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Water-Energy Cost Effectiveness Analysis

Public Workshop

October 14, 2014

DISPUTES & INVESTIGATIONS • ECONOMICS • FINANCIAL ADVISORY • MANAGEMENT CONSULTING

Content of Report

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October 14, 2014

1. **Overview of Study Goals**
2. Defining Cost Effectiveness
3. Overview of Methodology
4. Review Default Model Assumptions
5. The Water-Energy Calculator
6. Example Analysis

The goal of our research effort is to develop a method of valuing the monetary benefits of water savings via CPUC cost effectiveness tests.

- CPUC decision 12-05-01 stated it is *"not prudent to spend significant amounts of [energy] ratepayer funds on expanded water-energy nexus programs until the cost-effectiveness of these programs, and particularly the net benefits that accrue to energy utility ratepayers, are better understood."*
- This analysis asks: what future costs associated with water and energy infrastructure can be avoided as a result of water conservation?

California energy IOUs can already rebate high efficiency clothes washers …

… does it benefit energy ratepayers for IOUs to rebate high efficiency toilets?

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Objective: develop tools that can be used to augment existing Cost Effectiveness (CE) frameworks to include consideration of water.

- Existing cost effectiveness frameworks value “Site Energy” savings using the avoided cost (AC) of electricity and natural gas.

$$Benefit\ Cost\ Ratio = \frac{Site\ Energy\ AC}{Equipment\ Cost + Program\ Cost}$$

Where:

$$Site\ Energy\ AC = Site\ Energy\ Savings\ x\ Avoided\ Cost\ of\ Energy$$

- Modifications to the benefits portion of the equation are needed to account for water savings.

$$Benefit\ Cost\ Ratio = \frac{Site\ Energy\ AC + Embedded\ Energy\ AC + Water\ Capacity\ AC + Environmental\ Benefits}{Equipment\ Cost + Program\ Cost}$$

Scope of the study: examine three benefits of water efficiency not previously considered by the CPUC cost-effectiveness framework.

- Three added benefits
  - **Avoided Cost of Embedded IOU Energy in Water.** The economic value (in dollars) from embedded energy savings.
  - **Avoided Costs of Water Capacity.** The economic value (in dollars) from the avoided investment and fixed operating cost in constructing and operating new capacity in water supply and treatment infrastructure.
  - **Environmental Benefits of Reduced Water Use.** The economic value (in dollars) of environmental services from water that is left in the environment to serve other purposes (e.g., wildlife habitats, instream flows, etc.).
- The scope our study did not include the avoided commodity cost of water
- Scoped with:
  - Developing a set of models and calculators to enable the estimation of these three additional benefits.
  - Populating these models and calculators with reasonable default assumptions based on available secondary data and interviews with experts.

The tools developed in this study should be used to primarily inform energy utility efficiency programs.

- Intended uses:
  - Estimate the IOU and non-IOU embedded energy savings that result from joint water-energy programs
  - Assess the benefits that accrue to energy utilities and to water utilities from programs and measures that save both energy and water
  - Determine if incentivizing measures and programs that save both energy and water is a cost effective use of IOU energy utility funds
- This study does:
  - **not** require publicly owned utilities or municipal utilities to use these tools
  - **not** require water utilities to change their water supply planning decisions
  - **not** require water utilities to fund water efficiency programs
  - **not** require energy utilities to fund water efficiency programs (requirements would come from a CPUC decision)
  - **not** require water utilities to report their energy use
  - **not** dictate any goal or mandate for the level of funding, water savings, or energy savings for joint water energy programs from either energy or water utilities
  - **not** consider avoided commodity cost of water

Cost effectiveness is a minimum threshold that the CPUC requires for an energy utility to pay an incentive for an energy efficiency measure.

- An energy efficiency measure or program is cost effective if its energy benefits exceed its costs over the life of the measure/program.
- Note that cost effectiveness is an ***estimate*.**
- What cost effectiveness informs:
  - If programs are not proven cost effective to energy IOU ratepayers, then IOU energy ratepayer funds generally cannot be used to fund the programs.
  - If programs or measures are deemed cost effective, there is no requirement that the program has to be funded or the measure has to be incentivized.
- Program design and funding decisions are still in the hands of the utilities.

There are multiple cost effectiveness tests that can be used in California.

» **Total Resource Cost (TRC) Test** - net costs of a demand-side management program as a resource option based on the total costs of the program, including both the participants' and the utility's costs.

» **Program Administrator Cost (PAC) Test** – the net costs of a demand-side management program as a resource option based on the costs incurred by the program administrator (i.e. the utility) excluding any net costs incurred by the participant.

» **Participant Test** - measure of the quantifiable benefits and costs to the customer due to participation in a program.

» **Ratepayer Impact Measure (RIM) Test** – measure of what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program.

The primary test currently used for California energy efficiency programs is the TRC test.

