the drop-down lists for the Installation Zip Code, Installation Year, Sector, and Water Use Type.

Water-Energy Calculator 2.0

Project Description or Notes

Enter measure details in the table below. Please enter annual water savings per device (or per normalization unit); total annual water savings are calculated based on the number of devices (or normalization units) installed.

Measure Name	Installation Zip Code	Hydrologic Region	Installation Year	Measure Life (years)	Sector	Water Use Type	Annual Water Savings per Device (gallons)	Number of Devices Installed	Total Annual Water Savings (gallons)
High-Efficiency Toilet	91803	South Coast	2021	25	Urban	Indoor	10,000	1	10,000

Figure 6: The Measure Inputs Tab

3.2.2 Water System Inputs Tab

On the **Water System Inputs** tab (Figure 7), select the marginal water supply for the hydrologic regions identified on the **Measure Inputs** tab (Figure 6). The defaults for the marginal water supply and each water-system component are based on the marginal water supply selected, sector, and water use 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. Appendix B 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.

The defaults on the **Water System Inputs** tab for the relevant hydrologic regions are based on the installation zip codes entered on the **Measure Inputs** tab. You can select the marginal supply, water-system components, and energy-intensity values for each of the relevant hydrologic regions. Scroll down the page to review these values and modify as appropriate. Review the urban and the agricultural assumptions for measures installed in an urbanized and agricultural area, respectively.

For the example shown in Figure 7, the user overrode the default marginal water supply for the South Coast hydrologic region and selected potable recycled water as the marginal supply. Additionally, the user overrode the distribution-system topography, selecting a hilly 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:	***South Coast***		
	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
Water Extraction & Conveya	Groundwater pumping		696.8		0.97	
Water Treatment	Recycled Water (Potable) Treatment		1271.5		0.94	
Water Distribution	Urban Potable Distribution		318.0		0.95	
Topography	Moderate	Hilly	*Topography is factored into Distribution values above.*			
Wastewater Collection	Wastewater Collection		71.5		0.97	
Wastewater Treatment	Wastewater Secondary Treatment		654.1		0.97	

Figure 7: The Water System Inputs Tab

Agricultural water-efficiency measures are assumed to have no effect on wastewater collection and treatment and thus no wastewater-related embedded energy savings. However, should an agricultural water-efficiency measure reduce wastewater collection and treatment, you can override this assumption and insert the appropriate energy-intensity values for wastewater collection and treatment.

Additionally, as noted in section 2.1.2, the end user, especially in agricultural and some industrial settings, may extract water from a groundwater aquifer or nearby stream for their own use. In these instances, the embedded energy savings associated with pumping less groundwater may already be captured in the estimates of on-site direct energy savings. If so, the user should be careful to count those energy savings one time, i.e., as *either* embedded *or* direct energy savings.

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

3.3 Model Outputs

3.3.1 Calculations Tab

The **Calculations** tab (Figure 8) summarizes the calculator inputs, including the measure name, installation zip code, annual water savings, and the marginal supply. An asterisk (*) indicates any selection that differs from the default value.

Measure Information											
Measure Name	Installation Zip Code	Installation Year	Measure Life (years)	Sector	Water Use Type	Annual Water Savings per Device (gallons)	Number of Devices Installed	Annual Water Savings (gallons)	Annual Water Savings (ac-ft)	Hydrologic Region	Marginal Supply
High-Efficiency Toilet	91803	2021	25	Urban	Indoor	10,000	1	10,000	0.03	South Coast	Recycled Water (Potable)*

Figure 8: The Calculations Tab Showing a Summary of the Measure Information

Scroll to the right to view the historical and marginal embedded energy calculations and the annualized embedded energy savings (Figure 9). Click the "+" sign above columns W and AP to view detailed information on the energy intensity and fraction IOU-supplied energy for each water-system component for the historical and marginal embedded energy calculations, respectively. To hide this information, click the "–" sign above columns W and AP.

When a measure is installed after the RBY, the annualized embedded energy savings are equal to the marginal embedded 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 subsequent years. Summing the annual embedded energy savings and dividing by the measure life produces an annualized embedded energy savings.

W	X	Y	AP	AQ	AR	AS	AT	AU
Historical Embedded Energy Calculations			Marginal Embedded Energy Calculations					
Historical Embedded Energy Savings (Pre-2016)			Marginal Embedded Energy Savings (Post 2016)			Annualized Embedded Energy Savings		
Annual Embedded Energy Savings (kWh)	Annual IOU Embedded Energy Savings (kWh)	Annual Non-IOU Embedded Energy Savings (kWh)	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)
83.53	38.07	45.46	92.43	88.29	4.14	92.43	88.29	4.14

Figure 9: The Calculations Tab Showing the Historical and Marginal Embedded Energy Calculations and Annualized Embedded Energy Savings

3.3.2 Output Table Tab

The **Output Table** tab (Figure 10) summarizes outputs generated by the W-E Calculator 2.0. These include the measure name, hydrologic region, sector, water-use type, water savings, the annualized IOU and non-IOU embedded energy savings (in kWh), and the annualized IOU and non-IOU energy intensity (in kWh/kgal).

