Water Energy Nexus Cost Calculator Plan of Action

In Decision 16-12-047 (Decision), the California Public Utilities Commission (CPUC or Commission) ordered the four major investor-owned utilities (IOUs) Southern California Edison Company (SCE), San Diego Gas & Electric Company (SDG&E), Southern California Gas Company (SoCal Gas), and Pacific Gas and Electric Company (PG&E), together, the "Joint IOUs" or "Energy Utilities," to create a Plan of Action to update the Water Energy Nexus Cost Calculator and to file it with the Commission. By letter dated January 30, 2017, the Executive Director of the CPUC extended the deadline to allow for the completion of a study of the "Natural Gas Intensity of Water" by SoCal Gas prior to the filing of the Action Plan. The due date for the Plan of Action was extended until 45 days following completion of the SoCal Gas' natural gas study, or August 15, 2017, whichever is earlier. The study was completed and publicly posted on the CPUC's website on July 24, 2017. This Plan of Action is being filed with the Commission on August 14, 2017, as required by the CPUC.

I. Purpose

The Joint IOUs have prepared the following Plan of Action to update the Water Energy Nexus Embedded Energy Cost Calculator (Water-Energy Calculator). This Plan of Action addresses the three updates required by the Decision and provides next steps to implement the necessary changes.

The Decision states:

> *The Plan of Action shall address how best to do the following: (a) create, and incorporate into the Water-Energy Calculator, a greenhouse gas emissions reductions value for water-energy nexus energy efficiency measures; (b) connect the Water-Energy Calculator with the commonly-used E3 energy efficiency program calculator and the Database for Energy Efficient Resources; (c) within 6 months of the completion of Southern California Gas Company's natural gas study, incorporate into the Water-Energy Calculator a value representing the natural gas embedded in the water system.*[1]

On January 10, 2017 the CPUC Energy Division and representatives of the Joint IOUs met to discuss the Energy Division's "Recommendations for Water Energy Calculator Update." The Recommendations support improvements to the Water Energy (WEN) Calculator in addition to the upgrades required by the Decision. The IOUs are responsible for compliance with the Decision.

[1] D.16-12-047, OP 2.

II. Greenhouse Gas (GHG) Reduction Values

The Decision requires the Joint investor owned utilities (IOUs) to:

(a) create, and incorporate into the Water-Energy Calculator, a greenhouse gas emissions reductions value for water-energy nexus energy efficiency measures;[2]

The IOUs recommend using existing tools to calculate greenhouse gas (GHG) emissions reductions that result from water energy savings, rather than incorporating GHG emissions reductions into the Water-Energy Calculator. After discussion with CPUC staff, all parties agreed that GHG emissions should not be incorporated into the calculator at this time.

The Cost-Effectiveness Tool (CET, formerly known as the E-3 Calculator) that the Energy Utilities use to evaluate the cost-effectiveness of energy efficiency measures and programs already calculates GHG emissions, and adding the same functionality to the WEN Calculator would be redundant. Furthermore, the methodologies would likely be different, leading to inconsistent results and confusion. The IOUs recommend that a better understanding of the needs of water agencies and other stakeholders for whom GHG emissions would be useful be reached before any further discussion of adding GHG emissions to the WEN Calculator. For example, any attempt to quantify emissions within the Water-Energy Calculator will not address all water agency activities, such as emissions related to fleet vehicles, direct emissions from wastewater and sludge digestion processes, etc. without significant effort. Therefore, the IOUs recommend that water agencies or other WEN Calculator users seek alternative GHG emissions calculators such as those developed by the American Water Works Association (AWWA), the Water Environment Research Foundation (WERF), ICLEI-Local Governments for Sustainability (ClearPath tool), various universities (such as Clemson) and various water agencies. This would also allow water agencies to select the appropriate calculation methodology to meet their individual needs. The use of multiple tools seems unavoidable in this situation.

Timeline: No action required

Responsible Parties: None

III. Connecting the Water-Energy Calculator With the CET (Cost-Effectiveness Tool)

(b) connect the Water-Energy Calculator with the commonly-used E3 energy efficiency program calculator and the Database for Energy Efficient Resources;

The purpose of this connection is to include the benefits of water energy savings in the cost-benefit analysis of energy efficiency interventions. The Joint IOUs have developed three possible approaches to integrating the Water-Energy Calculator and Cost-Effectiveness Tool/CET (formerly the E3 Calculator). Of these three options, the IOUs have agreed that

[2] D.16-12-047, OP 2.

Option 3 is the simplest to implement and leads to the most accurate calculations. The three options are described below.

Option 1: Adding the Energy Utility TRC output from the WEN Calculator (embedded energy savings portion) to the TRC output from the CET (direct energy savings portion). This option was removed from consideration because TRCs are not additive and would produce incorrect results.

Option 2: Add costs from CET and WEN Calculator, add benefits from the CET and WEN Calculator, and calculate TRC as the ratio of costs to benefits. This method would require reporting of the cost and benefit data from the WEN Calculator such that it could be added to the CET results. Issues with this process include different base-years (in the WEN Calculator base year is locked to 2014 while in the CET the implementation year can be entered). The CET avoided costs are also updated annually as required by D.16-06-007, whereas the WEN Calculator is not updated annually.[3] Additionally, the costs and benefits calculations performed by each have other variations that have not yet been identified but could pose challenges to using this approach for integration. While this would be the most accurate approach, the limitations created by differing base years, additional reporting requirements, and the need to update the WEN Calculator annually make this approach unfeasible at this time.

Option 3 – **RECOMMENDED:** Take the IOU Embedded Energy in kWh output from the WEN Calculator and input it into the CET to calculate a TRC. This method would ensure that the TRC calculation for embedded energy is consistent with that for direct energy savings. CET calculations will be performed with the combined total (direct plus embedded) energy savings. The CET has different inputs than the WEN Calculator, therefore, measure attributes for the direct energy saving measure will be used for the embedded energy savings even if they don't directly apply to the water efficiency portion of the measure (for example, end use load shape, Climate Zone, building type, etc.). While these results aren't as accurate because of the assumptions that must be made for the inputs, from a usability perspective this is still the best path forward. The CPUC will also need to integrate the embedded energy with the direct energy savings of a measure when performing TRC calculations for direct and water saving measures in order for the IOUs and CPUC calculations to be the same.

While our recommended method does not directly use the cost-effectiveness functionality within the WEN calculator, this functionality still serves an important purpose in program planning. The cost-effectiveness functionality allows IOUs to determine costs, benefits, and rebate amounts; and is essential in program planning in conjunction with water agencies.

For a more detailed discussion of the reporting structure and cold water embedded energy savings, please see **Appendix B: Default CET Input Values for Water-Only Measures**.

[3] The WEN Calculator could be updated annually for any inputs that are consistent with updated avoided costs inputs as required by D.16-06-007 to ensure that common avoided costs inputs are consistent. These updates would be the responsibility of the Commission.

Timeline: Monthly CEDARS reporting[4] of embedded energy savings will begin in October 2017 for the month of August and year-to-date value beginning in January 2017. Quarterly reporting will begin Q3 2017 and annual reporting will follow Energy Efficiency reporting dates for 2017.

Responsible Parties: CPUC Reporting staff, IOU Reporting staff

IV. Connecting the Water-Energy Calculator With DEER

In addition to the CET, the WEN Calculator will also need to be integrated with the Database for Energy Efficiency Resources (DEER).

The next revision of DEER, DEER 2018, should include approved water savings from the Metropolitan Water District (MWD) and CET calculators as applicable per commission staff's recommendation. In the meantime, the IOUs will use the Workpaper process to include water measures as non-DEER measures. The values in the Workpaper (which are taken from MWD) could be included in DEER 2018, or the new system, in future.

Timeline: DEER updates will align with previously scheduled DEER updates.

Responsible Parties: Ex Ante Review team, IOU Engineering staff.

V. Incorporating Gas Values Into the Water-Energy Calculator

(c) within 6 months of the completion of Southern California Gas Company's natural gas study, incorporate into the Water-Energy Calculator a value representing the natural gas embedded in the water system.

SoCalGas completed its Natural Gas Intensity in Water study (dated July 5, 2017) which identified recommendations for SoCalGas to consider in determining a natural gas intensity value to incorporate into the WEN Calculator. The results of the study would dictate the appropriate steps taken to update the WEN Calculator where (1) if the results show significant embedded gas, the energy intensity (EI) values will be added as defaults to the existing fields in the Water-Energy Calculator; or (2) if it is determined that there is not significant embedded natural gas in the water system, values will not be added as defaults. SoCalGas provides its Natural Gas Intensity of Water study (**Appendix C: SoCalGas' Natural Gas Intensity of Water Study**) to further inform this discussion.

The study's analysis identified the amount of embedded natural gas in water within SoCalGas' service area, range of natural gas intensities observed, and wide variability in natural gas intensities.[5] The Study also confirms that while there is much less natural gas used (and available for embedded savings) for water sector purposes, the number is not "zero."[6,7] Noting the wide variability of EI and lack of a statistically valid sampling technique, there is no basis for extrapolating the average EI observed among participating Water/Waste Water utilities

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[4] https://cedars.sound-data.com/.
[5] WaterEnergy Innovations (2017, July 5). *Natural Gas Intensity of Water*, pp. 18-23.
[6] *Ibid*., p. 9.
[7] The amount of natural gas embedded in water is provided in Chapter 2 of the Natural Gas Intensity of Water Study. Determination of EI values are provided in Chapter 3.

throughout a hydrologic region, multiple hydrologic regions, SoCalGas' service area, or statewide.[8]

Further, the study conducted a review of the Water-Energy Calculator to understand the extent of updates needed to the Water-Energy Calculator.[9] Based on the key findings and conclusions in the study[10] and given the existence of the CPUC CET calculator (or successor) for computing cost-effectiveness, SoCalGas recommends that default natural gas values not be incorporated into the WEN Calculator. However, SoCalGas does recommend capturing natural gas savings outside of the calculator within its service territory. Please see Section VI: Southern California Gas Company for more information.

Timeline: No updates to the Calculator, however additional methodology to determine energy savings based on the natural gas energy intensity of water and wastewater to be adopted based on the approval of the Action Plan.

Responsible Parties: SoCalGas

VI. IOU Water-Energy Program/Partnership Plans

1) Pacific Gas & Electric Company

PG&E has partnered with water agencies extensively in the past. From 2008-2016, PG&E worked in partnership with 34 Bay Area water agencies serving 2.2 million residential customers. PG&E has also hosted the Water Conservation Showcase since 2004 in partnership with East Bay MUD (Municipal Utility District), SFPUC(San Francisco Public Utilities Commission), and others at the Pacific Energy Center, creating an opportunity for agencies to explore new solutions to saving water and energy. Another example of PG&E's partnership with water agencies is a series of pilots aimed at analyzing behavior-based interventions and their impact on reducing water usage, peak energy usage, and total energy usage.

PG&E's Business Plan outlines strategies to better use tools and technology to capture savings from embedded energy, particularly for large industrial and agricultural customers, and improve and prioritize energy efficiency offerings relevant to water conservation and the water-energy nexus. As part of the business plan process, PG&E identified the following additional opportunities for Water-Energy Nexus efforts: multi-family, hospitality, local government, and codes and standards. PG&E is working across market segments with our third-party implementers to assess water agency partnership programs. The goal is to establish a methodology to evaluate a program in partnership with a water agency to calculate the baseline installation rate and evaluate water technologies and savings. This will make it possible to determine how partnership programs would increase the adoption of measures above and beyond what water agencies and IOUs can achieve individually. The outcome will inform future solicitation planning efforts.

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[8] WaterEnergy Innovations (2017, July 5). *Natural Gas Intensity of Water*, p. 22.
[9] *Ibid*., pp. 8-9.
[10] *Ibid*., p. 30.

2) Southern California Edison

In support of coordination across agencies and utilities, SCE is jointly filing this Action Plan with IOUs to integrate the Water-Energy Nexus embedded Energy Calculator Tool with the Commission's approved CET. The goal is to better streamline, integrate, and evaluate multi-utility offerings. Integrating the tools and leveraging our experience with partnerships for multi-utility offerings, including water agencies, will provide guidance on assessing multi-utility offerings across SCE's Demand Side Management (DSM) portfolios.

SCE currently partners with water agencies to coordinate multi-utility offerings. For example, SCE works with the SoCalGas and retail water agencies to deliver our 10-10-10+ Multi-Family Pilot (aka "Communities for Conservation"), significantly coordinating and leveraging customer data to provide a "one-stop shop" for customers and utilities alike. New activities include the Residential Direct Install (DI) program, which works with water agencies to provide a targeted approach to the residential sector. Residential DI was proposed in SCE's 2017 Annual EE Program and Portfolio Budget Request Advice Letter (3465-E), based on lessons learned from previous program efforts to reach customers in the residential sector. These customers face many of the same barriers as our low-income customers, such as renters who face a split incentive, or homeowners who struggle with making EE improvements due to high upfront costs. More results are anticipated in the 2017 and 2018 program years.

SCE will utilize its lessons learned from programs and pilots (like Residential Direct Install and 10-10-10+), and utilize further developments from the WEN proceeding, to help plan matters such as the measure mix and scale of the future partnerships. Furthermore, these enhancements will enable third parties to propose approaches that include multi-utility offerings. SCE looks forward to evaluating opportunities to coordinate and leverage external existing partnerships to expand offerings. SCE will continue to leverage and expand partnerships with water agencies[11] to provide more complete offerings to our customers, where relevant and cost-effective, as outlined in SCE's recently submitted EE Business Plan.[12]

3) San Diego Gas & Electric Company

SDG&E has been developing lasting and successful relationships for many years with the water agencies and water districts. Some of the stand out achievements in the past have been providing over 500,000 low flow showerheads, 100,000 residential high efficiency clothes washers, and providing over 25,000 water and energy savings kits.

The most expansive program has been with the San Diego County Water Authority (SDCWA), where we have implemented large scale projects for both cold and hot water activities. With the approval of the WEN Calculator, significantly more opportunities have been created to both save water and save energy. SDG&E has contracted with Water Energy Innovation, a consulting firm, to further collaborate with SDCWA and help identify additional opportunities. Some of the recommendations SDG&E and SDCWA will be addressing in the future is the

[11] Water Agencies refers to either wholesale agencies, such as Metropolitan Water District, or retail agencies.

[12] Southern California Edison Company's Amended Energy Efficiency Rolling Portfolio Business Plan for 2018-2025 (U338-E), available at https://media.wix.com/ugd/0c9650_bc928ec1f1aa47c99d3e266c8b1591a2.pdf.

potential of coordinating commercial audits, expansion of both indoor and outdoor water use efficiency offers and targeting specific high potential savings projects.

4) <u>Southern California Gas Company</u>

SoCalGas has long been an active contributor in the water-energy proceeding, maintaining its role as a water advocate. Historically, SoCalGas has offered programs that educate on water savings, deliver energy savings measures associated with the savings of hot water, as well as partnered with water agencies for cross-promotion and intends to continue these activities to comprehensively address the needs of its customers. Further, given the evolution of the Water-energy nexus proceeding activities, SoCalGas began new research and study efforts to better inform, quantify and deliver natural gas energy savings through water in future programs and activities. To answer the question as to how and how much natural gas is used by the water sector, SoCalGas embarked upon a study about water-related uses of natural gas within its service area. This study confirmed that while there is much less natural gas used for water sector purposes, the number is not "zero." As such, SoCalGas can and should continue to have a role in supporting the state's goal of building long- term drought resilience.[13]

SoCalGas will continue its partnership with the Los Angeles Water and Power (LADWP) and the Los Angeles Metropolitan Water District (MWD) to co-deliver water-energy related activities. These activities include the Energy Smart Landscape seminars co-taught with MWD as well as SoCalGas and MWD co-funded research to document water energy saving ideas and strategies. SoCalGas will also utilize its current programs and partnerships to expand future water energy partnered offerings. One such example is the Commercial Restaurant Retrofit program, in which MWD will fund calculated water savings incentives. Another example is SoCalGas' partnered program with MWD where low income customers receive water savings rebates from MWD through SoCalGas' ESA low income program. Additionally, SoCalGas expects the Energy Efficiency Business Plan process to enable third parties to propose new approaches that provide comprehensive water-energy savings offerings to our customers that are cost-effective and relevant to this evolving area.

In order to capture natural gas savings, SoCalGas recommends that energy savings based on the natural gas EI of water and wastewater still be added to the amount of electricity to be saved by reducing water consumption, computed separately from the Water-Energy Calculator to enhance transparency, consistency and accuracy.[14] The Study offers three options to determine the natural gas EI of water value:

1) Compute the Average Natural Gas Intensity of Groundwater and Potable Water Distribution;

2) Compute the Average Natural Gas Intensity of Water and Wastewater Based on Regional Water Demand; and

3) Average Natural Gas Intensity of Water and Wastewater for SoCalGas' Service Area Overall.

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[13] WaterEnergy Innovations (2017, July 5). *Natural Gas Intensity of Water*, p. 9.
[14] *Ibid.,* pp. 30 and 31.

Of the three options, SoCalGas recommends Option 2[15] as the method to determine the Natural Gas EI of water as this structure is consistent with methodologies used by the CPUC's WEN Calculator and considers the lack of a valid basis for extrapolating results observed in the water and waste water utilities operating in SoCalGas' territory to all water sectors. Given that the study only covers the SoCalGas service territory, EI values and the computation of natural gas intensity in water should only be applied to the hydrologic regions within SoCalGas service territory.

VII. Responses to Energy Division and IOU Recommendations

Updates to the Water-Energy Calculator will be dependent on usage, feedback from other parties involved in the calculator's use, available resources, and other factors. Close collaboration between the IOUs and the Commission, as well as input from water agencies within each IOU's service territory, will be critical. To help guide the approach to updates, Commission Staff provided a series of Recommendations for Water-Energy Calculator Update. These Recommendations are addressed below. The Energy Division will be responsible for updates to the Calculator itself.

Energy Division Recommendations for Water Energy-Calculator Update:

GIS Overlay: The individual IOUs have performed their own mapping activities as needed for their service territories. For a hydrologic region look-up tool for the entire state see this tool developed by PG&E: www.pge.com/hydromap.

Make the model more user friendly – eliminate any two stage calculations with multiple models: Updating the model is the responsibility of the Commission.

Connect Calculator to DEER: See above

Easier way to change resource balance year and to have the marginal resource type change in future years: The IOUs recommend that the Commission evaluate the issues identified by RMS Energy Consulting, LLC and Water Energy Innovation (see attached white paper) with regard to the resource balance year and marginal resource type. Until evaluation, the default values will continue to be used, per D.15-09-023.

Additional User Support: The IOUs recommend that the Commission look back at user support documentation and ensure it continues to apply, given updates to the calculator and reporting process.

Greenhouse Gas Emissions: See Above

Embedded Natural Gas: See Above

[15] Natural gas intensity values provided in Table 3-4 of the Natural Gas Intensity of Water study. WaterEnergy Innovations (2017, July 5). *Natural Gas Intensity of Water*, p. 28.

Appendix A: Timeline of IOU Water-Energy Program Development:

Activity	Expected Completion Date	Lead
Submit Water Savings Workpaper	May 2017	SDG&E
Work Paper Passed Through	June 2017	CPUC EAR/ED
Meet and confer next steps, integration challenges, resource balance year differences. Agree on updates to calculator. ED recs and consultants memo.	Q3/Q4 2017	IOUs, ED,
IOUs will begin reporting water and embedded energy savings	Q3 2017	IOU reporting teams
Water Agency Partnership program development	2018 following business plan approval	IOUs and statewide implementers
Water Agency Partnership program launch	2019	IOUs and statewide implementers

Appendix B: Default CET Input Values for Water-Only Measures

The CEDARS reporting structure has been updated to accommodate the entry of Cold Water savings in a Water Measure reporting table, as well as a WATER_ONLY_FLAG. These updates allow for reporting of embedded energy savings, however testing is ongoing before claims can be submitted.

The Joint IOUs recognize that there are certain inputs to the CET tool which are not defined for cold-water measures. For measures with direct energy savings (aka hot water savings) the measure attributes from the direct energy savings measure will apply to the embedded energy savings. For cold-water only measures, where there is not direct energy savings measure to borrow attributes from, the IOUs have defined specific values and defaults.

These specific values and defaults include:

- Climate Zone defaults based on Zip Code;
- Bldg Type, Target Sector, Gas Sector, Combustion Type, and Residential Flag default based on Sector; and
- DEER:RefgFrzr_HighEff or DEER:HVAC_Chillers for End Use Load Shape depending on Target Sector is RES and NON-RES, Annual for Gas Sav Profile, IOU for Bldg Type, Ex for Bldg Vint, Any for Bldg HVAC, Each for Norm Unit, ROB for Meas App Type, NonUpStrm for Delivery Type, 1 for Num Units and Installed Num Units, 0.85 for NTG columns, ‘All-Default<=2yrs’ for NTG ID, ‘Water savings only measure’ for Why Savings Zeroed, 0 for Upstream Flag, Paid Date for Claim Date, 0 for Totals columns in CLAIM table.

Appendix C: SoCalGas' Natural Gas Intensity of Water Study

See accompanying study "Natural Gas Intensity of Water," dated July 5, 2017.

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

See accompanying white paper "Implementation of the California Public Utilities Commission's Water-Energy Calculator" for further details on concerns with regard to the resource balance year and marginal resource type identified by RMS Energy Consulting and Water Energy Innovations.

Natural Gas Intensity of Water

July 5, 2017

Developed for
Southern California Gas Company by:

www.waterenergyinnovations.com

ABBREVIATIONS AND ACRONYMS

Abbreviation/Acronym	Definition
AF	Acre-foot
CEC	California Energy Commission
CET	Cost-Effectiveness Tool
CPUC	California Public Utilities Commission
CRA	Colorado River Aqueduct
DWR	Department of Water Resources
EE	Energy Efficiency
EI	Energy Intensity
GHG	Greenhouse Gas
GWater	Groundwater
IOUs	Investor Owned Utilities
MG	Million Gallons
N.Gas	Natural Gas
NAICS	North American Industry Classification System
PA	Program Administrator
SDG&E	San Diego Gas & Electric Co.
SCAQMD	South Coast Air Quality Management District
SoCalGas	Southern California Gas Co.
SWP	State Water Project
TAF	Thousand Acre-feet
W-E	Water-Energy
W/WW	Water and/or Wastewater
WW	Wastewater

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EXECUTIVE SUMMARY

Background and Context

Ever since the California Energy Commission (CEC) reported in 2005 that the State's water-energy relationship was substantial, state and federal agencies, national laboratories, industry associations, non-governmental organizations, and a wide variety of water, energy and environmental stakeholders have conducted studies aimed at quantifying the amount of energy that could be saved by saving water. The diversity of the stakeholders and their respective interests are reflected in the wide range of recommendations as to types of programs and strategies for achieving those savings.

To-date, most studies have focused on estimating the amount of electricity that could be saved; few have attempted to quantify the amount of natural gas embedded in water. This gap was highlighted during a regulatory rulemaking in which the California Public Utilities Commission (CPUC) adopted a Water-Energy Calculator to guide design of energy efficiency programs that also save water (aka, "water-energy programs").[1] The Water-Energy Calculator adopted by the CPUC pursuant to Rulemaking 13-12-011 does not contain any natural gas data.

Southern California Gas Company (SoCalGas) is the nation's largest natural gas distribution utility, serving 21.6 million customers through 5.9 million meters in more than 500 communities throughout its 20,000 square miles service area.[2] To answer the question as to how and how much natural gas is used by the water sector, SoCalGas embarked upon a study about water-related uses of natural gas within its service area. This report presents the findings from that study, and recommendations as to how these data can be used to design water-energy programs and partnerships.

Natural Gas Embedded in Water and Wastewater

The amount of natural gas used for water and wastewater systems and processes averaged 23.7 million therms per year over the six year period that was selected for this study (2010-2015). The purpose of selecting this period was to enable identifying impacts of California's recent multi-year drought on natural gas use for water pumping.

Although water-related therm usage was about 10% less in CY2015 than in CY2010, water and wastewater utilities that participated in this study explained that their use of natural gas has declined not so much because of drought, but primarily due to the high costs of complying with increasingly stringent air quality regulations promulgated by the South Coast Air Quality Management District (SCAQMD) that has jurisdiction over much of SoCalGas' service area. To avoid the significant incremental operating risks and costs of air quality compliance, many water and wastewater utilities within SCAQMD's district are changing natural gas pumps to electric.

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[1] Order Instituting Rulemaking into Policies to Promote a Partnership Framework between Energy Investor Owned Utilities and the Water Sector to Promote Water-Energy Nexus Programs, California Public Utilities Commission, December 30, 2013 (R.13-12-011)

[2] Southern California Gas Co. website: https://www.socalgas.com/about-us/company-profile.

Some water and wastewater utilities also reported that they are increasing on-site production of renewable energy. West Kern Water District, one of SoCalGas' largest water sector customers, installed 4.6 MW of solar photovoltaics panels in 2013 for the purpose of displacing natural gas pumping of water uphill to the City of Taft in Kern County, California.[3,4]

Figure ES-1 below shows the relative distribution of water-related natural gas usage within SoCalGas' service area by hydrologic region. Service address zip codes were used to distribute the therms.

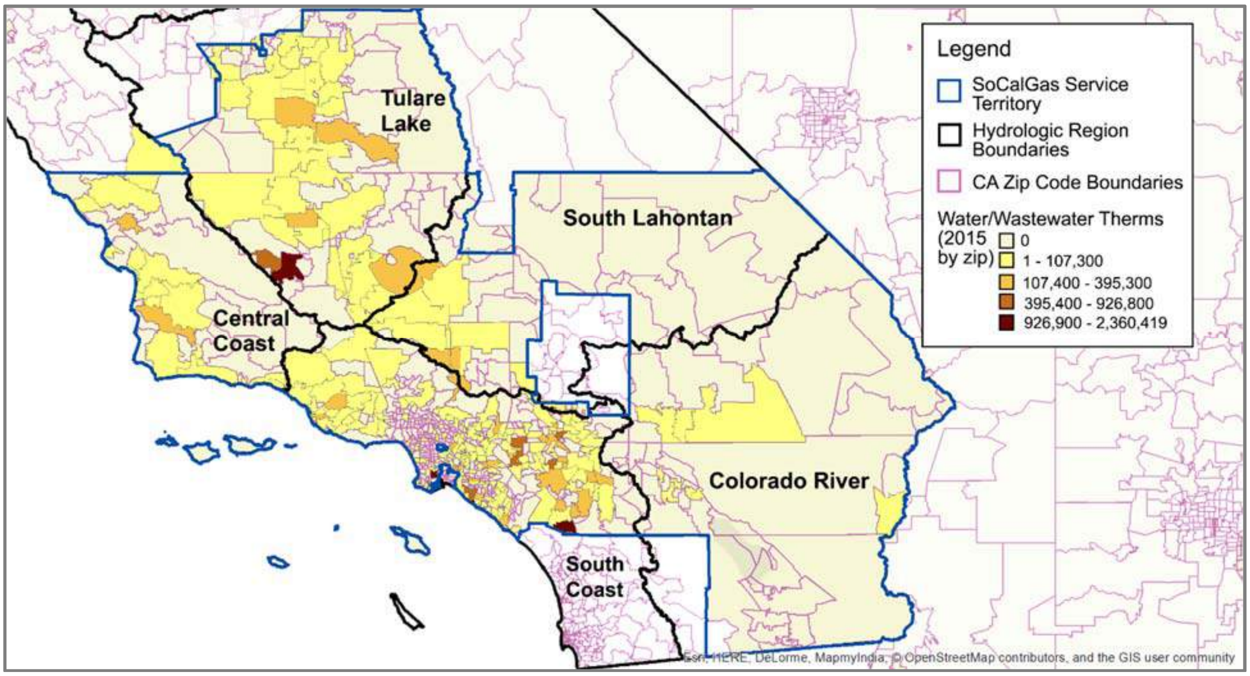

Figure ES-1. Embedded Natural Gas in Water and Wastewater by Hydrologic Region (CY2015)

Wide Variability in the Natural Gas Intensity of Water and Wastewater

Relatively little natural gas is used to produce water resources or to support water and wastewater systems and functions. As noted previously, 23 water and wastewater agencies account for 80% of all water sector natural gas usage within SoCalGas' service area. The primary water sector use of natural gas is for potable water distribution and groundwater pumping.

The natural gas intensity of water and wastewater was computed for each of the 23 participating water and wastewater utilities at the utility level, by hydrologic region, and by type of use. Tables ES-1, ES-2 and ES-3 show the natural gas intensities produced by these different computational methods.

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[3] Taft is located 30 miles west-southwest of Bakersfield, at an elevation of 955 feet: https://en.wikipedia.org/wiki/Taft,_California.

[4] Array Technologies press release, June 27, 2012: http://arraytechinc.com/news-item/4-6-mws-shipped-for-west-kern-water-district/.

Method 1. Water and Wastewater Utility Specific Natural Gas Uses

Table ES-1 shows the range of natural gas intensities computed at the water and wastewater utility level for potable water distribution pumping and groundwater pumping that accounted for 85% of water sector use by the 23 participating water and wastewater utilities during CY2015.[5]

Table ES-1. Range of Natural Gas Intensities of Potable Water Distribution Pumping and Groundwater Pumping Observed during CY2011-2015 (therms/Acre-Foot)[6]

Observed Range	Potable Water Distribution Pumping	Groundwater Pumping
MINIMUM	0.03	0.05
MAXIMUM	113.66	95.01
MEDIAN	16.94	26.93

Method 2. Average Natural Gas Intensity of Water and Wastewater by Hydrologic Region

Table ES-2 shows the average energy intensities of water and wastewater, and the resultant average energy intensities of water saved outdoors vs. indoors, within the five hydrologic regions served by SoCalGas. Annual water-related therms were averaged over regional water demand and estimated wastewater production, irrespective of whether natural gas is used to produce, transport, treat or distribute any particular unit of water, or to collect or treat wastewater. Consistent with the convention established by the CEC and the CPUC, the energy intensity of water saved outdoors is computed as the sum of average natural gas inputs to water upstream of end use, and the energy intensity of water saved indoors is based on the sum of average natural gas inputs to water both upstream and downstream of end use (i.e., including wastewater collection and treatment).

