Implementation of the California Public Utilities Commission's Water-Energy Calculator

Issues and Opportunities

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waterenergy INNOVATIONS

RMS ENERGY CONSULTING, LLC

ACRONYMS

AF	Acre-Foot
CEC	California Energy Commission
CPUC	California Public Utilities Commission
DPR	Direct Potable Reuse
E+C	Extraction & Conveyance
EI	Energy Intensity
IEPR	Integrated Energy Policy Report
kWh	Kilowatt-hour
PA	Program Administrator
RO	Reverse Osmosis
RW	Recycled Water
UV	Ultraviolet
W-E	Water-Energy
WW	Wastewater

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Executive Summary

While assisting multiple parties in implementing the Water-Energy Calculator (W-E Calculator) that was adopted by the California Public Utilities Commission (CPUC) on September 17, 2015, Water Energy Innovations, Inc. (WEI) and RMS Energy Consulting, LLC (RMS) identified several issues and opportunities that we believe are important to determining how the W-E Calculator should be applied to planning and design of CPUC-jurisdictional Water-Energy Programs. In particular, we identified the following uncertainties with respect to interpretation and application of the CPUC's Decision 15-09-023 *Regarding Tools for Calculating the Embedded Energy in Water and an Avoided Capacity Cost Associated with Water Savings*.

1. CPUC Policies and Protocols for Estimating Embedded Energy
2. Default Values Adopted by the CPUC for Computing Embedded Energy
3. The CPUC's Goal with Respect to Its Water-Energy Calculator

To attempt to bring clarity to these issues, WEI and RMS reviewed the specific language in CPUC Decision 15-09-023. We then reviewed the data, assumptions and calculations contained within the W-E Calculator (version 1.05) and reports prepared by the CPUC's Consultant, Navigant Consulting, Inc. (Navigant). Since both CPUC Decision 15-09-093 and Navigant's reports incorporate prior studies and reports by reference but do not specifically reiterate many foundational findings and principles upon which the development of the CPUC's W-E Calculator relied, we also revisited some of these prior works, especially: (a) the California Energy Commission's (CEC) white paper, *California's Water Energy Relationship*, that was developed to help inform the CEC's Integrated Energy Policy Report (IEPR) for 2005; and (b) the CPUC's *Embedded Energy Studies 1 and 2* that were published on August 31, 2010.[1]

Our findings and recommendations are summarized herein. A description of the work that we performed to develop these findings and the bases for our recommendations are described in more detail in the body of this white paper.

[1] The CPUC's *Embedded Energy in Water Studies* were conducted pursuant to CPUC Decision 12-07-050 [December 20, 2007] for the purposes of (a) validating claims that saving water can save energy, and (b) exploring whether embedded energy savings associated with water use efficiency are measurable and verifiable. *Study 1 Statewide and Regional Water Energy Relationship* focused on understanding the timing and amount of electric energy inputs to wholesale water supplies. *Study 2 Water Agency and Function Component Study and Embedded Energy -Water Load Profiles* collected and compiled data for participating water and wastewater agencies to understand how, when and how much electricity is used by water and wastewater systems and functions, and the coincidence of the timing of water sector electric use with electric demand on energy investor-owned utilities' systems.

Scope of This Review

WEI and RMS did not review the W-E Calculator's computations of cost-effectiveness, nor did we attempt to review the separate Avoided Capacity Cost of Water model that was developed as a companion to the W-E Calculator, or the separate model that was developed to estimate the environmental benefits of avoided water consumption for different types of water resources. Those additional tools were developed to facilitate stakeholders' discussions during multiple public workshops conducted during 2014 and 2015 pursuant to CPUC Rulemaking 13-12-010 into Policies to Promote a Partnership Framework between Energy Investor Owned Utilities and the Water Sector to Promote Water-Energy Nexus Programs.

WEI and RMS focused on reviewing the computation of embedded energy that the CPUC intended parties to rely upon when designing and implementing CPUC-jurisdictional Water-Energy Programs. We feel strongly that the default values, assumptions and computational protocols integrated into the W-E Calculator need to be well understood, since the embedded energy computation forms the basis for all other computations that follow.

During the course of our review, we performed some tests of the W-E Calculator's functions in order to trace and document the computations and assumptions that are used to compute embedded energy. We identified some computations that we believe may either be errors or inconsistencies with the CPUC's stated policies and objectives for its W-E Calculator.

Where we identified outcomes that we believed may represent either errors or inconsistencies, we have documented them. We did not, however, conduct a detailed analysis and verification of the W-E Calculator itself. That would require developing multiple error-trapping datasets and performing extensive additional tests, including (but not limited to) parallel computations of the W-E Calculator's functions.

Our objective was not to conduct a detailed analysis of the W-E Calculator itself, but to help Users of the W-E Calculator understand the basic issues and options with respect to computing embedded energy to support design, development and implementation of Water-Energy Programs.

Summary of Key Findings

1. **<u>CPUC Policies and Protocols for Estimating Embedded Energy</u>**

   A review of the CPUC Consultant's Report[2] confirms that the basic approach used in the W-E Calculator for computing embedded energy is the same as the convention initially established and recommended by the CEC in its 2005 white paper; i.e., the accumulation of energy inputs to water resources and water and wastewater systems along segments of the water cycle (referred to in the Consultant's Report as "water system components").

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[2] *Water-Energy Cost-Effectiveness Analysis Final Report*, Prepared for California Public Utilities Commission by Navigant Consulting, Inc., October 7, 2014 (as amended by Errata issued on May 22, 2015).

The basic methodology is to develop estimated "Energy Intensities" (average energy used to produce or extract, convey, treat and distribute each unit of water, plus the average amount of energy used to collect, transport and treat wastewater) along each water cycle segment or water system component. By adding average energy inputs to water upstream of water use and to wastewater downstream of water use, an average energy intensity can be developed to represent the amount of energy embedded in water used Indoors (the sum of all energy inputs, Upstream and Downstream of water use) vs Outdoors (Upstream energy inputs only). The figure below illustrates the path of energy inputs to water and wastewater.

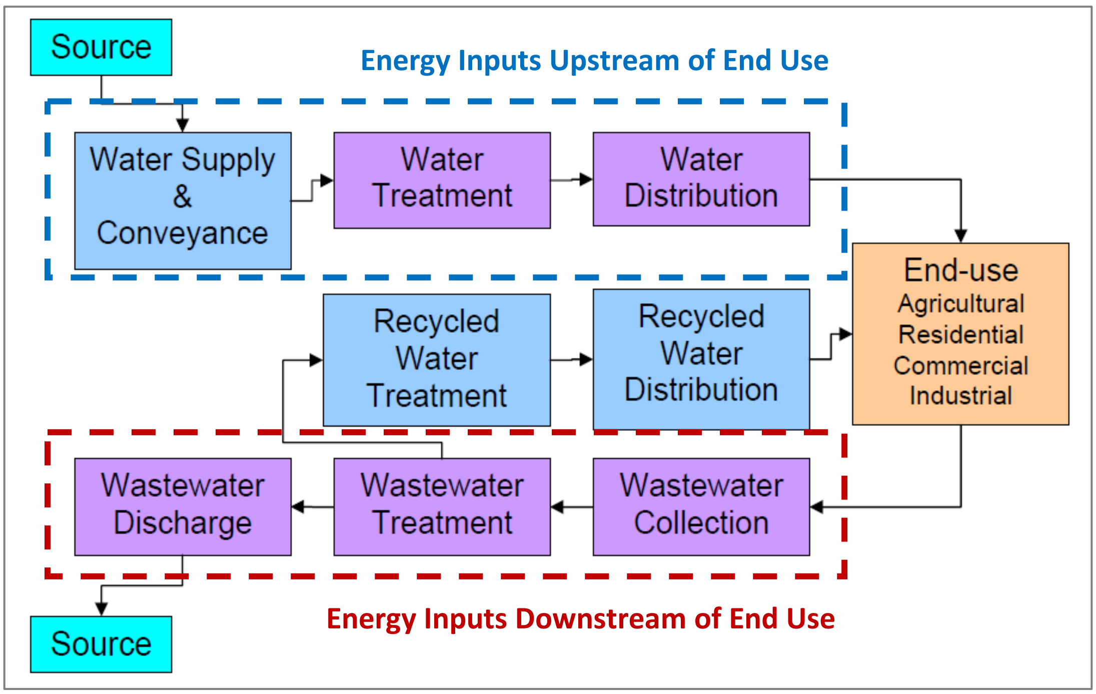

Figure 1. California's Water Use Cycle [Red and Blue dotted lines and titles added by WEI][3]

The CPUC's Consultant changed the nomenclature for the "Water Supply & Conveyance" segment to "Extraction & Conveyance" and made some other changes to the computation of embedded energy. The most significant difference was in the computation of the Energy Intensity of Recycled Water that changed the Energy Intensity of Outdoor Water Use. This and other types of changes recommended in the Consultant's Report are discussed under Chapters 2 and 3 of this white paper.

Confirming that the methodology for computing embedded energy was generally the same as it had been in prior studies was important to determining what specific policies the CPUC had adopted with respect to embedded energy. Below are the primary decisions that we identified:

[3] *California's Water-Energy Relationship*, California Energy Commission, CEC-700-2005-011-SF [November 2005], Figure 1-1.

a. ***Long-Run Marginal Water Supply***. The CPUC determined that it would be appropriate to use the energy intensity of the *long-run marginal water supply* as a basis for computing the embedded energy that could be saved by reducing water use. "*We still see significant problems with using short run marginal supply. 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. The W-E calculator addresses these concerns by using only the long-run marginal supply. … for purposes of defaults, taking a long-run approach is the only practical option.*"[4]

b. ***Hydrologic Region***. The CPUC decided that although it was not perfect, "*It is reasonable for the tools' default values to reflect data averaged across a DWR hydrologic region and for defaults averaged across hydrologic regions to be user-editable.*"[5] In explaining the basis for its decision, the CPUC explained that *"DWR and SWRCB regions offer an imperfect fit for marginal water supplies, as surface water hydrology fails to correlate with developed groundwater resources. Neither does hydrologic region correlate with water rights, management, governance, treatment, nor delivery.*" However, "*the W-E calculator defaults to DWR hydrologic regions for data on the energy intensity of the marginal water supply (averaged for each region). The determinative factor here was data availability.*"

Significantly, based on a thorough read of the CPUC's decision, we believe that the CPUC ***did not adopt its Consultant's recommendation to use Recycled Water as the statewide marginal water supply*** for all ten hydrologic regions. This is very important, because many Users have advised that they believed that they did not have the ability to change the W-E Calculator's default marginal water supply selection.