Measure Name	Hydrologic Region	Sector	Water Use Type	Annual Water Savings per Device (gallons)	Number of Devices Installed	Total Annual Water Savings (gallons)	Annualized IOU Embedded Energy Intensity (kWh/kgal)	Annualized Non-IOU Embedded Energy Intensity (kWh/kgal)	Annualized IOU Embedded Energy Savings (kWh)	Annualized Non-IOU Embedded Energy Savings (kWh)
High-Efficiency Toilet	South Coast	Urban	Indoor	10000	1	10,000	8.83	0.41	88.29	4.14
Totals						**10,000**			**88.29**	**4.14**

Figure 10: The Output Table Tab

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Appendices

Appendix A contains detailed descriptions of the short- and long-term solutions for integrating W-E Calculator 2.0 outputs into CEDARS.

Appendix B 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. Short- and Long-term Solutions for Integrating Embedded Energy Savings into CEDARS

On 20 December 2021, the California Public Utilities Commission (CPUC) published the final version of the Water-Energy Calculator 2.0 (W-E Calculator 2.0). The W-E Calculator 2.0 replaces the first version of the Water-Energy Calculator, and Program Administrators (PAs) will use its values going forward to calculate the embedded energy savings of Water-Energy Nexus (WEN) measures. PAs can now use the embedded energy savings from these WEN measures to claim incentives and they will count towards PAs' energy efficiency goals.

The two solutions described below detail how PAs will calculate the embedded energy savings using the California electronic Technical Reference Manual (eTRM).

Short-term Solution

Until the CPUC implements the Long-term Solution, existing and new WEN-measure packages will use the following method to calculate the embedded energy savings produced by a water-efficiency measure and add it to the direct (site) energy savings generated by that measure.

The measure or measure update will add the energy-intensity values in Table 1 to eTRM. The embedded energy savings for the measure will be the result of dividing the number of gallons saved by the measure by 1000 and multiplying that result by the "Total IOU Embedded Water Energy Intensity" value in Table 1, based on whether the measure is an indoor or outdoor measure. For IOUs, the embedded-water-energy intensity is 5.44 kWh/kgal for indoor measures, and 3.28 kWh/kgal for outdoor measures. Once the embedded energy savings have been calculated, they will be automatically added in eTRM to the direct energy savings of the measure (per D.17-12-010). That combined value, along with other site-specific savings values, will then be input into the Cost-Effectiveness Tool (CET) through California Energy and Data Reporting System (CEDARS) to calculate the measure's cost effectiveness. Program Administrators (PAs) will also use the combined value if they submit a claim for this measure.

As the embedded energy savings are present regardless of whether the measure uses hot or cold water, the total annual water savings including both hot and cold water will be multiplied by the appropriate "Total IOU Embedded Water Energy Intensity" value in Table 1. The calculation of direct energy savings will be unchanged.

This approach is only suitable for measures that use the default marginal water supply—recycled water (non-potable). PAs may claim measures that use a different marginal supply only if they use the long-term solution, and thus must wait until that solution is implemented. Additionally, per D.15-09-023, where PAs depart from default values, they must show that the departure is reasonable in all documents submitted to CPUC.

Table 1: Embedded Water Energy Intensities

Climate Zone	Sector	Water Use Type	Marginal Supply	Total IOU Embedded Water Energy Intensity (kWh/kgal)	Total Non-IOU Embedded Water Energy Intensity (kWh/kgal)
Any	Urban	Indoor	Recycled Water (Non-Potable)	5.44	0.25
Any	Urban	Outdoor	Recycled Water (Non-Potable)	3.28	0.19

Long-term Solution

Once CPUC finalizes this solution, it will replace the Short-term Solution for the measure. When the CPUC informs the relevant PAs of this transition, the PAs will create a Measure Log Entry that includes a Measure Package Plan (MPP). The MPP will describe the administrative change to the measure package that will incorporate the long-term solution used to calculate the total energy savings as well as when the change will take effect. This administrative change will not trigger a new version of the measure package since impacts (including savings, cost, and measure life) have not changed. It is expected that total energy savings will be broken out in this long-term approach so that direct energy savings can be distinguished from IOU embedded-water-energy savings and stored separately in permutation data fields.