Table ES-2. Natural Gas Intensity of Water and Wastewater by Hydrologic Region (CY2015)[7]

Hydrologic Region	Natural Gas Intensity (therms/AF)		Application to Water Savings (therms/AF)	
	[1] Water	[2] Wastewater	Indoor Savings [1]+[2]	Outdoor Savings [1]
Central Coast	1.62	5.49	7.12	1.62
Colorado River	0.02	0.02	0.04	0.02
South Coast	2.98	2.37	5.35	2.98
South Lahontan	3.89	0.05	3.95	3.89
Tulare Lake	0.61	0.87	1.48	0.61

[5] The range of natural gas intensities is wider when computed at more granular levels (e.g., prime mover or meter/submeter).
[6] Acre-foot (AF) is the amount of water needed to cover one acre of land with water one-foot deep. This metric is often used to measure water supplies. One acre-foot is equivalent to 325,851.432 gallons.
[7] See Appendix F, Table F-12.

Method 3. Average Natural Gas Intensity of Water and Wastewater for SoCalGas' Service Area Overall

The most conservative approach is to average all therms sold by SoCalGas over total water demand and estimated wastewater treatment volume within the portions of the five hydrologic regions served by SoCalGas. The result of this simple averaging method is shown in **Table ES-3**.

Table ES-3. Natural Gas Intensity of Water and Wastewater within SoCalGas' Service Area (CY2015)[8]

SoCalGas Service Area Overall	Natural Gas Intensity (therms/Acre-Foot)		Application to Water Savings (therms/AF)	
	[1] Water	[2] Wastewater	Indoor Savings [1]+[2]	Outdoor Savings [1]
All SoCalGas	1.40	1.84	3.24	1.40

Use of Natural Gas Intensity Values in Water-Energy Program Design

The same wide variability observed in the Electric Energy Intensity of Water and Wastewater Systems through the CPUC's Embedded Energy in Water Studies (2009-2010)[9] was observed for natural gas. **Table ES-4** describes key issues to consider with respect to using highly variable energy intensities such as the natural gas intensities documented in this report.

Table ES-4. Issues to Consider When Using Highly Variable Energy Intensities in Program Design

Factor	Issues
There is wide variability in the Natural Gas Intensity of Water/Wastewater (W/WW) resources, systems, facilities, functions and service areas.	Given the wide variability of Energy Intensities (EI) and lack of a statistically valid sampling technique, there is no basis for extrapolating the average EI observed among participating W/WW utilities throughout a hydrologic region, multiple hydrologic regions, SoCalGas' service area, or statewide.
The appropriate unit of measurement depends on how the energy intensity will be applied.	EIs can be applied at multiple levels: ▪ Type of resource, system, function ▪ W/WW utility service area ▪ Hydrologic region, DEER climate zone, energy IOU service area, statewide ▪ Water demand vs. supply The key objective is to identify a metric appropriate to the program objective.

Given lack of a valid statistical basis for extrapolating average observed EIs to the remainder of the population - and also given the objective of creating a simple, consistent metric - the average EI could be simply computed over all water demand, either within a hydrologic region or for SoCalGas' service area overall. This approach results in a very conservative estimate of Natural Gas Intensity. Conservatism in absence of perfect information is consistent with the CPUC's policies with respect to protection of energy ratepayers' investments.

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[8] See Appendix F, Table F-13.

[9] Embedded Energy in Water Study 1, Statewide and Regional Water-Energy Relationship and Study 2, Water Agency and Function Component Study and Embedded Energy-Water Load Profiles; California Public Utilities Commission, August 31, 2010: http://www.cpuc.ca.gov/general.aspx?id=4388.

Use of Natural Gas Intensity Data in Water-Energy Program Design

The decision as to how the data developed through this study should be employed for purposes of program design depends upon the individual program objectives. **Table ES-5** illustrates how specific program objectives drive decisions as to how the natural gas intensity of water should be applied to energy investor-owned utilities' design of water-energy programs.

Table ES-5. Designing Water-Energy Programs

Program Objective	Application of Natural Gas Intensity Data
Support the State's Goal of Building Drought Resilience	If saving water is a statewide priority, the actual amount of embedded energy deemed saved by saving a unit of water may be less important than helping to advance the state's policy goal. This is important since, as this study has confirmed, relatively little natural gas is embedded in the state's water resources and water and wastewater systems. It is therefore unlikely that natural gas programs aimed at saving cold water will be able to meet the CPUC's threshold for "cost-effectiveness". Nevertheless, SoCalGas should not be precluded from helping the state to achieve this important goal.
Protect Energy Ratepayers' Investments through Cost-Effective Water-Energy Programs	Under the CPUC's current energy efficiency program policies and methodologies, the amount of electricity or natural gas deemed "embedded" or "embodied" in water alone are not sufficient to produce cost-effective energy savings. Embedded energy can, however, be added to direct energy savings that are already recognized through CPUC jurisdictional energy efficiency programs to recognize the incremental energy and related Greenhouse Gas emissions reduction benefits achieved by saving water.
Facilitate Water-Energy Partnerships	One of the CPUC's stated goals in recognizing energy embedded in water was to encourage water-energy partnerships. While simple recognition of embedded energy may not achieve cost-effective energy efficiency savings, it does provide a mechanism for facilitating partnerships between energy IOUs and their water sector customers. It also provides a platform for achieving other types of benefits for energy ratepayers, such as reducing the costs of energy programs by conducting joint marketing, education and outreach to shared water and energy customers.

A conservative natural gas energy intensity averaged over all water used within a specific hydrologic region or SoCalGas' service area overall would enable SoCalGas to support objectives aimed at supporting the state's goal of building drought resilience. By computing a conservative natural gas intensity that is averaged over all water supplies, irrespective of whether or not natural gas is used to produce, transport, treat or deliver any particular unit of water to end use customers, SoCalGas would be able to demonstrate linkage between natural gas savings and water savings, albeit at a very small amount, while continuing to support water savings through sustainable landscape and irrigation strategies, and other cold water savings measures, that are critically important to achieving the state's vision for long-term drought resilience.

Programs that target cost-effective natural gas savings would benefit by partnering with water and wastewater utilities that use substantial amounts of natural gas in their systems. These water and wastewater utilities are natural partners for SoCalGas:

- Assisting these large natural gas users to improve the efficiency of their systems and equipment can result in saving both direct and embedded natural gas, increasing the likelihood of identifying cost-effective measures.

- In addition, SoCalGas can partner with these water sector customers to deliver joint water and energy efficiency programs to shared customers, reducing energy efficiency program costs while increasing breadth and effectiveness of its energy efficiency marketing, education and outreach activities.

Marginal Water Supply

The Water-Energy Calculator (W-E Calculator) adopted by the California Public Utilities Commission (CPUC) to support design of water-energy programs required that the long-range marginal supply be selected as the basis for determining the amount of energy embedded in water that could be saved when saving a unit of water. The CPUC's current W-E Calculator [version 1.05] defaults to Recycled Water as the long-range marginal water supply for each of the state's ten hydrologic regions. However, the CPUC's Decision 16-12-047 implementing its W-E Calculator allows Program Administrators to select other types of long-run marginal water supplies. In fact, for many water utilities within SoCalGas' service area, groundwater is the long-run extra-marginal water supply.

Table ES-6 below was compiled from publicly available Urban Water Management Plans (2015) for 9 water utilities that participated in this study and for which UWMPs were available.

Table ES-6. Short and Long-Run Avoided Marginal Water Resources[10]

Water/Wastewater Agency	Hydrologic Region	Water Supply Portfolio [2025]	Short-Run Avoided Marginal Water Resource	Long-Run Avoided Extra-Marginal Resources [Future Water Supply Projects]
City of Cerritos	South Coast	▪ Purchased Recycled Water ▪ Local Groundwater	Purchased Imported Water	Groundwater Infrastructure Improvements (Remediation Stations & Rehabilitations)
City of Huntington Beach	South Coast	▪ Local Groundwater	Purchased Imported Water	Improvements: ▪ Groundwater Wells ▪ Reservoirs ▪ Saltwater Intrusion Barrier
Montebello Land and Water	South Coast	▪ Local Groundwater	Groundwater leases within the same basin	Distribution System only
Palmdale Water District	South Lahontan	▪ Purchased Recycled Water ▪ Surface Water (Raw)	Purchased Imported Water	Groundwater Recharge and Recovery Project

[10] The short-run avoided marginal water resource was determined by reviewing current and near-term water supply portfolios for 2015-2020. The long-run extra-marginal water resource was determined by reviewing future water supply projects described in these water utilities' UWMPs.

Water/Wastewater Agency	Hydrologic Region	Water Supply Portfolio [2025]	Short-Run Avoided Marginal Water Resource	Long-Run Avoided Extra-Marginal Resources [Future Water Supply Projects]
		▪ Local Groundwater		
Suburban Water Systems	South Coast	▪ Purchased Recycled Water ▪ Local Groundwater	Purchased Imported Water	Purchased Recycled Water
City of San Bernardino	South Coast	▪ Purchased Recycled Water ▪ Surface Water ▪ Local Groundwater	Purchased Imported Water	Planned New Wastewater Reclamation Plant (Participant)
West Kern Water District	Tulare Lake	▪ Water Transfers & Exchanges	Purchased Imported Water	Potential Regional Recycled Water[1]
Western Municipal Water District	South Coast	▪ Recycled Water[2] ▪ Desalter ▪ Groundwater	<u>Purchases</u>: ▪ Local Groundwater ▪ Imported Water ▪ Banked Water	<u>Groundwater</u>: ▪ Aquifer Storage & Recovery Project ▪ Recharge Project ▪ Expansion of Brackish Groundwater Desalter
Yorba Linda Water District	South Coast	▪ Groundwater	Purchased or Imported Water	New Groundwater Wells

[1] West Kern Water District is exploring the feasibility and costs of developing and delivering recycled water in partnership with other agencies within the region.

[2] Western Municipal Water District is both a recycled water producer and retailer.

The water supply portfolios for these water utilities, all of which are customers of SoCalGas, have the following characteristics:

- **<u>Groundwater</u>** is a major source of local water for most of these water utilities, as it is for many other water utilities throughout central and southern California, except those that reside within San Diego County that has relatively little groundwater.

- **<u>Recycled Water</u>**. Most small to medium-size water utilities within SoCalGas' service area do not own and operate their own wastewater treatment facilities. Instead, they send their wastewater to regional wastewater treatment plants that take the responsibility for developing and providing recycled water. Consequently, many of the water supply portfolios show modest amounts of recycled water in their portfolios throughout the 30 year UWMP projection period (through 2035), based on the estimated quantity that they will be able to purchase from regional reclamation districts. For these water utilities, recycled water is treated as a base load water supply – not marginal.

- **<u>Supplemental Water</u>**. Throughout SoCalGas' service area, the primary source of supplemental water is purchased imported water from state and federal wholesale water projects. In addition, many water utilities are now collaborating on water transfers, exchanges and banking arrangements, both intra- and inter-basin.

In accordance with the CPUC's directive, the long-run avoided marginal water resources were identified on an extra-marginal basis (i.e., the new water resources that would need to be procured or constructed to meet future water demand). This approach is consistent with CPUC Decision 07-12-052 that stated: *"… it would be logical to rely on extra-marginal supply assumptions for long term planning (more than one to two years in the future) and intra-marginal assumptions for the short term (one to two years ahead)*." CPUC Decision 15-09-053 reaffirmed the CPUC's prior conclusion by stating that the CPUC's Water-Energy Calculator "addresses these concerns by using only the long-run marginal supply."

While the CPUC adopted a default proxy for the long-run marginal water resource of recycled water, many water utilities within SoCalGas' service area do not own or operate recycled water facilities and are thus limited to purchases of recycled water from regional providers. For many of these water utilities that rely heavily on groundwater as their primary water resource and that have limited access to purchased recycled water, groundwater is their long-run *extra-marginal* water resource. Future water projects for these water utilities focus on increasing usable local groundwater supplies by increasing groundwater production from existing and future new wells, and/or remediating water quality from brackish groundwater wells.

CPUC's Water-Energy Calculator

The CPUC asked whether there is a need to revise its Water-Energy Calculator (W-E Calculator) to integrate natural gas. To answer this question, a detailed review was conducted of the CPUC's W-E Calculator. This review resulted in the following findings and recommendations:

Findings

1. The CPUC's W-E Calculator is comprised of 29 worksheets within a single Excel workbook. Many of these worksheets are used to compute the cost-effectiveness of water-energy measures; only a few of the worksheets are used to compute the energy intensity of water and wastewater.
2. Placeholders have been provided for inputting natural gas energy intensities of water and wastewater; however, natural gas inputs bypass most of the computations within the CPUC's current W-E Calculator [version 1.05].
3. The CPUC has an existing tool for computing the cost-effectiveness of energy efficiency measures. For consistency, it would be prudent to use the same tool (the CPUC's E3 Calculator) to compute the cost-effectiveness of all energy efficiency programs and measures, including those that may also save water and associated embedded energy.

Recommendations

Given that:

1. Water sector use of natural gas is distinctly different from electric;
2. The computation of the natural gas intensity of water and wastewater is very simple; and
3. Documenting the natural gas intensity of water and wastewater separately from electricity and outside of the CPUC's W-E Calculator will enhance transparency, consistency and a clear audit trail,

It would be beneficial to keep the natural gas intensity calculations outside of the W-E Calculator and to use the CPUC's existing E3 Calculator (and/or its successors) to compute the cost-effectiveness of water-energy measures that save natural gas.

Conclusion

This study confirmed that while there is much less natural gas used for water sector purposes, the number is not "zero". SoCalGas can and should continue to have a role in supporting the state's goal of building long-term drought resilience.

Since the quantity of natural gas embedded in water is relatively low, it will be difficult for SoCalGas to develop water-energy programs that can meet the CPUC's threshold for "cost-effectiveness". However:

1. One of the cornerstones of SoCalGas' energy efficiency programs has been to increase efficient use of hot water. This remains one of the most important strategies for achieving cost-effective natural gas savings; and in most cases, increasing efficient use of hot water also saves water.

2. Water and wastewater utilities that use substantial quantities of natural gas for pumping water, wastewater and/or recycled water are excellent candidates for potential efficiency improvements. Although many water and wastewater utilities are already extremely knowledgeable about strategies for improving pump efficiency, there may still be cost-effective opportunities for achieving natural gas savings through other types of system and process improvements.

3. Partnering with water and wastewater utilities to jointly deliver water and energy efficiency programs to shared customers increases the breadth and effectiveness of marketing, education and outreach while reducing program costs.

With respect to the CPUC's Water-Energy Calculator:

Since the computation of the natural gas intensity of water and wastewater is very simple, there is no need to integrate natural gas into the CPUC's existing Water-Energy Calculator. In fact, consistency and transparency would be significantly enhanced if the natural gas intensities used to compute the amount of natural gas embedded in water and wastewater are maintained separately, outside of the W-E Calculator. For consistency with other types of energy efficiency programs and measures, cost-effectiveness of water-energy measures should be evaluated using the CPUC's existing E3 Calculator (and/or its successors).

1 INTRODUCTION

Background and Context

On December 30, 2013, the California Public Utilities Commission (CPUC) opened a Rulemaking into Policies to Promote a Partnership Framework between Energy Investor Owned Utilities and the Water Sector to Promote Water-Energy Nexus Programs (R.13-12-011). The rulemaking has been considering a broad range of issues and opportunities around the State's "water-energy nexus." One of the cornerstones of the rulemaking was to consider adopting policies that would establish a framework for designing and implementing cost-effective energy programs that also save water. These included:[11]

- *The appropriate methodology for quantifying energy embedded in water;*
- *The appropriate methodology for determining water system benefits to water sector partners, and other local, state, and federal entities to which such benefits may accrue; and*
- *The appropriate methodology for allocating program costs among partners.*

Several public workshops were convened during 2014-2015 to review the work of CPUC Energy Division staff and its consultants related to the above policy issues. One of the key activities included developing a Water-Energy Calculator that would facilitate implementation of a new water-energy cost-effectiveness framework.

On December 15, 2016, the CPUC adopted Decision 16-12-047 Updating the Water Energy Nexus Cost Calculator, Proposing Further Inquiry, and Next Steps. Below is an excerpt of the first 4 ordering paragraphs addressing next steps for the W-E Calculator:

IT IS ORDERED *that:*

1. *Within 7 days of the date of this Decision, Pacific Gas & Electric Co., Southern California Edison Co., San Diego Gas & Electric Co., and Southern California Gas Co., shall begin collaborating with Energy Division to create a Plan of Action to update the Water Energy Nexus Cost Calculator.*
2. *The Plan of Action shall address how best to do the following: (a) create, and incorporate into the Water-Energy Calculator, a greenhouse gas emissions reductions value for water-energy nexus energy efficiency measures; (b) connect the Water-Energy Calculator with the commonly-used E3 energy efficiency program calculator and the Database for Energy Efficient Resources; and, (c) within 6 months of the completion of Southern California Gas Co.'s natural gas study, incorporate into the Water-Energy Calculator a value representing the natural gas embedded in the water system.*
3. *Within 45 days of the date of this Decision, Pacific Gas & Electric Company, Southern California Edison Company, San Diego Gas and Electric Company, and Southern California Gas Company*

[11] CPUC Rulemaking 13-12-011, December 30, 2013, pp. 20-21.

shall file and serve in this proceeding a Motion requesting Commission approval of the Plan of Action.

4. *Within 6 months of Commission approval of the Plan of Action, Pacific Gas & Electric Company, Southern California Edison Company, San Diego Gas and Electric Company, and Southern California Gas Company shall update the Water-Energy Calculator in the manner approved by the Commission.*

On January 30, 2017, the CPUC granted a request by the energy IOUs for extension of compliance with paragraphs 2 and 3 of the above order until completion of SoCalGas' study about the amount of natural gas embedded in water within SoCalGas' service area or August 15, 2017, whichever is sooner.[12]

The purpose of this report is to document the results of SoCalGas' study about the natural gas intensity of water and wastewater within its service area.

"Embedded Energy" vs. "Energy Intensity"

Two concepts are fundamental to implementing the CPUC's order to "… *incorporate into the Water-Energy Calculator a value representing the natural gas embedded in the water system.*"[13]

- Energy Embedded in Water, also referred to as "Embedded" or "Embodied" Energy; and
- Energy Intensity of Water.

For simplicity, the CPUC and other state agencies genericize "Embedded Energy in Water" to include the energy embedded in wastewater.

"Energy Embedded in Water", "Embedded Energy", "Embodied Energy" refers to the sum of energy inputs to water and/or wastewater from the point of origin through to disposal.

The current methodology applied by the CPUC and the CEC accumulates all energy inputs, both electric and natural gas, from the point of collection of surface water and extraction of groundwater, to transport ("conveyance") of water to water treatment plants, if needed, and then to water distribution systems that deliver water to end users. The following key principles guide computation of "Energy Embedded in Water" for purposes of the CPUC's Water-Energy Calculator and design of CPUC-jurisdictional Water-Energy Programs:

- Only energy inputs by water and wastewater utilities are considered, and only energy inputs provided by energy investor owned utilities (IOUs) that are directly related to collecting, extracting or otherwise preparing (e.g., treating) water supplies to levels appropriate for their intended end uses; delivering that water to the end users; and treating wastewater to levels that meet regulatory guidelines for safe discharge to the environment or for beneficial reuse (e.g., recycled water).

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[12] Letter dated January 30, 2017 from Timothy J. Sullivan, Executive Director of the California Public Utilities Commission.

[13] CPUC Decision 16-12-047, Ordering Paragraph 2.

- For purposes of CPUC Water-Energy programs, “Energy Embedded in Water” does not include the amount of energy used by end users during their consumption or use of water.
- The level of treatment and associated treatment energy needed to prepare water supplies for their intended end uses vary significantly, depending on the water source and the intended end use of that water source. For example, water used for irrigating crops is often “raw” (i.e., not treated); and when treated, irrigation water is typically not subjected to the same level of treatment as water intended for direct human consumption.

Energy Embedded in Water, *Embedded Energy* or *Embodied Energy* is the sum of all energy inputs used for water production, treatment and delivery to end users. The sum of energy inputs for wastewater collection, transport, treatment, and either discharge or reuse, is used to compute the Energy Embedded in Wastewater. For simplicity, the energy embedded in both water and wastewater is often referred to as “Energy Embedded in Water”.

Embedded Energy can be expressed at the level of a specific water or wastewater system or function, a single water or wastewater utility, or for groups of water or wastewater utilities.

“Energy Intensity” of Water or Wastewater is simply the average amount of energy, whether electric or natural gas, used to perform any water or wastewater function. It is computed by dividing the total amount of Energy Embedded in any specific water resource or water supply portfolio by the volume of water produced, transported, treated and/or delivered (distributed) to water end users. Just as for Embedded Energy, the Energy Intensity of Water and Wastewater can be computed at any level: a specific water or wastewater system or function, a single water or wastewater utility, or for groups of water or wastewater utilities. If natural gas is integrated into the CPUC’s Water-Energy Calculator, the *Natural Gas Intensity of Water and Wastewater* will need to be computed at the level of Hydrologic Regions. For other types of purposes, such as for design of cost-effective Water-Energy Programs and evaluation of the cost-effectiveness of specific water-energy measures, computing the Natural Gas Intensity of Water and Wastewater at the meter or prime mover level will enable more effective targeting of cost-effective natural gas savings.

The Role of Hydrologic Regions in Computing Natural Gas Embedded in Water

The California Department of Water Resources (DWR) divides the state into ten hydrologic regions for statewide water planning purposes. The hydrologic regions are shown in **Figure 1-1** on the next page.

Each of the hydrologic regions has unique characteristics that define its water supply portfolio and water use, and the resultant energy intensity of both its water supplies and water and wastewater portfolio. Hydrologic regions are defined by the State’s major groundwater basins and watersheds. Since these are defined by geology and topology, they do not follow geopolitical boundaries, causing some challenges during implementation. For example, hydrologic regions are not contiguous with zip codes or local government boundaries; nor are they contiguous with the 16 “building climate zones” established and maintained by the California Energy Commission (CEC) for purposes of establishing and implementing the State’s Title 24 California Building Standards Code.[14]

[14] See California Energy Commission’s website: http://www.energy.ca.gov/maps/renewable/building_climate_zones.html.

In its Decision 16-12-047,[15] the CPUC acknowledged that "…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 CPUC also stated that "… the determinative factor here was data availability. DWR data are available for all state regions and provided the necessary types and format of data. … Accordingly, the tool adopts a default supply by DWR hydrologic region."

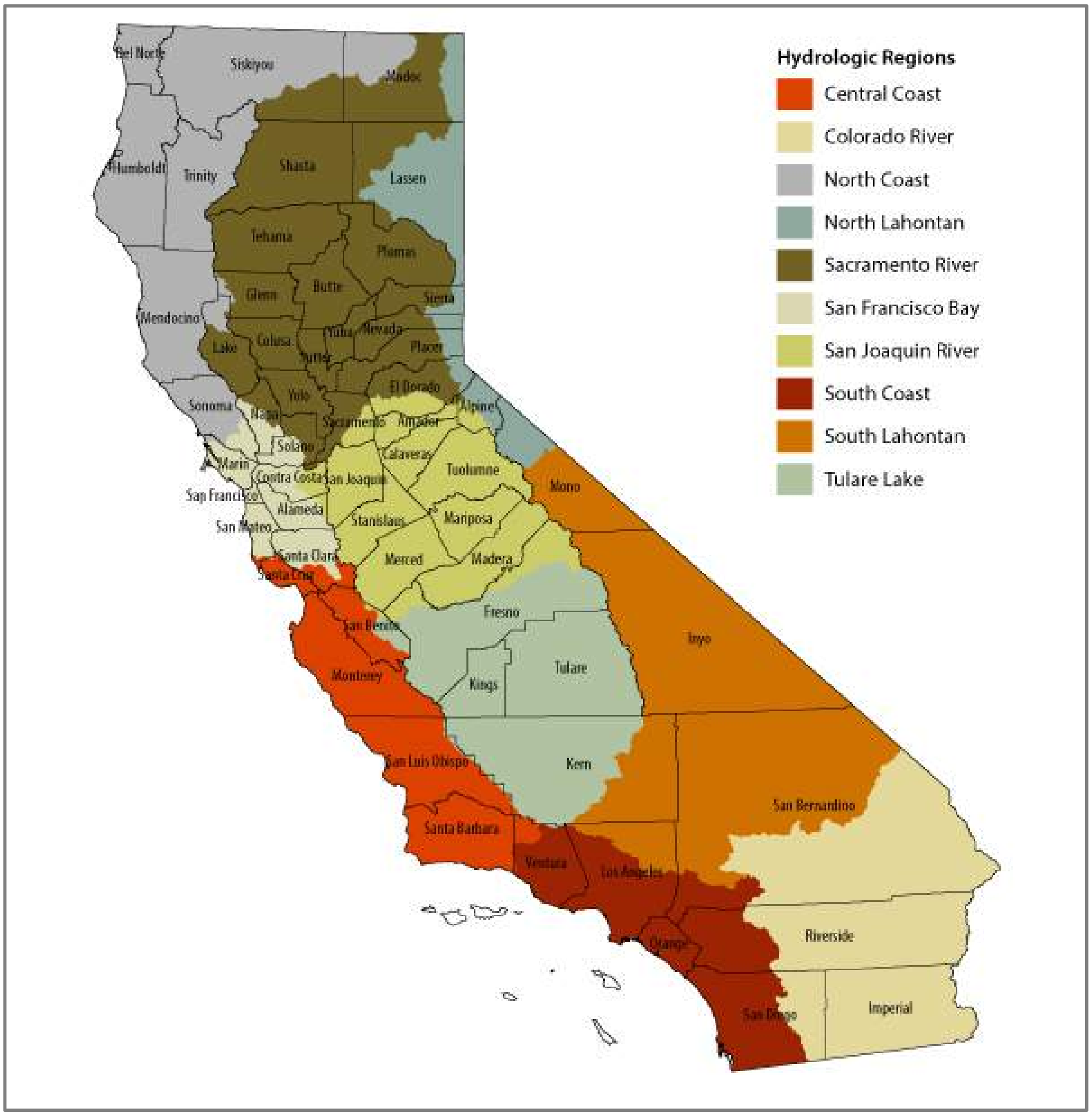

Figure 1-1. California's Hydrologic Regions[16]

[15] Conclusions of Law paragraph 3, p.70.
[16] Source: Public Policy Institute of California.

SoCalGas' service area overlaps portions of 5 of the state's 10 hydrologic regions and 8 building climate zones[17] (see **Figure 1-2** below).

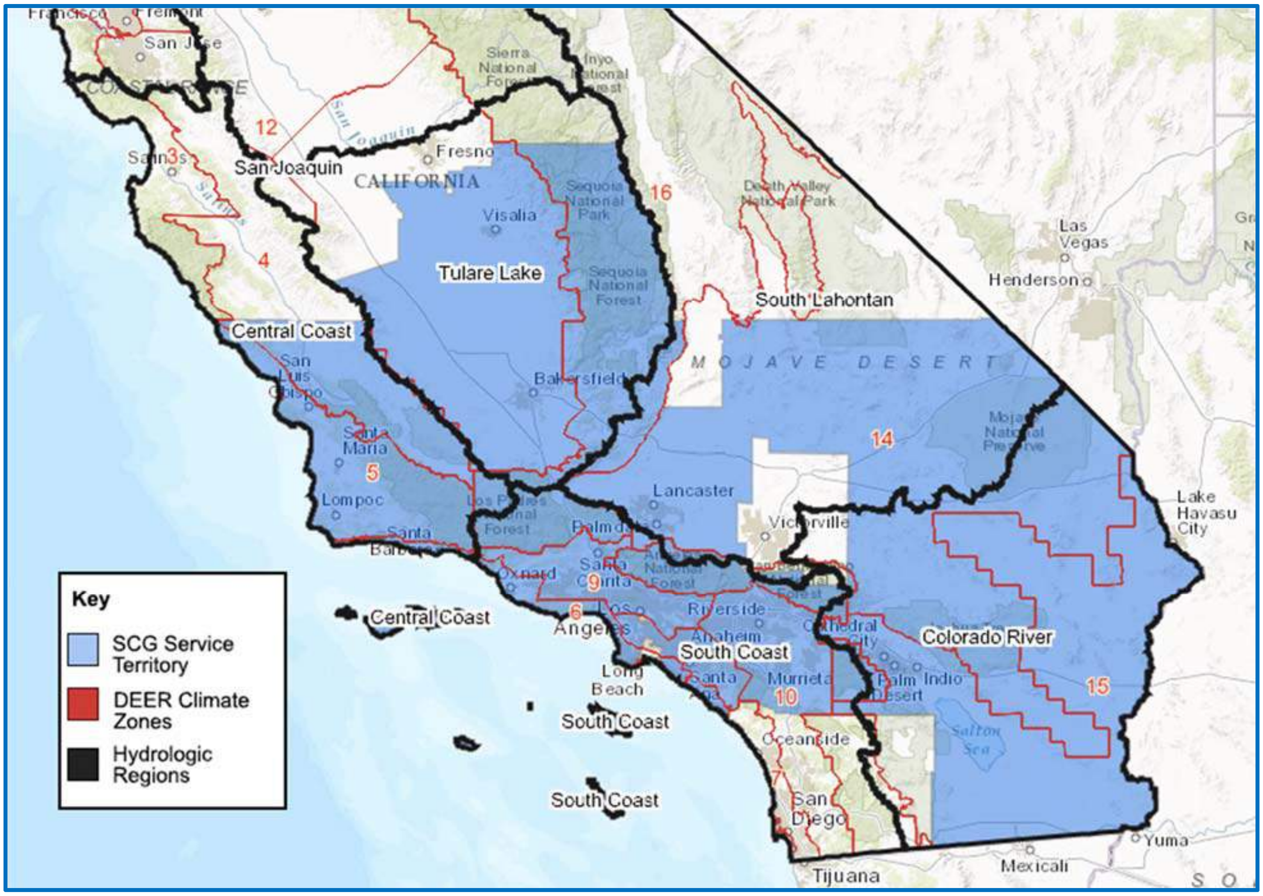

Figure 1-2. Overlay of SoCalGas' Service Area with Hydrologic Regions and DEER Climate Zones

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[17] The State's building climate zones are commonly referred to as "DEER" Climate Zones, for the Database of Energy Efficiency Resources (DEER) developed and managed by the California Public Utilities Commission that provides estimated "deemed" energy savings by type of energy efficiency measure, both residential and non-residential, by climate zone. See CPUC's website: http://www.deeresources.com/.