To the contrary, throughout its decision, the CPUC emphasized that Users should select energy intensities, technologies, and water and wastewater system characteristics that are more appropriate to their proposed water-energy programs. Ordering paragraph 4 in the CPUC's decision states that "*The tools correctly consider costs for the marginal water supply (e.g., recycled water) rather than average supply.*" In other words, we believe that the CPUC reiterated use of the energy intensity of the marginal water supply (and not the historical average supply), acknowledging Recycled Water as one example of a marginal supply. In other places, the CPUC stated that users should "*enter marginal supply options that may be most appropriate for their local circumstances*."[6]

2. <u>Default Values Used to Compute Embedded Energy</u>

During our review, we scrutinized the language in the CPUC's decision to determine whether the CPUC intended to lock in the default energy intensities used by the W-E Calculator to compute embedded energy. Based on numerous passages throughout the decision, the CPUC

[4] Decision 15-09-023, pp.25-26.
[5] Decision 15-09-023, Ordering Paragraph 3, p.70.
[6] Decision 15-09-023, p.24.

encourages Users to develop energy intensity and other data that are more appropriate to their programs, and help to improve the W-E Calculator's initial default values that were developed as a matter of convenience while better data is being developed. In fact, the CPUC directed Class A and Class B water investor-owned utility companies subject to its jurisdiction to develop district-level energy intensity data (not company-wide) and to use those numbers in the W-E Calculator.[7]

In Chapters 4, 5 and 7 of this white paper, we document the default values that we believe the CPUC intended to adopt, and differentiate "values" from other types of selections within the W-E Calculator which, although they have been hard-coded into the W-E Calculator, we do not believe the CPUC specifically adopted. Chapter 4 details the default energy intensity values by type of water resource, water treatment technology, water distribution system, wastewater collection and wastewater treatment technologies that are documented in the CPUC Consultant's report and also incorporated into the W-E Calculator. We then describe how these data are used to compute the default energy intensity of Indoor vs. Outdoor Water Uses by type of sector (Agricultural vs. Urban) by Hydrologic Region.

The below table illustrates a menu-based approach that would enhance the ability of Users to select the variables and respective default energy intensities that are most appropriate to their water-energy programs.

Table ES-1. A Simple Menu for Selecting Energy Intensities by Water System Component[8]

Build-Up of Embedded Energy by Water System Component					Embedded Energy Saved by Reducing Water Use	
Energy Inputs "Upstream" of Water Use			Energy Inputs "Downstream" of Water Use			
[1] Extraction & Conveyance	[2] Treatment	[3] Distribution	[4a] Wastewater Collection	[4b] Wastewater Treatment	Outdoors ∑ **[1]**-[3]	Indoors ∑ **[1]**-[4]
Select: Marginal Water Supply	Select: Water Treatment Level/Technology	Select: Water Service Area Physical Characteristics	Select: Wastewater Collection (only one choice provided: "Yes" or "No"	Select: Level of Wastewater Treatment	Compute	Compute

This simple menu-driven approach enables clearly documenting the selections and values that are used to compute Indoor vs. Outdoor energy intensities for each type of marginal water supply. The default energy intensities documented in the CPUC Consultant's Report and included in the W-E Calculator can be used as a startpoint. The energy intensities of water resources, treatment technologies, and service area specific characteristics can then be updated within the template with better energy intensity data as those become available. In addition to enabling transparency and understanding of the energy intensity and embedded energy computations, this approach has the added benefit of creating an audit trail that clearly

[7] Decision 15-09-023, p.33.
[8] All default values in the CPUC's W-E Calculator are electric, expressed in kWh/AF.

identifies any departures from the default energy intensities that were compiled at the hydrologic region level from the CPUC's Embedded Energy in Water Studies 1 and 2.

By reviewing the CPUC Consultant's Report and the CPUC's decision, we believe that the above simple framework was intended to be implemented through the W-E Calculator; however, during implementation, the W-E Calculator locked in default choices that we do not believe were consistent with the CPUC's intent.

3. **<u>The CPUC's Goal with Respect to Its Water-Energy Calculator</u>**

Probably the most persuasive evidence that substantiates our belief that the CPUC intended Users to tailor their selections in the W-E Calculator to their water-energy programs is the following excerpt from Decision 15-09-023:

> "*Our goal in allowing departure from defaults here is to facilitate energy IOUs seeking out high energy intensity, high water use, areas. Targeting such areas should maximize energy savings per dollar spent on water saving measures.*"[9]

The primary problem is that the CPUC also placed "*the burden of proving the departures reasonable in all documents submitted to Commission Staff*"[10], observing that:

> *"As PG&E notes, "In some cases, agency-specific energy intensity data will be available and suitable for use in custom projects with proper documentation and standards (which raises a number of questions about length of baseline period, how to account for varying sources of supply that may not have intensity data available, and how to account for locational factors such as site elevation). User-specified input values would be documented and evaluated through normal calculated project review mechanisms."*

The CPUC did not provide any further guidance, which makes it very difficult (and even a bit risky) for program implementers to depart from the W-E Calculator's defaults. As a consequence, every party we have worked with to-date is using Recycled Water as the marginal water supply for every hydrologic region, and all of the default technology, service area characteristics and other selections related to the Recycled Water assumption that appear to have been hard-coded into the W-E Calculator.

Recommendations

1. **<u>Unlock the W-E Calculator Defaults</u>**. If the CPUC intended to encourage Users to tailor their selections in the W-E Calculator, the first step would be to unlock the default selections in the W-E Calculator and allow Users to select the appropriate marginal water supplies, water and wastewater treatment technologies, and other key drivers of Indoor and Outdoor embedded

[9] Decision 15-09-023, pp.43-44.
[10] Ibid.

energy. The simple menu shown in Table ES-1 would suffice for this purpose. In addition to significantly simplifying the process of selecting the technologies and other characteristics appropriate to their water-energy programs, this menu-driven approach would facilitate transparency and verifiability in the embedded energy computations.

We believe that Users do not need to defend their selection of appropriate technologies and other water and wastewater system characteristics when using the default energy intensities compiled by the CPUC's Consultant from data collected and compiled for the CPUC's Embedded Energy in Water Studies 1 and 2. Program implementers should only be required to document changes from the default energy intensities contained in the W-E Calculator for each of the components. The specific default values that we believe were adopted by the CPUC are documented in Chapter 4 of this white paper.

2. **Substantially Reduce the Risk to Users that Develop and Apply Program-Specific Energy Intensities**. To encourage Users to develop program specific energy intensities and thereby build knowledge, understanding and a more comprehensive database of water sector energy intensities and embedded energy, the CPUC should provide simple guidelines for how these user-defined values can be developed and approved. Based on our extensive work in this area, we do not believe that is difficult. For example:
    a. **Marginal Water Supplies** can be readily determined for each water utility subject to the Urban Water Management Planning Act[11] through Urban Water Management Plans that are prepared and submitted every five years to the Department of Water Resources. These plans require water utilities to include their plans to build or acquire new water resources to provide reliable water supplies to their customers over a minimum 20 year forecast period. (I.e., 2015 Urban Water Management Plans are required to document their plans for providing reliable water supplies through 2035).
    b. **Water Resource Energy Intensity** can be fairly readily computed for the marginal water supply of any particular water utility or groups of water utilities. The energy intensity of some water resources such as seawater desalination are fairly uniform since the energy intensity depends primarily on the quantity of salts and other minerals that need to be removed. The energy intensity of other types of water resources, such as groundwater, are highly variable, depending on the characteristics of the specific groundwater basin, especially the depth-to-groundwater that drives pump energy, and the quality of the groundwater. Our studies have shown substantial variances in groundwater energy intensity that the default values do not capture. Every water utility we have worked with that pumps groundwater knows the energy intensity of its resource, or can compute it very simply.
    c. **Distribution Energy Intensity** can be very simply computed for an entire water utility's service area by dividing total annual energy used for distribution by total volume of water transported. This very simple computation will produce a much more accurate energy

[11] Water purveyors that provide over 3,000 acre-feet of water annually, or serve more than 3,000 urban connections.

intensity of Water Distribution than the W-E Calculator's default selection at the hydrologic region level.

d. <u>Water and Wastewater Treatment Energy Intensity</u> has been studied extensively by multiple parties. Those studies show that the primary drivers of treatment energy intensity, whether for water or wastewater, are the quality of the water or wastewater being treated, the technology being utilized, and the level of treatment. These values tend to be uniform throughout the state because the key drivers of energy intensity are independent of hydrology, climate, topography and geology.

Establishing a simple to use template that participating water utilities can use to provide information about the energy intensities of their water resources and water and wastewater system components would substantially increase willingness of program implementers to provide and use energy intensity data that more accurately reflects their anticipated program results.

3. **<u>Move the Avoided Cost of Energy and Related Computations of the Cost-Effectiveness of Embedded Energy</u>** to the CPUC's E3 and CET cost-effectiveness calculators as soon as possible. While this was not the focus of our investigations, it became clear that the complexity of the CPUC's current W-E Calculator makes it difficult to understand its default data, processes and computations, and to assure that computations are performed on bases consistent with other energy efficiency programs.

Additional findings and recommendations have been provided in the body of this report.

1 Introduction

A large body of work has been conducted by multiple parties since 2005, when the Energy Commission issued its findings with respect to *California's Water-Energy Relationship*.[12] Most recently, the California Public Utilities Commission conducted a *Rulemaking Into Policies to Promote a Partnership Framework between Energy Investor Owned Utilities and the Water Sector to Promote Water-Energy Nexus Programs* [CPUC R.13-12-011 opened December 19, 2013]. The rulemaking encompassed multiple efforts, including:

- A Project Coordination Group (PCG) led by the CPUC's Energy Division that developed a scope of work and issued a solicitation for a consultant to develop a Water-Energy Calculator and an Avoided Capital Cost of Water Model;
- Multiple public workshops at which parties had an opportunity to provide input to the W-E Calculator, Avoided Capital Cost of Water Model, and other issues being considered by the CPUC with respect to whether and how energy embedded in water should be computed and valued for purposes of CPUC-jurisdictional energy efficiency programs; and
- A wide variety of CPUC rulings and decisions related to implementing energy efficiency programs and measures that also save water.

On September 17, 2015, the CPUC directed Energy Efficiency Program Administrators (PAs) to use the Water-Energy Calculator and the companion Avoided Water Capacity Cost Model in preparing their requests for ratepayer funding for measures and programs that reduce water use and thus save embedded energy.[13] The decision stated that "Energy efficiency Program Administrators (PAs) may depart from the Water-Energy Calculator and the Avoided Water Capacity Cost Model (collectively, tools) defaults where the tools allow. Where PAs depart from ***default values***, they bear the burden of proving the departure(s) reasonable in all documents submitted to Commission Staff." [*emphasis added*]

Purpose of This White Paper

Through work with multiple parties that are using the W-E Calculator to support design of water-energy programs, Water Energy Innovations, Inc. (WEI) and RMS Energy Consulting, LLC (RMS) became aware that there was confusion about what specifically the CPUC adopted in its Decision 15-09-023. For example, the CPUC stated that PAs "bear the burden" of proving departures from "default values". But the CPUC also states throughout its Decision 15-09-023 that Users can override virtually all of the default values, selections and assumptions within the W-E Calculator.

[12] *California's Water-Energy Relationship.*

[13] CPUC Decision 15-09-023, September 17, 2015, p.72.

Many Users of the W-E Calculator have interpreted Decision 15-09-023 to mean that any change to the W-E Calculator will create a need to justify those changes. WEI and RMS believe that this is not necessarily the case. Specifically, we believe that as the CPUC, Energy and Water IOUs, Third Party Implementers, Customers and other Stakeholders apply the W-E Calculator, they should separate the definition of "default values" from "default selections." We do not believe that these are the same. We further believe that a decision to rely solely upon the defaults that have been hard-coded into the W-E Calculator will have the effect of thwarting one of the CPUC's stated objectives in adopting the W-E Calculator, and that was to provide a platform for continually improve data and understanding about the Energy Intensity (EI) of different types of water supplies and systems, and sharing that data.[14]

To substantiate the bases for our findings and recommendations, WEI and RMS looked first to CPUC Decision 15-09-023 adopting the W-E Calculator. We then reviewed the data, assumptions and calculations contained within the W-E Calculator, and the accompanying CPUC Consultant's reports.