The measure or measure update will use the new CET functionality to accept the direct energy savings and IOU embedded energy savings separately into the CET. The direct energy savings will be calculated using the measure-package methodology. The IOU embedded-water-energy savings will be calculated following the same methodology described in the Short-term Solution but will be stored independently within the eTRM to facilitate reporting and cost-effectiveness calculations. The PA will still receive the same credit for both the direct and embedded energy savings as they received using the Short-term Solution, but for accounting purposes the two types of savings will be entered into the CET separately through CEDARS.

B. Default Values Used in the Water-Energy Calculator 2.0

Table 2: 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	197	197	197	197	197	197	197	197	197	197
Brackish Desalination -Groundwater Pumping	383	491	506	697	294	301	347	381	401	532
Brackish Desalination - Local Surface Water	89	89	89	89	89	89	89	89	89	89
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
Recycled Water (Potable) – Groundwater Pumping	383	491	506	697	294	301	347	381	401	532
Recycled Water (Potable) – Local Surface Water	89	89	89	89	89	89	89	89	89	89
Local Surface Water	89	89	89	89	89	89	89	89	89	89
Local Imported Water	89	112	N/A	33	N/A	N/A	N/A	N/A	N/A	N/A

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

The default energy intensity of extraction and conveyance for brackish desalination and potable reuse is assumed to be the same as for groundwater because most brackish water and potable recycled water are drawn from groundwater basins; however, the user can select "local surface water" if the brackish water or potable recycled water is drawn from a local surface water body.

Data Sources: Data Sources: EPRI 2002, Klein et al. 2005, Wilkinson 2007, GEI Consultants/Navigant Consulting 2010a, GEI Consultants/Navigant Consulting 2010b, Cooley et al. 2012, Plappally 2012, Tarroja et al. 2014, Liu et al. 2017, and Stokes-Draut et al. 2017

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

Treatment Type	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 4: 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

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

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

Table 5: 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: EPRI 2002, Klein et al. 2005, GEI Consultants/Navigant Consulting 2010b, Cooley et al. 2012, Tarroja et al. 2014, Tidwell et al. 2014, and Liu et al. 2017.

Table 6: 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 Surface Water	0.27
	Local Imported Water	0.27
	Colorado River Deliveries	0
	Central Valley Project	0
	State Water Project	0
Water Treatment		0.94
Water Distribution		0.95
Wastewater Collection		0.97
Wastewater Treatment		0.97

Data Source: McDonald et al. 2014

Table 7: 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%	0.47%	4.14%	0.0%	0.0%	0.0%	0.0%	0.1%	0.3%
Recycled Water (Potable)	0.0%	0.0%	0.03%	0.36%	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 Surface Water	96.4%	21.1%	2.2%	4.5%	54.3%	41.1%	16.9%	76.4%	15.9%	0.1%
Local Imported Water	0.1%	35.7%	0.0%	4.4%	0.3%	0.1%	0.0%	0.0%	0.0%	0.0%
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%

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.
California Energy Data and Reporting System (CEDARS)	Data and reporting system that maintains California Energy Efficiency Program data reported by Investor-Owned Utilities, Regional Energy Networks, and certain Community Choice Aggregators.
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.
Cost Effectiveness Tool (CET)	An online tool designed for the California Public Utilities Commission to determine the cost effectiveness and examine other properties of energy efficiency programs and portfolios.
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 energy used to extract, convey, treat, and distribute water to end users, and energy used to collect and transport wastewater for treatment prior to safe discharge of the effluent in accordance with regulatory rules.
Embedded Energy Savings	The energy saved due to reductions in the amount of water extracted, conveyed, treated, and delivered as well as the wastewater collected, treated, and discharged.
Entergy Intensity	The amount of energy used to extract, 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) or kWh per 1,000 gallons (kWh/kgal)
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.

Term	Definition
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.
IOU Energy	Energy provided by an investor-owned utility.
Local Surface Water	Water delivered by local water agencies and individuals. It includes direct deliveries of water from stream flows, as well as local water storage facilities.
Local Imported Water	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.
Non-IOU Energy	Energy that is not provided by an investor-owned utility
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.
State Water Project	A collection of canals, pipelines, reservoirs, and hydroelectric power facilities that extends more than 700 miles and is managed by the California Department of Water Resources.
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.

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Distribution	The transport of treated water (both potable and non-potable) to the customer.
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Embedded Energy	The energy used to extract, convey, treat, and distribute water to end users, and energy used to collect and transport wastewater for treatment prior to safe discharge of the effluent in accordance with regulatory rules.
Embedded Energy Savings	The energy saved due to reductions in the amount of water extracted, conveyed, treated, and delivered as well as the wastewater collected, treated, and discharged.
Entergy Intensity	The amount of energy used to extract, 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) or kWh per 1,000 gallons (kWh/kgal)
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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.
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Water Treatment	Processes and technologies that treat water prior to its distribution to the end user.
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Wastewater Treatment	Application of biological, physical, and/or chemical processes to bring wastewater to discharge standards.