The Role of the Long-Run Marginal Water Supply

In its Decision 15-09-023 adopting the Water-Energy Calculator, the CPUC decided that the Water-Energy Calculator should be used for designing water-energy programs; that embedded energy should be determined at the level of DWR's hydrologic regions; and that the long-run avoided marginal avoided water supply should be used to determine the amount of energy saved by saving water.[18]

Computing embedded natural gas in water on the basis of the long-run marginal water supply within a hydrologic region presents a challenge for natural gas that has a limited role in water and wastewater systems. However, groundwater pumping remains one of the major water-related uses of natural gas. The CPUC's Water-Energy Calculator currently defaults to recycled water. Under current CPUC policies and recycled water technologies, the natural gas intensity of recycled water is likely to be zero, leaving natural gas without a role in saving water.

The CPUC did not, however, require that recycled water be selected as the statewide long-run marginal supply.[19]

> "*The W-E calculator's users can override the default value for water supply. This feature allows users to enter data for a variety of marginal water supply options, e.g. recycled water with or without purple pipe, desalination, etc. This will allow users to enter marginal supply options that may be most appropriate for their local circumstances.*"[20]

Selection of groundwater as the long-run marginal water supply may be more appropriate for SoCalGas water sector customers that are highly dependent on groundwater and that do not own or operate their own wastewater treatment and recycled water facilities.

Application of Embedded Energy and Energy Intensity to Program Design

The amount of energy deemed "embedded" in a unit of water – i.e., the Energy Intensity of that unit of water – provides a basis for estimating the amount of energy that can be saved by saving water. The amount of that saved energy can then be valued using the CPUC's cost-effectiveness protocols that ascribe an economic value to saved energy based on the "avoided cost" of the saved energy (avoided cost of energy).

- Saving water indoors is deemed to save the amount of energy that is avoided by not needing to collect, produce or extract the saved water, and to transport that water to retail water utilities for treatment and delivery to end use customers. Saving water indoors is also deemed to result in saving energy that would otherwise have been needed to treat the wastewater from that indoor use.

[18] Op.cit.

[19] CPUC Decision 15-09-023, Ordering Paragraph 4.

[20] Ibid, p.24.

- Saving water outdoors is deemed to save the amount of energy that would otherwise have been needed to collect, produce, extract, convey, treat and distribute that saved water to end users. However, wastewater treatment is not typically incurred for outdoor water use that often recharges groundwater or runs off urban hard scape for collection in storm drains and ultimate discharge to natural waterways.

For purposes of computing the estimated amount of natural gas that can be saved by reducing indoor vs. outdoor water consumption:

- ***Energy Intensity of Outdoor Water Use*** is deemed to be the sum of energy inputs to water upstream of the End User (water collection and production, conveyance to retail water utilities, treatment of potable water supplies, and distribution of potable water to end users).
- ***Energy Intensity of Indoor Water Use*** is deemed to be the sum of energy inputs to water both upstream and downstream of the End User (i.e., including wastewater collection and treatment).

Chapter 2 of this report documents the quantity of natural gas used by water and wastewater utilities within SoCalGas' service area, the types of natural gas usage, and the range of Natural Gas Intensities observed for 23 participating water and wastewater utilities.

Chapter 3 summarizes how the data from this study can be applied by SoCalGas to support cost-effective and strategic water-energy program design.

Chapter 4 summarizes findings and recommendations.

2 Natural Gas Embedded in Water

The purpose of this chapter is to document the data, analyses and assumptions that were used to compute the amount of natural gas embedded in water and wastewater within SoCalGas' service area, and the resultant Natural Gas Intensity of Water and Wastewater that could be used in the CPUC's Water-Energy Calculator or a simpler tool.

Embedded Natural Gas in Water within SoCalGas' Service Area

SoCalGas provided an extract of annual natural gas usage within its service area for NAICS[21] Codes 221310 Water Supply and Irrigation Systems and 221320 Sewage Treatment Facilities for the six year period 2010-2015. The purpose of extracting annual data for this period was to enable assessing the extent to which drought may have affected the amount of natural gas used by water and wastewater utilities.

Table 2-1 shows the total amount of natural gas provided by SoCalGas to customers with these two NAICS codes during the study period.

Table 2-1. Annual Therms by NAICS Code (2010-2015)

NAICS	Description	2010	2011	2012	2013	2014	2015
221310	Water Supply & Irrigation	15,090,322	13,817,484	14,764,609	14,732,648	15,742,419	13,888,641
221320	Wastewater Treatment	8,831,985	9,572,585	10,768,872	9,260,394	8,106,243	7,644,734
	Total Therms by Year	**23,922,307**	**23,390,069**	**25,533,481**	**23,993,042**	**23,848,662**	**21,533,375**

The above recap includes all types of natural gas uses coded to these 2 NAICS codes. Customers included water and wastewater utilities, as well as other customers that use natural gas for water-related purposes.

For purposes of this study, only natural gas used by water and wastewater utilities is included in the computation of the Natural Gas Intensity of Water and Wastewater. After eliminating customers that are not water or wastewater utilities, the amount of water-related therms decreased by 32%.

Table 2-2. Annual Therms by NAICS Code (2010-2015) for Water and Wastewater Utilities Only

NAICS	Description	2010	2011	2012	2013	2014	2015
221310	Water Supply & Irrigation	12,663,341	11,607,361	12,365,852	12,157,063	12,722,816	11,665,055
221320	Wastewater Treatment	4,010,008	3,782,529	4,096,269	4,294,471	3,908,336	3,389,838
	Total Therms by Year	**16,673,349**	**15,389,890**	**16,462,121**	**16,451,534**	**16,631,152**	**15,054,893**

[21] North American Industry Classification System.

In order to determine the quantity of therms used for water and wastewater purposes and the types of uses, 27 water and wastewater utilities that accounted for nearly 70% of the total water sector therms usage were asked to confirm: (a) the types of water and wastewater functions being performed at each natural gas metered site, and (b) the annual volume of water or wastewater that was pumped or treated at each site. Each water and wastewater utility was also asked to help identify natural gas usage that was not related to water or wastewater processes or functions so that these could be excluded from the analysis.

Through these inquiries, the following types of natural gas uses were excluded from this analysis:

- Natural gas used to produce electricity, including emergency stand-by generators;
- Natural gas used for space heating within office buildings; and
- Any other type of use of natural gas that is not directly related to producing water resources or to other water or wastewater systems or processes.

Ultimately, 23 water and wastewater utilities provided data and information for this study (four other agencies responded that they only utilized natural gas for grid-related power generation so were not included in this study). Each participating utility was provided with a copy of its own energy intensity profile for review and approval, and also to support its own water-energy planning.

Table 2-3 summarizes the amount of water-related natural gas used by participating water and wastewater utilities within the respective hydrologic regions. After adjusting for non-water and wastewater use:

- South Coast (61%) and Tulare Lake (33%) accounted for 94% of total therms usage by the 23 water and wastewater utilities.
- The 23 participating water and wastewater utilities accounted for most (about 98%) of the water-related therms usage within the South Lahontan and Tulare Lake hydrologic regions, and 73% of water-related therms usage within the South Coast hydrologic region. Only 11% of therms usage within the Central Coast hydrologic region was accounted for, but water-related therms usage within the Central Cost hydrologic region was only 8.8% of total water-related natural gas usage.

Table 2-3. Annual Water-Related Therms Used by 23 Participating Water/Wastewater Utilities (2010-2015) by Hydrologic Region

Hydrologic Region	2010	2011	2012	2013	2014	2015	Region% of Total	23 Utilities as % of Region
Central Coast	82,118	136,383	152,845	213,517	212,704	149,246	1.23%	11.2%
South Coast	8,194,169	7,594,733	8,053,935	7,795,024	8,037,446	7,491,172	61.03%	73.1%
South Lahontan	437,774	453,206	564,046	722,195	901,084	855,062	5.09%	98.2%
Tulare Lake	4,948,314	4,333,678	4,351,146	3,961,240	4,498,655	3,150,652	32.66%	97.5%
TOTALS	**13,662,375**	**12,518,000**	**13,121,972**	**12,691,976**	**13,649,889**	**11,646,132**	**100.00%**	**80.0%**

<u>**Note**</u>: SoCalGas provided very small quantities of natural gas to the Colorado River hydrologic region. During CY2015, natural gas sales to this region accounted for only 0.15% of water sector natural gas usage. No water or wastewater utilities from this region participated in this study.

As can be seen in **Table 2-4** below, a significant portion of water-related natural gas was used for potable water distribution (57%), followed by groundwater pumping (28%) and wastewater treatment (14%). Less than 1% was used for water treatment, wastewater and stormwater collection, and recycled water distribution.

Table 2-4. Annual Water-Related Therms Used by Participating Water/Wastewater Utilities by Type of Use (2010-2015)

Therms by Type of Use	2010	2011	2012	2013	2014	2015	% of Totals
Groundwater	4,001,349	3,292,177	3,630,902	3,417,193	3,806,337	3,310,549	27.76%
Treatment, Potable	2,029	1,805	1,382	1,692	1,052	1,408	0.01%
Distribution, Potable	7,564,192	7,063,524	7,368,005	7,337,743	8,035,445	6,591,563	56.88%
WW Collection/Storm	109,773	107,246	63,999	69,247	24,633	96,555	0.61%
WW Treatment	1,956,077	1,999,903	2,018,116	1,830,248	1,767,472	1,598,611	14.45%
Distribution, Recycled	28,955	53,345	39,568	35,853	14,950	47,446	0.28%
TOTAL N.GAS USES	**13,662,375**	**12,518,000**	**13,121,972**	**12,691,976**	**13,649,889**	**11,646,132**	**100.00%**

More than 64% of the total natural gas used by the 23 water and wastewater utilities during the 6 year study period occurred within the South Coast hydrologic region. This region also had the greatest diversity of water-related therms usage.

Table 2-5. Annual Natural Gas Usage within the South Coast Hydrologic Region (therms)

South Coast Hydrologic Region	2010	2011	2012	2013	2014	2015	Wtd. Avg.
Groundwater	2,562,258	2,042,750	2,357,092	2,392,421	2,238,926	2,507,818	29.90%
Treatment, Potable	0	0	0	0	0	0	0.00%
Distribution, Potable	3,537,106	3,391,489	3,575,160	3,467,255	3,991,465	3,240,742	44.95%
WW Collection/Storm	109,773	107,246	63,999	69,247	24,633	96,555	1.00%
WW Treatment	1,956,077	1,999,903	2,018,116	1,830,248	1,767,472	1,598,611	23.68%
Distribution, Recycled	28,955	53,345	39,568	35,853	14,950	47,446	0.47%
Total South Coast	**8,194,169**	**7,594,733**	**8,053,935**	**7,795,024**	**8,037,446**	**7,491,172**	**100.00%**

As can be seen from **Table 2-5** above, within the South Coast hydrologic region, about 45% of the natural gas was used for potable water distribution, and 30% for groundwater pumping. Wastewater treatment accounted for 24% of total natural gas consumption, with all other uses (wastewater collection and recycled water distribution) accounting for a little more than 1%.

Range of Natural Gas Intensities Observed

Table 2-6 below shows the types of natural gas uses for 7 of SoCalGas' water sector customers. The average natural gas energy intensity of each water and wastewater utility is also shown by type of use.

Table 2-6. Use of Natural Gas (CY2015) by Seven SoCalGas Water Sector Customers [Natural Gas Intensities shown in therms/AF]

Water/Wastewater Utility	NGas Pumps	Type of Use	Average N.Gas Intensity (therms/AF)		
			Groundwater	Potable Distribution	Wastewater Treatment
City of Cerritos	2	▪ Groundwater [1] ▪ Booster Pump [1]	80.00	43.00	N/A
City of Huntington Beach	22	▪ Wastewater Collection [1] ▪ Groundwater [7] ▪ Stormwater [14]	41.34	N/A	N/A
Palmdale Water District	7	▪ Groundwater [4] ▪ Water Treatment [1] ▪ Boosters [2]	74.72	0.09	N/A
South Orange County Wastewater Authority	3	▪ Wastewater Collection [1] ▪ Boilers (Digester) [1] ▪ Watewater Treatment [1]	N/A	N/A	0.02
Suburban Water Systems	9	▪ Groundwater [2] ▪ Boosters [7]	1.16	0.01	N/A
West Kern Water District	5	▪ Groundwater [1] ▪ Boosters [4]	95.01	113.66	N/A
Yorba Linda Water District	9	▪ Groundwater [2] ▪ Boosters [7]	25.57	19.76	N/A

Understanding the quantity and types of natural gas usage will help SoCalGas identify high potential opportunities for reducing natural gas embedded in water. **Table 2-7** shows the range of natural gas intensities observed at the water utility level among the 23 participating water and wastewater utilities.

Table 2-7. Range of Natural Gas Intensities of Potable Water Distribution Pumping and Groundwater Pumping Observed during CY2011-2015 (therms/AF)

Observed Range	Potable Water Distribution Pumping					Groundwater Pumping				
	2011	2012	2013	2014	2015	2011	2012	2013	2014	2015
MIN	0.21	0.16	0.34	0.25	0.03	0.09	0.05	0.07	0.04	0.05
MAX	87.26	86.20	110.28	111.27	113.66	77.37	86.50	82.18	126.05	95.01
MEDIAN	13.98	14.12	11.85	18.09	16.94	44.49	34.40	29.38	28.29	26.93

The wide variability of average natural gas energy intensities is consistent with what has been observed for electricity during the CPUC's Embedded Energy in Water Studies 1 and 2. Note that the above energy intensities were averaged at the water and wastewater utility level, since many of the 23 participating utilities did not provide water and wastewater data at the prime mover level.

Insufficient data existed to draw any conclusions about the range of natural gas energy intensities for water treatment, wastewater collection, wastewater treatment, and recycled water distribution.

Other Water Sector Uses of Natural Gas

Other water and wastewater related uses of natural gas included:

- Heating of Digesters. Two wastewater utilities used natural gas to heat sewage digesters.
- Stormwater Pumping. One water utility uses natural gas to pump stormwater which is discharged into the ocean or recovered for treatment and reuse (discharge is dependent on the seasons).

Wide Variability in Observed Natural Gas Intensities

The same wide variability observed in CPUC Studies 1 and 2 when computing the average Electric Energy Intensity of Water and Wastewater was observed for natural gas. Since only a few water and wastewater utilities use substantial quantities of natural gas for water and wastewater systems and functions, it would not be valid to extrapolate the observations gleaned from some of the largest users of natural gas – the 23 water and wastewater utilities that accounted for 76% of water-related therms usage during CY2010-CY2015 – to all water and wastewater utilities.

Table 2-8 below describes the key issues to consider with respect to using the natural gas energy intensities observed through this study.

Table 2-8. Issues to Consider in Using Highly Variable Energy Intensities in Program Design

Factor	Issues
There is wide variability in the Natural Gas Intensity of Water/Wastewater (W/WW) resources, systems, facilities, functions and service areas.	Given the wide variability of Energy Intensities (EI) and lack of a statistically valid sampling technique, there is no basis for extrapolating the average EI observed among participating W/WW utilities throughout a hydrologic region, multiple hydrologic regions, SoCalGas' service area, or statewide.
The appropriate unit of measurement depends on how the energy intensity will be applied.	EIs can be applied at multiple levels: ▪ Type of resource, system, function ▪ W/WW utility service area ▪ Hydrologic region, DEER climate zone, energy IOU service area, statewide ▪ Water demand vs. supply The key objective is to identify a metric appropriate to the program objective.

Given lack of a valid statistical basis for extrapolating average observed EIs to the remainder of the population - and also given the objective of creating a simple, consistent metric - the average EI could be simply computed over all water demand, either within a hydrologic region or for SoCalGas' service area overall. This approach results in a very conservative estimate of Natural Gas Intensity. Conservatism in absence of perfect information is consistent with the CPUC's policies with respect to protection of energy ratepayers' investments.

Note that since the Natural Gas Intensity is averaged over ***all*** water and wastewater within SoCalGas' service area, Natural Gas Intensity increases the energy benefits attributable to saving water (i.e., it is additive to any savings of embedded electricity).

3 Use of Natural Gas Embedded Energy Data

Depending upon the objective(s), there are several different ways in which Natural Gas Embedded in Water and the Natural Gas Intensity of Water and Wastewater could be used to support cost-effective water-energy program design:

A. Integrate Natural Gas Intensity into the CPUC's Water-Energy Calculator

B. Estimate Average Natural Gas Savings from Water Conservation

C. Target High Potential Natural Gas Savings Opportunities in the Water Sector

All three of the above approaches could be included in a comprehensive, cost-effective and strategic water-energy program portfolio.

A. Integrate Natural Gas Intensity into the CPUC's Water-Energy Calculator

Although not large, the average amount of natural gas used within SoCalGas' service area by hydrologic region is not zero. **Figure 3-1** below shows the concentration of natural gas usage by water and wastewater utilities within SoCalGas' service area by zip code and by hydrologic region. The meter service address was used to allocate therms by zip code. **Figure 3-2** on the next page shows the natural gas usage by DEER Climate Zone.

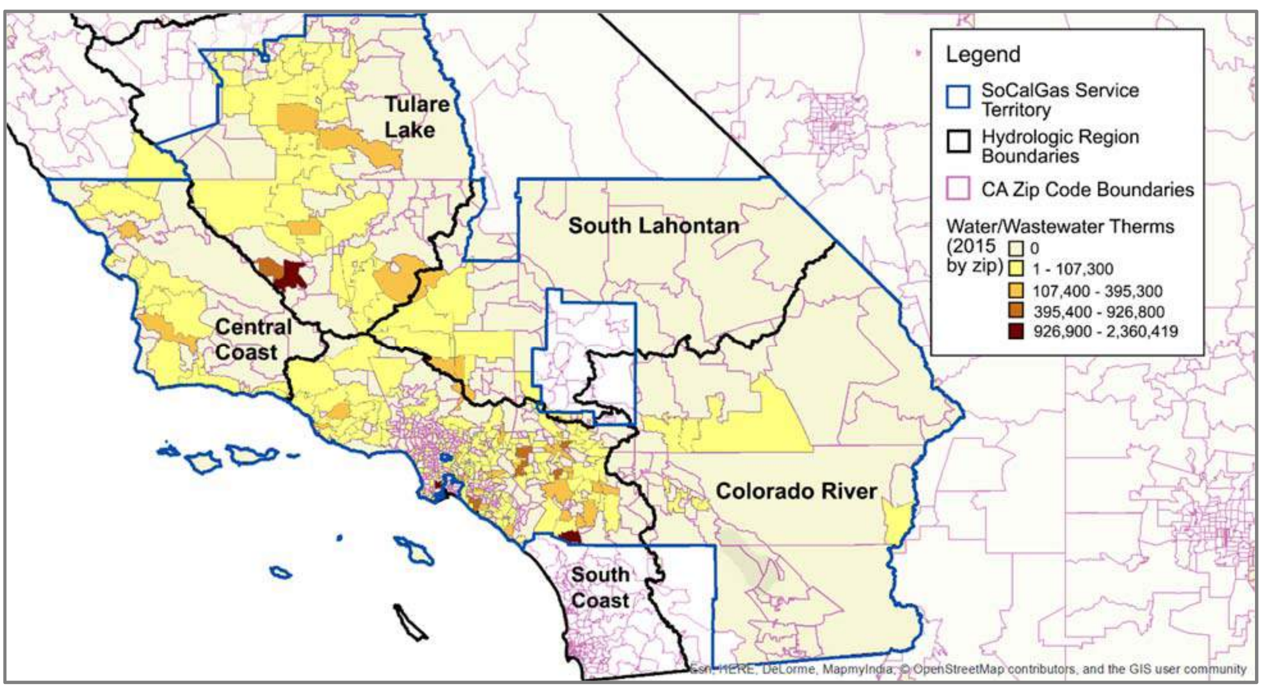

Figure 3-1. Embedded Natural Gas in Water and Wastewater (CY2015) by Hydrologic Region

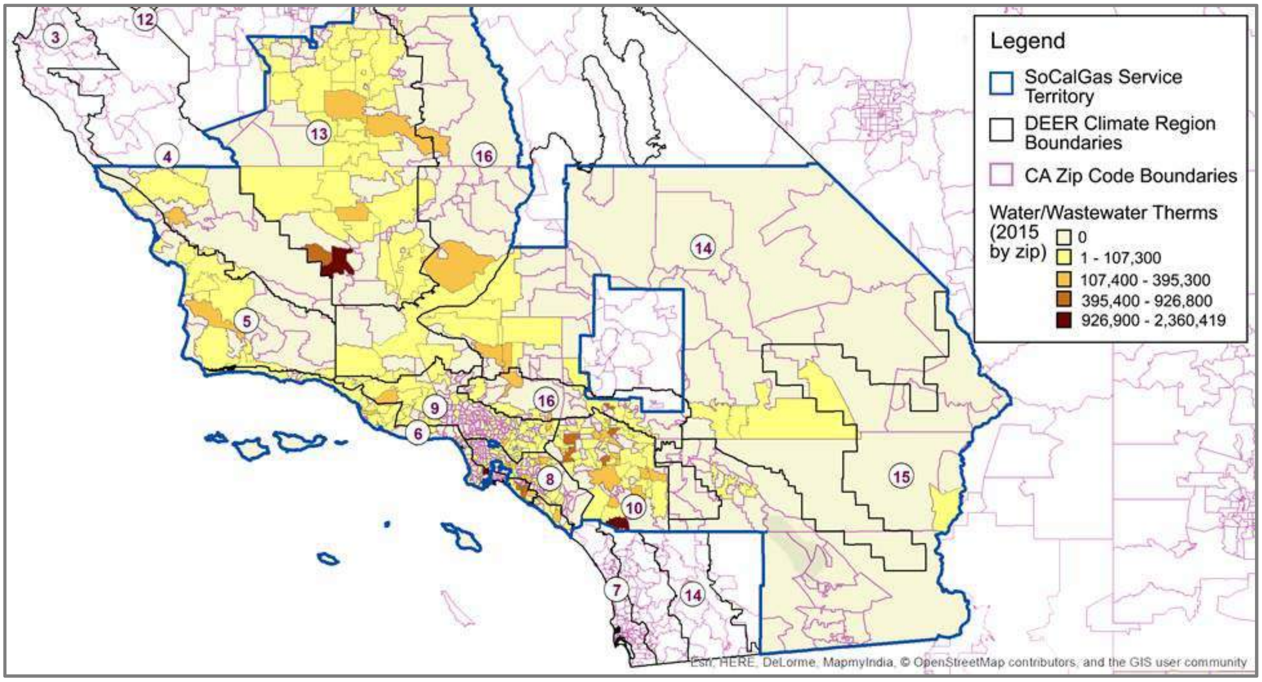

Figure 3-2. Embedded Natural Gas in Water and Wastewater (CY2015) by DEER Climate Zone

The following process was used to estimate the amount of water demand and wastewater treatment witihin SoCalGas' service area:

Step 1: Estimate Total Water Supplies, Water Demand and Wastewater Treatment Volume Within SoCalGas' Service Area

Water demand by hydrologic region was excerpted from the Department of Water Resources (DWR) California Water Plan Update 2013, Volume 2 Regional Reports. Demand was allocated to SoCalGas based on estimated percentage of area served by SoCalGas.

Table 3-1. Water Demand within SoCalGas' Service Area (TAF by Hydrologic Region)[22]

Hydrologic Region	Total Water Demand[23] Thousands of AF (TAF)			SoCalGas Area %	Allocated Water Demand Within SoCalGas' Service Area (TAF)		
	Ag	Urban	Total Demand		Ag	Urban	Total Demand
Central Coast	895	305	1,200	**50%**	448	153	600
Colorado River	3,836	686	4,522	**85%**	3,261	592	3,852
South Coast	645	3,541	4,186	**65%**	419	2,302	2,721
South Lahontan	385	280	665	**40%**	154	112	266
Tulare Lake	10,663	668	11,331	**80%**	8,530	534	9,065
Totals	**16,424**	**5,480**	**21,904**		**12,812**	**3,692**	**16,504**

[22] See Appendix F, Table F-4.
[23] California Water Plan Update 2013, Department of Water Resources.

A similar allocation was performed for Supplies (excluding imported water supplies). **Table 3-2A** shows the total amount of water supplies by hydrologic region. **Table 3-2B** allocates water supplies to SoCalGas based on the estimated percentage of area served by SoCalGas within each hydrologic region.

Table 3-2A. Water Supplies by Region (Excludes Imported Water Supplies)[24]

Hydrologic Region	Supplies (TAF)						Total Supplies
	Local	Federal	SWP	CRA	GWater	Recycled	
Central Coast	23	112	22	0	999	3	1,159
Colorado River	2	0	5	3,661	338	16	4,022
South Coast	489[25]	1	830	990	1,408	204	3,922
South Lahontan	53	0	106	0	413	1	573
Tulare Lake	2,785	2,021	979	0	5,537	0	11,322
Totals	**3,352**	**2,134**	**1,942**	**4,651**	**8,695**	**224**	**20,998**

Table 3-2B. Water Supplies by Region (Excludes Imported Water Supplies) – Allocated to SoCalGas Service Area[26]

Hydrologic Region	% of Region Served by SoCalGas	Supplies (TAF)						Total Supplies
		Local	Federal	SWP	CRA	GWater	Recycled	
Central Coast	50%	12	56	11	0	500	2	580
Colorado River	85%	2	0	4	3,112	287	14	3,419
South Coast	65%	318	1	540	149	1,197	133	2,336
South Lahontan	40%	21	0	42	0	165	0	229
Tulare Lake	80%	2,228	1,617	783	0	4,430	0	9,058
Totals		**2,580**	**1,673**	**1,380**	**3,260**	**6,578**	**148**	**15,621**

Note: The quantity of water supplies attributed to SoCalGas' service area was allocated on the basis of the estimated percentage served by SoCalGas (see **Table 3-1** on the previous page), except for the following adjustment within the South Coast Hydrologic Region:

> *About 65% of the South Coast Hydrologic is served by SoCalGas; the other 35% is served by SDG&E. The area served by SDG&E receives most of its water from the Colorado River Aqueduct (CRA); very little groundwater is available within that part of the region. Conversely, the area served by SoCalGas has substantial quantities of groundwater; very little water is provided from the CRA. For this reason, CRA supplies delivered to the South Coast Hydrologic Region were allocated 15% to SoCalGas, and 85% to SDG&E. Groundwater supplies were allocated 85% to SoCalGas, and 15% to SDG&E.*

[24] Source: California Water Plan Update 2013, Volume 2 – Regional Reports (also see Appendix F, Table F-2).
[25] Includes 269 TAF of local water imports (i.e., water imported from within the hydrologic region).
[26] See Appendix F, Table F-7.

Step 2: Determine Allocation Basis

Option 1: Compute the Average Natural Gas Intensity of Groundwater and Potable Water Distribution

The total amount of natural gas used for groundwater pumping and for potable water distribution were computed as the average of total therms divided by the amount of groundwater pumping that was deemed extracted within SoCalGas' service area and a corresponding allocated share of all potable water distributed within each hydrologic region.

The impact of the foregoing conservative allocation approach can be seen in the resultant average Natural Gas Intensity of Groundwater in the below table. The Natural Gas Intensity of groundwater within the South Coast hydrologic region was averaged over 65% of the total groundwater pumped in that region during CY2015. The Natural Gas Intensity of groundwater and potable water distribution within the Colorado River hydrologic region was averaged over 85% of total water demand within the region, even though very few therms are used by the water sector within that region.

Table 3-3. Natural Gas Intensity of Groundwater Pumping and Potable Water Distribution (CY2015)[27]

H.Region	% of Region Served by SoCalGas	Natural Gas Intensity (therms/Acre-Foot)	
		Groundwater	Potable Water Distribution
Central Coast	50%	0.91	2.13
Colorado River	85%	0.03	0.01
South Coast	65%	3.14	1.61
South Lahontan	40%	2.63	3.37
Tulare Lake	80%	0.34	1.26

The natural gas intensity of groundwater pumping can be used to represent the amount of natural gas saved by reducing use of groundwater. If the groundwater would have been delivered to end users via booster pumps, the additional natural gas saved by reducing potable water distribution should be added to compute the energy savings benefit.[28] If electricity was used to pump groundwater, the above ***conservative average*** amount of natural gas for potable water distribution should be added to the estimated savings of embedded electricity.

Option 2: Compute the Average Natural Gas Intensity of Water and Wastewater Based on Regional Water Demand

Table 3-4 on the next page shows the average amount of natural gas (i.e., the Natural Gas Intensity of Water and Wastewater) using Water Demand as the method for averaging the Natural Gas in Water and Wastewater within SoCalGas' service area. This structure is consistent with that used in the CPUC's Water-Energy Calculator, except that it is ***much more conservative*** since water-related therms are averaged over ***all*** water demand within the portion of the region that is deemed to be served by

[27] See Appendix F, Table F-9.

[28] Typically, groundwater does not require treatment, unless it is brackish.

SoCalGas, irrespective of whether a water resource uses any natural gas.