Our review focused exclusively on reviewing the W-E Calculator's default assumptions with respect to the types of water system components and their respective default energy intensity values that are used to compute Measure-Level Embedded Energy. Our review did not include the separate Avoided Water Capacity Cost Model, the computation or relative merits of environmental benefits deemed associated with saving water, or any other topics that may have been addressed during the CPUC workshops that informed CPUC Decision 15-09-023 that are not directly related to computing embedded energy.

To document our understanding about issues and opportunities related to use of the CPUC's W-E Calculator with respect to computing the energy intensities of different types of water resources and water uses:

- We first discuss and describe the history and general framework for computing energy intensity and embedded energy that was first established by the CEC in 2005 and (we believe) adopted by the CPUC.
- We then document the default values that the CPUC adopted in Decision 15-09-023, vs. the types of *choices* (not *values*) that Users are allowed to override in the W-E Calculator.
- We highlight several assumptions integrated into the current W-E Calculator (version 1.05) may not be consistent with the CPUC's intent.
- Finally, we provide several recommendations with respect to modifications to the CPUC's W-E Calculator that we believe will enhance transparency, accuracy, consistency, and verifiability of measure-level embedded energy computations and resultant avoided costs of energy.

[14] Decision 15-09-023 *Regarding Tools for Calculating the Embedded Energy in Water and an Avoided Capacity Cost Associated with Water Savings* (September 17, 2015) states that "*… we also allow user inputs to provide and share data on embedded energy in water, for example by Water IOUs and other water providers. This will allow for more granular and accurate data that accounts for differences in water supply.*", p.21.

2 Energy Embedded in Water

One of the most important functions of the W-E Calculator is to compute the Electric Energy Intensity (EI) of different types of water resources by type of water use (Urban/ Agricultural, Indoor/Outdoor) and by Hydrologic Region.

The Water Cycle

In 2005, the California Energy Commission (CEC) issued a white paper, *California's Water-Energy Relationship*,[15] in which the CEC described how energy inputs are made to water along all segments of the water cycle,[16] and how these energy inputs could be measured for use in evaluating the energy benefits attributable to saved water.

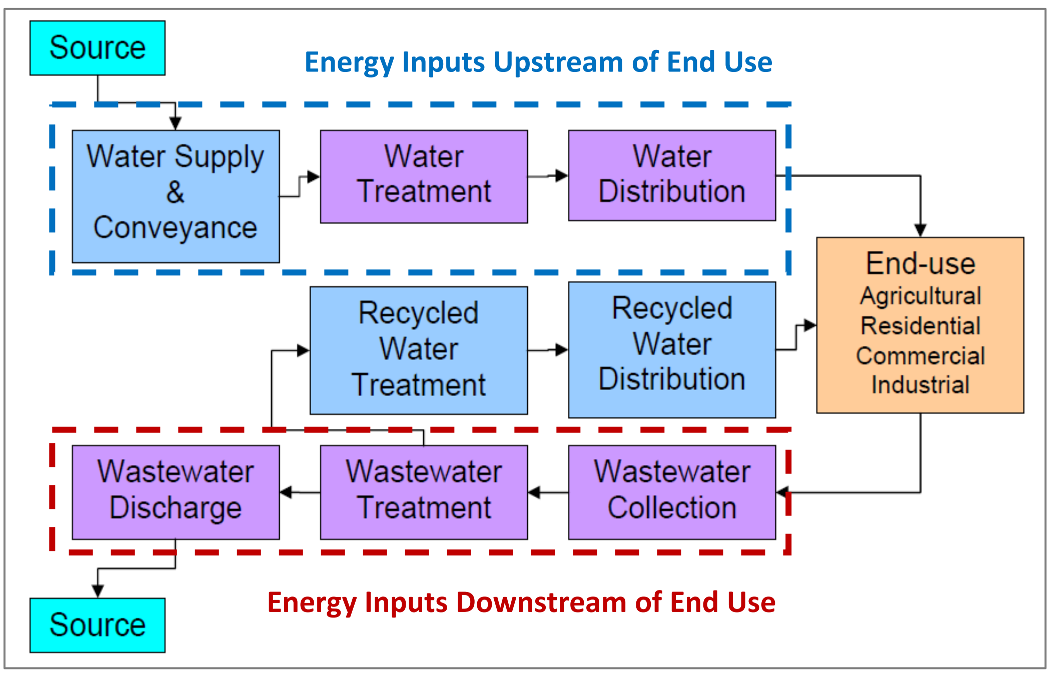

Figure 1. California's Water Use Cycle [Red and Blue dotted lines and titles added by WEI][17]

The CEC's diagram is key to understanding the embedded energy computations that underlie the CPUC's W-E Calculator.

[15] *California's Water-Energy Relationship*, California Energy Commission, CEC-700-2005-011-SF [November 2005].
[16] In the Consultant's 2014 Report accompanying the W-E Calculator, Navigant Consulting made slight changes to the definitions and nomenclature: "water cycle" became "water system components", and "Supply & Conveyance" became "Extraction & Conveyance".
[17] *California's Water-Energy Relationship*, Figure 1-1.

Energy Inputs to Water and Wastewater

The CEC recommended that the "energy intensity" (i.e., the average amount of energy - kWh and/or therms - used to pump or treat water or wastewater) be measured for each segment of the water cycle (aka, "water system component"). These "energy intensities" could then be added up along multiple segments to estimate the amount of energy that could be saved by saving water.

The CEC noted that different types of water resources have very different energy intensities, that various types of water and wastewater treatment technologies have different energy intensities, and that the average amount of energy needed to transport wholesale water or to distribute retail water varied significantly with water utility service area characteristics (especially distance and changes in elevation).

Despite all of these variations, the CEC posited, and multiple stakeholders including the CPUC have generally agreed, that this simple arithmetic framework provides a logical and credible means for evaluating the amount of energy that could be saved by saving water.

Upstream vs. Downstream Embedded Energy

Another convention recommended by the CEC that has survived more than a decade of policy and regulatory deliberations is the concept that the amount of energy saved by reducing indoor water use should be measured differently than water saved outdoors. The CEC's concept was simple: that most urban water used outdoors either recharges groundwater or flows to storm drains or to natural waterways; whereas most urban water used indoors discharges to sewers that collect and transport sewage to wastewater treatment plants where the effluent is either treated and discharged to the environment, or recycled and delivered via purple pipes for reuse.

> *In California, saving cold water, both indoors and outdoors, saves energy. The energy saved is primarily electricity. Saving outdoor water saves the energy it takes to extract, convey, treat, and distribute water to customers. Saving indoor water saves the additional energy, again mostly electricity, used to collect, treat and dispose of the waste water. Saving indoor hot water saves the additional energy needed to heat this water. In California, this additional energy is mostly in the form of natural gas.*[18]

The premise, therefore, is that water saved indoors should be credited with the full amount of avoided energy inputs along all segments of the water cycle: from point of water collection or production (in the W-E Calculator, "Extraction"), through delivery ("Conveyance") to retail water utilities for Treatment and Distribution to Water End Users (Customers); and, since water used indoors is ordinarily sent via sanitary sewers to wastewater treatment plants, water saved indoors should also be credited for the full amount of energy saved by avoiding Wastewater Collection and Treatment.

[18] *California's Water-Energy Relationship*, p.44.

Computing Embedded Energy

Once (a) the avoided water supply has been selected, (b) the energy intensity of that water supply and related water system components (i.e., energy intensity by segment of the water cycle) have been computed, and (c) the energy intensity of water saved Indoors vs. Outdoors has been computed, calculating the amount of "Embedded Energy" deemed saved by avoiding use of water is very simple:

- Divide the Measure-Level Annual Water Savings (gallons) by 325,851 (gallons/AF).
- Multiply that result times the Electric EI of the type of water resource being saved, and the type of water use being avoided (Agricultural/Urban, Indoor/Outdoor) by hydrologic region [kWh/AF].

This simple computation yields the amount of embedded energy that is deemed saved by reducing use of that type of water for that type of use within that the specified hydrologic region.

3 The W-E Calculator's Default Values

The CPUC Consultant's Report contains a table that illustrates how energy inputs within each segment of the water use cycle (referred to in the CPUC Consultant's Report as "water system components") contribute to the energy intensity of various types of water resources and systems. That table is vital to understanding how default Electric EI values in the W-E Calculator are used to:

- Compute the Electric EI (kWh/AF) of water by type of use (Agricultural/Urban and Indoor vs. Outdoors) and by Hydrologic Region, and then
- Applied to Measure-Level Water Savings to compute the amount of Embedded Energy that will be saved by not using that water.

Navigant Table ES2. IOU Marginal Energy Intensity (kWh/AF) [19]

Region	Extraction and Conveyance	Treatment	Distribution	Wastewater Collection + Treatment	Outdoor (Upstream of Customer)	Indoor (All Components)
North Coast	0	490	153	406	643	1,049
San Francisco	0	490	299	406	789	1,195
Central Coast	0	490	153	406	643	1,049
South Coast	0	490	153	406	643	1,049
Sacramento River	0	490	17	406	507	913
San Joaquin River	0	490	17	406	507	913
Tulare Lake	0	490	17	406	507	913
North Lahontan	0	490	17	406	507	913
South Lahontan	0	490	153	406	643	1,049
Colorado River	0	490	17	406	507	913

Table ES-2 substantiates the fact that the W-E Calculator's general methodology for computing Electric EI and Embedded Energy is consistent with the conventions first recommended by the CEC in 2005; i.e.,

- Energy Intensities by Water System Component (aka, "Segments of the Water Cycle") are added together to compute Embedded Energy in Water.
- The Embedded Energy of Water Saved Indoors is the sum of Energy Intensities of all Water System Components, both upstream and downstream of water use; while the Embedded

[19] *Water-Energy Cost-Effectiveness Analysis Final Report*, Prepared for California Public Utilities Commission by Navigant Consulting, Inc., October 7, 2014; Table ES-2 IOU Marginal Energy Intensity (kWh/Acre-Foot [AF]) as amended by Errata issued on May 22, 2015.

Energy of Water Saved Outdoors is equal to the sum of energy intensities upstream of water use only (i.e., does not include wastewater collection and treatment).[20]

> *"Marginal EI used to evaluate outdoor water efficiency represents energy use upstream of the customer (Extraction and Conveyance, Treatment, and Distribution) and does not include wastewater treatment systems. Marginal EI used to evaluate indoor water efficiency includes all components (Extraction and Conveyance, Treatment, Distribution, and Wastewater Collection and Treatment systems)."*[21]

The Energy Intensity of Recycled Water

When viewing Table ES-2, it is important to recognize that the values contained therein represent the Electric EI of the CPUC Consultant's recommended long-run marginal water supply, Recycled Water.

Recycled Water is distinctly different from other types of water resources in the following ways:

1. **Extraction & Conveyance Electric EI**. Since Recycled Water is considered a by-product of wastewater treatment, its Extraction & Conveyance (E+C) Electric EI is deemed to be 0 kWh. This treatment of Recycled Water is consistent with the convention that was recommended by the CEC in 2005.
2. **Treatment Electric EI**. Similarly, since Recycled Water is deemed a by-product of Wastewater Treatment, its Water Treatment Electric EI would be deemed to be comprised solely of any incremental treatment needed to treat the Recycled Water to levels necessary for its intended beneficial use. In this respect, the CPUC Consultant's report deviates from the CEC's recommended convention by showing Treatment Electric EI as equivalent to the energy intensity of Tertiary Wastewater Treatment.
3. **Distribution Electric EI**. The water cycle diagram made a distinction between potable and recycled water distribution. Since the W-E Calculator does not provide default values for Recycled Water (RW) Distribution, the CPUC's Consultant assumed that Recycled Water Distribution Electric EI is equal to that of Potable Water.[22]
4. **Wastewater Collection and Treatment Electric EI**. As explained previously, the energy intensity of wastewater collection and treatment increases the embedded energy savings attributable to Indoor Water Savings. The energy intensity of wastewater collection and treatment is typically not included in the embedded energy saved by reducing Outdoor Water Use.