Table 3-4. Natural Gas Intensity of Water and Wastewater by Hydrologic Region Using Water Demand[29]

H.Region	Natural Gas Intensity (therms/AF)		Application to Water Savings (therms/AF)	
	[1] Water	[2] Wastewater	Indoor Savings [1]+[2]	Outdoor Savings [1]
Central Coast	1.62	5.49	7.12	1.62
Colorado River	0.02	0.02	0.04	0.02
South Coast	2.98	2.37	5.35	2.98
South Lahontan	3.89	0.05	3.95	3.89
Tulare Lake	0.61	0.87	1.48	0.61

The above ***very conservative*** approach considers the lack of a valid basis for extrapolating the results observed for 23 water and wastewater utilities to all water sector uses of natural gas.

The resultant conservative estimate of the natural gas intensity of water and wastewater can be used to develop a proxy representing the amount of embedded natural gas deemed saved by saving a unit of water Indoors vs. Outdoors. This approach is consistent with the methodology used in the CPUC's W-E Calculator.

The CPUC's W-E Calculator did not include any default values for the natural gas intensity of water and wastewater; further, the sections in the W-E Calculator that are designated for natural gas inputs are independent of the computations for electric energy intensity.

Option 3. Average Natural Gas Intensity of Water and Wastewater for SoCalGas' Service Area Overall

The most conservative approach would be to average all therms sold by SoCalGas over total water demand within the portions of the four hydrologic regions served by SoCalGas. The result of this simple averaging method is shown in **Table 3-5**.

Table 3-5. Natural Gas Intensity of Water and Wastewater for SoCalGas Service Area (CY2015)[30]

SoCalGas Service Area Overall	Natural Gas Intensity (therms/Acre-Foot)		Application to Water Savings (therms/AF)	
	[1] Water	[2] Wastewater	Indoor Savings [1]+[2]	Outdoor Savings [1]
All SoCalGas	1.40	1.84	3.24	1.40

The three options show that the average Natural Gas Intensity of Water and Wastewater, and the amount of embedded Natural Gas deemed saved by reducing consumption of a unit of outdoor vs. indoor water, becomes much lower (more conservative) as the therms are spread over a larger volume of water and wastewater.

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[29] See Appendix F, Table F-12.
[30] See Appendix F, Table F-13c.

B. Estimate Average Natural Gas Savings from Water Conservation

Every study conducted to-date on the energy intensity of water resources and water and wastewater facilities, systems, processes and functions has substantiated the fact that water sector energy intensities vary significantly from one site to the next, and among water and wastewater utilities within the same hydrologic region.

Some water sector participants in the CPUC's Water-Energy Nexus Rulemaking stated that averaging water-related embedded energy and energy intensities across hydrologic regions ignores the unique water-energy relationships of individual water and wastewater utilities. Energy program implementers, however, asserted that it would be too complicated and expensive to design cost-effective water-energy programs using water and wastewater utility-specific energy intensities.

Considerable time and resources have been spent by numerous parties to debate these issues for electricity. The amount of time and costs that would be needed to reconcile this issue for natural gas is probably not warranted.

Tables 3-3, 3-4 and 3-5 show that no matter how it is computed, a fairly small amount of natural gas is embedded in water. If the objective is to support the State's policy goal of building long-term drought resilience, it may be sufficient to simply average water-sector natural gas usage over SoCalGas' entire service area, or by the hydrologic regions that it serves.

Irrespective of the methodology ultimately selected, SoCalGas would need to offset investments in water conservation programs with other types of natural gas efficiency programs to achieve cost-effectiveness at the portfolio level, since recognition of embedded energy alone will not meet the CPUC's threshold for cost-effectiveness.

C. Target High Potential Natural Gas Savings Opportunities in the Water Sector

Since natural gas usage for water and wastewater systems and functions is not prevalent, especially within the Los Angeles Air Basin, utility specific information about meter level energy intensities is helpful in identifying opportunities for increasing the efficiency of specific water and wastewater systems and processes that use natural gas.

For example, some groundwater basins require high quantities of natural gas to extract water from deep wells; others use natural gas to pump water uphill at relative high energy intensities. Targeted reductions of these and other high energy intensity water supplies and systems could form the basis for cost-effective water-energy measures. Water and wastewater utilities that use substantial quantities of natural gas are also excellent candidates for water-energy partnerships aimed at increasing end use water and energy efficiency by shared customers.

4 Summary Findings and Recommendations

This study estimated the Natural Gas Intensity of water and wastewater by hydrologic region for the areas served by SoCalGas. These data can be used to estimate the value of the incremental energy (natural gas embedded in water) saved when saving a unit of water.

A summary of the key findings from this study and recommended next steps, follow.

Key Findings

- Relatively little natural gas is used for water and wastewater systems and processes.
- The primary non-electric generation uses of natural gas within the water use cycle in SoCalGas' service area are for pumping – primarily groundwater wells, or booster pumps within the potable and recycled water distribution systems. Natural gas is sometimes used to supplement biogas for heating (digestion, drying sewage sludge) during the wastewater treatment process. A small amount of natural gas is also used for aeration blowers and wastewater collection (lift stations). The City of Huntington Beach also uses natural gas engines to pump stormwater, either to points of discharge to natural waterways, or for recovery and reuse.
- The Natural Gas Intensity of water and wastewater can be computed in many different ways, and at different levels. The key options include:
    - Selecting an appropriate allocation basis (e.g., averaging water sector use of natural gas over all water demand within SoCalGas' service area and/or by hydrologic region; or computing the Natural Gas Intensity of select water system components, such as groundwater pumping, potable water distribution, recycled water distribution, and wastewater pumping and treatment).
    - Natural Gas Embedded in Water and Wastewater, and the Natural Gas Intensity of Water and Wastewater, can also be computed at the level of individual water and wastewater systems and processes, at the water or wastewater utility level, or for multiple water and wastewater utilities (e.g., by DEER Climate Zone or Hydrologic Region).
    - Natural Gas Embedded in Water and Wastewater, and the Natural Gas Intensity of Water and Wastewater, can also be computed for each individual natural gas metered site.

  The level at which these computations are made and applied to water-energy program design depends on the program goals and objectives.
- The manner in which the Natural Gas Intensity of Water or Wastewater is computed also determines its application to design of cost-effective Water-Energy programs. For example:
    - Averaging water-sector usage of natural gas over all water demand within SoCalGas' service area is a very conservative approach that results in a very low Natural Gas Intensity of water and wastewater.
    - More granular data about the Natural Gas Intensity of specific groundwater wells, booster distribution pumps, and other water and wastewater systems and components enables developing targeted programs and measures that maximize water-related energy savings.

Reducing use of high energy intensive water supplies and systems are more likely to produce cost-effective energy savings.

- The CPUC's adopted approach to computing the Energy Intensity of Recycled Water results in a zero energy intensity within the Extraction and Conveyance water system component for both electricity and natural gas.
- Although the CPUC's Water-Energy Calculator currently defaults to Recycled Water as the long-run avoided marginal water supply for each of the State's ten hydrologic regions, this assumption is editable by the user. The CPUC clarified in its Decision 15-09-023 adopting the Water-Energy Calculator that users may select a long-run marginal water supply that is more appropriate to their circumstance. Within some regions of SoCalGas' service area, groundwater may be a more appropriate selection.
- The CPUC's current Water-Energy Calculator does not include natural gas, and the sections within the Water-Energy Calculator that provide space for entering natural gas data bypass all of the computations for the electricity embedded in water and wastewater. Given this circumstance, it would be simpler and more expedient to separately compute savings of embedded natural gas in water and wastewater. Keeping these computations separate will enhance transparency, consistency and accuracy.
- Irrespective of how it is computed, the Natural Gas Intensity of water and wastewater should be added to the amount of electricity to be saved by reducing water consumption.

Recommendations

1. ***Continue to Reduce Hot Water Consumption***. One of the cornerstones of SoCalGas' energy efficiency programs has been to increase efficient use of hot water. This remains one of the most important strategies for achieving cost-effective natural gas savings; and in most cases, increasing efficient use of hot water also saves water. For these types of programs, embedded natural gas should be added to direct natural gas savings when evaluating cost-effectiveness.

2. ***Continue to Identify Opportunities for Increasing Water Pumping and Water and Wastewater System and Process Efficiencies***. Water and wastewater utilities that use substantial quantities of natural gas for pumping water, wastewater and/or recycled water are excellent candidates for potential efficiency improvements. Although many water and wastewater utilities are already extremely knowledgeable about strategies for improving pump efficiency, there may still be cost-effective opportunities for achieving natural gas savings through other types of system and process improvements. Water and wastewater process and system improvements may not have any embedded energy savings, but they will ultimately result in reducing water sector natural gas use, which benefits both the water or wastewater utility itself, and both water and energy ratepayers.

3. ***Continue to Partner with Water and Wastewater Utilities*** to jointly deliver water and energy efficiency programs to shared customers. Water conservation and efficiency programs may include both hot and cold water savings by end users. Even though embedded natural gas is unlikely to significantly affect cost-effectiveness, it should be included in the cost-effectiveness evaluations of end use programs and measures.

Ultimately, the decision as to whether embedded natural gas needs to be computed and reported is a policy decision for the CPUC. As this report illustrates, from an embedded natural gas perspective, since the number is so small, SoCalGas and the CPUC can agree upon a simple proxy representing all savings of natural gas attributable to saved water.

Since the computation of the natural gas intensity of water and wastewater is very simple, there is no need to integrate natural gas into the CPUC's existing Water-Energy Calculator. In fact, consistency and transparency would be significantly enhanced if the natural gas intensities used to compute the amount of natural gas embedded in water and wastewater are maintained separately (i.e., outside of the CPUC's W-E Calculator that is structurally very complex, and consequently not transparent). For consistency with other types of energy efficiency programs and measures, cost-effectiveness of water-energy measures should be evaluated using the CPUC's existing E3 Calculator (and/or its successors).

5 References

CPUC Proceedings and Decisions

Order Instituting Rulemaking into Policies to Promote a Partnership Framework between Energy Investor Owned Utilities and the Water Sector to Promote Water-Energy Nexus Programs (R.13-12-011), December 30, 2013

CPUC Decision 12-05-015, May 10, 2012.

CPUC Decision 15-09-023, September 17, 2015.

CPUC Decision 16-12-047, December 15, 2016.

CPUC Water-Energy Calculator and Study

"Water/Energy Cost Effectiveness Analysis, Revised Final Report Prepared for the California Public Utilities Commission," Navigant Consulting, Inc. in collaboration with GEI Consultants, April 2015 [referred to herein as "Navigant study"] (as amended by Errata issued on May 22, 2015).

"Water-Energy Calculator" (DRAFT) version 1.05, February 2016 Update, posted on the CPUC's website: http://www.cpuc.ca.gov/nexus_calculator/.

California Department of Water Resources

California Water Plan Update 2013, Volume 2 – Regional Reports.

Prior Studies

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The Role of Natural Gas in California's Water-Energy Nexus, Water Energy Innovations, Inc., April 10, 2013.

Case Study: Natural Gas Saved by the City of Cerritos By Reducing Leaks in Its Water Distribution System, Water Energy Innovations, Inc., August 21, 2015.

APPENDIX A

Water and Wastewater Utilities' Natural Gas Profiles

Agency Approved Profiles for Public Release

Hydrologic Zones of Water and Wastewater Agencies

City of Cerritos: Natural Gas Embedded in Water Profile

<u>Agency Size:</u> City of Cerritos has a service area of 9 square miles and serves approximately 54,946 customers through 16,000 metered service connections.

<u>Water Supply:</u> The City has three supply sources that include groundwater from the Groundwater Central Basin (managed by the Water Replenishment District), imported water from Metropolitan's Central Basin and recycled water provided by the City's wastewater services provider—Los Angeles County Sanitation District.

<u>Natural Gas Usage:</u> The City of Cerritos uses natural gas for pumping water, both for supply and conveyance of groundwater and booster pumping for potable water distribution. Total installed capacity for these pumps is 1,414 hp.

Table Cerritos-1. Annual Therms Usage by Service Address for Pumping (CY2011-CY2015)

Function	Facility	Service Address	2011	2012	2013	2014	2015
Booster Pumping (to treatment plants)	Booster C-2	16522 MARQUARDT AVE	140,379	117,894	144,440	160,988	16,343
Groundwater Pumping (direct to distribution system)	Well C-1	12701 ARTESIA BLVD	102,286	193,629	193,780	164,881	225,676

Table Cerritos-2. Water Supply (Acre Feet [AF])[31]

Supply	2011	2012	2013	2014	2015
Groundwater	1,322	2,430	2,358	2,061	2,821
Boosted Water	3,447	2,734	3,294	3,744	380
Total:	**3,460**	**5,248**	**N/A**	**N/A**	**N/A**

[31] CY2014 and CY2015 estimated based on observed average natural gas intensity.

Table Cerritos-3. Natural Gas Energy Intensity (EI) for Groundwater and Booster Pumping CY2011-CY2015 (Therms/AF)

Year	Groundwater (Well C-1)			Boosted (C-2)		
	Therms	AF	EI	Therms	AF	EI
2011	102,286	1,322	77.37	140,379	3,447	40.72
2012	193,629	2,430	79.68	117,894	2,734	43.12
2013	193,780	2,358	82.18	144,440	3,298	43.85
2014	164,881	2,061	80	160,988	3,744	43
2015	225,676	2,821	80	16,343	380	43

City of Huntington Beach
Natural Gas Embedded in Water Profile

About:	Huntington Beach meets the majority of its water demand from groundwater wells located throughout the City. The City pays a replenishment assessment to the Orange County Water District for each acre-foot of water taken from the groundwater basin. The remainder of the City's water demand is met with imported water delivered by the Metropolitan Water District of Southern California.
Agency Size:	City of Huntington Beach utilities' water service area is 27.3 square miles and serves over 198,000 residents through 53,091 service connections.
Water Supply:	The City's supply is a combination of local groundwater (Lower Santa Ana River Groundwater Basin) and imported water (Colorado River Aqueduct and the State Water Project provided by Metropolitan and delivered by MWDOC). The mix varies but in FY 2014-2015 the City used approximately 72% groundwater and 28% imported.
Water Quality:	Metropolitan is responsible for the high quality potable water imported and Orange County Water District manages the groundwater basin. Quality issues for OCWD include salinity (TDs and nitrates).
Natural Gas Usage:	The City uses natural gas to pump groundwater for direct distribution at 6 metered sites and is very minimally used for wastewater pumping collection at 1 metered site. Natural gas is also used for storm drain pump stations.

Table HB-1. Annual Therms Usage by Service Address (CY2011-CY2015)

Function	Service Address	2011	2012	2013	2014	2015
Groundwater Pumping	6401 Overlook Dr.	1559	10	75	50	12
	19071 Huntington St.	248	402	579	298	371
	14561 Springdale St.	397,659	459,969	414,635	324,785	330,320
	16192 Sher Ln.	6,860	196,588	232,501	233,734	255,961
	16221 Gothard St. Apt A.	40,276	26,239	23,624	47,128	104,781
	8851 Warner Ave.	64,574	51,350	20,573	123,817	80,253
	Total Groundwater:	**511,176**	**734,558**	**691,987**	**729,812**	**771,698**
Wastewater Pumping (Collection)	17413 Oakbluffs Ln.	X	X	X	22	22
	Total Wastewater:	**X**	**X**	**X**	**22**	**22**
Storm Drain Pump Station	4742 Scenario Dr.	1,371	856	570	692	688
	9211 Yorktown Ave	898	844	561	589	557
	20192 Midland Ln.	1,270	1,123	741	1,024	939
	22001 Malibu Ln	6,208	2,503	2,153	2,829	3,831
	19961 Chesapeake Ln	3,549	2,667	1,469	1,648	2,217
	7231 Heil Ave.	260	260	181	185	148
	9221 Indianapolis Ave.	2,933	2,032	1,902	2,072	1,942
	9731 Flounder Dr.	1,262	876	473	718	642
	10101 Hamilton Ave.	2,119	5,203	3,064	2,761	3,428
	5250 Slater Ave	27,837	17,527	10,932	5,253	7,349
	8097 Atlanta Ave	1,990	1,775	2,030	2,224	4,222
	6744 Marilyn Dr.	743	411	373	336	272
	8612 Hamilton Ave	2,750	4,647	3,103	1,490	3,404
	6252 Shields Dr.	1,871	1,028	907	651	778
	Total Storm Drain:	**55,061**	**41,752**	**28,459**	**22,472**	**30,417**
TOTALS:		**566,237**	**776,310**	**720,446**	**752,306**	**802,137**

Table HB-2. Water Supply (Acre Feet [AF])

Supply	2011	2012	2013	2014	2015
Purchased	14,875	9,553	12,554	11,149	6,060
Groundwater	14,927	20,344	18,585	16,604	18,668
Total:	**29,801**	**29,897**	**31,138**	**27,753**	**24,728**

Table HB-3: Water Demand by Sector (AF)

Demand	2011	2012	2013	2014	2015
Commercial	3,775	3,720	3,730	3,404	3,299
Institutional/Governmental	185	289	176	121	173
Landscape	2,615	2,930	3,371	2,337	2,647
Multi-Family	6,284	6,225	6,128	5,740	5,712
Single-Family	13,958	14,260	14,401	12,316	11,952
Industrial	504	445	446	365	303
Other: AES Power Plant	256	240	202	144	155
Other: Meadowlark Golf Course	212	237	254	239	248
Totals:	**27,790**	**28,345**	**28,709**	**24,667**	**24,489**
(Production minus consumption):	2,011	1,552	2,429	3,085	239

*See **Figure HB-1** below.

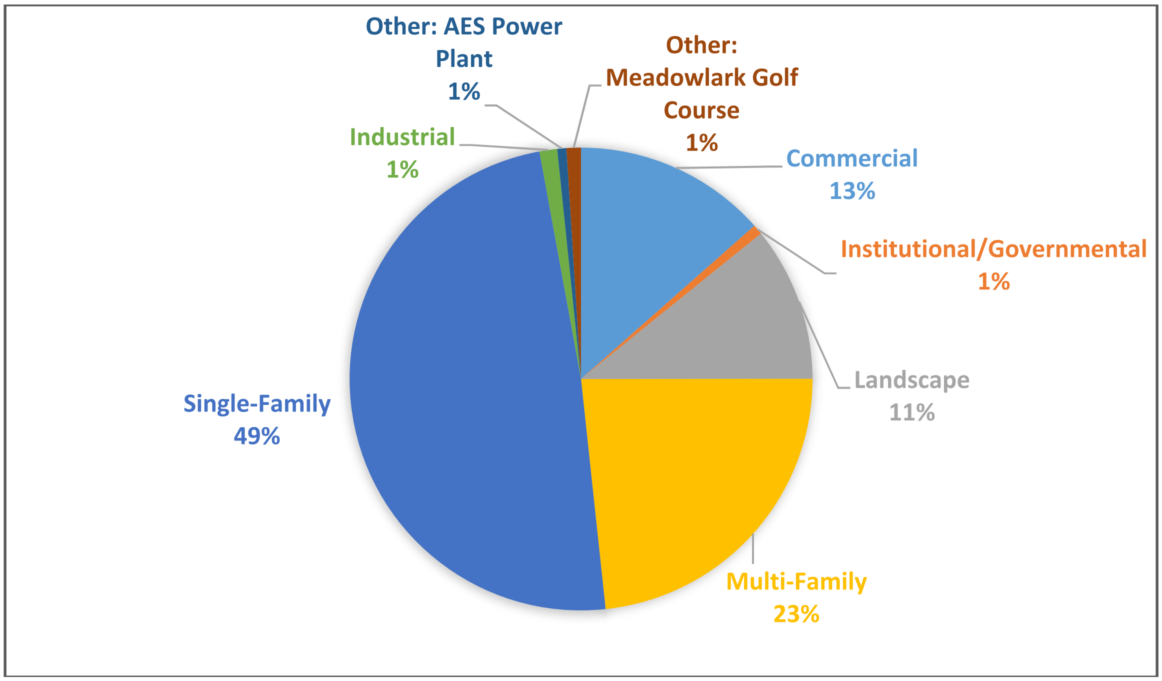

Figure HB-1: 2015 Snapshot - Top Water Users

Table HB-4. Natural Gas Energy Intensity for Groundwater Pumping CY2011-CY2015 (Therms/AF)

Year	Groundwater		
	Therms	AF	EI
2011	511,176	14,927	34.25
2012	734,558	20,344	36.11
2013	691,987	18,585	37.23
2014	729,812	16,604	43.95
2015	771,698	18,668	41.34

Montebello Land and Water
Natural Gas Embedded in Water Profile

About: The Company's potable water service is located in the County of Los Angeles. The Company's potable water system was originally developed by William Mulholland and incorporated on January 12, 1900. The company is governed by a five-member Board of Directors who are elected by the stock holders.

Agency Size: Montebello Land and Water has a service area of 1,250 acres and serves approximately 26,250 customers through 3,979 metered service connections.

Water Supply: Montebello's water supply is 100% groundwater from the adjudicated Central Groundwater Basin that is managed by the Water Replenishment District of Southern California (WRD). There are currently 7 active wells.

Water Quality: Quality is managed by WRD. They annually collect over 600 groundwater samples. A large threat is sea water intrusion but the Basin continues to be of high quality and is suitable for potable water uses.

Natural Gas Usage: Natural gas is used to pump groundwater directly into the distribution systems and also to fill reservoirs.

Drought Impacts: Reduced production.

Table MLW-1. Annual Therms Usage by Service Address for Groundwater Pumping (CY2011-CY2015)

Function	Service Address	2011	2012	2013	2014	2015
Groundwater Pumping (direct to distribution)	344 E Madison Ave.	75,889	80,667	93,504	99,719	84,468

Table MLW-2. Water Supply (Acre Feet [AF])

Supply	2011	2012	2013	2014	2015
Groundwater	3,301	3,370	3,468	3,525	3,137

Table MLW-3. Natural Gas Energy Intensity (EI) for Groundwater Pumping CY2011-CY2015 (Therms/AF)

Year	Groundwater		
	Therms	AF	EI
2011	75,889	3,301	22.99
2012	80,667	3,370	23.94
2013	93,504	3,468	26.96
2014	99,719	3,525	28.29
2015	84,468	3,137	26.93

Palmdale Water District: Natural Gas Embedded in Water Profile

About:	Palmdale Water District has a five-member Board of Directors and and infrastructure that includes 400 miles of pipe, 24 wells, 20 tanks, 2 reservoirs and a state of the art treatment plant.
Agency Size:	Palmdale Water District (PWD) serves approximately 118,227 customers through 26,500 active connections.
Water Supply:	PWD's three sources include groundwater from the Antelope Valley Groundwater Basin, surface water from Littlerock Dam Reservoir and imported water from the State Water Project (SWP).
Water Quality:	PWD regularly monitors the supply quality by constantly testing all three of its sources.
Natural Gas Usage:	Natural gas is used to pump groundwater directly into the distribution systems and is also used to pump a mixture of groundwater and surface water. It is also used to boost water at PWD's water treatment plant.
Drought Impacts:	The district has always been proactive in pumping efficiencies to minimize energy costs. Availability of imported water will always be a concern as demands increase, groundwater pumping is a concern as well for meeting future demands or water quality issues.

Table PWD-1. Annual Therms Usage by Service Address for Groundwater and Booster Pumping (CY2011-CY2015)

Function	Facility	Service Address	2011	2012	2013	2014	2015
Booster Pumping (potable distribution)	45th St. Boosters	36510 45TH ST E	1,351	1,130	3,069	1,125	246
	25th St. Boosters	36946 25TH ST E	645	667	1,108	1,141	140
		Total Booster:	**1,996**	**1,797**	**4,177**	**2,266**	**386**
Booster Pumping (within potable water treatment plant)	Water Treatment Plant	700 E AVENUE S	1,805	1,382	1,692	1,052	1,408
		Total Water Treatment:	**1,805**	**1,382**	**1,692**	**1,052**	**1,408**
Groundwater Pumping (direct to distribution system)	Well 15	1003 E AVE. P, W-15	112,698	168,753	159,433	196,002	166,464
	Well 11A	39511 15TH ST E, W-11	0	3,457	2,089	184,195	199,256
	Well 2A	39400 20TH ST E, W-2	2,142	3,852	8,067	12,374	1,259
	Well 3A	2163 E AVE. P8, W-3	3,509	14,524	19,974	26,038	6,920
		Total Groundwater Pumping:	**118,349**	**190,586**	**189,563**	**418,609**	**373,899**

Table PWD-2: Water Supply by Meter in AF

Function	Facility	Service Address	Acre-Feet (AF)				
			2011	2012	2013	2014	2015
Booster Pumping (potable distribution)	45th St. Boosters	36510 45TH ST E	5,132	4,692	4,892	4,723	4,012
Booster Pumping (potable distribution)	25th St. Boosters	36946 25TH ST E	632	989	341	323	9.8
Booster Pumping (within potable water treatment plant)	Water Treatment Plant	700 E AVENUE S	12,612	13,915	12,220	8,323	17,014
Groundwater Pumping (direct to distribution system)	Well 15	1003 E AVE. P, W-15	1,062	1,593	1,506	1,722	1,427
Groundwater Pumping (direct to distribution system)	Well 11A	39511 15TH ST E, W-11	0	0	0	1,057	1,124
Groundwater Pumping (direct to distribution system)	Well 2A	39400 20TH ST E, W-2	732	918	1,095	1,434	1,384
Groundwater Pumping (direct to distribution system)	Well 3A	2163 E AVE. P8, W-3	831	337	950	1,199	1,069

Table PWD-3. Natural Gas Energy Intensity (EI) for Groundwater/Surface Water Pumping CY2011-CY2015 (Therms/AF)

Year	Groundwater (Well C-1)			Boosted (C-2)		
	Therms	AF	EI	Therms	AF	EI
2011	118,349	2,625	45.09	3,801	18,376	0.21
2012	190,586	2,848	66.92	3,179	19,596	0.16
2013	189,563	3,551	53.38	5,869	17,453	0.34
2014	418,609	5,412	77.35	3,318	13,369	0.25
2015	373,899	5,004	74.72	1,794	21,035.8	0.09

Table PWD-4: Water Demand by Sector (AF)

Sector	2011	2012	2013	2014	2015
Single-Family	12,144	13,159	13,128	12,473	10,251
Multi-Family	1,512	1,638	1,634	1,553	1,276
Institutional/Governmental	0	0	0	0	0
Commercial	1,022	1,108	1,105	1,050	863
Industrial	1,834	1,987	1,982	1,884	1,548
Landscape	1,012	1,096	1,094	1,039	744
Other	49	53	53	50	41
Recycled	0	0	0	0	110
Total:	**17,572**	**19,040**	**18,995**	**18,048**	**14,833**

South Orange County Wastewater Authority Natural Gas Embedded in Water Profile

<u>About:</u> South Orange County Wastewater Authority (SOCWA) collects, treats and beneficially reuses and disposes of wastewater across South Orange County. SOCWA also manages production of recycled water for irrigation and commercial purposes which saves approximately 1.6 billion gallons of domestic water. SOCWA is a Joint Powers Authority with ten member agencies consisting of local retain water agencies and cities that provide water to their residents. It operates three treatment plants and two ocean outfalls in addition to programs.

<u>Agency Size:</u> South Orange County Wastewater Authority (SOCWA) manages the collection, treatment, transmission and disposal of wastewater for more than 500,000 homes and businesses.

<u>Water Management:</u> SOCWA currently operates four wastewater treatment facilities, two ocean outfalls and a treated effluent pipeline. Core services include wastewater treatment and recycled water production.

<u>Natural Gas Usage:</u> Natural gas is used for wastewater pumping treatment and collection and at one site for digester heating.

<u>Drought Impacts:</u> The wastewater plants processed about 30% less water with the recent drought, but the amount of pounds of wastewater solids remained the same through the drought period.

Table SOCWA-1. Annual Therms Usage by Service Address for Pumping (CY2011-CY2015)

Function	2011	2012	2013	2014	2015
Total Therms Wastewater Pumping:	3,018	2,835	3,473	2,940	1,637

Table SOCWA-2. Water Supply (Acre Feet [AF])

Supply	2011	2012	2013	2014	2015
Recycled (Delivered)	212	234	256	279	258
Influent	24,458	23,501	23,331	22,235	20,450
Total:	**24,670**	**23,735**	**23,587**	**22,514**	**20,708**

Table SOCWA-3. Natural Gas Energy Intensity (EI) for Influent Pumping CY2011-CY2015 (Therms/AF)

Function	Influent (WW Collection)			WW Treatment		
	Therms	AF	EI	Therms	AF	EI
CY2011	2,594	212	0.11	424	24,258	0.02
CY2012	2,495	234	0.11	340	23,501	0.01
CY2013	2,688	256	0.12	785	23,331	0.03
CY2014	1,859	279	0.08	1,081	22,235	0.05
CY2015	1,197	258	0.06	440	20,450	0.02

Suburban Water Systems: Natural Gas Embedded in Water Profile

<u>About:</u> Suburban Water Systems, a part of SouthWest Water Company, is an investor-owned water utility that covers all or portions of Glendora Covina, West Covina, La Puente, Hacienda Heights, City of Industry, Whittier, La Mirada, La Habra, Buena Park and unincorporated portions of Los Angeles and Orange counties. The distribution system includes 18 wells, 32 reservoirs and more than 800 miles of pipeline.

<u>Agency Size:</u> Suburban has a service area of 41.7 square miles and serves a population of 293,000. 95% of their service area is residential.

<u>Water Supply:</u> Suburban supplies include groundwater from the Main Basin and Central Basin, purchased surface and groundwater from Covina Irrigating Company (CIC), treated water from CDWC and imported surface water (Colorado River and State Water Project) from Metropolitan's member agencies including Upper District, CBMWD and TVMWD.

<u>Natural Gas Usage:</u> Natural gas is used for groundwater pumping and potable water distribution; however, most of Suburban's natural gas pumps are primary used for back up when there is a power outage.