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[20] See Figure 1 on p.5 of this White Paper for water system components (aka, "segments of the water cycle") deemed to be "Upstream" vs. "Downstream" of Water End Use.

[21] Navigant Report, p.39.

[22] Recycled Water Distribution Energy Intensity is believed to be higher than Potable Distribution, because wastewater treatment and recycling facilities have historically been sited at the lowest elevations in wastewater utilities' service areas, both to reduce costs for pumping sewage uphill, and to reduce risks of sewage spills.

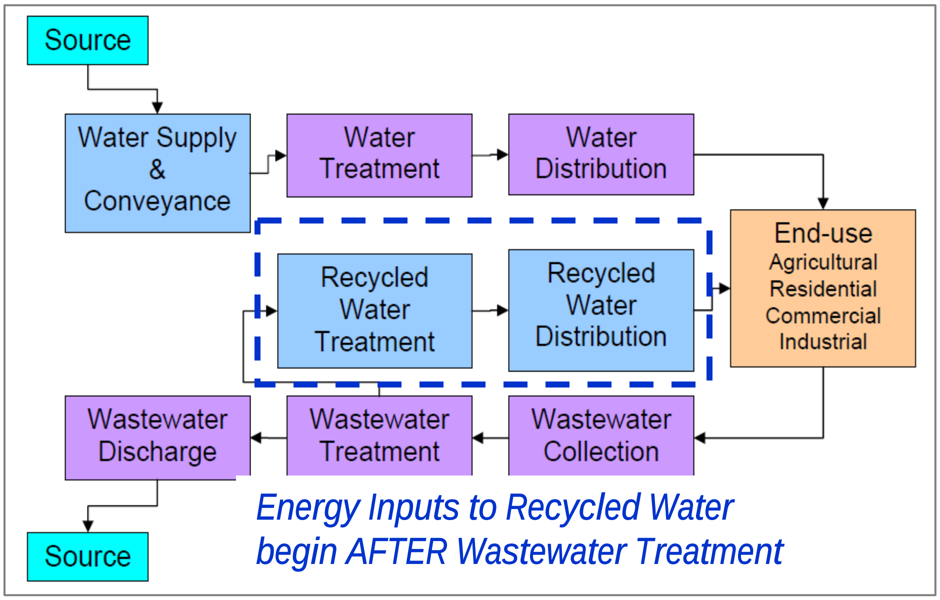

Figure 2. The Energy Intensity of Recycled Water

The Energy Intensity of Indoor vs. Outdoor Water Savings

The W-E Calculator and Table ES-2 departed from the CEC's recommended convention for computing the Energy Intensity of Indoor vs. Outdoor Water Savings in two ways:

- Tertiary Wastewater Treatment was included in the Energy Intensity of Water Treatment, and
- A new variable named "Runoff" was introduced that affects the Energy Intensity of Outdoor Water Savings.

These departures and their impacts on Indoor and Outdoor Energy Intensity are described below.

1. Energy Intensity of Tertiary Wastewater Treatment included in Water Treatment Technology.[23] The ostensible basis for departing from the CEC's convention for computing the energy intensity of Indoor vs. Outdoor Water Use ***for Recycled Water*** was to enable additional granularity with respect to determining the energy intensity of Recycled Water. Specifically, instead of defaulting to tertiary treated wastewater, the CPUC's Consultant reclassified energy associated with Tertiary Wastewater Treatment as "Conventional Tertiary Treatment" under the "Treatment" component.

   While this departure from convention may have seemed inconsequential, allocating a portion of the *Wastewater Collection and Treatment Energy Intensity* to *Water Treatment Energy Intensity* changes the energy intensity of Outdoor Water Savings. It also results in an inconsistency with respect to the role of the energy intensity of the *Wastewater Collection & Treatment*

[23] See Navigant Table ES-2 on p.7 of this White Paper.

component when computing the energy intensities of Indoor vs. Outdoor Water Savings. Specifically,

- The W-E Calculator allows Users to select Treatment Electric EI ***for Recycled Water only*** from two different types of technologies: "Conventional Tertiary Treatment" or "Membrane Treatment". The default Electric EI values for each "Treatment Technology" (IOU energy only) are 490 kWh/AF and 1,225 kWh/AF respectively.

- The Electric EI of the Wastewater Collection and Treatment component then defaults to Secondary Treatment plus Wastewater Collection (total IOU energy of 406 kWh/AF).

Table 1 shows the contribution to Outdoor and Indoor Energy Intensities by water system component when tertiary treatment is included as a Water Treatment Technology and Wastewater Collection & Treatment defaults to secondary treatment[24] plus wastewater collection.

Table 1. Electric Energy Intensity of Outdoor vs. Indoor Water Savings (*for Recycled Water Only*)[25]

Hydrologic Region	Water EIs (kWh/AF)			[4] Wastewater EI (kWh/AF)			Resultant Electric EIs	
	[1] E+C	[2] Treatment	[3] Distribution	Primary + Secondary	WW Collection	Total WW	OUTDOOR ∑[1]-[3]	INDOOR ∑[1]-[4]
NC	0	490	155	333	72	406	645	1,051
SF	0	490	302	333	72	406	792	1,198
CC	0	490	155	333	72	406	645	1,051
SC	0	490	155	333	72	406	645	1,051
SR	0	490	17	333	72	406	507	912
SJ	0	490	17	333	72	406	507	912
TL	0	490	17	333	72	406	507	912
NL	0	490	17	333	72	406	507	912
SL	0	490	155	333	72	406	645	1,051
CR	0	490	17	333	72	406	507	912

Issues and Options

The key issue pertains to how the energy intensity of Wastewater Collection and Treatment is intended to be used in the computation of the energy intensity of water used Outdoors vs. Indoor.

If the energy intensity of Wastewater Collection and Treatment represents the additional amount of energy deemed embedded in Indoor Water Use due to a need to treat water discharged to sewers, the energy intensity of Wastewater Collection and Treatment

[24] When describing the level of wastewater treatment, the highest level is presumed to include the previous levels of treatment. Therefore, "Secondary Wastewater Treatment" includes both Primary and Secondary, and "Tertiary Wastewater Treatment" includes Primary, Secondary and Tertiary.

[25] There are slight differences between the above table and Table ES-2. These differences appear attributable to differences in the values shown in the CPUC Consultant's Report vs. the W-E Calculator (rounding, trailing decimals, and other slight differences) that are not documented or explained.

(component 4) should reflect ***all*** of the energy used in that component. This is important, since the energy intensity of Wastewater Collection and Treatment is the sole difference between the energy intensity of water used Indoors vs. Outdoors. (I.e., Indoor Water Use includes the energy intensities of all 4 components shown in Table 1, while Outdoor Water Use only includes the energy intensities of the 3 components Upstream of Water End Use.)

We believe that the correct selection representing the energy intensity of Wastewater Collection and Treatment ***for Recycled Water*** is ***Tertiary Wastewater Treatment plus Collection***.

a. When Tertiary Wastewater Treatment was reclassified as a Water Treatment technology, the energy intensity of Wastewater Collection and Treatment was reduced by the amount of energy attributable to Tertiary Treatment. Users of the W-E Calculator are precluded from changing the Wastewater Collection and Treatment assumption to Tertiary Treatment. This created a circumstance in which the energy intensity of Outdoor Water Use increased by 490 kWh/AF, the energy intensity of Tertiary Wastewater Treatment (because it is now being treated as energy use Upstream of Water End Use).
b. Since the energy intensity of Indoor Water Use is computed as the sum of energy intensities of all 4 components, the energy intensity of Indoor Water Use remained the same as it would have if Treatment energy had been deemed to be 0, and tertiary treatment was included in Wastewater Collection and Treatment.
c. It should be noted that ***particularly when the avoided water resource is Recycled Water***, the default assumption as to the level of Wastewater Treatment should be Tertiary, Tertiary Treatment is needed to create recyclable water.

Another way of viewing this issue, however, could be that the approach used in the W-E Calculator ***understates the energy intensity of Indoor Use of Recycled Water***. State water policy is on a trajectory to mandate recycled water production and use. Tertiary Wastewater Treatment is already the norm (rather than the exception) for most large urban wastewater systems. (In fact, the CPUC's Consultant stated that "a default marginal water supply of recycled water [*is assumed to be*] (wastewater treated to tertiary, unrestricted standards)".[26]

Table 2 on the next page shows the impact of optional approaches to computing the energy intensity of Recycled Water on the resultant energy intensity of Indoor vs. Outdoor use of Recycled Water. Understanding these options and the logic for selecting one assumption over another is important, since these ultimately determine the quantity of embedded energy that will be deemed saved by reducing Indoor vs. Outdoor water consumption.

[26] Navigant 2014 Report, p.19.

Table 2. Options for Computing the Energy Intensity of Indoor vs. Outdoor Use of Recycled Water[27]

Water System Component	Option 1 W-E Calculator		Option 2 Move Tertiary back to WW		Option 3 Keep Tertiary in Treatment Increase WW Treatment to Tertiary		Option 4 Direct Potable Reuse[28]	
	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor
1 - E+C	0	0	0	0	0	0	0	0
2 – Treatment	490	490	0	0	490	490	*TBD*	*TBD*
3 – Distribution	17-302	17-302	17-302	17-302	17-302	17-302	17-302	17-302
4 - Wastewater	0	406	0	888	0	888	0	888
Total Electric EI (kWh/AF)	507-792	913-1,198	17-302	905-1,190	507-792	1,395-1,680	*17-302 plus Treatment*	*905-1,190 plus Treatment*

Option 1: ***W-E Calculator (version 1.05)***

a. Reclassifies Tertiary Treatment energy as an upstream energy input to the Treatment component; and
b. Assumes Wastewater Collection and Treatment is Secondary.

Option 2: ***Prior Convention***

a. Assumes Recycled Water is a by-product of the Wastewater Treatment process, and that both E+C and Treatment components = 0 kWh; and
b. Assumes Wastewater Collection and Treatment = Collection + Tertiary Treatment.

Option 3: ***Hybrid of Options 1 and 2***

a. Accepts W-E Calculator assumption that Tertiary Treatment should be included in upstream energy inputs; but also
b. Recognizes that the state is on a trajectory towards mandating recycled water, meaning that the default energy intensity of Wastewater Collection and Treatment should be based on *Wastewater Collection plus Tertiary Treatment*.

Option 4: ***The Long-Run Marginal Perspective***

a. Recognizes that state policy is on a trajectory towards mandating recycled water, causing the default Wastewater energy intensity to be Wastewater Collection plus Tertiary Treatment; and
b. Recognizes that advanced filtration and disinfection will ultimately be needed if/when the SWRCB approves Direct Potable Reuse (DPR). Such incremental treatment needed for DPR would be appropriately included in the Treatment (Upstream) component.

The fundamental issue related to computing the energy intensity of Indoor vs. Outdoor use ***of Recycled Water*** is the assumed energy inputs ***Upstream vs. Downstream of Water End Use***. Specifically, the W-E Calculator defaults to an assumption that most wastewater is treated to secondary levels, so tertiary treatment is then needed to produce Recycled Water.

[27] Electric EIs shown represent IOU energy only. Distribution Electric EIs reflect the variable energy intensities of the various hydrologic regions deemed attributable to differences in water service area characteristics (topology, geology, distance and elevation).
[28] See discussion on next page about state policy deliberations with respect to approval of Direct Potable Use of Recycled Water.

Although most wastewater may still be treated to secondary standards on a statewide volumetric basis, most large densely-populated urban areas are converting to, or have already converted, to tertiary treatment.

CPUC Decision 15-09-023 was explicit about the fact that Users of the W-E Calculator should select the technologies that are most appropriate to their programs. Further,

- The CPUC ordered *"… each Class A and each Class B water utility to provide Commission Staff with data about their respective [Avoided Pre-Use Treatment Embedded] energy intensity, formatted for use in the W-E calculator and water tool …"*.[29]

- Similarly, with respect to Avoided Wastewater Treatment Embedded Energy, the CPUC stated that "*The W-E calculator again defaults to values from the past CPUC embedded energy Studies 1 and 2 and other secondary studies and applies values from them to the Department of Water Resources hydrologic regions. Once again, this was a function of data adequacy, and is the only practical choice for default values. The tool permits users to enter their own data in place of the default data.* ***This is important as the embedded energy in wastewater conveyance and treatment may differ in local areas.***"[30] [emphasis added]

While CPUC Decision 15-09-023 encourages users to select the appropriate technologies for Water and Wastewater Treatment:

- The W-E Calculator does not allow Users to select Water Treatment technologies, except for Recycled Water, for which the choices are either "Conventional Tertiary Wastewater Treatment" or "Membrane Treatment".

- The W-E Calculator does not allow Users to select the level of Wastewater Treatment. Although one of the options shown is "Primary + Secondary + Tertiary", the W-E Calculator does not allow Users to select that option for either Recycled Water or any other selected marginal supply.[31]

The CPUC selected the long-run marginal water supply as the basis for computing embedded energy of saved water. As noted earlier, given the State's recycled water policy and the fact that Tertiary Treatment is already prevalent throughout densely populated urban areas, there is merit for selecting Tertiary Treatment as the default technology for Wastewater Treatment.

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[29] Decision 15-09-023, p.33.

[30] Decision 15-09-023, p.34.

[31] The function for selecting alternate marginal water supplies in W-E Calculator version 1.05 does not appear to work. Although the worksheet named "Inputs" provides dropdown menus that allow Users to change the marginal water supply for each of the State's 10 hydrologic regions, and the new Marginal Water Supply choices appear on the worksheet named "Marginal Supply", the embedded energy by Measure and Hydrologic Region on the "Summary Outputs" worksheet is identical for Recycled Water, Groundwater, and Seawater Desal. (I.e., the W-E Calculator uses the energy intensity of Recycled Water to compute Measure-Level Embedded Energy irrespective of the User's selection of marginal water supply.)

Note: The State Water Resources Control Board (SWRCB) is considering new regulations that would allow Direct Potable Reuse (DPR) of recycled water. DPR will likely require advanced filtration and disinfection beyond tertiary treatment. These advanced treatment technologies (e.g., membrane treatment, UV disinfection, and others) are very energy intensive. These incremental water treatment technologies that use energy above and beyond Tertiary Wastewater Treatment would be properly included under the (Upstream) Water Treatment component (#2).

2. **Impact of New "Runoff" Variable**. An additional level of complexity was integrated into the W-E Calculator that should not be used in its current form. This variable was apparently included to enable recognizing incremental downstream embedded energy attributable to capturing storm water and runoff in combined sewers.

   Combined Sewers allow storm water and runoff to enter sewers that then transport these flows along with sewage to wastewater treatment plants. Storm water and runoff increase the volume of wastewater treated in the following ways:

   (a) During wet weather events, storm water flowing into combined sewers significantly increases the volume of wastewater that needs to be treated.

   (b) Urban runoff increases the volume of wastewater that needs to be treated throughout the year, although the contribution of urban runoff tends to be seasonal (i.e., mostly during hot, dry periods when there landscape irrigation is at its peak).

   With respect to this new variable, the CPUC's Consultant states:

   "… users are prompted if urban runoff enters the user's sewer system. The default assumption is urban runoff does not enter a sewer system and thus does not save any energy in the wastewater system."[32,33]

   A test of the "runoff" function revealed the following:

   A "No" selection causes Urban Indoor Energy Intensity to default to a Wastewater Collection and Treatment value of *Secondary Treatment + Collection* (i.e., the W-E Calculator does not provide the opportunity to include Tertiary Treatment which, given State water policy, would be the appropriate choice on a long-run marginal basis for all marginal water resources statewide). The "No" option therefore understates the Energy Intensity of Indoor Water Savings by not allowing the User to select the option that should be the statewide default ***for all marginal water supply options***:

   Primary+Secondary+Tertiary Wastewater Treatment plus Wastewater Collection

[32] Navigant 2014 Report, p.37.

[33] In actuality, the W-E Calculator does something a bit different: The W-E Calculator is hard-coded as "No". I.e., although a cell has been provided in the "Inputs" Worksheet to override the default, the cell it is intended to advise (Worksheet "WW Systems EI") contains a static "No" that cannot be overridden in the protected version of W-E Calculator version 1.05.

- A "Yes" selection increases Urban Outdoor energy intensity by the Electric EI associated with Secondary Wastewater Treatment + Wastewater Collection. This outcome overstates the EI of Outdoor water savings, because it is never true that 100% of urban runoff flows to sewers and is treated at wastewater treatment plants.

Table 3. W-E Calculator Output When "Runoff" = "Yes"

Urban vs. Ag	Water Use	2014	2015	2016	2017	2018	2019	2020
Urban	Indoor	418	418	418	418	418	418	418
Urban	Outdoor	418	418	418	418	418	418	418
Ag	Indoor	0	0	0	0	0	0	0
Ag	Outdoor	0	0	0	0	0	0	0

Note: The "Runoff" variable does not appear to affect computations of Agricultural-related Indoor or Outdoor water savings.

The Runoff variable affects the energy intensity of Wastewater Collection and Treatment for all water supplies, in that it selects the energy intensity of Wastewater Collection plus Secondary Treatment for all types of Urban water uses.

- The default selection of "No" Combined Sewer applies the Electric EI of Wastewater Collection plus Secondary Treatment to all Urban Indoor Water Uses, irrespective of the type of water supply.
- The optional reply of "Yes" Combined Sewer applies the Electric EI of Wastewater Collection plus Secondary Treatment to all Urban Outdoor Water Uses, irrespective of type of water supply.

Neither is correct, for the following reasons:

- There is no relationship between Combined Sewers and the Level of Wastewater Treatment. Old urban areas still have some combined sewers; however newer communities separate sanitary flows (e.g., wastewater) from runoff to reduce risk of overflows.[34] The existence and use of Combined Sewers are more a function of vintage of the sewer system, than of the treatment technology used at the wastewater treatment plant(s) that receive the flows.
- There is no basis for increasing the energy intensity of Outdoor Water Use by the energy intensity of Wastewater Collection plus Secondary Treatment. While it is true that some runoff from outdoor water use is likely to flow to a Combined Sewer, where one is used, the volume of runoff is never 100%. Here, too, there is no basis for assuming that the wastewater treatment plant receiving the combined flows is treating wastewater to secondary levels.

[34] Combined sewers increase risks of overflows, in which untreated sewage may be discharged into areas where people live, work and play. The risk is highest when wet weather events of high intensity and/or long duration cause inflows to exceed the capacity of the sewer system.

If this level of refinement to embedded energy computations is desired, the appropriate way to apply a factor for the incremental amount of embedded energy that may be attributable to outdoor water use entering a combined sewer is as follows:

- A study would be needed to measure the approximate amount of Outdoor Water Use that enters the Combined Sewer System and therefore increases the volume of wastewater that needs to be treated. The Runoff Adjustment should then be based on the percentage of Outdoor Water Use that is deemed to flow to the Combined Sewer, and applying that percentage to the energy intensity of Wastewater Collection and Treatment for the applicable water or wastewater system. The Runoff Adjustment would then be added to Wastewater Collection and Treatment EI.
- When conducting the study, care would need to be taken to not over-estimate the volume of incremental wastewater flows by adjusting treated wastewater volumes that are relied upon for the estimate to exclude any wet weather flows that may also have entered the Combined Sewer System.

In other words, the incremental energy associated with additional sewage collection and treatment from urban runoff entering a Combined Sewer System should:

a. Be based on a volumetric estimate of the amount of urban runoff during each month that enters the Combined Sewer System, and
b. Exclude inflows from wet weather events (i.e., storm water flows).

4 What the CPUC Adopted

CPUC Decision 15-09-023 relied upon multiple bodies of prior work that are important to understanding what the CPUC adopted. Prior works include, but are not limited to, the following:

- CPUC Embedded Energy in Water Studies 1 and 2, GEI Consultants and Navigant Consulting on behalf of the CPUC [*August 2010*]
- Project Coordination Group (PCG) White Paper [*circulated for comment via ruling dated April 29, 2015*]
- *Water/Energy Cost-Effectiveness Analysis Final Report*, Navigant Consulting on behalf of the CPUC [*October 7, 2014*]
- *California's Water-Energy Relationship*, California Energy Commission, CEC-700-2005-011-SF [*November 2005*]
- CPUC Rulemaking 13-12-011 *Into Policies to Promote a Partnership Framework between Energy Investor Owned Utilities and the Water Sector to Promote Water-Energy Nexus Programs*
- CPUC Rulemaking 09-11-014 *to Examine the Commission's Post-2008 Energy Efficiency Policies, Programs, Evaluation, Measurement, and Verification, and Related Issues*
- Other related CPUC regulatory proceedings, workshops, rulings and decisions

Many of the computational conventions that were established in prior proceedings or bodies of work were not repeated in either the CPUC's Decision 15-09-023 or the CPUC Consultant's Report. Further, nowhere does the W-E Calculator produce a table similar to the CPUC Consultant's Table ES-2. As a consequence, Users of the W-E Calculator were unable to perform simple checks on the W-E Calculator's outputs.

Many Users of the W-E Calculator reported that they believed the W-E Calculator was computing embedded energy either too high or too low, but were unable to confirm their suspicions. A simple table of the kind included within the CPUC Consultant's Report would have made those computations transparent and enabled a quick check on the amount of Measure-Level Embedded Energy by type of Water Resource, Hydrologic Region, and Water Use (Ag/Urban, Indoor/Outdoor). This fundamental first step is important because it forms the basis for all subsequent computations related to evaluating measure-level cost-effectiveness, particularly the *Avoided Cost of [Embedded] Energy* and *Total Resource Cost (TRC)*.

To facilitate transparency and verifiability, and to provide an audit trail for programs that use the W-E Calculator, we have prepared a simple to use table that illustrates how the default energy intensity values in the W-E Calculator should be used to compute the Electric EI of Indoor vs. Outdoor Water Uses for any particular type of water resource. This chapter documents (a) what we believe the CPUC adopted in its Decision 15-09-023 and the bases for our conclusions, and (b) the resultant Electric EI's of marginal water supplies that can be used to support water-energy program planning. Importantly, these simple tables documenting the default energy intensities of Indoor vs. Outdoor Water Uses by type of water resource will facilitate transferring the cost-effectiveness functions to the CPUC's E3 and CET Calculators to assure that the avoided cost of embedded energy in water is computed on a basis consistent with other energy efficiency programs.