Table SWS-1. Annual Therms Usage by Service Address for Pumping (CY2011-CY2015)

Function	Service Address	2011	2012	2013	2014	2015
Groundwater Pumping (direct to distribution system)	9820 E MISSION MILL RD	167,621	2,060	42,682	19,198	22,252
Groundwater Pumping (direct to distribution system)	187 N WILLOW AVE	576	698	39	40	16
	Total Groundwater Pumping:	**168,197**	**2,758**	**42,721**	**19,238**	**22,268**
Booster Pumping (potable distribution)	807 S CALIFORNIA AVE	0	X	204	22	1
Booster Pumping (potable distribution)	15439 WHITTIER BLVD	15	288	.	38	0
Booster Pumping (potable distribution)	16115 AURORA CREST DR	4	3	146	97	89
Booster Pumping (potable distribution)	12824 NEWCOMB AVE	1	X	X	1	0
Booster Pumping (potable distribution)	128 N VALENCIA AVE	8	X	X	9	0
Booster Pumping (potable distribution)	10760 SCOTT AVE	2	X	34	26	217
Booster Pumping (potable distribution)	9802 POUNDS AVE	16	6	1	27	1
	Total Booster Pumping:	**46**	**297**	**385**	**220**	**308**

Table SWS-2. Water Supply (Acre Feet [AF])

Supply	2011	2012	2013	2014	2015
Recycled	688	365	562	869	743
Groundwater	32,212	30,512	32,522	30,594	19,147
Purchased	17,035	21,165	19,467	19,409	22,655
Total Water:	**49,935**	**52,042**	**52,551**	**50,871**	**42,544**

Table SWS-3. Natural Gas Energy Intensity (EI) for Pumping CY2011-CY2015 (Therms/AF)

Function	Groundwater			Boosted		
	Therms	AF	EI	Therms	AF	EI
CY2011	168,197	32,212	5.22	46	49,247	0.00
CY2012	2,758	30,512	0.09	297	51,677	0.01
CY2013	42,721	32,522	1.31	385	51,990	0.01
CY2014	19,238	30,594	0.63	220	50,003	0.00
CY2015	22,268	19,147	1.16	308	41,801	0.01

Table SWS-4 below includes additional water supply usage information by demand sector.

Table SWS-4: Water Demand by Sector (AF)

Sector	2011	2012	2013	2014	2015
Single-Family*	33,131	35,018	35,359	34,975	28,577
Multi-Family	0	0	0	0	0
Institutional/Governmental	2,639	3,271	3,344	3,041	2,198
Commercial	8,937	9,323	9,382	9,457	8,125
Industrial	1,397	1,403	1,081	955	1,011
Landscape	0	0	0	0	0
Recycled	0	0	0	0	0
Total:	**46,103**	**49,014**	**49,166**	**48,428**	**39,910**

City of San Bernardino Municipal Water District (SBMWD): Natural Gas Embedded in Water Profile

About:	On May 8, 1905, in accordance with the city charter, the Mayor and Common Council appointed the first Board of Water Commissioners of the San Bernardino Municipal Water Department. The Water Department's Water Reclamation Plant and Rapid Infiltration and Extraction (RIX) Facility reclaims millions of gallons of water a day that are ideal for many commercial and agricultural uses.
Agency Size:	San Bernardino Municipal Water District (SMWD) has a water service area of 45 square miles and serves a population of 200,000 through 46,000 service connections.
Water Supply:	San Bernardino's supply includes water from the Bunker Hill Groundwater Basin through a facility that includes 54 groundwater production wells.
Water Quality:	SBMWD collects thousands of samples each year.
Natural Gas Usage:	Natural gas is used for groundwater and wastewater pumping for treatment.
Drought Impacts:	Most recently, the Water Board revised the emergency conservation regulation requirements, and allowed water suppliers to set their own conservation standards through a Water Board defined "Stress-test" that took into account previous years' supplies and projected future demands. SBMWD implemented a self-imposed 15% conservation standard. Most recently, the Governor issued Executive Order B-40-17 which directed the Water Board to rescind the conservation standard requirement. The Water Board has since rescinded the standards, but SBMWD maintains its self-imposed standard as groundwater levels in the basin remain at or near historic lows. Public awareness, education, and conservation efforts have resulted in decreased demands and decreased production.

Table SBMWD-1. Annual Therms Usage by Service Address for Pumping (CY2011-CY2015)

Function	Service Address	2011	2012	2013	2014	2015
Groundwater Pumping (to treatment plants)	19199 Cajon Blvd	27	30	26	23	0
	1847 W 20th St.	4	5	4	4	3
Wastewater Pumping (treatment)	1301 S E St.	23,098	15,360	8,709	5,286	1,985
	Total:	**23,129**	**15,395**	**8,739**	**5,313**	**1,988**

Table SBMWD-2. Water Supply (Acre Feet [AF])

Supply	2011	2012	2013	2014	2015
Groundwater	48,767	48,757	45,835	43,429	36,035

Table SBMWD-3. Natural Gas Energy Intensity (EI) for Pumping Groundwater CY2011-CY2015 (Therms/AF)

Function	Groundwater		
	Therms	AF	EI
CY2011	31	48,767	0.00
CY2012	35	48,757	0.00
CY2013	30	45,835	0.00
CY2014	27	43,429	0.00
CY2015	3	36,035	0.00

Table SBMWD-4 below provides additional water supply information based on sector usage.

Table SBMWD-4: Water Demand by Sector (AF)

Demand Sector	2011	2012	2013	2014	2015
Single-Family	19,502	20,719	20,316	19,379	15,806
Multi-Family	6,087	6,269	6,111	5,988	5,370
Commercial/Institutional	7,932	8,574	8,168	8,142	6,083
Landscape	4,858	5,540	5,423	5,209	4,954
Fire Service	20	809	139	23	29
Sales/Transfers/Exchanges	7,079	3,915	1,688	113	370
Nonrevenue	3,288	2,931	3,991	4,575	3,424
Total:	**48,766**	**48,757**	**45,836**	**43,429**	**36,036**

West Kern Water District (WKWD)
Natural Gas Embedded in Water Profile

About:	West Kern Water District is a county water district formed by election in 1959. The District is located within the southern San Joaquin Valley and provides municipal and industrial water to a variety of consumers. West Kern is governed by a 5 member publicly elected Board of Directors that are responsible for the policies and decision making.
Agency Size:	West Kern Water District (WKWD) has a service area of approximately 318 square miles and serves 22,434 customers through 7,319 service connections.
Water Supply:	West Kern's primary supply source is imported State Water Project (SWP) water purchased from Kern County Water Agency (KCWA). This water is recharged into the underground (groundwater banking) and recovered with wells.
Natural Gas Usage:	WKWD uses natural gas engines for water pumping in its system. The majority of this is for boosting water through our distribution system. Since the development of our solar project, the majority of our groundwater pumping is accomplished with solar/electrics with a minor amount of groundwater pumped with natural gas engines.
Drought Impacts:	During the drought conservation was mandated through various restrictions such as 3-day a week watering limitations. As a result, water sales reduced which also resulted in a proportional reduction in energy usage.

Table WKWD-1. Annual Therms Usage by Service Address for Pumping (CY2011-CY2015)

Function	Facility	Service Address	2011	2012	2013	2014	2015
Groundwater Pumping (direct to distribution system)	South Wells	23420 TUPMAN RD	994,695	930,379	621,692	936,098	279,586
Booster Pumping (potable distribution)	Station A	24420 HIGHWAY 119	904,839	934,538	887,952	921,644	717,607
Booster Pumping (potable distribution)	Station D	99 E SOUTH ST	102,353	116,364	112,742	105,974	101,267
Booster Pumping (potable distribution)	Station B	26680 AIRPORT RD	1,377,032	1,428,501	1,460,151	1,631,598	1,261,905
Booster Pumping (potable distribution)	Station G	26406 WESTSIDE HWY	714,959	785,925	718,260	798,899	649,346

Table WKWD-2. Water Supply (Acre Feet [AF])

Supply	2011	2012	2013	2014	2015
Groundwater	19,561.69	19,657.84	11,712.88	7,426.47	2,942.55
Other: Water pushed through Station G Booster	8,193	9,117	6,513	7,180	5,713
Total Water:	**72,597**	**19,658**	**11,713**	**7,426**	**2,943**

Table WKWD-3. Natural Gas Energy Intensity (EI) for Groundwater and Booster Pumping CY2011-CY2015 (Therms/AF)

Function	Groundwater			Boosted (Station G)		
	Therms	AF	EI	Therms	AF	EI
CY2011	994,695	19,561.69	50.85	714,959	8,193	87.26
CY2012	930,379	19,657.84	47.33	785,925	9,117	86.20
CY2013	621,692	11,712.88	53.08	718,260	6,513	110.28
CY2014	936,098	7,426.47	126.05	798,899	7,180	111.27
CY2015	279,586	2,942.55	95.0	649,346	5,713	113.66

Western Municipal Water District (WMWD)
Natural Gas Embedded in Water Profile

About: Western Municipal Water District was formed in 1954 and provides reliable water and wastewater services for retail customers and wholesale agencies from Corona to Temecula. The District is a member of Metropolitan Water District of Southern California.

Agency Size: Western Municipal Water District's (WMWD) retail agency includes 73 square miles with a total service area (retail and wholesale) of 520 square miles. The District serves approximately 85,500 customers through 23,654 service connections.

Water Supply: The District's supply sources include purchases from Metropolitan Water District (Colorado River), imported water from the State Water Project and San Bernardino Basin and groundwater from its Murrieta Division.

Natural Gas Usage: The District utilizes natural gas for potable water distribution booster pumps as well as heating for wastewater treatment.

Drought Impacts: Western reduces the impacts of the drought by partnering with other agencies to construct regional water supply and groundwater storage projects. As an example, The La Sierra pipeline project will connect two local water supply sources (the Arlington Desalter and Chino Desalter) to Western's Riverside Retail Service Area at the La Sierra Tank. This regional reliability project will reduce Western's dependence on costly imported water and is part of Western's long-term reliability planning.

Table WMWD-1. Annual Therms Usage by Service Address for Pumping (CY2011-CY2015)

Function	2011	2012	2013	2014	2015
Booster, Potable	515,403	512,395	489,072	504,269	372,105
WW Collection	19	80	36	51	150
WW Treatment	11,547	10,833	25,188	59,753	5,991
Groundwater Pumping	157	10	27	33	35

Table WMWD-2. Water Supply (Acre Feet [AF])

Supply	2011	2012	2013	2014	2015
Groundwater	7,324	7,390	7,497	5,692	10,008

Table WMWD-3. Natural Gas Energy Intensity (EI) for Groundwater and Booster Pumping CY2011-CY2015 (Therms/AF)

Function	Groundwater			Groundwater + Booster		
	Therms	AF	EI	Therms	AF	EI
CY2011	157	7,324	0.02	515,403	7,324	70.37
CY2012	10	7,390	0	512,395	7,390	69.34
CY2013	27	7,497	0	489,072	7,497	65.24
CY2014	33	5,692	0.01	504,269	5,692	88.59
CY2015	35	10,008	0	372,105	10,008	37.18

Yorba Linda Water District (YLWD)
Natural Gas Embedded in Water Profile

<u>About:</u> Yorba Linda Water District is a public agency serving residents of Yorba Linda and portions of Placentia, Brea, Anaheim and areas of unincorporated Orange County. The District is totally independent of all city and county governments and is governed by a locally elected Board of Directors.

<u>Agency Size:</u> Yorba Linda Water District (YLWD) has a service area of approximately 23.2 square miles and serves approximately 76,000 customers through approximately 25,000 potable water service connections.

<u>Water Supply:</u> YLWD's supply sources include groundwater managed by Orange County Water District (OCWD) and imported water via Metropolitan Water District (MWD).

<u>Water Quality:</u> MWD is responsible for providing high quality potable water through its service area and performs over 300,000 water quality tests per year. OCWD is responsible for managing the OC Basin and continually conducts extensive sampling. Salinity is a significant water quality problem in Orange County.

<u>Natural Gas Usage:</u> YLWD utilizes natural gas for groundwater producing wells or booster pumps. The water pumped through the booster is typically either groundwater or purchased imported water.

Table YLWD-1. Annual Therms Usage by Service Address for Pumping (CY2011-CY2015)

Function	Service Address	2011	2012	2013	2014	2015
Groundwater Pumping (direct to distribution system)	913 RICHFIELD RD	244,679	370,827	344,310	292,867	362,554
Booster Pumping (potable distribution)	4150 1/2 FAIRMONT BLVD	61,541	70,031	67,069	70,971	45,859
	4685 1/2 GREEN CREST DR	190	18	19	166	289
	4045 LAKEVIEW AVE	36,145	19,039	37,908	45,915	40,787
	5252 1/2 HIGHLAND AVE	58,640	120,469	118,379	306,743	248,965
	3500 VALLEY VIEW CIR E	8,844	8,898	4,085	24,185	29,537
	4009 PASO FINO WAY	1,303	8,232	11,852	27,357	25,159
	3727 FAIRMONT BLVD	512	161	303	239	177
	Total Booster Pumping:	**167,175**	**226,848**	**239,615**	**475,576**	**390,773**

Table YLWD-2. Water Supply (Acre Feet [AF])

Supply	2011	2012	2013	2014	2015
Groundwater	9,548	10,780	11,756	14,718	14,181
Purchased	9,740	10,052	10,033	7,928	5,595
Total Water:	**19,288**	**20,832**	**21,789**	**22,646**	**19,776**

Table YLWD-3. Natural Gas Energy Intensity (EI) for Groundwater and Booster Pumping[32] CY2011-CY2015 (Therms/AF)

Function	Groundwater			Boosted: Groundwater + Purchased		
	Therms	AF	EI	Therms	AF	EI
CY2011	244,679	9,548	25.63	167,175	19,288	8.67
CY2012	370,827	10,780	34.40	226,848	20,832	10.89
CY2013	344,310	11,756	29.29	239,615	21,789	11.00
CY2014	292,867	14,718	19.90	475,576	22,646	21.00
CY2015	362,554	14,181	25.57	390,773	19,776	19.76

[32] The Booster pumps a mixture of groundwater and purchased water.

Zone Mutual Water Company (ZMW)
Natural Gas Embedded in Water Profile

Background: Zone Mutual has 10 wells in its system, 2 of which are natural gas (Well #20 and Well #19). Demand is to agricultural users and supplied to shareholders.

Drought Impacts: Zone pumps groundwater under the regulatory restriction set by the Fox Canyon Groundwater Management Agency.

Table ZMW-1. Annual Therms Usage by Service Address for Pumping (CY2011-CY2015)

Function	Service Address	2010	2011	2012	2013	2014	2015
Groundwater Pumping (direct to distribution system)	3980 BRADLEY RD	39,741	41,418	66,566	25,559	43,154	26,934
Groundwater Pumping (direct to distribution system)	6648 E LOS ANGELES AVE	48,609	42,639	60,514	75,814	103,459	84,669
	Total Groundwater:	**88,350**	**84,057**	**127,080**	**101,373**	**146,613**	**111,603**
Booster Pumping (potable distribution)	5544 N GREENTREE DR UNIT 4 GE	14,011	13,755	17,208	18,318	21,959	17,819

Table ZMW-2. Water Supply (Acre Feet [AF])

Supply	2010	2011	2012	2013	2014	2015
Groundwater (Well #19 and #20)	1,472.8	1,417	1,779	2,147	2,203	1,841
Boosted (Plant #4)	1,210.1	1108.2	1285.5	1611.6	1445.7	1329.6
Total Water:	**2,682.9**	**2,526**	**3,065**	**3,759**	**3,649**	**3,171**

Table ZMW-3. Natural Gas Energy Intensity (EI) for Groundwater and Booster Pumping CY2011-CY2015 (Therms/AF)

Function	Groundwater			Booster		
	Therms	AF	EI	Therms	AF	EI
CY2011	84,057	1,417	59.30	13,755	1108.2	12.41
CY2012	127,080	1,779	71.43	17,208	1285.5	13.39
CY2013	101,373	2,147	47.21	18,318	1611.6	11.37
CY2014	146,613	2,203	66.54	21,959	1445.7	15.19
CY2015	111,603	1,841	60.61	17,819	1329.6	13.40

APPENDIX B

Case Studies:

Natural Gas Energy Intensity of Water

Reprinted from:

The Role of Natural Gas in California's Water-Energy Nexus

Water Energy Innovations

April 10, 2013

Water/Wastewater Utility Natural Gas Intensity Case Studies[33]

A prior study conducted by SoCalGas showed that during CY2010, 18 water and wastewater agencies used 17 million therms for water pumping, irrigation and treatment within SoClaGas' service area. Of this amount, 10 million therms were provided by SoCalGas. The other 7 million therms were purchased from other natural gas suppliers.

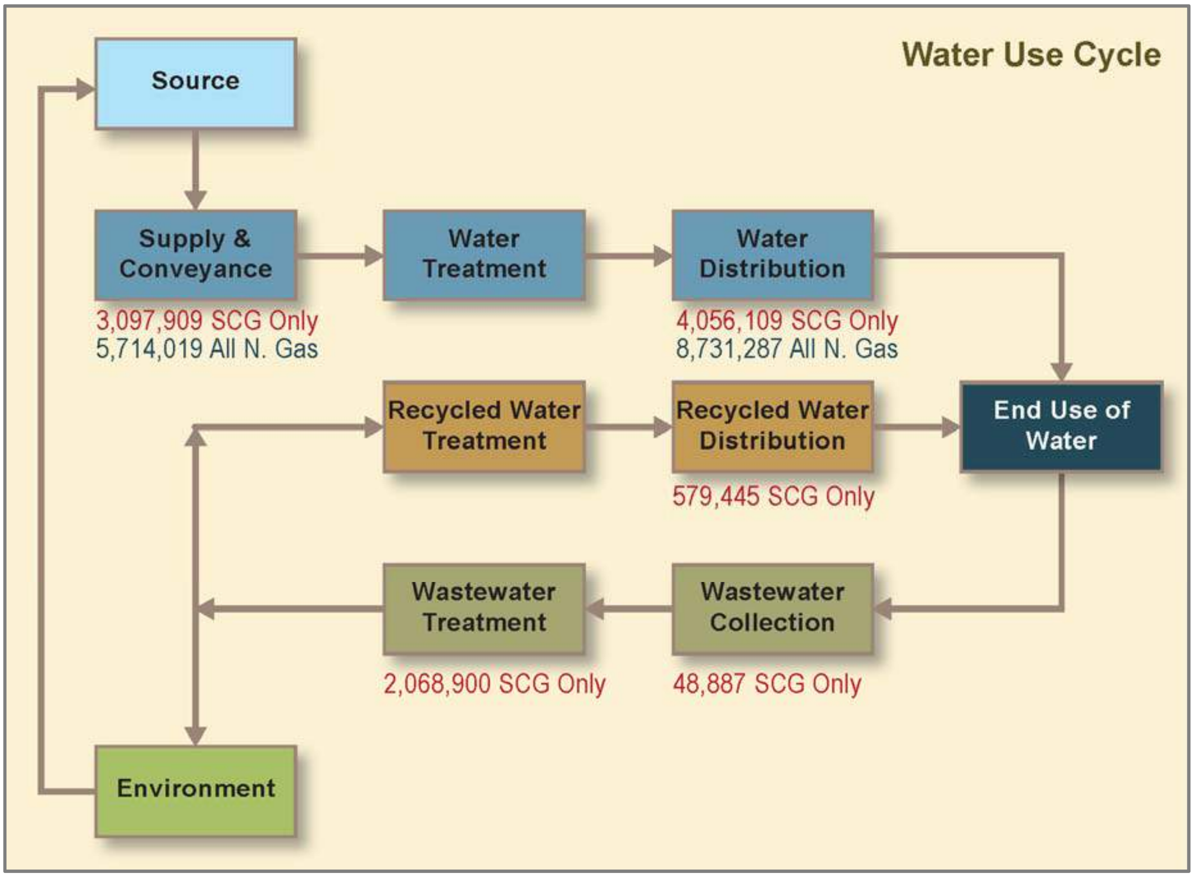

Figure B-1. Uses of Natural Gas for Water and Wastewater Systems and Processes (CY2010)

This study confirms the results of SoCalGas' prior study: that the primary non-electric generation uses of natural gas within the water use cycle in its service area are for pumping – primarily groundwater wells, or booster pumps within the potable water distribution systems. Natural gas is sometimes used to supplement biogas for heating (digestion, drying sewage sludge) during the wastewater treatment process. A small amount of natural gas is used for aeration blowers and wastewater collection (lift stations).

[33] The data and case studies presented herein were excerpted from a prior study conducted on behalf of SoCalGas: *The Role of Natural Gas in California's Water-Energy Nexus*, Water Energy Innovations, Inc., April 10, 2013.

Following are descriptions of how 3 utilities within SoCalGas' service area – West Kern Water District, Eastern Municipal Water District, and Tehachapi-Cummings County Water District - used natural gas during CY2009-2011. These case studies were prepared during a prior study of natural gas intensity conducted for SoCalGas during 2012-2013.

West Kern Water District (WKWD)

West Kern Water District (WKWD) has a relatively high natural gas energy intensity since it relies primarily on natural gas for pumping groundwater and also for water distribution at its booster pump stations. Based on annual retail water sales of 20,387 AF in CY2010, the average natural gas embedded in WKWD's delivered potable water (excluding losses) was about 235 therms/AF. Most of the natural gas used by WKWD is purchased through the California Department of General Services' Natural Gas Services program for state and local governments.

Figure B-2 shows the amount of natural gas used by WKWD during 2009-2011. **Figure B-3** shows that WKWD's natural gas intensity for groundwater pumping was 190 therms per million gallons (MG) (62 therms/AF). The energy intensity of its booster pumps in its southern distribution system was 209 therms/MG (68 therms/AF).

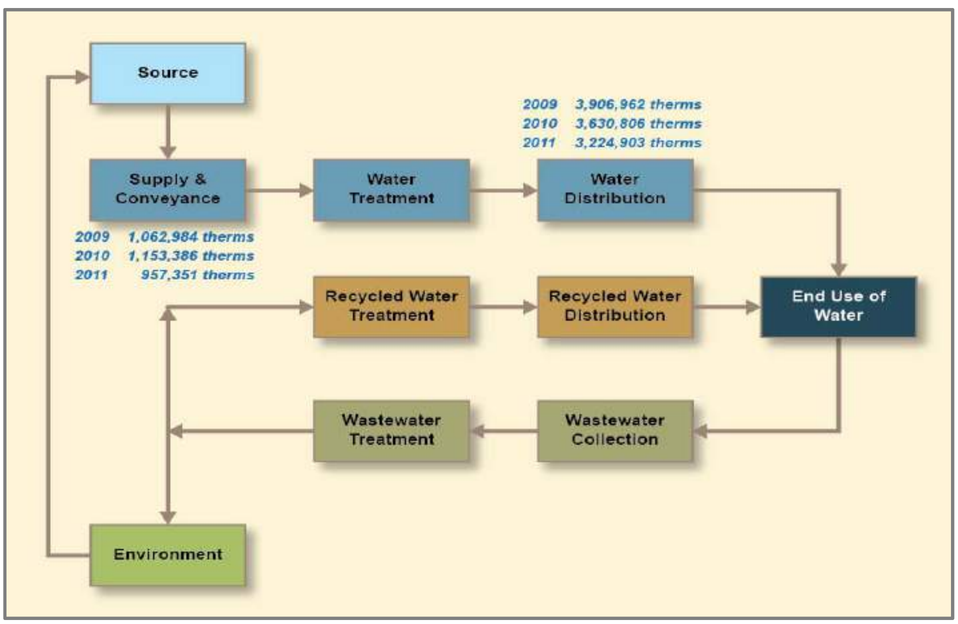

Figure B-2. Natural Gas Use: West Kern Water District (therms per year, 2009-2011)

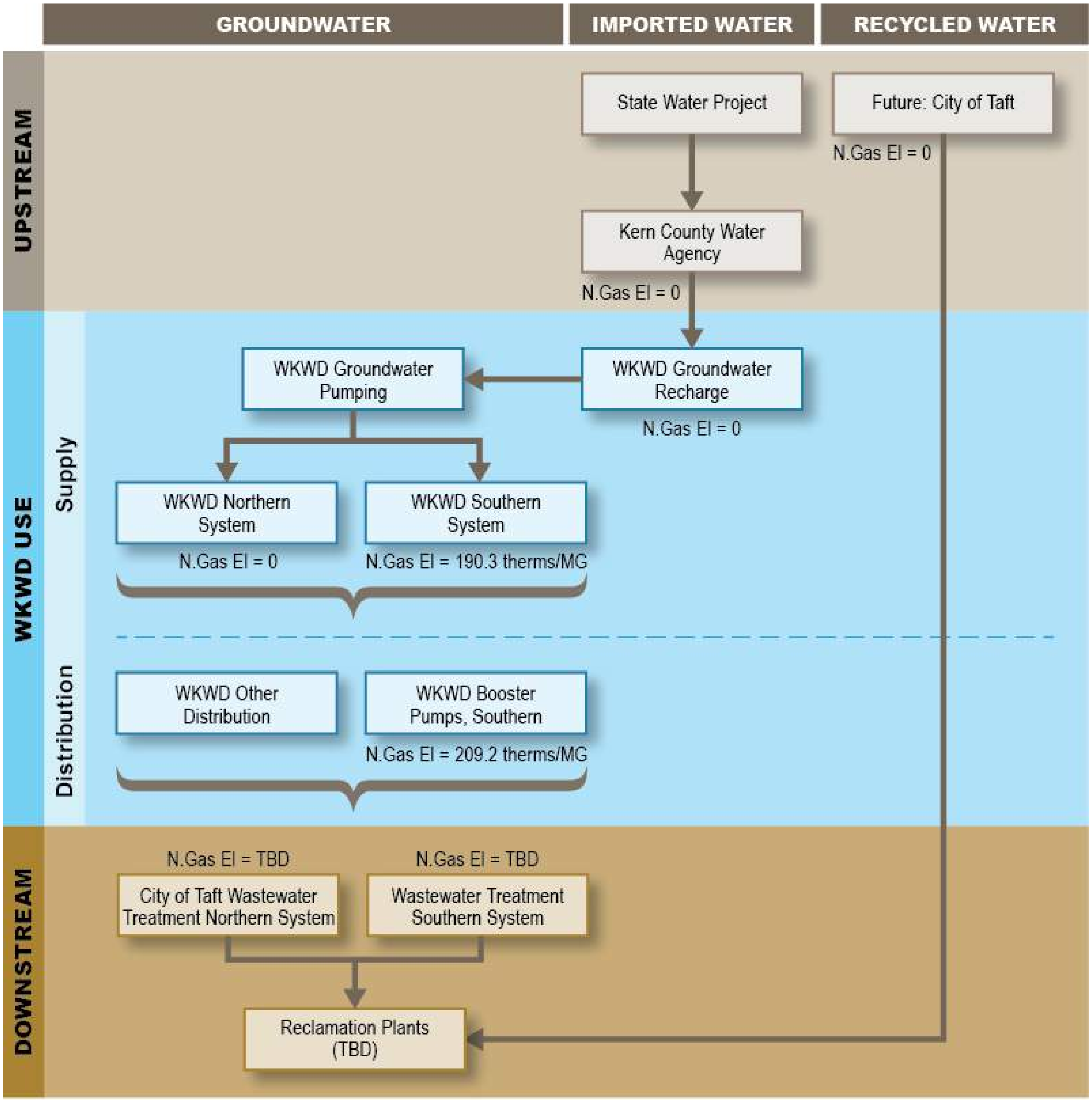

Figure B-3. Natural Gas Energy Intensity (therms/MG): West Kern Water District (CY2010)

To the extent that WKWD could avoid groundwater pumping, the natural gas savings would be equivalent to the energy intensity of that avoided groundwater pumping (190 therms/MG or 62 therms/AF).

If a water savings measure could be identified within WKWD's southern distribution system that reduced groundwater consumption and the associated distribution pumping, the total amount of natural gas avoided would be equivalent to the sum of the two energy intensities (399 therms/MG or 130 therms/AF).

Eastern Municipal Water District (EMWD)

Eastern Municipal Water District (EMWD) uses natural gas in all of its water and wastewater systems and processes.

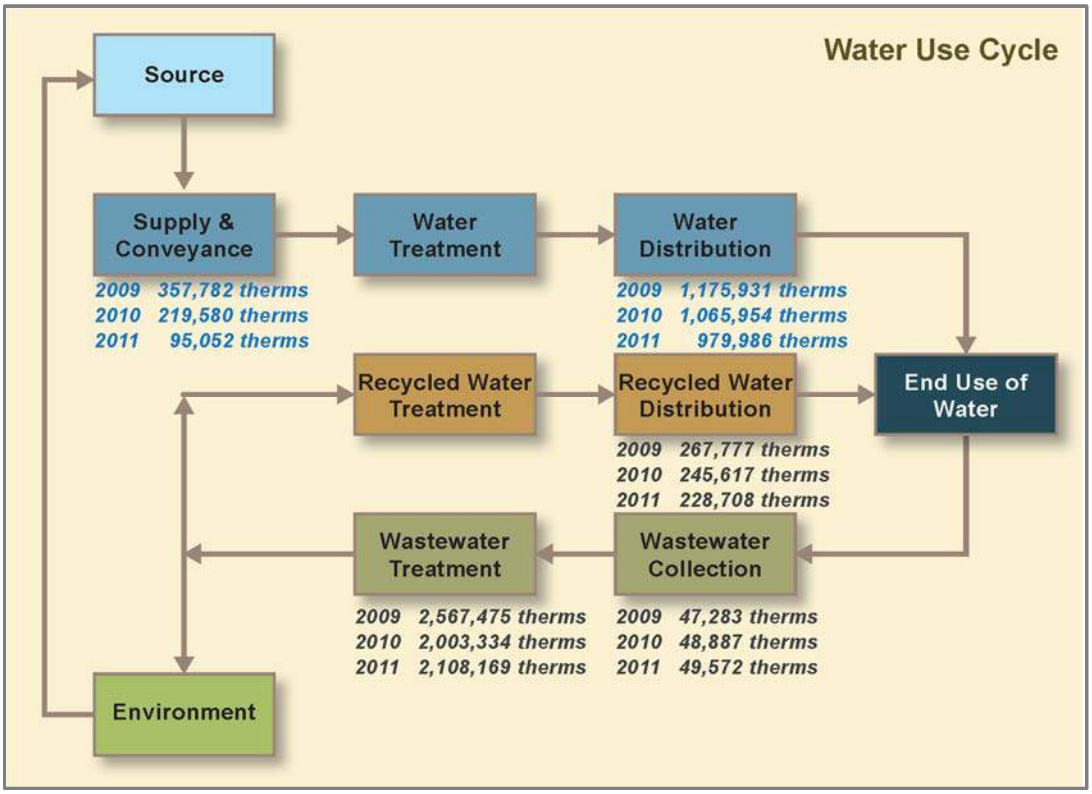

Figure B-4. Natural Gas Use: Eastern Municipal Water District (therms/year 2009-2011)

Figure B-5 on the next page shows the build-up of natural gas intensity of water resources and water and wastewater systems' processes and functions by segment of the water cycle.