Basis for Computing the Amount of Energy Saved by Saving Water

CPUC Decision 15-09-023 adopted the following policies with respect to computing energy embedded in saved water.

Long-Run Marginal Water Supply

The CPUC stipulated that the long-run marginal water supply should be used to compute the amount of energy that could be saved by saving water (i.e., "embedded energy"). All excerpts below are from CPUC Decision 15-09-023 adopting the W-E Calculator.

- *"… marginal avoided water supplies have reasonable uniformity on a regional basis. Looking at marginal rather than average costs simplifies the analytical challenge considerably, and allows us to be forward-looking as we consider water supply to accommodate California's economic activity and projected population growth."*[35]
- *"The tools correctly consider costs for the marginal water supply (e.g., recycled water) rather than average supply."*[36]
- *"The tools correctly consider only the long-run marginal water supply."*[37]

Hydrologic Regions

- *"Hydrologic regions are currently the only practical choices for default values."*[38]
- *"The framework the Commission adopts here contains a default set of values averaged across a hydrologic region."*[39]
- *"It is reasonable for the tools' default values to reflect data averaged across a DWR hydrologic region and for defaults averaged across hydrologic regions to be user-editable."*[40]

[35] Decision 15-09-023, p.22.
[36] Decision 15-09-023, Conclusions of Law, paragraph 4, p.70.
[37] Decision 15-09-023, Conclusions of Law, paragraph 5, p.70.
[38] Decision 15-09-023, Findings of Fact, paragraph 20, p.69.
[39] Decision 15-09-023, p.21.
[40] Decision 15-09-023, Conclusions of Law, paragraph 3, p.70.

Default Energy Intensities of Different Types of Water Resources

CPUC Decision 15-09-023 was clear that its sole purpose in providing default values to represent the energy intensity of different types of water resources was due to concerns about inadequate data.

- *"Different water sources have different energy intensity associated with them. … In many cases inadequate data mean there needs to be provide default estimates for energy intensity."*[41]
- *"The framework the Commission adopts here contains a default set of values averaged across a hydrologic region."*[42]

Variables that Contribute to the Energy Intensity of Water

- *Data from CPUC embedded energy Studies 1 and 2 and other secondary studies and applies averaged by DWR hydrologic region are the practical choice for default values for avoided distribution embedded energy and avoided wastewater conveyance treatment embedded energy.*[43]

Resource Balance Year

- *"2016 is a reasonable choice for the resources balance year as water agencies and utilities are currently facing choices about where and how they will produce water supply."*[44]

Computation of Measure-Level Embedded Energy

- *"With energy intensity in place, the next step is to determine the energy embedded in the water saved by virtue of the efficiency or conservation measure. This means, essentially, multiplying the energy intensity by the amount of water saved over the measure's useful life."*[45]

Default Values

WEI and RMS believe that in interpreting the CPUC's intent in its Decision 15-09-023, it is important to distinguish between "default values" that were prepared by the CPUC's Consultant by averaging data from the CPUC's prior Embedded Energy in Water Studies 1 and 2, and "choices that can be over-ridden by the User."

Specifically, "***Default Values***" are those that were computed by the CPUC's Consultant and included in the W-E Calculator to facilitate computations of the Energy Intensity of the long-run marginal water supply by hydrologic region where that data may not otherwise be readily available. The CPUC stated that "*any attempt to populate the tools with default values that are specific to individual utilities carries with it significant data availability challenges*"[46]; consequently, default

[41] Decision 15-09-023, p.20.
[42] Decision 15-09-023, p.21.
[43] Decision 15-09-023, Findings of Fact, paragraph 22, p.69.
[44] Decision 15-09-023, p.27.
[45] Decision 15-09-023, p.21.
[46] Decision 15-09-023, p.23.

values had been compiled for water resources, water treatment, water distribution, wastewater collection, and wastewater treatment from the CPUC's Embedded Energy in Water Studies 1 and 2 "*as a function of data adequacy*".[47] "*Data from CPUC embedded energy Studies 1 and 2 and other secondary studies and applies averaged by DWR hydrologic region are the practical choice for default values for avoided distribution embedded energy and avoided wastewater conveyance treatment embedded energy.*"[48]

Given the above interpretation, we believe that the CPUC adopted the following default values:

- **Electric Energy Intensities** (EIs, expressed in kWh/AF) for different types of water resources within the Extraction and Conveyance component, and for other water system components (Treatment, Distribution, and Wastewater Collection and Treatment).
- **Percentage of Energy Deemed Provided by IOUs vs. Non-IOUs** (estimated for each type of water resource and water system component), see Tables

The Consultant's Report states that these default values were developed from data collected, compiled and analyzed for the CPUC's Embedded Energy in Water Studies 1 and 2 (2010).[49]

Tables 4, 5, 6 and 7 document the default energy intensity values that are documented in the CPUC Consultant's report and in the W-E Calculator.

Table 4. Default Electric Energy Intensities of Different Water Resources by Hydrologic Region

Electric EI by Water Resource and Hydrologic Region by % IOU	EXTRACTION AND CONVEYANCE Electric Energy Intensity (kWh/AF)								
	Seawater Desal	Brackish Desal	Recycled Water	Ground-water	Local Deliveries	Local Imported Deliveries	CRA	CVP and Other Federal Deliveries	SWP
%IOU	94%	94%	97%	59%	27%	27%	0%	0%	0%
%NON-IOU	6%	6%	3%	41%	73%	73%	100%	100%	100%
NC	342	168	0	178	10	10		0	
SF	342	342	0	352	10	43		273	926
CC	342	461	0	471	10			255	2,155
SC	342	566	0	576	10	10	2,500	0	3,214
SR	342	181	0	191	10			15	0
SJ	342	231	0	241	10			75	287
TL	342	389	0	399	10			174	495
NL	342	167	0	177	10				
SL	342	352	0	362	10				3,495
CR	342	466	0	476	10				4,468

Table 5. Default Electric Energy Intensities of Treatment Technologies by Hydrologic Region

[47] Decision 15-09-023, pp.34-35.
[48] Decision 15-09-023, Findings of Fact #22, p.69.
[49] CPUC W-E Calculator and Navigant Study (April 2015), Tables 7, 8, 9, 10 & 11]

Electric EI by Water Treatment Technology and Hydrologic Region by % IOU	POTABLE TREATMENT Electric Energy Intensity (kWh/AF)					
	Conventional Treatment	Chlorination	Membrane Treatment	Conventional Tertiary Treatment[50]	Brackish Desal	Ocean Desal
%IOU	94%	94%	94%	94%	94%	94%
%NON-IOU	6%	6%	6%	6%	6%	6%
NC	144	3	1,303	521	2,715	4,546
SF	144	3	1,303	521	2,715	4,546
CC	144	3	1,303	521	2,715	4,546
SC	144	3	1,303	521	2,715	4,546
SR	144	3	1,303	521	2,715	4,546
SJ	144	3	1,303	521	2,715	4,546
TL	144	3	1,303	521	2,715	4,546
NL	144	3	1,303	521	2,715	4,546
SL	144	3	1,303	521	2,715	4,546
CR	144	3	1,303	521	2,715	4,546

Table 6. Default Electric Energy Intensities of Potable Distribution by Hydrologic Region

Electric EI by Water Treatment Technology and Hydrologic Region by % IOU	POTABLE DISTRIBUTION Electric Energy Intensity (kWh/AF)
	Distribution
%IOU	95%
%NON-IOU	5%
NC	163
SF	318
CC	163
SC	163
SR	18
SJ	18
TL	18
NL	18
SL	163
CR	18

[50] As noted previously, we believe that the Energy Intensity of Tertiary Wastewater Treatment should continue to be classified as a Wastewater Collection and Treatment value, to avoid distorting the energy intensities of Indoor and Outdoor Water Savings.

Table 7. Default Electric Energy Intensities of Wastewater Collection and Treatment by Hydrologic Region

Electric EI by Water Treatment Technology and Hydrologic Region by % IOU	WASTEWATER COLLECTION & TREATMENT Electric Energy Intensity (kWh/AF)		
	Primary + Secondary	Wastewater Collection & Treatment	Wastewater Collection Pumps
%IOU	97%	97%	97%
%NON-IOU	3%	3%	3%
NC	344	915	74
SF	344	915	74
CC	344	915	74
SC	344	915	74
SR	344	915	74
SJ	344	915	74
TL	344	915	74
NL	344	915	74
SL	344	915	74
CR	344	915	74

Selecting Appropriate "Water System Components"

Computing the energy intensity of Indoor vs. Outdoor Water Use is as simple as first selecting the long-run marginal water supply from the E+C energy intensities (Table 4), and then adding the energy intensities of the applicable technologies for the remaining three components: Treatment, Distribution, and Wastewater Collection and Treatment (Tables 5, 6 and 7). We have already discussed the issues and options associated with estimating the energy intensity of Indoor vs. Outdoor Water Use when the marginal water supply is Recycled Water. As discussed in Chapter III, Recycled Water is the most complex of the marginal water supplies from an energy intensity perspective. Other types of water resources are relatively simple to understand and their energy intensities straightforward to compute.

To illustrate the methodology for computing the energy intensity of various marginal water resources, the Energy Intensity computations for Groundwater are provided in Table 8 on the next page. Table 8 illustrates how the energy intensities from the four types of system components are added to compute the energy intensity of Indoor vs. Outdoor Water Use for each type of water resource (in this case, Groundwater).

Table 8. Energy Intensity of Groundwater

Hydrologic Region	Water EIs (kWh/AF)			[4] Wastewater EI (kWh/AF)	Resultant Electric EIs	
	[1] E+C	[2] Treatment	[3] Distribution	**Wastewater Collection & Treatment (Tertiary)**	OUTDOOR ∑[1]-[3]	INDOOR ∑[1]-[4]
NC	105	3	155	888	263	1,151
SF	208	3	302	888	513	1,401
CC	278	3	155	888	436	1,323
SC	340	3	155	888	498	1,385
SR	113	3	17	888	132	1,020
SJ	142	3	17	888	162	1,050
TL	235	3	17	888	255	1,143
NL	104	3	17	888	124	1,012
SL	214	3	155	888	371	1,259
CR	281	3	17	888	300	1,188

Notes:

[1] Energy Intensity of the E+C Component of Groundwater. The W-E Calculator Default Electric EI of Groundwater by Hydrologic Region is shown in Table 4, along with the default IOU vs. Non-IOU factors (59% and 41% respectively, for all hydrologic regions). We believe that these IOU and Non-IOU factors vary significantly from one hydrologic region to another. Further, since the CPUC Findings of Fact, Conclusions of Law and Ordering Paragraphs are silent with respect to these percentages, we believe that the IOU% can and should be changed by Users where the default percentages are not accurate.

[2] Energy Intensity of the Treatment Component of Groundwater. Table 5 documents the default Electric EIs for the Treatment water system component that are contained in the W-E Calculator. Although this is not always the case, the W-E Calculator pre-selects Chlorination as the sole Water Treatment for Groundwater. The Electric EI of Chlorination is assumed to be 3 kWh/AF for all hydrologic regions. The percentage of IOU energy deemed attributable to Chlorination is 97% for all hydrologic regions. The Treatment component of Groundwater is an example of a technology that is pre-selected and locked by the W-E Calculator. Since the CPUC stated specifically that Users should select the treatment technology that is most appropriate to their program, this feature should be unlocked. Users still have the burden of proving the basis for changing the energy intensity of the treatment component, but have the right and obligation to most closely match the correct treatment technology to their programs.