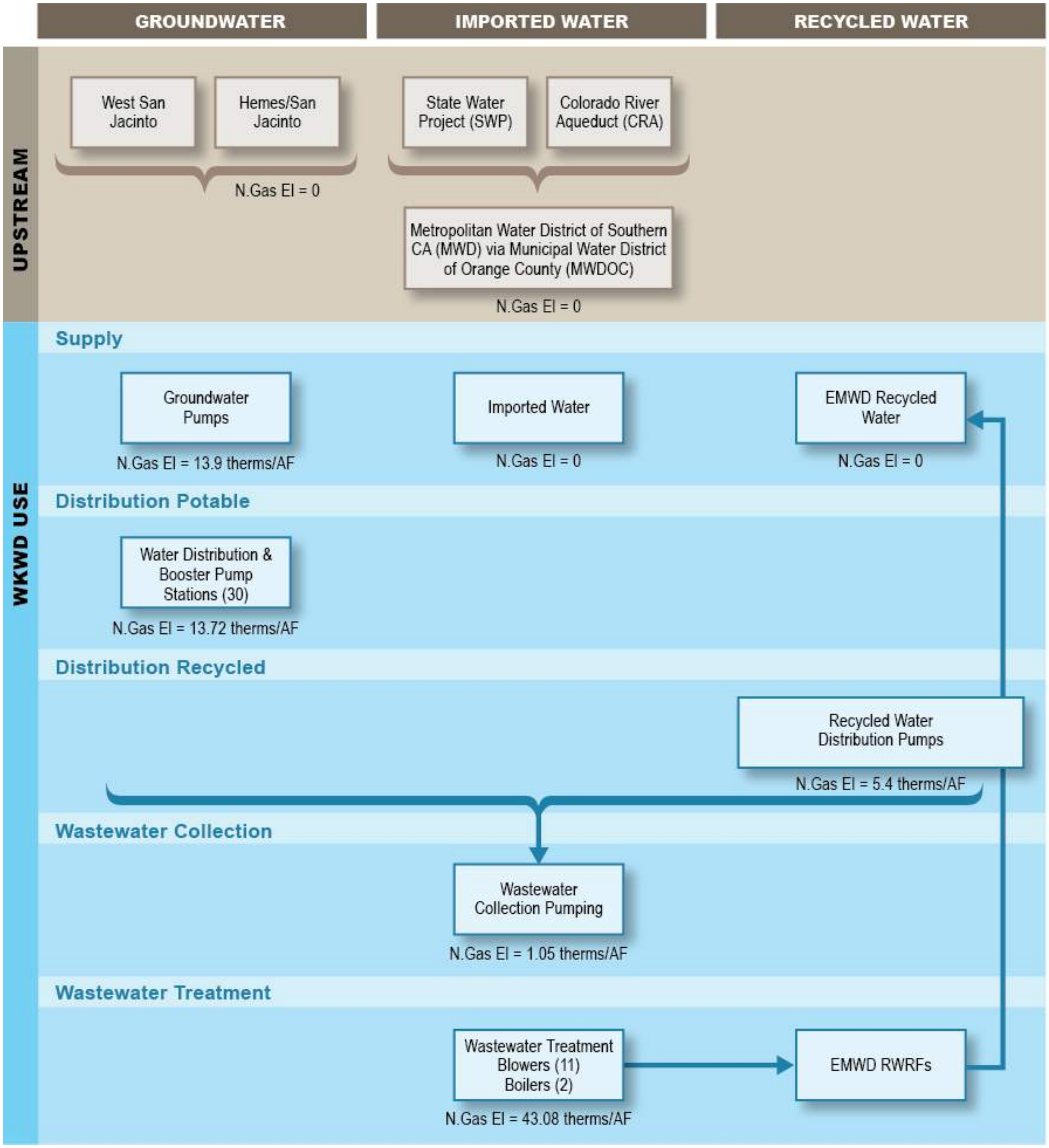

Figure B-5 Natural Gas Intensity (therms/AF): Eastern Municipal Water District (CY2010)

Tehachapi Cummings County Water District (TCCWD)

TCCWD uses natural gas to pump State Water Project (SWP) water uphill.

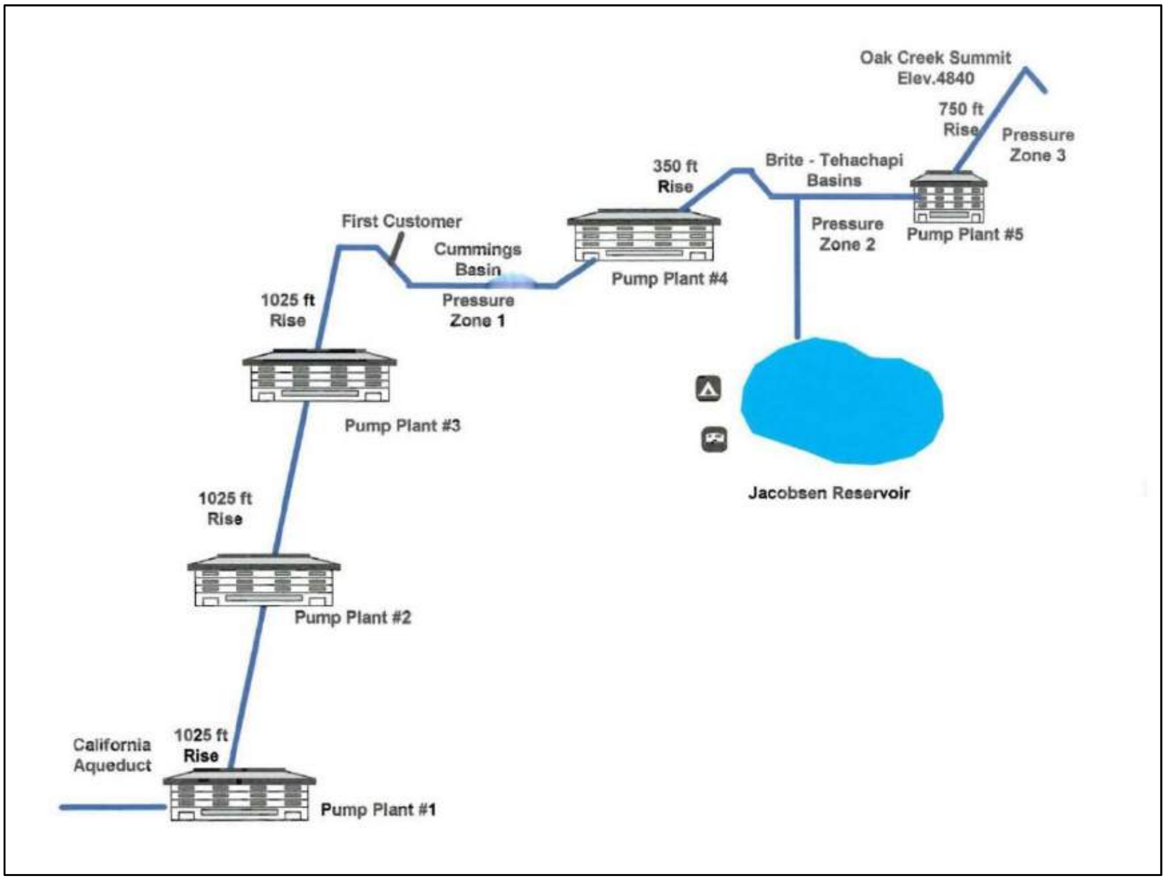

Figure B-6. TCCWD Pumping Elevation Diagram

- SWP water is taken from a turnout just prior to Edmonston Pumping Plant where it gravity feeds to Pump Plant 1.
- Each pump plant has 4 motors and 4 engines. Two or three operate seasonally (April-October).

Pump Plants #1-3 each has 4x1200 hp pumps. Pump Plant 4 has 4x500 hp pumps.

During CY2010, TCCWD used an average of 521.5 therms/AF of water for pumping. Using natural gas for pumping avoids 8,850 kW of summer peak electric demand. Pump Plant #5 is presently 100% electric but could be converted to natural gas. TCCWD's SCADA system is already programmed for this possibility. Any avoided water use along this path would yield significant reductions in natural gas usage.

APPENDIX C

Natural Gas Saved by the City of Cerritos
By Reducing Leaks
In Its Water Distribution System

Case Study from

SoCalGas Water Loss Control Pilot Study

Conducted by:
Water Energy Innovations

August 21, 2015

APPENDIX C

CASE STUDY

Natural Gas Saved by the City of Cerritos By Reducing Leaks in Its Water Distribution System

Estimated Savings of Water, Natural Gas and Electricity

Energy benefits of a water loss control program are achieved through two types of strategies:

- Finding and repairing leaks in the water system, and
- Reducing pressure in the distribution system to decrease the amount of energy required for pumping water, and also to potentially decrease the volume of real losses – i.e., "leaks" – in the water system. (The volume of water that escapes through leaks is decreased when the pipeline is operated at lower pressure.)

SCG's Cerritos WLC Program did not find significant opportunities to reduce pressure in the City's distribution system. Consequently, this report focuses on documenting the data and methodology used to estimate the amount of energy saved by repairing leaks identified through this program that were repaired by the City.

Energy Characteristics of the City's Water System

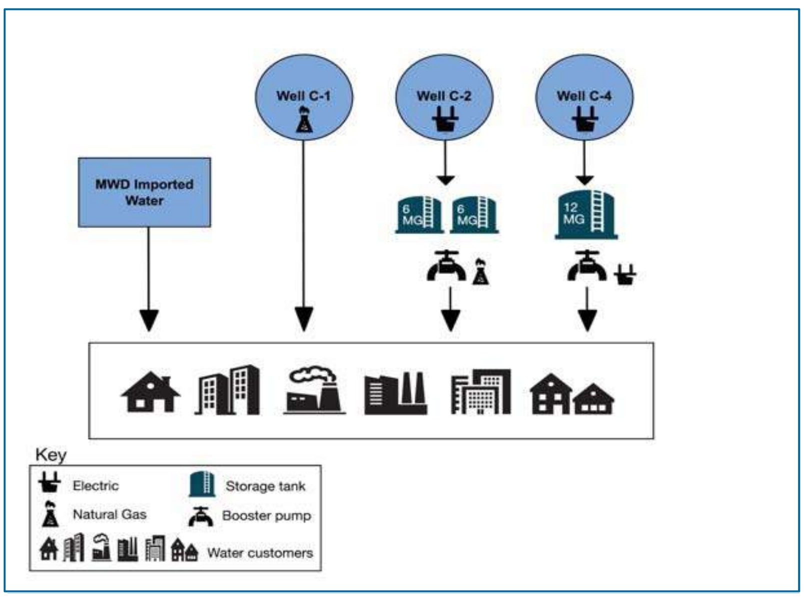

Figure C-1 City of Cerritos Water Pumps

The City obtains potable water from two sources: local groundwater wells that pump water from the adjudicated Central Groundwater Basin, and purchases of imported water from the Metropolitan Water District of Southern California (MWD). Local groundwater is the City's primary water supply. Imports from MWD are the City's marginal water supply (i.e., only purchased when needed to meet water demand).

The City's water resources do not require any treatment before delivery to retail water customers. Water from one groundwater well (C-1) and imported water directly enter the City's water distribution system at pressure. Water from two groundwater wells (C-2 and C-4) is pumped into temporary storage to more efficiently meet real time fluctuations in daily water demand, and also to assure that sufficient water is available when needed for fire fighting.

Withdrawals from the storage tanks require boosting water pressure before injection into the distribution system. The City's water distribution system is comprised of a single pressure zone.

Methodology for Estimating the Quantity of Energy Saved by Repairing Leaks in the City's Water Distribution System

As described above and shown in **Figure C-2** below, the City inputs energy at two points in the City's water cycle:

- To pump groundwater, and
- To boost the pressure of water stored in tanks as the water is input to the distribution system for delivery to water customers.

The only other water resource that is delivered to the City's customers is imported water purchased from MWD. The City purchases treated water from MWD that enters the City's system at pressure. Consequently, no energy is input by the City to treat or to deliver imported water.

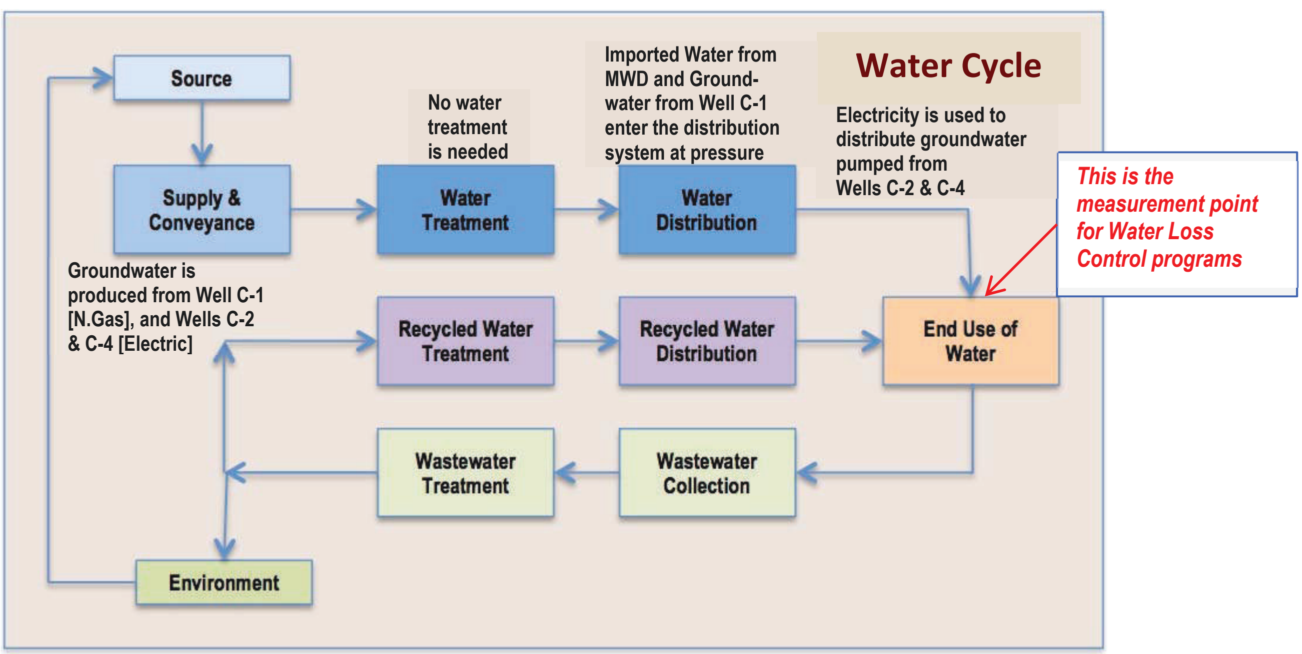

Figure C-2. Energy Inputs to Water Sold by City of Cerritos to Its Retail Customers

The methodology used to estimate energy saved by repairing leaks on the City's water distribution system thus starts with estimating the amount of water saved. Thereafter, the amount of energy saved by the City is computed on a per unit basis of water saved.

Water Saved by Repairing Leaks in the City's Water Distribution System

The technical water loss control contractor for this project, Water Systems Optimization (WSO), conducted acoustic leak detection on all 182 miles of the City's water distribution system. Acoustic leak detection, the method most commonly used by the water sector to detect potential distribution system leaks, uses acoustic emission sensors to detect sounds from pipelines. Technicians are taught to interpret the sounds that they hear to identify potential leaks. Additional tests, such as acoustic sensing upstream and downstream of the site of a suspected leak, help to better pinpoint the leak site.

It is important to note that acoustic sensing is not a measurement. Leak detection technicians estimate the volume of water they believe may be leaking at any particular site on the basis of the type of sound that they hear. To alert users of these data to the fact that these are not measurements, WSO qualifies its leak volume estimates at +/- 50%. However, this qualification is not based on any empirical data – it is principally provided as a caution that these leak estimates are just that – "estimates" – and should therefore not be relied upon as definitive. The primary purpose of acoustic leak detection is not to estimate the volume of water that may be leaking, but to help water utilities identify points at which leaks may be occurring so that they can take proactive steps to find and repair leaks.

WSO classifies leaks in 5 types: Customer, Hydrant, Main, Meter and Service.

- The City is not responsible, nor does it have authority, to repair leaks on the Customer's side of the meter (i.e., on the Customer's property).
- The City is responsible for repairing all four of the other types of leaks because these occur on the City's system.

Estimated Volume of Water Saved by Repairing Leaks

WSO identified 38 potential leaks within the City's water distribution system. The leak detection technician estimated that these leaks could be losing as much 122 million gallons per year (MGY) [375 acre-feet per year (AFY)].

Table C-1. Number of Leaks By Type Identified by Acoustic Leak Detection

Leaks Identified by Acoustic Leak Detection					
	Hydrant	Main	Meter	Service	Total
Potential Leak Sites Identified by WSO	1	5	20	12	38
Vs. Leaks Found and Repaired by the City	0	1	10	5	16

The City investigated all reported leaks, and repaired all leaks found. As seen in **Table C-1** above, the City was not able to confirm all of the potential leaks identified by WSO. The amount of water saved by repairing the 16 leaks that were verified by the City was estimated by WSO at approximately 42 MGY [129 AFY (+/- 50%)].

The Energy Intensity of the City's Water

Once the volume of water saved has been determined, the amount of energy saved by saving that water must be computed.

The program scope of work specified that only direct energy – i.e., energy inputs by the City itself – were to be considered in this program. Consequently, this analysis does not consider any energy inputs by others. [For example: *MWD used energy to import wholesale water from other hydrologic regions, and to treat and deliver water to the City. None of MWD's energy inputs - i.e., "embedded" energy - is considered here*.]

As shown in **Figure C-2**, the City uses energy to produce groundwater, and also uses energy to deliver water to its customers. The typical approach to computing the energy saved by saving water is to compute the Energy Intensity (i.e., the average amount of energy used per unit of water) separately for each segment of the Water Cycle. However:

- At one well site (C-4), a single electric meter serves both the groundwater pump (Supply & Conveyance segment) and the booster pump (Distribution segment). These data cannot be readily allocated by segment of the water cycle.
- All groundwater supplies are comingled in the City's system prior to delivery to customers.
- Imported water is also comingled in the distribution system prior to delivery to customers.

The above factors make it impossible to identify which type or quantity of energy (natural gas and/or electric) was used to pump which water resource. Consequently, for purposes of this analysis, all energy inputs by the City to its water system and resources prior to delivery to the City's customers were averaged over the total quantity of water supplied. In other words, every acre-foot of water saved is deemed to have some quantity of natural gas and electricity.

Energy data for 4 years (2010-2013) were obtained from the City's energy utilities, SCG and SCE to compute energy intensity. The City provided water data for the same period.

During 2011, site C-1 was out of service for 5 months for well rehabilitation, resulting in atypical energy intensities for that year. The program team therefore used calendar years 2010, 2012 and 2013 to compute the average energy intensity of the City's water.

Table C-2. Annual Energy Used by the City for Water Production and Distribution

Year	Groundwater Site C-1 (therms)	Booster Site C-2 (therms)	Groundwater Site C-2 (kWh)	Combined Site C-4 (kWh)	Total Gas Usage (therms)	Total Electric Usage (kWh)
2010	195,348	111,057	1,122,222	2,558,421	306,405	3,680,643
2012	193,629	117,894	908,610	2,464,530	311,523	3,373,140
2013	193,780	144,440	1,232,081	2,360,859	338,220	3,592,940

Table C-3. Annual Volume of Water Supplied by Type of Resource (AF)

Year	Groundwater			Imported Water (AF)	Total Water
	Site C-1	Site C-2	Site C-4		
2010	2,328	2,916	4220	164	9,629
2012	2,430	3,365	3,917	407	10,119
2013	2,358	2,907	3,836	366	9,468

The Average Energy Intensity shown in **Table C-4** is computed as Total Energy ÷ Total Water. Since the purpose of this analysis is to ascribe an energy value to water saved by repairing leaks in the distribution system, Total Water includes all water resources (i.e., all water that was injected into the City's water distribution system to meet retail water demand, including water that was ultimately "lost" due to leaks).

Table C-4. Energy Intensity of the City's Water (AF)

Year	Total Water (AF)	Energy Inputs to the City's Water		Average Energy Intensity (EI) of the City's Water	
		Total Gas Energy (therms)	Total Electric Energy (kWh)	Gas EI (therms/AF)	Electric EI (kWh/AF)
2010	9,629	306,405	3,680,643	31.82	382.26
2012	10,119	311,523	3,373,140	30.79	333.36
2013	9,468	338,220	3,592,940	35.72	379.49
			Three Year Average Energy Intensity	**32.78**	**365.04**

<u>The Quantity of Energy Saved by Repairing Leaks in the City's Distribution System</u>

Once the volume of water saved and the average energy intensity of each unit of water are known, the amount of energy saved can be computed simply as:

Quantity of Water Saved x Energy Intensity of Water

Table C-5 below shows the estimated quantity of energy saved by this program. Given the uncertainty as to how much water was actually saved, the potential range of energy saved was computed +/- 50%.

Table C-5. Estimated Range of Energy Saved by Repairing Leaks in the City's Distribution System

Est. Water Saved (AF)	Energy Intensity of Saved Water (per AF)		Estimated Range of Energy Saved					
			-50%		Mid-Case		+50%	
	N.Gas (therms)	Electricity (kWh)	N.Gas (therms)	Electricity (kWh)	N.Gas (therms)	Electricity (kWh)	N.Gas (therms)	Electricity (kWh)
129	32.78	365.04	2,114.31	23,545.08	4,228.62	47,090.16	6,342.93	70,635.24

APPENDIX D

CPUC W-E Calculator Structure
[ver. 1.05]

APPENDIX D

CPUC Water-Energy Calculator Structure [ver. 1.05]

This appendix generally describes the CPUC's Water-Energy (W-E) Calculator's structure, and highlights areas within the W-E Calculator in which space has been provided for natural gas data.

Embedded Energy Basics

Computation of the Energy Embedded in Water begins by computing the Energy Intensity of Water.

The purpose of computing the Energy Intensity of Water is to determine the amount of energy that can be saved by saving a unit of water – i.e., the amount of energy deemed *embedded in a unit of saved water itself* - that has not previously been included in the CPUC's cost-effectiveness protocols for programs and measures that save water in addition to energy.[34]

The Navigant study focused on reviewing prior studies conducted by or on behalf of the CPUC, CEC and others to develop default Energy Intensity (EI) values for four "water system components":

- Water Extraction and Conveyance,
- Water Treatment,
- Water Distribution, and
- Wastewater Collection and Treatment.

> ***Energy Intensity (EI) of Water*** is the sum of energy used by water and wastewater utilities and other purveyors of water resources to collect or "extract" water and to transport ("convey") wholesale water, to treat the water to standards suitable for beneficial use by the targeted end users, to deliver (distribute) the water to end use customers, and to treat disposed water (wastewater) to levels that meet regulatory requirements for safe discharge to the environment, and/or to recycle and reuse the treated wastewater.

[34] Savings of direct site energy uses that occur during the use of water by customers (e.g., water heating) are already recognized in the CPUC's distributed energy resource programs. The quantity of Energy Embedded in Water that is not currently recognized is an additional benefit that, depending on the amount of incremental program costs, may increase cost-effectiveness of programs and measures that save both energy and water.

The Navigant team used prior studies to develop default assumptions for the following variables:

- Percentage of Electric Energy Provided by Energy IOUs,
- Energy Intensity of Water Used by Agricultural vs. Urban Sectors, and
- Energy Intensity of Water and Wastewater Treatment Levels and Technologies.

Since very little information was available about the amount of natural gas used by the four water system components, the Navigant study and the W-E Calculator focus on computing the Electric Energy Intensity of Water. EI is therefore expressed in kWh per unit of water (the W-E Calculator uses kWh/AF). Space was provided to add natural gas intensities for each of the four water system components at a later time (no default values were provided for the natural gas intensity of water for any of the water system components).

Figure D-1 on the next page describes the key variables that are used by the W-E Calculator to compute the Electric Energy Intensity of Water.

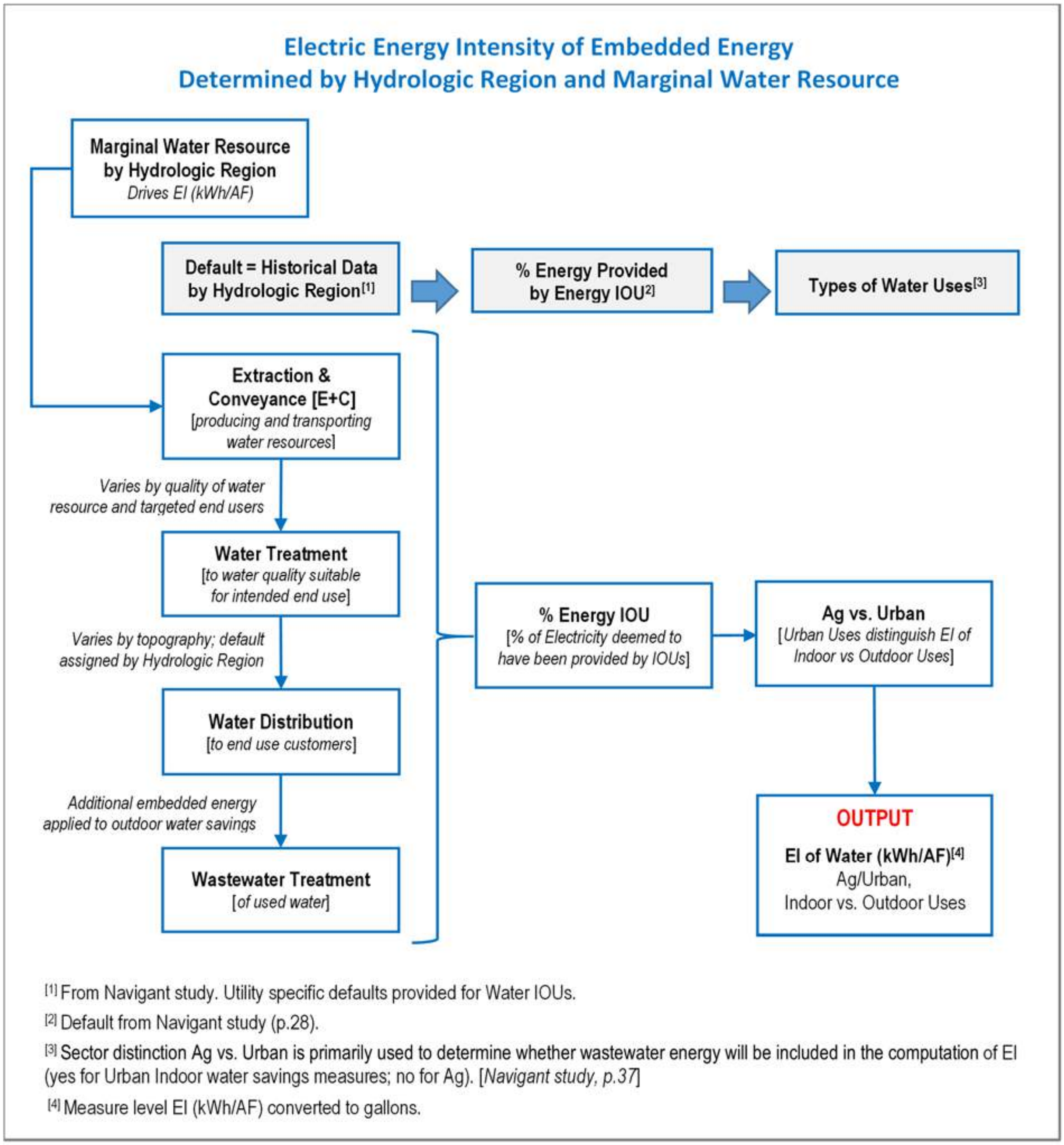

Figure D-1. Key Variables Used to Compute the Energy Intensity of Water

Figure D-2 on the next page illustrates how the resultant EIs for the selected marginal water resource and hydrologic region are used to compute the Measure-Level Embedded Energy savings that increase water-energy program benefits.[35]

[35] Measure-Level Embedded Energy in Water is computed as EI x the quantity of water saved. Note that energy and water/wastewater utility program costs also affect the cost-effectiveness computation.