[3] Energy Intensity of the Distribution Component of Groundwater. The W-E Calculator contains default Electric EIs for different types of water service area characteristics (i.e., "Moderate", "Hilly" and "Flat"), but then selects a default Electric EI for Distribution for each Hydrologic Region. Both CPUC Study 2 and comments from water sector participants in the CPUC's Rulemaking 13-12-011 observed that the key drivers of water distribution energy intensity (primarily distance and elevation) are not uniform throughout an entire Hydrologic Region. Nevertheless, the CPUC adopted the W-E Calculator's Distribution Electric EI defaults at the level of the Hydrologic Region with an assumption that 95% of the energy is provided by IOUs (see Table 6).[51] Consequently, while Users can change these defaults, this is another example of a change that the User would need to justify.

[4] Energy Intensity of the Wastewater Collection and Treatment Component of Groundwater. As discussed elsewhere in this White Paper, we recommend that the default technology for Wastewater Treatment be changed to Tertiary for all programs that target reductions of urban water use.

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[51] Decision 15-09-023, Conclusions of Law, paragraph 10, p.71.

5 The CPUC Did Not Adopt …

1. Recycled Water as the default Statewide Marginal Water Supply.

2. Historical Average Energy Intensity of Water Supply Portfolios by Hydrologic Region.

The bases for our assessment follow.

1. Recycled Water

In its decision, the CPUC summarized stakeholder deliberations about whether recycled water was the appropriate long-run marginal supply.

> *"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."* [52]

The CPUC acknowledged that there were both merits and challenges to designating recycled water as the long-run marginal water supply, but stated that:

> *"The W-E calculator's users can override the default value for water supply. This will allow users to enter marginal supply options that may be most appropriate for their local circumstances."* [53]

Nowhere in its Decision 15-09-023 or subsequent decisions related to the W-E Calculator does the CPUC require Program Administrators to use Recycled Water as the long-run marginal water supply. Conclusions of Law paragraphs 4 and 5 are consistent with CPUC language elsewhere in the Decision:

> *4. The tools correctly consider costs for the marginal water supply (e.g., recycled water) rather than average supply.*
>
> *5. The tools correctly consider only the long-run marginal water supply.*

Specifically, the CPUC accepted recycled water as an EXAMPLE of a *long-run marginal water supply*, without precluding selection of other long-run marginal water supplies.

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[52] Decision 15-09-023, p.23.

[53] Decision 15-09-023, p.24.

2. Historical Average Energy Intensity of Water Supply Portfolios

The W-E Calculator attempted to apply the historical average energy intensity of water supplies and water supply portfolios to compute measure-level embedded energy for implementation years that **precede** the selected Resource Balance Year.[54]

CPUC D.15-09-023 stipulated that *only the regional energy intensity of the long-run marginal supply should be used when evaluating the cost-effectiveness of measures that save water* (not historical and not at the portfolio level). Consequently, there is no circumstance in which the historical average energy intensity of one water supply or the historical water supply portfolio should be used.

CPUC D.15-09-023 further stated that "It is reasonable for the tools to use a default assumption that 2016 will be the "resource balance year" -- the year in which additional water capacity is needed – and for this default to be user-editable."[55] Consequently, the Resource Balance Year should be greater to or equal to the Measure Implementation Year; again, ***obviating need to compute any energy intensities prior to the Resource Balance Year***.

[54] When doing do, it appears that the W-E Calculator made some errors, incorrectly using the energy intensity of the historical energy supply portfolio (not the energy intensity of the marginal water supply as stipulated by the CPUC) to compute measure-level embedded energy.
[55] Decision 15-09-023, Conclusions of Law, Paragraph 6, p.

6 Issues and Opportunities

The table below lists issues and opportunities with respect to implementation of the CPUC's W-E Calculator. (The Avoided Cost of Water Capacity is a separate tool, and is not addressed here.)

Table 8. Water-Energy Calculator Issues and Opportunities

<table>
<tr><th>ISSUES</th><th>OPPORTUNITIES</th></tr>
<tr><td>Some of the W-E Calculator's computations and processes do not appear consistent with the CPUC's directives in its Decision15-09-023.[56]</td><td rowspan="2"><u>Assure Compliance and Consistency with CPUC D.15-09-023</u> (and any subsequent CPUC decisions that may have modified the CPUC's directives with respect to the default values that were adopted by the CPUC and the manner in which those values should be applied to Program Administrators' water-energy programs.

<u>Foster Transparency</u>:
▪ Clearly document the default Electric Energy Intensities of each water supply using the default values in the W-E Calculator that were adopted by the CPUC.
▪ Clearly document the W-E Calculator computations that are used to calculate the CPUC-adopted values for Embedded Electric Energy that is deemed saved for each Marginal Water Supply.</td></tr>
<tr><td>The W-E Calculator's computations are not easy to identify.</td></tr>
<tr><td>The W-E Calculator performs multiple functions that make it difficult to separately identify the embedded energy data and computations from other (e.g., avoided cost of energy) computations.</td><td rowspan="2"><u>Separate Embedded Energy Data and Computations</u>:
▪ Once the Default Electric Energy Intensities are separately identified by type of marginal water supply, and
▪ The amount of electric energy deemed embedded in a unit of saved water designated for use Indoors vs. Outdoors is documented,

The cost-effectiveness computations that are currently being performed by the W-E Calculator for the embedded energy portion only can be re-integrated into the CPUC's authorized electric cost-effectiveness calculators (E3 and later, CET).

Finding a means to include the amount of additional electric energy deemed saved by saving a unit of water (i.e., "Embedded (Electric) Energy") in the CPUC's existing and future cost-effectiveness tools will minimize risks of errors and inconsistencies when computing cost-effectiveness of measures that save water.</td></tr>
<tr><td>The W-E Calculator computes the cost-effectiveness of measure-level embedded energy separately from the cost-effectiveness of direct energy savings that continue to be computed via a separate tool: the CPUC's Cost-Effectiveness Calculator (currently E3). Conducting parallel computations of cost-effectiveness of a single program or measure via two separate tools operated in parallel substantially increases opportunities for errors & inconsistencies in the analysis.</td></tr>
</table>

[56] <u>For Example</u>: The W-E Calculator contains default values for the historical average energy intensity of water supplies and regional water supply portfolios. The W-E Calculator then seeks to apply those historical average energy intensities to compute the embedded energy saved by measure for implementation years that precede the Resource Balance Year. Use of the historical average energy intensity to compute measure level embedded energy was not approved by the CPUC.

Moving Cost Effectiveness Computations to the CPUC's E3 and CET Calculators

One concern raised by stakeholders about moving the avoided cost of energy computations for Embedded Energy to E3 and CET relates to how the Water Savings Profiles can be accommodated.

The W-E Calculator provides 3 default water savings profiles and the capability for adding 5 customized water savings profiles. The purpose of including these water savings profiles is to enable adjusting the avoided cost of Embedded Energy for seasonal price differences. To recognize these seasonal cost differences, the W-E Calculator provides monthly allocation factors. The monthly allocation factors must add to 100% for the year.

The monthly water saving profiles add a layer of complexity to the W-E Calculator that may not be needed, for the following reasons:

1. **Differences Between Timing of Embedded Energy Inputs and Water End Use**. The timing of when energy inputs are made to different types of water resources depends on (a) which water resources, and (b) which hydrologic region.

   a. **Inter-Basin Transfers**. Within Hydrologic Regions dominated by the very large state and federal water supplies that traverse multiple hydrologic regions (State Water Project, Central Valley Project and Colorado River Aqueduct), most energy inputs are Non-IOU, and the timing of those energy inputs are highly variable.[57]

      For Example:

      The State Water Project collects some water in large reservoirs and are pumped throughout the year to (1) meet season demands, while (b) maximizing the value of hydropower production from state aqueduct deliveries. However, Bay Delta water is pumped in accordance with stringent environmental policy rules and regulations (i.e., to minimize adverse wildlife and ecosystem impacts).

   b. **Surface Water.** The timing of pumping surface water depends on where it is collected (e.g., remotely vs. locally), and the type of storage. Most remote systems are large reservoirs; most local systems are either very small reservoirs or tanks. Often, energy used to pump surface water from large reservoirs does not necessarily coincide with seasonal water use. Smaller local storage typically does coincide with seasonal water use.

   c. **Seawater Desalination** is typically produced 24/7 because it is very costly to start and stop – much like aged base-loaded fossil fuel power plants or wastewater treatment plants.

   d. **Groundwater.** Whether potable or brackish, groundwater is one of the water resources that is mostly likely to use energy nearly contemporaneously (on a monthly or seasonal basis) with water demand. Many (but not ALL) systems in urban areas have pressurized systems

[57] Significantly, the Non-IOU energy inputs are not applicable to embedded energy for purposes of IOUs' W-E programs.

that pump groundwater when needed to maintain pressure in the distribution system. I.e., as water is used by customers, pressure drops in the distribution system, and a signal is sent to groundwater pumps to extract more water from wells to keep the water distribution system at its targeted pressure.

e. **Recycled Water** also is produced and used fairly contemporaneously with water demand.

2. **Timing of Energy Inputs to Other Water System Components (Treatment, Distribution, and Wastewater Collection and Treatment)**. The timing of embedded energy inputs for the Treatment, Distribution and Wastewater Collection and Treatment components is more closely related to the timing of water demand than within the E+C component.

The default Water Savings Profiles in the W-E Calculator do not recognize the differences by type of water resource. In the absence of a “perfect” profile, a conservative approach – e.g., use of a “Constant” water use profile – seems reasonable.

In Summary

Except for Groundwater and Recycled Water, there is little seasonal synchronization between embedded energy inputs to water resources and urban water demand. The linkage is closer for agricultural irrigation.

One approach could be to benchmark urban water use profiles to climate sensitive measures such as air conditioning, since urban water use tends to synchronize well with temperature-related measures.

Agricultural irrigation is highlight seasonal; for these types of water uses, an irrigation profile seems reasonable.

7 Findings and Recommendations

Throughout the CPUC's Decision 15-09-023, the CPUC reiterates that:

- Default energy intensities were computed from the CPUC's own Embedded Energy in Water Studies 1 and 2 (2009-2010) because water and wastewater utility specific data was believed too difficult to obtain.
- Default assumptions were made about technologies and other factors (e.g., distribution system characteristics) at the hydrologic region level to simplify and expedite implementation of water-energy programs.
- Users should replace the default values and selections with values and selections that are more appropriate to their programs, where better data exists.

The CPUC then cautioned Users that they would bear the burden of substantiating variances from the defaults.

> "The Commission requires that Commission-jurisdictional energy utilities use the tools in preparing their requests for ratepayer funding for measures/programs that reduce water use and thus save embedded energy. The Commission adopts a rebuttable presumption that use of the tool with defaults to generate inputs to the Cost Effectiveness Calculator is reasonable for purposes of gauging measure/program cost effectiveness, and for purposes of estimating the economic value of energy savings from measures/programs with a cold-water savings component.
>
> "This does not preclude PAs from using alternatives to the defaults."[58]

Summary Findings

1. **<u>Better Energy Intensity Data Already Exists.</u>**

   Based on the substantial body of work that we have conducted for California energy and water utilities, we believe that (a) much more energy intensity data has been developed for many water and wastewater utilities in southern California since the CPUC issued its Decision 15-09-023, and (b) reliable energy intensity data have already been computed for medium to large size water and wastewater utilities in southern California that collectively account for more than 50% of electricity and natural gas used for water sector functions.

[58] Decision 15-09-023, p.43.

2. **<u>The CPUC Did Not Intend to Deter Use of Better Energy Intensity Data.</u>**

Although the CPUC's cautioned that "Where PAs depart from default values, they bear the burden of proving the departure(s) reasonable in all documents submitted to Commission Staff",[59] we do not believe that the CPUC intended to deter anyone from departing from the default values compiled from CPUC Studies 1 and 2 in 2009-2010. Quite the contrary:

a. **<u>The CPUC Ordered Class A and Class B Water Utilities to Develop Their Own Energy Intensity Data</u>.**

"*The Commission hereby* ***orders each Class A and each Class B water utilit****y to provide Commission Staff with data about their respective energy intensity, formatted for use in the W-E calculator and water tool, within 120 days of the mailing date of this decision. Commission Staff will post these data to a Commission-maintained web site.*" [emphasis added]

Footnote 60 further stated: "*CWA, in comments on the proposed decision, asks that the Commission not make this order. Alternatively, CWA asks that the Commission clarify what data jurisdictional water utilities are to provide. We will maintain the requirement that jurisdictional Class A and B water utilities provide energy intensity data. We leave it to these water corporations in the first instance to make a good faith effort to develop the requested inputs on a district (as opposed to company-wide) basis.*"[60]

"*Within 120 days of the mailing date of this decision, Class A and Class B water corporations shall provide to Commission Staff district-specific inputs for use in place of default values for the Water-Energy Calculator and the Avoided Water Capacity Cost Model (collectively, tools).*"[61]

b. **<u>The CPUC stated that its "goal in allowing departure from defaults" is to facilitate identifying "high energy intensity, high water use, areas</u>."**

"PAs may depart from defaults where the tools allow, as discussed above. Where PAs depart from default values, they will bear the burden of proving the departures reasonable in all documents submitted to Commission Staff, per existing rules. ***Our goal in allowing departure from defaults here is to facilitate energy IOUs seeking out high energy intensity, high water use, areas. Targeting such areas should maximize energy savings per dollar spent on water saving measures.***"[62] [emphasis added]

Recommendations

1. **<u>Separately Document the Electric EIs for Each Water Resource by Hydrologic Region</u>**. Given that the Water-Energy Nexus is a new and evolving area for CPUC energy efficiency programs, we believe it is imperative that the basic underpinnings of the computation of Energy Intensities that drive the computation of Measure-Level Embedded Energy be clearly understood.

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[59] Decision 15-09-023, Ordering Paragraph 3, p.72.
[60] Decision 15-09-023, p.33.
[61] Decision 15-09-023, Ordering Paragraph 6, p.73.
[62] Decision 15-09-023, pp.43-44.

To that end, Table ES-2 in the Consultant's 2014 Report (amended by Errata in 2015) is essential to facilitating that understanding as to which water system components are deemed to contribute what values to the energy intensity of Indoor vs. Outdoor water use by Type of Water Resource and by Hydrologic Region.

Unfortunately, this important table appears only once – in the Consultant's Report - and only to illustrate the buildup of embedded energy in one marginal water resource: Recycled Water. While the W-E Calculator is intended to perform those computations and then to apply the resultant energy intensities to compute measure level embedded energy (which is then used to compute measure-level avoided cost of energy), the W-E Calculator does not output (display) its calculations of Energy Intensity by Type of Water Resource, Water System Components, and Water Use.

Many Users of the W-E Calculator informally commented that they believed the W-E Calculator was computing embedded energy either too high or too low, but were unable to confirm their suspicions. A simple table would have made those computations transparent and enabled a quick check on the amount of Measure-Level Embedded Energy by type of Water Resource, Hydrologic Region, and type of Water Use.

Individuals and organizations that are not conversant in the state's multi-year deliberations about how embedded energy in water should be measured have been hampered in their implementation of the W-E Calculator by the unavailability of a simple table showing the energy intensities of different marginal water supply options, and the energy intensities of Indoor vs. Outdoor water savings for each. This type of simple table is important to being able to verify the W-E Calculator's computations of embedded energy, the fundamental first step to verifying computations of the avoided cost of embedded energy and overall cost-effectiveness of water-energy programs.

2. <u>**Enable Selection of Appropriate System Components Used in Computing the Energy Intensity of Indoor vs. Outdoor Water Use by Water Resource and Hydrologic Region**</u>.

   Our detailed reading of CPUC Decision 15-09-023 indicates that in adopting the W-E Calculator, the CPUC never intended that Users would be prohibited from tailoring their selections of long-run marginal water supplies, treatment technologies, water distribution service area characteristics, and wastewater system characteristics to their water-energy programs.

   The CPUC's caution was that when Users change ***default energy intensity values***, they should be prepared to substantiate the basis for those changes.

   > "*As PG&E notes, "In some cases, agency-specific energy intensity data will be available and suitable for use in custom projects with proper documentation and standards (which raises a number of questions about length of baseline period, how to account for varying sources of supply that may not have intensity data available, and how to account for locational factors such as site elevation). User-specified input values would be documented and evaluated through*

normal calculated project review mechanisms." PAs may depart from defaults where the tools allow, as discussed above. Where PAs depart from default values, they will bear the burden of proving the departures reasonable in all documents submitted to Commission Staff, per existing rules."[63]

However, the CPUC did not intend to restrict or inhibit Users' ability to select the correct types of water and wastewater treatment, Distribution system characteristics, or other specific water system components that are more applicable to their programs. This outcome occurred primarily due to the structure of the W-E Calculator which locked in Recycled Water as the Marginal Water Supply, Distribution EIs by hydrologic region, and Water and Wastewater Treatment Technologies by Hydrologic Region.

For these reasons, we recommend that:

- The W-E Calculator's default selections be unlocked to enable Users to implement the CPUC's guidance with respect to selecting assumptions and values that are appropriate to the programs being proposed, and
- The W-E Calculator's default assumptions be adjusted to what we believe is more appropriate, given our extensive studies of the energy intensity of water and wastewater systems in southern California; i.e.,

  a. **Wastewater Electric EI**. The statewide default for the Wastewater Collection and Treatment Component of all water resources used for Urban Indoor purposes should be changed to Tertiary Treatment + Wastewater Collection (labeled in the Consultant's Report as "*Wastewater Collection & Treatment*"). There are very few examples where no energy is used to pump wastewater. Further, treatment of wastewater to Tertiary levels is consistent with statewide Recycled Water policy. Omitting Tertiary Treatment from the energy intensity of Wastewater Collection and Treatment understates the amount of energy that would be saved by reducing Urban Indoor water usage within most California communities.

  b. **Water Treatment Electric EI**. Tertiary Wastewater Treatment should be deleted as a Water Treatment option. Additional treatment that may ultimately be needed to increase the quality of Recycled Water to levels deemed safe for Direct Potable Use would properly be included under the Water Treatment system component; but Tertiary Wastewater Treatment is Wastewater Treatment.

  c. **Outdoor Water Electric EI**. Re-compute the Electric EIs for Urban Outdoor Water Use for Recycled Water to exclude all energy inputs used for WW Collection and Treatment, including Tertiary Wastewater Treatment.

  d. **Runoff**. Delete the "Runoff" variable. If this type of refinement is later desired – e.g., to compute the embedded energy attributable to reducing Urban Runoff for a water-energy program design specifically for that purpose - the incremental energy associated

[63] D.15-09-023, p.43.

with additional sewage collection and treatment from urban runoff should (a) be based on a volumetric estimate of the amount of urban runoff that flows into Combined Sewers each month, and (b) exclude storm water flows.

A simple menu-driven approach could be used to produce the Indoor vs. Outdoor energy intensities for each type of marginal water supply using the default energy intensities documented in the CPUC Consultant's Report and included in the W-E Calculator as a startpoint. The energy intensities of water resources, treatment technologies, and service area specific characteristics can then be updated within the template with better energy intensity data as those become available. In addition to enabling transparency and understanding of the energy intensity and embedded energy computations, this approach has the added benefit of creating an audit trail that clearly identifies any departures from the default energy intensities that were compiled at the hydrologic region level from the CPUC's Embedded Energy in Water Studies 1 and 2.

Table 9. A Simple Menu for Selecting Energy Intensities by Water System Component[64]

Build-Up of Embedded Energy by Water System Component					Embedded Energy Saved by Reducing Water Use	
Energy Inputs "Upstream" of Water Use			Energy Inputs "Downstream" of Water Use			
[1] Extraction & Conveyance	[2] Treatment	[3] Distribution	[4a] Wastewater Collection	[4b] Wastewater Treatment	Outdoors ∑ **[1]**-[3]	Indoors ∑ **[1]**-[4]
<u>Select</u>: Marginal Water Supply	<u>Select</u>: Water Treatment Level/Technology	<u>Select</u>: Water Service Area Physical Characteristics	<u>Select:</u> Wastewater Collection (only one choice provided: "Yes" or "No"	<u>Select</u>: Level of Wastewater Treatment	Compute	Compute

3. **<u>Substantially Reduce the Risk to Users that Develop and Apply Program-Specific Energy Intensities</u>**. To encourage Users to develop program specific energy intensities and thereby build knowledge, understanding and a more comprehensive database of water sector energy intensities and embedded energy, the CPUC should provide simple guidelines for how these user-defined values can be developed and approved. Based on our extensive work in this area, we do not believe that is difficult. For example:

   a. **<u>Water Resource Energy Intensity</u>** can be fairly readily computed for the marginal water supply of any particular water utility or groups of water utilities. The energy intensity of some water resources such as seawater desalination are fairly uniform since the energy intensity depends primarily on the quantity of salts and other minerals that need to be removed. The energy intensity of other types of water resources, such as groundwater, are highly variable, depending on the characteristics of the specific groundwater basin, especially the depth-to-groundwater that drives pump energy, and the quality of the groundwater. Our studies have shown substantial variances in groundwater energy intensity

[64] All default values in the CPUC's W-E Calculator are electric, expressed in kWh/AF.

that the default values do not capture. Every water utility we have worked with that pumps groundwater knows the energy intensity of its resource, or can compute it very simply.

b. **Distribution Energy Intensity** can be very simply computed for an entire water utility's service area by dividing total annual energy used for distribution by total volume of water transported.

c. **Water and Wastewater Treatment Energy Intensity** has been studied extensively by multiple parties. Those studies show that the primary driver of treatment energy intensity, whether for water or wastewater, depends on the quality of the water or wastewater being treated, the technology being utilized, and the level of treatment. These values tend to be uniform throughout the state because the key drivers of energy intensity are independent of hydrology, climate, topography and geology.

Establishing a simple to use template that participating water utilities can use to provide information about the energy intensities of their water resources and water and wastewater system components would substantially increase willingness of program implementers to provide and use energy intensity data that more accurately reflects their anticipated program results.

4. **Move the Avoided Cost of Energy and Related Computations of the Cost-Effectiveness of Embedded Energy** to the CPUC's E3 and CET cost-effectiveness calculators as soon as possible. While this was not the focus of our investigations, it became clear that the complexity of the CPUC's current W-E Calculator makes it difficult to understand its default data, processes and computations, and to assure that computations are performed on bases consistent with other energy efficiency programs.