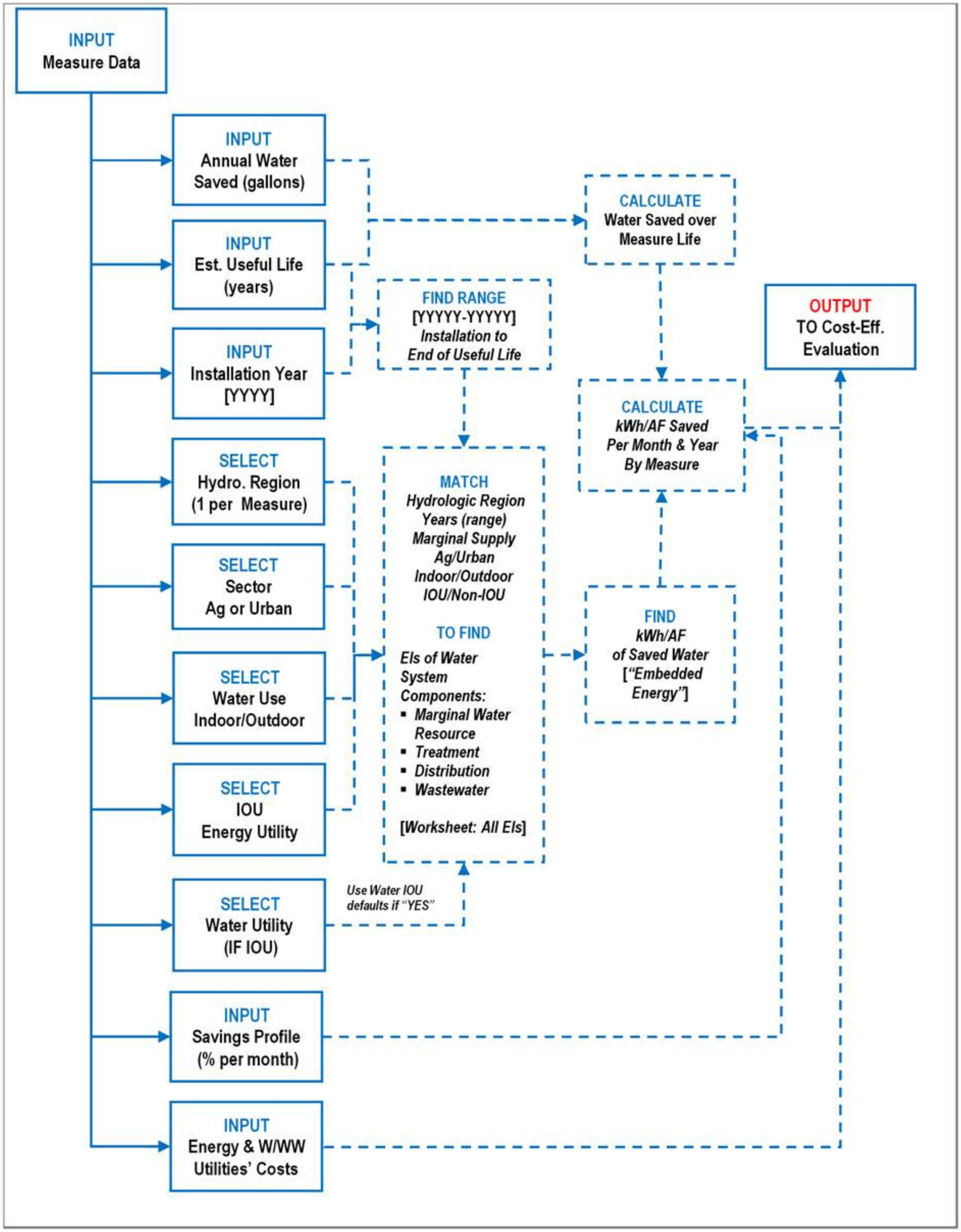

Figure D-2. Computing Measure-Level Energy Intensity of Water

Water-Energy Calculator Structure

The W-E Calculator is comprised of 29 Excel worksheets within a single Excel workbook. Only a few of the worksheets are important to the user. Only a few are directly relevant to computing the Electric Intensity of Water and Wastewater.

Primary W-E Calculator Functions

The W-E Calculator performs 3 primary functions:

1. Computes the Energy Intensity of Water by Hydrologic Region. This function is not presently met by any other CPUC tool.
2. Computes Measure-Level Embedded Energy. This function is also not presently performed for water-energy measures by any other CPUC tool. However, the CPUC's Cost-Effectiveness Tool (CET) is designed to accommodate inputs at the Measure level.
3. Computes Measure-Level Cost-Effectiveness. If the CET could be modified to incorporate (a) Embedded Energy in saved water by Measure, and (b) Avoided Water/Wastewater Capacity Costs (and Water Commodity Costs, if any), the CET could be used to evaluate the cost-effectiveness of water-energy programs and measures.[36]

Table D-1 on the next page lists the 29 worksheets and their function, and maps these worksheets to the three primary W-E Calculator functions.

[36] Since hydrologic regions do not map perfectly to DEER Climate Zones, some type of workaround will be needed. This is true whether the cost-effectiveness evaluation is performed by the W-E Calculator or by the CET, since many water-energy programs and measures have both embedded and direct energy savings that will need to be considered within a single tool, and direct energy savings are mapped within the CET to DEER Climate Zones.

Table D-1. Primary Function(s) Served by the 29 Worksheets

<table>
<tr><th rowspan="2">Section</th><th rowspan="2">Worksheet Name</th><th rowspan="2">Purpose & Content</th><th colspan="3">Primary Function(s) Served</th></tr>
<tr><th>Energy Intensity of Water</th><th>Measure Level Embedded Energy</th><th>Cost-Effectiveness</th></tr>
<tr><td rowspan="4">User Guidance and Inputs</td><td>Information</td><td>General Information</td><td colspan="3">n/a</td></tr>
<tr><td>Inputs</td><td>▪ <u>Primary Inputs</u>: Water-Energy System and Measure Information
▪ <u>Default Overrides</u></td><td colspan="3">X</td></tr>
<tr><td>Water IOU Data</td><td>Historical Water Supply Portfolios and Average EIs by Water System Component</td><td>X</td><td colspan="2">Used only when the Installation Year precedes the Resource Balance Year</td></tr>
<tr><td>Glossary</td><td>Key Terms and Acronyms</td><td colspan="3">n/a</td></tr>
<tr><td rowspan="8">Model Outputs</td><td>Summary Outputs</td><td><u>Looks Up</u>: Embedded Energy by Measure and Avoided Costs
<u>Computes</u>: Cost-Effectiveness</td><td colspan="2" rowspan="8">n/a

All Model Outputs Are related to Computing Cost-Effectiveness</td><td rowspan="8">X</td></tr>
<tr><td>Avg Embedded Electric Svgs</td><td>Applies Water Savings Profile to allocate Measure-Level Savings (kWh/AF) by Month (one year, 2014)[37]</td></tr>
<tr><td>Avg Embedded Gas Svgs</td><td>Applies Water Savings Profile to allocate N.Gas Measure-Level Savings (therms/AF) by Month (one year, 2014)</td></tr>
<tr><td>AC Marginal Embedded Elec</td><td rowspan="2">Imported Energy Avoided Costs applied to compute Measure Level Avoided Costs of Energy by Month/Year using the monthly Water Savings Profile</td></tr>
<tr><td>AC Marginal Embedded Gas</td></tr>
<tr><td>AC Water Capacity</td><td rowspan="2">Imported Water/WW Avoided Capacity Costs applied to compute Measure Level Avoided Costs of Water/WW by Year</td></tr>
<tr><td>AC WW Capacity</td></tr>
<tr><td>Env Benefits</td><td>Imported Environmental Benefits applied to compute Measure Level Incremental Environmental Benefits of Saved Water by Month/Year using the monthly Water Savings Profile</td></tr>
<tr><td rowspan="2">Internal Calculations</td><td>Marg Elec EI by Measure</td><td><u>Looks Up</u>: Historical EI of Water Resource by Hydrologic Region; Uses Historical EI for Installation Years < Resource Balance Year, and EI of the Marginal Resource for all other years</td><td>X</td><td>X</td><td>X</td></tr>
<tr><td>All EI</td><td><u>Looks Up</u>: EIs for each Water Resource and Water System</td><td>X</td><td>X</td><td>X</td></tr>
</table>

[37] The Average Embedded Electric Savings and the Average Embedded Gas Savings allocate annual embedded energy by month in accordance with a presumed Water Savings Profile. The purpose of the Water Savings Profile is to adjust the avoided costs of energy for seasonal price differences.

<table>
<tr><th rowspan="2">Section</th><th rowspan="2">Worksheet Name</th><th rowspan="2">Purpose & Content</th><th colspan="3">Primary Function(s) Served</th></tr>
<tr><th>Energy Intensity of Water</th><th>Measure Level Embedded Energy</th><th>Cost-Effectiveness</th></tr>
<tr><td rowspan="2"></td><td></td><td>Component by Hydrological Region, Year, Sector (Ag/Urban), Water Use (Indoor/ Outdoor), IOU/Non-IOU</td><td></td><td></td><td></td></tr>
<tr><td>Monthly Water Svgs</td><td>Zero for Years < Installation Year; Monthly Water Savings for Installation through the end of the Measure’s useful life</td><td>n/a</td><td>X</td><td>X</td></tr>
<tr><td rowspan="13">Data and Default Assumptions</td><td>Env Ben</td><td>Imported from External Source</td><td colspan="2" rowspan="5">n/a</td><td rowspan="5">X</td></tr>
<tr><td>Water Capacity AC</td><td>Imported from External Source</td></tr>
<tr><td>Commodity Cost</td><td>No defaults provided</td></tr>
<tr><td>Water Svgs Profiles</td><td>3 Default Profiles for allocating water savings by month, with space for up to 5 Custom Profiles</td></tr>
<tr><td>IOU AC</td><td>Imported from External Source</td></tr>
<tr><td>% IOU</td><td rowspan="6">Defaults provided, can be over-ridden via Worksheet: INPUTS</td><td rowspan="6">X</td><td rowspan="6">X</td><td rowspan="6">X</td></tr>
<tr><td>Marginal Supply</td></tr>
<tr><td>E+C EI</td></tr>
<tr><td>Treatment EI</td></tr>
<tr><td>Distribution EI</td></tr>
<tr><td>WW Systems EI</td></tr>
<tr><td>Gas AC</td><td>Imported from External Source</td><td colspan="2">n/a</td><td>X</td></tr>
<tr><td>Hist. Supply</td><td>Results of Navigant Study (uses for reference, and also to compute Measure-Level Marginal EIs for Installation Years < Resource Balance Year</td><td>n/a</td><td>X</td><td>X</td></tr>
<tr><td>Reference</td><td>Reference</td><td>Data Sources and Other Background Information</td><td colspan="3">n/a</td></tr>
</table>

Figure D-3 on the next page depicts the W-E Calculator’s primary processes, inputs and outputs.

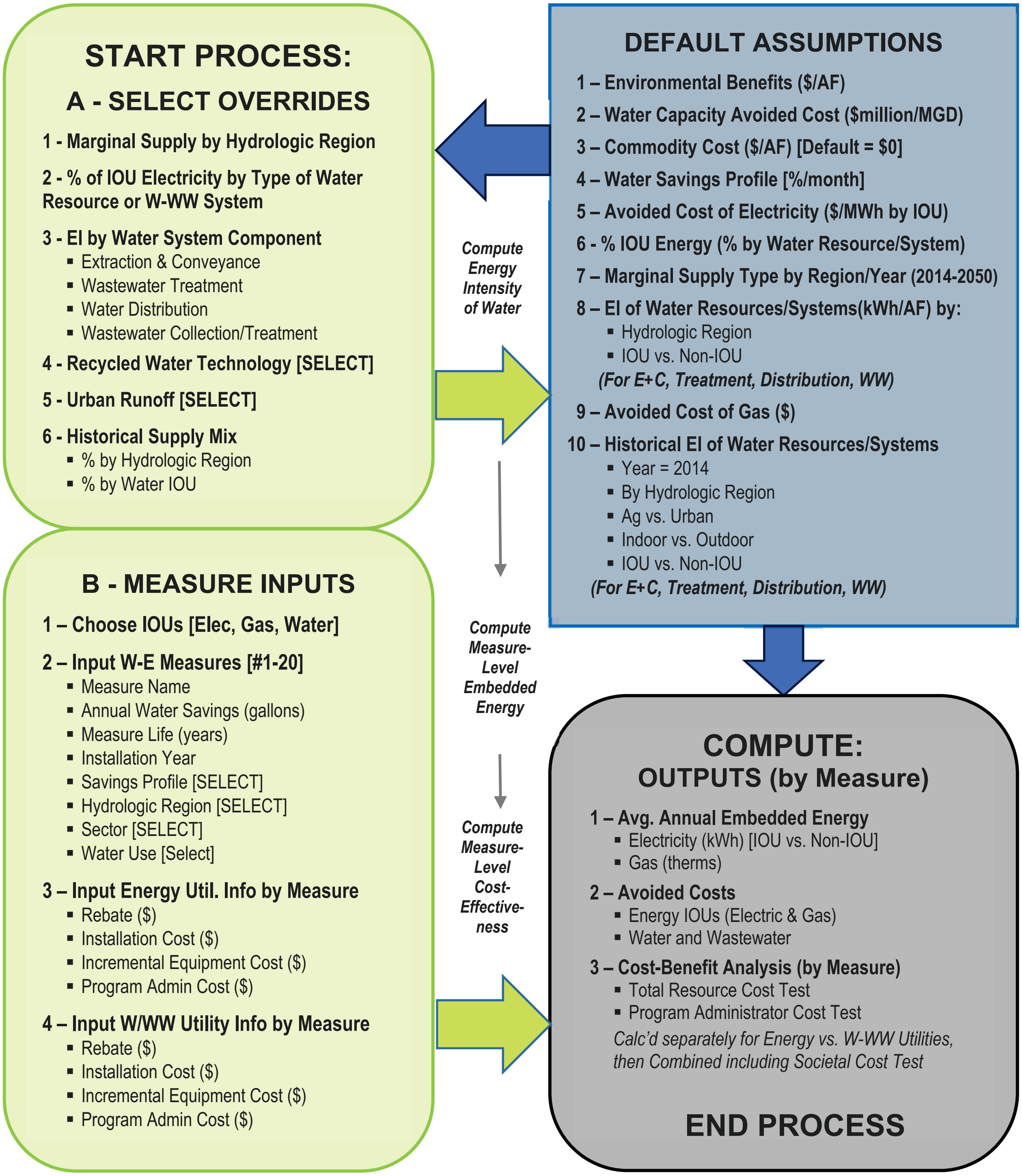

Figure D-3. CPUC Water-Energy Calculator Primary Processes, Inputs and Outputs

Electric Energy Intensity Default Values by Water System Component

Default energy intensities were computed by Navigant for four water system components that are collectively deemed to comprise the Electric Energy Intensity of saved water:

- Extraction and Conveyance
- Water Treatment
- Distribution
- Wastewater Treatment

Water resources are included in the Extraction and Conveyance component.

Table D-2 below shows the default energy intensities that were recommended by Navigant for each of the four water system components to compute the IOU Marginal Energy Intensity (kWh/AF) for the default long-run marginal water resource: Recycled Water. Note that the default value for the Extraction and Conveyance component of Recycled Water is deemed to be zero.

Table D-2. IOU Marginal Energy Intensity (kWh/AF)[38]

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

In addition to showing the energy intensity of the default marginal water supply by water system component within each hydrologic region, **Table D-2** shows how these data are used to develop the Energy Intensity of Water for water-energy program planning purposes.

The energy embedded in the avoided marginal supply is comprised of the sum of energy inputs by water and wastewater utilities within each water system component. The sum of energy

[38] Navigant study, Errata, Table ES-2. IOU Marginal Energy Intensity (kWh/Acre-Foot[AF]). One acre-foot is the amount of water that would be needed to cover one acre under one foot of water (approximately 325,851 gallons).

inputs represents the amount of energy that could be "avoided" (saved) by saving water indoors vs. outdoors.

- ***The energy intensity of water saved via indoor measures*** is deemed to be comprised of the energy intensities of all 4 water system components.
- ***The energy intensity of water saved via outdoor measures*** is deemed to be comprised of the energy intensities of the first 3 water system components only. Wastewater collection and treatment is not included on the premise that outdoor water uses and other urban runoff either recharge groundwater or flow to storm drains; they are typically not collected and transported to wastewater treatment plants.[39]

The values in **Table D-2** represent the default amount of electricity supplied by energy IOUs that are considered to be "embedded in water". **Table D-3** contains the factors that were recommended and applied by the Navigant team to compute the default IOU energy intensities in **Table D-2** (i.e., the amount of electricity embedded in saved water that was estimated to have been provided by an electric IOU, and can therefore be included when evaluating the cost-effectiveness of CPUC jurisdictional programs and measures that save both energy and water).

Table D-3. Percent of Energy Supplied by an IOU[40]

System Component	Supply Type	% IOU
Extraction and Conveyance	Ocean water Desalination	94%
	Brackish Desalination	94%
	Recycled Water	97%
	Groundwater	59%
	Local Deliveries	27%
Treatment		94%
Distribution		95%
Wastewater Systems		97%

The IOU Marginal Energy Intensity for Outdoor and Indoor Water Savings represent the default proxies for estimating the amount of energy saved by saving water within each of the ten hydrologic regions.

General descriptions of each of the four water system components and the default energy intensities that were recommended by the Navigant team (before applying the IOU% in **Table D-3** above) follow.[41]

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[39] Some combined sewer systems collect sewage, stormwater and industrial wastewater in the same pipe. In these cases, outdoor water use that makes its way into the combined sewer does receive wastewater treatment. The W-E Calculator provides the opportunity to include wastewater treatment in the energy intensity of water used outdoors, as well.

[40] Navigant study, Table 11, p.28. Note that the Extraction and Conveyance water system component contains nine types of water resources. The energy intensities of these water resources are found in Table 3 of this Manual.

[41] Since the purpose of this Manual is not to critique the data or the methodologies used by the Navigant Team, but primarily to provide background, context and structure for understanding the design and operation of the W-E Calculator, descriptions of Water System Components and the Navigant team's recommended default energy intensities for each that are contained on pages 21-26 of this chapter were excerpted directly from the Navigant study with only minor edits where helpful to facilitate understanding.

Extraction and Conveyance

Extraction and Conveyance is defined as “the removal of water from its source and its relocation to the next water system component.” **Table D-4** below shows the default energy intensities recommended by the Navigant team for the state’s major water resources, expressed in kWh/AF.

Each of the types of water resources listed in **Table D-3** is described in the Navigant study and not repeated here.[42]

Table D-4. Total Electric Energy Intensity of Extraction and Conveyance for Each Hydrologic Region (kWh/AF)[43]

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

Supply Type Abbreviations:	Hydrologic Region Abbreviations:
CRA = Colorado River Aqueduct, CVP = Central Valley Project, SWP = State Water Project	NC = North Coast, SF = San Francisco Bay, CC = Central Coast, SC = South Coast, SR = Sacramento River, SJ = San Joaquin River, TL = Tulare Lake, NL = North Lahontan, SL = South Lahontan, CR = Colorado River

[42]Note that the Energy Intensity of Recycled Water is deemed to be zero within the Extraction and Conveyance component for all hydrologic regions. The reason for this is that the energy inputs that create Recycled Water are deemed to have been input during the wastewater treatment component.

[43] Navigant study, Table 7, p.26.

Treatment

"Treatment energy intensities vary by technology …

- Chlorination EI is relatively low as it requires minimal processing (mostly chemical injection and monitoring).
- Conventional potable treatment EI requires removal of solids and disinfection; water is pumped through multiple processes during treatment.
- Recycled water treatment using tertiary treatment and disinfection has an EI on the same order of magnitude as conventional potable treatment. Tertiary treated recycled water EI represents only the incremental treatment requirements beyond secondary wastewater treatment.
- Membrane treated recycled water has an even higher EI as high pressure pumps are used to force water through membranes in a reverse osmosis process.
- Brackish and ocean desalination also uses as reverse osmosis processes. Their EIs are respectively higher than membrane treated recycled water as the total dissolved solids (TDS) content of their sources are much higher. The higher the TDS, the more pressure (and energy) is required for the reverse osmosis process."[44]

Table D-5. Total Electric Energy Intensity of Treatment (kWh/AF)[45]

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[46]	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

[44] Navigant study, pp.26-27.

[45] Navigant study, Table 8, p.27.

[46] 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.

Distribution

"Distribution energy intensity was calculated by topography, broken down into flat, moderate, and hilly. The Navigant team assigned an assumed topography to each hydrologic region … EI for flat, moderate, and hilly areas progressively increase relative to one another. Hilly areas require pumping to higher pressures and elevations which results in increased energy use compared to moderate and flat areas."[47]

Table D-6. Total Electric Energy Intensity of Distribution (kWh/AF)[48]

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

[47] Navigant study, p.27.

[48] Navigant study, Table 9, p.27.

Wastewater

"Wastewater systems energy intensity encompasses both treatment and collection pumps …"[49]

Table D-7. Total Electric Energy Intensity of Wastewater Systems (kWh/AF)[50]

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

Computing the IOU Energy Intensity of Water for Indoor vs. Outdoor Water Use

Tables D-4, D-5 and D-6 contained herein (excerpted from the Navigant study and renumbered) represent the total amount of electricity for each type of water system component and **Table D-7** shows the default electric energy intensity of wastewater collection and treatment.

As explained previously, the total energy intensities were multiplied by the IOU% factors shown in **Table D-3** to estimate the amount of electricity that was estimated to have been provided by an energy IOU, and therefore eligible for recognition as a benefit to IOU energy ratepayers.

Once the default values were selected by water system component, values for all components were added together by type of water resource and hydrologic region to compute the energy intensity of water saved indoors. **Table D-8** on the next page shows how the W-E Calculator adds the default values for each water and wastewater system component to compute the Electric Intensity of Water Saved, Outdoors vs. Indoors. The Electric Intensity per unit of water saved is then used to calculate the amount of electricity deemed saved by measures that save water.

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[49] Navigant study, p.28.

[50] Navigant study, Table 10, p.28.

Table D-8. Calculating the Amount of Energy Saved by Saving a Unit of Water Outdoors vs. Indoors

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

The same process can be used to compute the amount of natural gas deemed embedded in water and wastewater. **Table D-9** below illustrates how the data collected and compiled through this study can be used to calculate the natural gas intensity of water used outdoors vs. indoors. **Table D-10** illustrates how the natural gas intensity of water and wastewater can then be used to calculate the amount of natural gas deemed embedded (and thereby saved) by reducing water consumption.

Table D-9. The Natural Gas Intensity of Water and Wastewater by Hydrologic Region

ILLUSTRATION: Marginal Supply = Recycled Water[51]

Region	Extraction and Conveyance	Treatment	Distribution	Wastewater Collection + Treatment	Outdoor (Upstream of Customer)	Indoor (All Components)
Central Coast	0	0	2.13	5.49	**2.13**	**7.62**
Colorado River	0	0	0.01	0.02	**0.01**	**0.03**
South Coast	0	0	1.61	2.37	**1.61**	**3.98**
South Lahontan	0	0	3.37	0.05	**3.37**	**3.42**
Tulare Lake	0	0	1.26	0.87	**1.26**	**2.13**

ILLUSTRATION: Marginal Supply = Groundwater[52]

Region	Extraction and Conveyance	Treatment	Distribution	Wastewater Collection + Treatment	Outdoor (Upstream of Customer)	Indoor (All Components)
Central Coast	0.91	0	2.13	5.49	**3.04**	**8.53**
Colorado River	0.03	0	0.01	0.02	**0.04**	**0.06**
South Coast	3.14	0	1.61	2.37	**4.75**	**7.12**
South Lahontan	2.63	0	3.37	0.05	**6.00**	**6.05**
Tulare Lake	0.34	0	1.26	0.87	**1.60**	**2.47**

[51] See Appendix F, Tables F-9 and F-11.

[52] See Appendix F, Tables F-8, F-9 and F-11.

Table D-10. Embedded Natural Gas Saved When Saving Water Outdoors vs. Indoors

***ILLUSTRATION*: Measure Saves 100,000 Gallons/Year OUTDOORS vs. INDOORS**

Region	Marginal Supply = Recycled Water (th/AF)		Embedded Natural Gas Saved (th/year)		Marginal Supply = Groundwater (th/AF)		Embedded Natural Gas Saved (th/year)	
	Outdoors[53]	Indoors[54]	Outdoors	Indoors	Outdoors[55]	Indoors[56]	Outdoors	Indoors
Central Coast	2.13	7.62	0.64	1.06	3.04	8.53	0.91	1.34
Colorado River	0.01	0.03	0.00	0.00	0.04	0.06	0.01	0.01
South Coast	1.61	3.98	0.49	0.96	4.75	7.12	1.45	1.93
South Lahontan	3.37	3.42	0.99	0.99	6.00	6.05	1.79	1.80
Tulare Lake	1.26	2.13	0.25	0.26	1.60	2.47	0.36	0.37

The above table computes embedded natural gas savings in therms/year when saving 100,000 gallons of water Outdoors vs. Indoors for two types of potential marginal water supplies: Recycled Water and Groundwater.

In Summary

1. The CPUC's W-E Calculator focuses on computing the electric energy intensity of water.
2. Placeholders have been provided for inputting natural gas energy intensities of water and wastewater; however, these values are only used to compute:
    a. Measure level embedded natural gas, which is then used to compute
    b. The avoided cost of natural gas saved by Measure and by Hydrologic Region.
3. Of the 29 worksheets within the W-E Calculator:
    a. Three (3) are used for general information and documentation (Information, Glossary and References).
    b. Fifteen (15) are used for compute cost-effectiveness. Functions performed by these worksheets are highly duplicative of the CPUC's existing cost effective tools, except for new water-related variables: the Avoided Capacity Cost of Water and Wastewater, and

[53] Only includes the Natural Gas Intensity of Potable Distribution – see Appendix F, Table F-9.
[54] Includes the Natural Gas Intensity of Potable Distribution and of Wastewater – see Appendix F, Tables F-9 and F-11.
[55] Includes the Natural Gas Intensity of Groundwater and Potable Water Distribution – see Appendix F, Tables F-8 and F-9.
[56] Includes the Natural Gas Intensity of Groundwater, Potable Water Distribution, and Wastewater – see Appendix F, Tables F-8, F-9 and F-11.

the Commodity Cost of Water. These new variables are used to calculate the avoided cost of saved water. They are not used to compute embedded energy.

c. Two (2) are used to document the results of the Navigant team's study about the average electric energy intensity of historical water supply portfolios (2014) for Water IOUs and for each of the ten hydrologic regions (Water IOU Data and Hist. Supply).

d. One (1) is used to compute Measure-Level Embedded Energy Savings (worksheet "Marg Elec EI by Measure"). The Marginal Electric Energy Intensity applies the Resource Balance Year to determine which portion of embedded energy savings is computed on the basis of the Historical Average Water Supply (i.e., energy savings that occur prior to the Resource Balance Year), and which portion is computed on the basis of the marginal water resource (Installation date >= Resource Balance Year).

The remaining 8 worksheets in the W-E Calculator document the default values by system component and the resultant energy intensities of water and wastewater by hydrologic region.

Given that:

1. Water sector use of natural gas is distinctly different from electric;
2. The computation of the natural gas intensity of water and wastewater is very simple; and
3. Documenting the natural gas intensity of water and wastewater separately from electric and outside of the CPUC's W-E Calculator will enhance transparency, consistency and a clear audit trail,

There is no need to incur additional time and costs associated with integrating natural gas into the CPUC's existing W-E Calculator.

APPENDIX E

Water-Energy Calculator Glossary,

Abbreviations and Acronyms

and Shorthands

Appendix E

Water-Energy Calculator Glossary, Abbreviations and Acronyms, and Shorthands

<u>Sources</u>:

- CPUC Water Energy Calculator version 1.05, Worksheet named "Glossary" (supplemental information provided herein to provide additional background and context where deemed beneficial).
- *Water/Energy Cost Effectiveness Analysis, Revised Final Report Prepared for the California Public Utilities Commission*, Navigant Consulting, Inc. in collaboration with GEI Consultants, April 2015 [hereafter referred to as "Navigant study".

Term	Calculator Definitions	Supplemental Information
GENERAL		
Acre-Foot	The volume of water that would cover one acre to a depth of one foot.	Typically applied to quantities of wholesale water. One acre-foot is equivalent to 43,560 cubic feet, or 325,851 gallons.
avoided capacity cost	Costs incurred to overcome a potential scarcity of resources (i.e. a shortage) or provide the ability to provide service on demand to customers.	See Chapter 6 References: CPUC Policies and Practices for definitions of the avoided cost of capacity and energy.
avoided energy cost	Costs incurred to provide a unit of energy to customers.	
brackish water	Water with a salinity that exceeds normally acceptable standards for municipal, domestic, and irrigation uses, but less than that of seawater.	See California Water Plan Update 2013, Volume 3 Resource Management Strategies, Chapter 10 Desalination (Brackish and Sea Water).[57]
desalination	Water treatment process for the removal of salt from water for beneficial use. Source water can be brackish (low salinity) or seawater	
embedded energy savings	The amount of energy that is saved in the water system as a result of reduced water use.	In context of the CPUC's W-E Calculator, it is the sum of energy inputs to any particular water resource, from the point of collection and/or production, up to the point of (but not including) use/consumption.

[57] Department of Water Resources' website: http://www.water.ca.gov/waterplan/docs/cwpu2013/Final/Vol3_Ch10_Desalination.pdf

Term	Calculator Definitions	Supplemental Information
energy intensity (EI)	The average amount of energy needed to transport or treat water or wastewater on a per unit basis (kilowatt hours per acre-foot of water [kWh/AF] or therms per acre-foot of water [therms/AF]).	In context of the CPUC's W-E Calculator, EI is a benchmark of the average amount of energy per unit of water deemed "embedded" in that water. It includes all energy inputs to water, including "production", transport of wholesale water supplies, water treatment, and delivery to the end user (water customer).
energy load profile	The hourly variation in energy use over the course of a day.	The W-E Calculator employs a Water Savings Profile to allocate annual water volumes by month. Three default profiles ("Constant", "Irrigation" and "Cooling Tower") are provided, with the ability for up to 5 additional user-defined monthly profiles.
environmental benefits	Environmental services from water that is left in the environment to serve other purposes (wildlife habitats, recreation, etc.).	The W-E Calculator includes a new benefit: the estimated value of incremental environment benefits attributable to reduced water consumption.[58]
marginal water supply	The next increment or unit of water supply developed within a region to meet demand in the absence of water conservation and efficiency.	In resource planning, whether water or energy, the "marginal" supply is the last resource needed in order to meet demand.
resource balance year	the year in which new capacity will be required to meet water demand	For energy: the year that new capacity is deemed needed to maintain planning reserve margins to reliably meet load.[59]
WATER TERMS		
WATER SUPPLIES		
Local Deliveries	Water delivered by local water agencies and individuals. It includes direct deliveries of water from stream flows, as well as local water storage facilities.	"Local" is defined as within a single hydrologic region.
Local Imported Deliveries	Water transferred by local agencies from other regions of the state.	"Imported" is defined as originating in a hydrologic region other than that in which the water will be used/consumed.
Colorado River Aqueduct (CRA)	Water diverted from the Colorado River by the Metropolitan Water District of Southern California, Imperial Irrigation District, Coachella Valley Water District, Palo Verde Irrigation District, the Yuma Project, and others under California's entitlement to use Colorado River Water.	See Quantification Settlement Agreement for more information.
Central Valley Project (CVP) and Other Federal Deliveries	Project water delivered to Central Valley Project contractors, and from federal projects other than the Central Valley Project.	See Central Valley Project website for information about its resources, systems and facilities.
State Water Project (SWP)	Project water delivered to State Water Project contractors.	See State Water Project website for information about its resources, systems and facilities.
Groundwater	Water located beneath the earth's surface in soil pore spaces and in the fractures of rock formations.	See Department of Water Resources website: Groundwater.
Recycled Water	The application of treated water/reclaimed	See Department of Water Resources website: Recycling.

[58] Navigant study, Table 22. Components of Possible Updated CPUC Cost Effectiveness Framework.

[59] Resolution E-4801 Adopts updates to the Avoided Cost Calculator for use in demand-side distributed energy resources cost effectiveness analyses, California Public Utilities Commission, September 29, 2016, p.6.

Term	Calculator Definitions	Supplemental Information
	water to meet a beneficial use, supplanting a potable or potentially potable supply.	
Seawater Desalination	Water coming from seawater that is desalted by reverse osmosis or other processes.	California Water Plan Update 2013, Volume 3, Chapter 10 Desalination (Brackish and Sea Water).
Brackish Desalination	Water coming from groundwater that is desalted by reverse osmosis or other processes.	
WATER SYSTEM COMPONENTS		
Extraction and Conveyance	The removal of water from its source and its relocation to the next water system component.	The removal of water from its source and its relocation ("conveyance") to the next water system component.[60]
Treatment	The treatment of a water supply such that it can be delivered to customers.	Treatment energy intensity varies with technology and level of treatment needed.[61]
Distribution	System of ditches or conduits and their controls that conveys water from the supply canal to the farm points of delivery	For urban water systems, distribution includes small reservoirs and tanks, booster pumps and pipes used to deliver potable water to end users.
Wastewater Systems	The systems that both collect and treat water leaving the customer site.	Collection and treatment of water post-use.
MEASURE SPECIFIC INPUTS		
Measure Specific Inputs	Inputs specific to each measure that should be entered on a per-unit basis (e.g., per low flow shower head).	The W-E Calculator provides room for up to 20 measures.
Measure ID#	A tracking number used by the Calculator.	
Measure Name	Identifier that will be displayed with the results, but has no bearing on the analysis.	
Annual Water Savings (gallons)	Amount of water saved each year.	
Measure Life (years)	An estimate of the median number of years that the measure installed will remain in place and operable.	
Installation Year	The year the measure will be implemented and begin to save water.	
Savings Profile	The profile of monthly variation in water savings over the course of a year.	The W-E Calculator contains 3 default water use profiles: "Constant", "Irrigation" and "Cooling Tower"; also allows up to 5 user-defined profiles.
Hydrologic Region	A geographical division of the state based on the local hydrologic basins. The Department of Water Resources divides California into 10 hydrologic regions, corresponding to the state's major water drainage basins.	The 12 counties served by SoCalGas fall within 5 hydrologic regions: Central Coast, Tulare Lake, South Lahontan, South Coast, and Colorado River.[62]

[60] Navigant study, section 2.3.2 Energy Intensity Data, p.24.

[61] Navigant study, pp. 26-27.

[62] See Figure 8. Overlay of SoCalGas' Service Area with Hydrologic Regions and DEER Climate Zone.

Term	Calculator Definitions	Supplemental Information
Sector	Sector implementing the measure - either urban or agriculture.	The W-E Calculator provides the ability to enter different energy intensities for water used by 2 different sectors on the premise that the quality of water needed for Ag vs. Urban may differ.
Water Use	End-use of saved water - either indoor or outdoor.	Water used for indoor purposes is deemed to have a higher energy intensity (EI) because used water is discharged to wastewater systems for treatment before discharge to the environment, while outdoor water use bypasses wastewater treatment.[63]
Rebate ($)	Amount of money provided to the customer by the utility for implementing the measure.	Measure costs (net of any applicable water and/or energy rebates) can be input by the user for up to 20 measures.
Installation Cost ($)	Cost to install the measure.	
Incremental Equipment Cost ($)	Cost of the efficient equipment being installed minus the cost of the baseline equipment.	
Program Administration Cost ($)	Cost to the utility of administering the program installing the measure.	

[63] Navigant study, section 2.2.1.1 Average Embedded Energy Savings.

Abbreviations and Acronyms

Abbreviation/Acronym	Definition
AF	Acre-foot
CEC	California Energy Commission
CET	Cost-Effectiveness Tool
CPUC	California Public Utilities Commission
CRA	Colorado River Aqueduct
CUWCC	California Urban Water Conservation Council
CVP	Central Valley Project
Desal	Desalination
DRA	Division of Ratepayer Advocates
E3	Energy + Environmental Economics (consultant to CPUC)
EE	Energy Efficiency
EI	Energy Intensity
EUL	Estimated Useful Life
GHGs	Greenhouse Gas Emissions
IOU	Investor Owned Utility
kWh	Kilowatt hour
MG	Million Gallons
MWD	Metropolitan Water District of Southern California
MWh	Megawatt hour
N.Gas	Natural Gas
ORA	Office of Ratepayer Advocates
PA	Program Administrator
RPS	Renewable Portfolio Standard
SoCalGas	Southern California Gas Co.
SWP	State Water Project
W-E	Water-Energy
W/WW	Water and/or Wastewater
WW	Wastewater

Calculator Shorthands

Shorthand	Definition
AC	Avoided Cost(s)
AVG	Average
BEN	Benefit(s)
ELEC	Electric
ENV	Environmental
HIST	Historical
MARG	Marginal
SVGS	Savings

Appendix F

Data Tables and Computations

Appendix F

Data Tables and Computations

Table F-1. Water Demand and Population by Hydrologic Region (CY2010)

Hydrologic Region	Population (CY2010)	Source	Water Demand (TAF) in CY2010*		
			Urban	Ag	Total
Central Coast	1,507,945	Table CC-8	305	895	1,200
Colorado River	747,100	pg. CR-34	696	3,836	4,532
South Coast	19,579,208	Table SC-7	3,541	645	4,186
South Lahontan	930,800	pg. SL-36	280	385	665
Tulare Lake	2,267,335	Table TL-9	668	10,663	11,331
Annual Water Demand (TAF)	**25,032,388**		**5,490**	**16,424**	**21,914**

Source: Department of Water Resources (DWR) Water Plan Update 2013

Table F-2. Water Supplies by Hydrologic Region (CY2010)

Hydrologic Region	Source	Water Supplies (TAF) in CY2010*						
		Local	CRA	Federal	State	G.Water	Recycled	Total
Central Coast	Regional Water Balance by Year Tables (TAF)	23	0	112	22	999	3	1,159
Colorado River		2	3,661	0	5	338	16	4,022
South Coast		489	990	1	830	1,408	204	3,922
South Lahontan		53	0	0	106	413	1	573
Tulare Lake		2,785	0	2,021	979	5,537	0	11,322
Annual Water Supplies (TAF)		**3,352**	**4,651**	**2,134**	**1,942**	**8,695**	**224**	**20,998**

Source: DWR Water Plan Update 2013

Table F-3. Water Sector Therms by Hydrologic Region and NAICS Code (CY2015)

Hydrologic Region	Therms by NAICS Code (CY2015)			Population	Area (sq. miles)
	Water 221310	Wastewater 221320	Total Therms		
Central Coast	908,554	418,894	1,327,448	1,020,600	39,037
Colorado River	15,940	5,755	21,695	175,425	6,278
South Coast	7,522,719	2,730,529	10,253,248	6,713,944	823,534
South Lahontan	867,782	3,038	870,820	362,905	3,605
Tulare Lake	2,999,406	231,607	3,231,013	527,720	7,434
Totals	**12,314,401**	**3,389,838**	**15,054,893**	**8,800,889**	**879,931**

Sources:

[1] SoCalGas Data Extract: Annual Therms by NAICS Code

[2] Population and Area by Zipcode from 2010 U.S. Census

[3] Database of Zipcodes by DWR Hydrologic Regions provided by California Investor-Owned Utilities' Water-Energy Nexus Committee

[4] Database of Zipcodes for DEER Climate Zones from California Energy Commission

Table F-4. Portion of Water Demand Served by Water Utility Customers of SoCalGas (CY2010)

Hydrologic Region	Estimated % of Region Served by Water Utility Customers of SoCalGas	*ALLOCATED* Water Demand (TAF) [CY2010 per 2013 Water Plan Update * SoCalGas%]		
		Urban	Agricultural	Total Demand
Central Coast	50%	153	448	600
Colorado River	85%	592	3,261	3,852
South Coast	65%	2,302	419	2,721
South Lahontan	40%	112	154	266
Tulare Lake	80%	534	8,530	9,065
Annual Water Demand Served by Water Utility Customers of SoCalGas (TAF)		**3,692**	**12,812**	**16,504**

Sources:

[1] DWR Water Plan Update 2013

[2] Estimated % of Region served by Water Utility Customers of SoCalGas based on visual inspection of therm sales by zipcode provided by SoCalGas

[3] Allocated Water Demand (TAF) computed as Total Regional Water Demand per DWR Water Plan Update 2013 * Estimated % of Region

Table F-5. Estimated Quantity of Water Demand by Region Met by Water Utility Customers of SoCalGas (CY2010)[64]

Hydrologic Region	Groundwater% [Estimated % of Agricultural Water Met by Groundwater]	Source	*ALLOCATED* Agricultural Water Demand (TAF) [CY2010 per 2013 Water Plan Update * Groundwater%]	
			Quantity of Agricultural Water Demand Met by Water Utility Customers of SoCalGas	Adjusted Quantity of Agricultural Water Demand met by Groundwater from Water Utility Customers of SoCalGas
Central Coast	91%	Vol. 2 Regional Reports, p. CC-57	448	407
Colorado River	1%	Vol. 2 Regional Reports, p. CR-43	3,261	33
South Coast	54%	Vol. 2 Regional Reports, p. SC-48	419	226
South Lahontan	72%	Vol. 2 Regional Reports, p. SL-43	154	111
Tulare Lake	51%	Vol. 2 Regional Reports, p. TL-44	8,530	4,351
Annual Quantity of Groundwater Est. Pumped by Water Utility Customers of SoCalGas (TAF)			**12,812**	**5,128**

Sources:

[1] DWR Water Plan Update 2013, Vol. 2 Regional Reports

[2] Estimated % of Region served by Water Utility Customers of SoCalGas based on visual inspection of therm sales by zipcode provided by SoCalGas

[3] Allocated Water Demand (TAF) computed as Total Regional Agricultural Water Demand per DWR Water Plan Update 2013 * Estimated % of Region

[64] Groundwater percentage was used to identify the estimated quantity of water used to meet agricultural water demand that would have been eligible for pumping with natural gas. (Most of the additional water used to meet agricultural water demand was from surface reservoirs or waterways; and in many cases, imported via inter-basin state and federal wholesale water projects.)

Table F-6. Adjusted Quantity of Water Demand Met by Water Utility Customers of SoCalGas (CY2010)

Hydrologic Region	*ALLOCATED* Water Demand (TAF) [CY2010 per 2013 Water Plan Update * SoCalGas%]		
	Urban [Table F-4]	Agricultural [Table F-5]	Total Demand
Central Coast	153	407	560
Colorado River	592	33	625
South Coast	2,302	226	2,528
South Lahontan	112	111	223
Tulare Lake	534	4,351	4,885
Adjusted Annual Water Demand Served by Water Utility Customers of SoCalGas (TAF)	**3,692**	**5,128**	**8,820**

Sources:

[1] Allocated Quantity of Urban Water Demand (TAF) Met by Water Utility Customers of SoCalGas [see Table F-4]

[2] Allocated Quantity of Agricultural Water Demand (TAF) Met by Water Utility Customers of SoCalGas [see Table F-5]

Table F-7. Adjusted Quantity of Water Supplies Provided by Water Utility Customers of SoCalGas (CY2010)

Hydrologic Region	Estimated % of Region Served by Water Utility Customers of SoCalGas	Water Supplies (TAF) in CY2010*						
		Local	CRA	Federal	State	G.Water	Recycled	Total
Central Coast	50%	12	0	56	11	500	2	**580**
Colorado River	85%	2	3,112	0	4	287	14	**3,419**
South Coast	65%	318	**149**	1	540	**1,197**	133	**2,336**
South Lahontan	40%	21	0	0	42	165	1	**229**
Tulare Lake	80%	2,228	0	1,617	783	4,430	0	**9,058**
Annual Water Supplies (TAF)		**2,580**	**3,260**	**1,673**	**1,380**	**6,578**	**148**	**15,621**

Sources:

[1] DWR Water Plan Update 2013 and Table F-2. Water Supplies by Hydrologic Region

[2] Estimated % of Region Served by Water Utility Customers of SoCalGas from Table F-4

[3] Additional Adjustments for South Coast Hydrologic Region:

- About 65% of the South Coast Hydrologic is served by SoCalGas; the other 35% is served by SDG&E.
- The area served by SDG&E receives most of its water from the Colorado River Aqueduct (CRA); very little groundwater is available within that part of the region. Conversely, the area served by SoCalGas has substantial quantities of groundwater; very little water is provided from the CRA.

CRA supplies delivered to the South Coast Hydrologic Region were allocated 15% to SoCalGas and 85% to SDG&E. Groundwater supplies were allocated 85% to SoCalGas and 15% to SDG&E.

The results of these additional South Coast Hydrologic Region adjustments for CRA and Groundwater shown in **RED** text.

Table F-8. Average Natural Gas Intensity of Groundwater (CY2015)

Hydrologic Region	[A] Total CY2015 Therms (NAICS 221310)	Groundwater Pumping		
		[A]*50%=[B] Allocated CY2015 Therms (50%)	[C] Est. Quantity of Groundwater Pumped (TAF)	[B]÷[C]=[D] Avg. NGas Intensity (therms/AF)
Central Coast	908,554	454,277	500	**0.91**
Colorado River	15,940	7,970	287	**0.03**
South Coast	7,522,719	3,761,360	1,197	**3.14**
South Lahontan	867,782	433,891	165	**2.63**
Tulare Lake	2,999,406	1,499,703	4,430	**0.34**
Totals	**12,314,401**	**6,157,201**	**6,578**	

Sources:

[1] Quantity of Annual Therms [NAICS 221310] estimated at 50% of CY2015 water sector natural gas usage based on data provided by participating water utilities

[2] Annual Quantity of Groundwater Pumped from Table F-7

[3] Average Natural Gas Intensity of Groundwater = Allocated CY2015 Therms ÷ Est. Quantity of Groundwater Pumped

Table F-9. Average Natural Gas Intensity of Potable Water Distribution (CY2015)

Hydrologic Region	[A] Total CY2015 Therms NAICS 221310	[A]*50%=[B] Allocated CY2015 Therms (50%)	Potable Distribution Pumping			
			[C] Urban Water Demand @ 100% (TAF)	[D] Ag. Water Demand @ 15% (TAF)	[C]+[D]=[E] Urban + Ag. Water Distributed (TAF)	[B]÷[E] Avg. NGas Intensity (th/AF)
Central Coast	908,554	454,277	153	61	214	**2.13**
Colorado River	15,940	7,970	592	5	597	**0.01**
South Coast	7,522,719	3,761,360	2,302	34	2,336	**1.61**
South Lahontan	867,782	433,891	112	17	129	**3.37**
Tulare Lake	2,999,406	1,499,703	534	653	1,187	**1.26**
Totals	**12,314,401**	**6,157,201**	**3,692**	**769**	**4,461**	

Sources:

[1] Quantity of Annual Therms [NAICS 221310] estimated at 50% of CY2015 water sector natural gas usage based on data provided by participating water utilities

[2] Annual Quantity of Groundwater Pumped from Table F-7

[3] Average Natural Gas Intensity of Potable Distribution Pumping = Allocated CY2015 Therms ÷ (Urban + Ag. Water Distributed)

Table F-10. Average Natural Gas Intensity of Water Using Allocated Urban Water Demand and Adjusted Agricultural Water Demand (CY2015)

Hydrologic Region	[A] Total CY2015 Therms (NAICS 221310)	[B] Allocated Urban Water Demand (TAF)	[C] Allocated Adjusted Ag. Water Demand (TAF)	[B]+[C]=[D] Total Water Demand Served by Water Utility Customers of SoCalGas (TAF)	[A]÷[D] Average Natural Gas Intensity of Water Demand Served by Water Utility Customers of SoCalGas (therms/AF)
Central Coast	908,554	153	407	560	**1.62**
Colorado River	15,940	592	33	625	**0.03**
South Coast	7,522,719	2,302	226	2,528	**2.98**
South Lahontan	867,782	112	111	223	**3.89**
Tulare Lake	2,999,406	534	4,351	4,885	**0.61**
Totals	**12,314,401**	**3,692**	**5,128**	**8,820**	

Sources:

[1] Quantity of Annual Water Sector Therms [NAICS 221310] for CY2015

[2] Allocated Urban Water Demand from Table F-4

[3] Allocated Adjusted Agricultural Water Demand from Table F-5

[4] Average Natural Gas Intensity of Water Demand Served by Water Utility Customers of SoCalGas = CY2015 Therms (NAICS 221310) ÷ Total Water Demand Served by Customers of SoCalGas

Table F-11. Average Natural Gas Intensity of Wastewater (CY2015)

Hydrologic Region	[A] Total CY2015 Therms (NAICS 221320)	[B] Allocated Urban Water Demand (TAF)	[B]*50% = [C] Est. Quantity of Wastewater (TAF)	[A]÷[C]=[D] Average Natural Gas Intensity of Wastewater (therms/AF)
Central Coast	418,894	153	77	**5.49**
Colorado River	5,755	592	296	**0.02**
South Coast	2,730,529	2,302	1,151	**2.37**
South Lahontan	3,038	112	56	**0.05**
Tulare Lake	231,607	534	267	**0.87**
Totals	**3,389,838**	**3,692**	**1,846**	

Sources:

[1] Quantity of Annual Water Sector Therms [NAICS 221320] for CY2015

[2] Allocated Urban Water Demand from Table F-4

[3] Quantity of Wastewater estimated at 50% of Urban Water Demand

[4] Average Natural Gas Intensity of Wastewater = CY2015 Therms (NAICS 221320) ÷ Est. Quantity of Wastewater

Table F-12. Average Natural Gas Intensity of Water Saved Outdoors vs. Indoors (CY2015)

Hydrologic Region	[A] Average Natural Gas Intensity of Water (therms/AF)	[B] Average Natural Gas Intensity of Wastewater (therms/AF)	[A] = [C] Average Natural Gas Intensity of Water Saved Outdoors (therms/AF)	[A]+[B]=[D] Average Natural Gas Intensity of Water Saved Indoors (therms/AF)
Central Coast	1.62	5.49	1.62	7.12
Colorado River	0.03	0.02	0.03	0.04
South Coast	2.98	2.37	2.98	5.35
South Lahontan	3.89	0.05	3.89	3.95
Tulare Lake	0.61	0.87	0.61	1.48

Sources:

[1] Average Natural Gas Intensity of Water from Table F-10

[2] Average Natural Gas Intensity of Wastewater from Table F-11

[3] Average Natural Gas Intensity of Water Saved Outdoors = Average Natural Gas Intensity of Water

[4] Average Natural Gas Intensity of Water Saved Indoors = Average Natural Gas Intensity of Water + Average Natural Gas Intensity of Wastewater

Table F-13. Natural Gas Intensity of Water and Wastewater within SoCalGas' Service Area – High Level Averaging Method (CY2015)

Table F-13A. Total Water-Related Therms Divided by Total Water Demand Allocated to SoCalGas

[A] Total CY2015 Therms (NAICS 221310)	[B] Total Urban Water Demand Allocated to SoCalGas (TAF)	[C] Total Agricultural Water Demand Allocated to SoCalGas, Adjusted for Groundwater Only (TAF)	[B]+[C]=[D] Total Water Demand Allocated to SoCalGas (TAF)	[A]÷[D]=[E] Average Natural Gas Intensity of Water (therms/AF)
12,314,401	3,692	5,128	8,820	1.40

Sources:

[1] Quantity of Annual Water Sector Therms [NAICS 221310] for CY2015

[2] Allocated Urban Water Demand from Table F-4

[3] Allocated Adjusted Agricultural Water Demand from Table F-5

Table F-13B. Total Wastewater-Related Therms Divided by Total Wastewater Allocated to SoCalGas

[A] Total CY2015 Therms (NAICS 221320)	[B] Total Urban Water Demand Allocated to SoCalGas (TAF)	[C] Estimated Quantity of Wastewater from Urban Water Use (TAF)	[A]÷[C]=[D] Average Natural Gas Intensity of Wastewater (therms/AF)
3,389,838	3,692	1,846	1.84

Sources:

[1] Quantity of Annual Water Sector Therms [NAICS 221320] for CY2015

[2] Allocated Urban Water Demand from Table F-4

[3] Est. Quantity of Wastewater from Table F-11

Table F-13C. Natural Gas Intensity of Outdoor vs. Indoor Water Saved (High Level Averaging Method)

[A] Natural Gas Intensity of Water (TAF)	[B] Natural Gas Intensity of Wastewater (TAF)	[A=[C] Natural Gas Embedded in Water Saved Outdoors (therms/AF)	[A]+[B]=[D] Natural Gas Embedded in Water Saved Indoors (therms/AF)
1.40	1.84	1.40	3.24

Sources:

[1] Average Natural Gas Intensity of Water from Table F-13A, Column [E]

[2] Average Natural Gas Intensity of Wastewater from Table F-13B, Column [D]

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

Issues and Opportunities

April 17, 2017

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.

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[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").

[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.

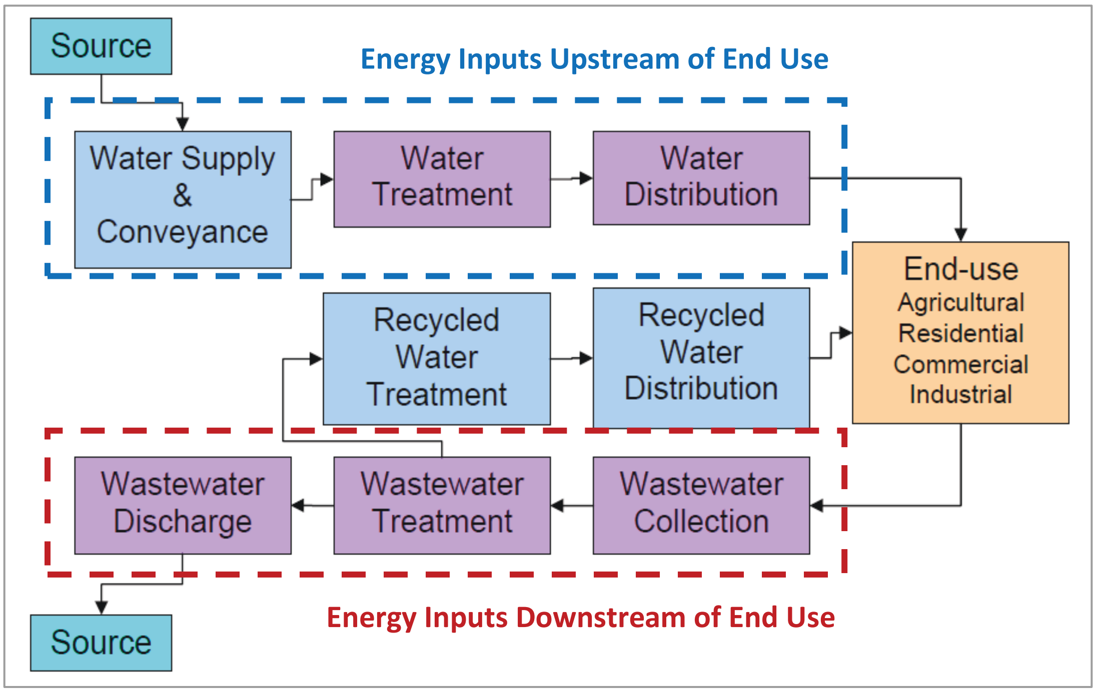

Figure 1. California's Water Use Cycle [Red and Blue dotted lines and titles added by WEI][3]

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. Default Values Used to Compute Embedded Energy

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]
<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**

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. **Water and Wastewater Treatment Energy Intensity** 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. **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.

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.

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[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.

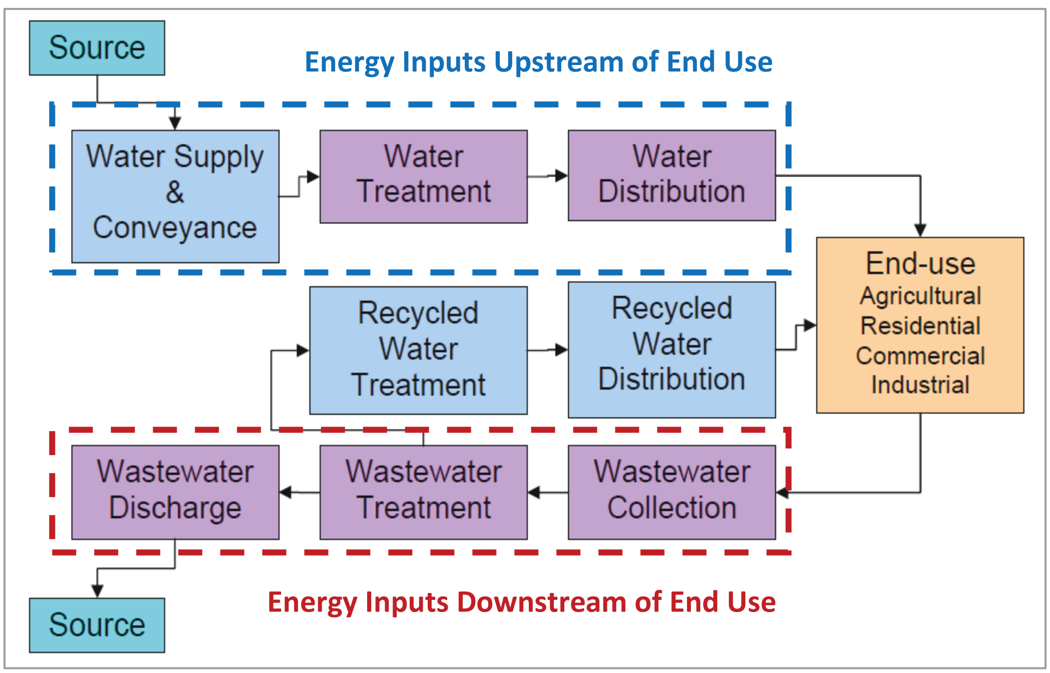

Figure 1. California's Water Use Cycle [Red and Blue dotted lines and titles added by WEI][17]

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

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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.

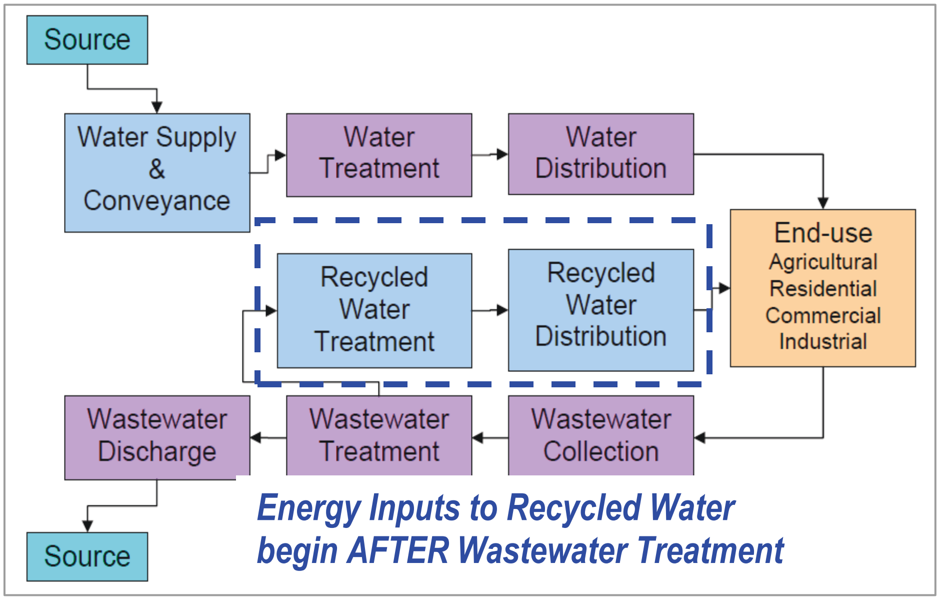

Figure 2. The Energy Intensity of Recycled Water

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. <u>Energy Intensity of Tertiary Wastewater Treatment included in Water Treatment Technology</u>.[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

<u>Issues and Options</u>

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.

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[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]

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[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.

[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.

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

   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]
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

3. **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. **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

[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. **<u>Distribution Energy Intensity</u>** 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. **<u>Water and Wastewater Treatment Energy Intensity</u>** 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. **<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.