Comparison of Current Cost Effectiveness Tests

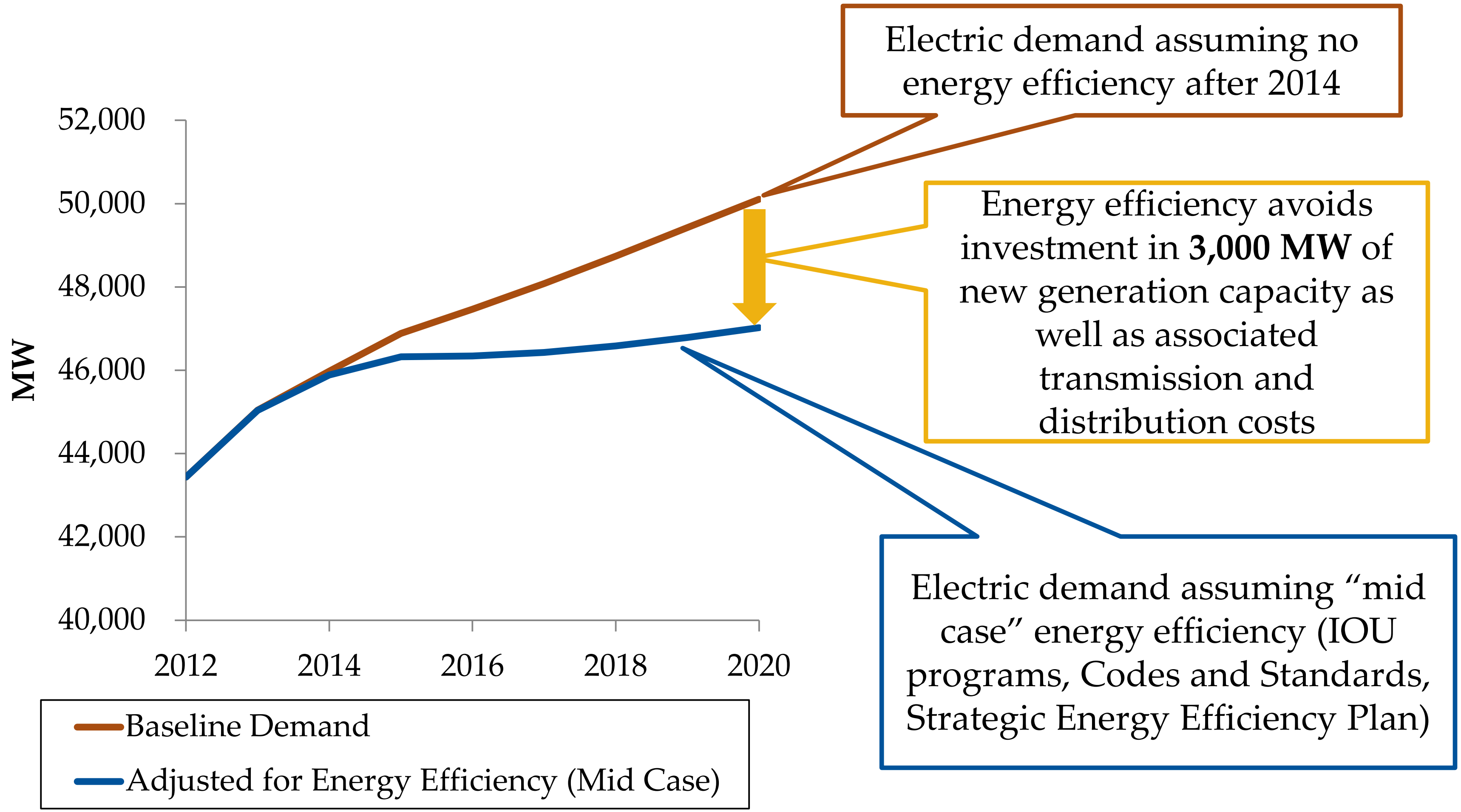
	Benefit/Cost Test			
Component	**TRC**	**PAC**	**RIM**	**Participant**
Administrative costs to energy utility	Cost	Cost	Cost	
Avoided costs of supplying electricity and natural gas*	Benefit	Benefit	Benefit	
Energy and water bill Reductions				Benefit
Capital (measure) costs to participant	Cost			Cost
Capital (measure) costs to energy utility	Cost	Cost	Cost	
Incentives paid by energy utility		Cost	Cost	Benefit
Increased supply costs	Cost	Cost	Cost	
Revenue loss from reduced energy sales			Cost	
Tax credits	Benefit			Benefit

***Primary benefit in most tests**

Avoided costs represent the costs the utility would incur to produce new resources in the absence of efficiency programs.

- Efficiency reduces, defers, or eliminates new resource infrastructure investments, and these saving are referred to as avoided costs.
- Avoided costs contain consideration of both fixed costs (including both capital and fixed operations and maintenance [O&M]) as well as variable costs (variable O&M).
- Components of California's electric avoided costs:
  - Fuel (Energy)
  - Generation Capacity
  - Transmission and Distribution
  - Ancillary Services
  - System Losses
  - Emissions
  - Avoided Renewable Portfolio Standard
- Avoided **capacity** cost analysis specifically focuses on avoiding the next increment of **capacity** needed to serve the system.

Below is a simplified interpretation of how California's electric sector values energy efficiency savings.



CEC. *California Energy Demand 2014–2024 Final Forecast*. January 2014

The avoided cost of electricity places an economic value on each unit of energy saved (avoided investment in generation, transmission, etc.)

- Standard practice assumes energy efficiency reduces reliance of energy supply "on the margin" (i.e. the Marginal Electric Supply)
- Energy efficiency avoids development of the **<u>next</u>** power plant
- While certain types of power plants are being phased out as a result of policy decisions, these are not considered to be the marginal supply

Avoided cost analyses look at the next resource that would be developed in the absence of efficiency. It does not look at the last increment of resource used.

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Standard practice in California avoided cost analysis is to assume efficiency reduces the reliance on a "proxy" resource (i.e. an assumed marginal technology).

The CPUC currently maintains two core tools to assist the energy utilities in determining the cost effectiveness of energy efficiency programs.

- CPUC Demand Side Avoided Cost Calculator (based on proxy plants)
  - Determines the avoided costs of supplying electricity and natural gas on a per unit basis ($/kWh and $/Therm)
  - Maintains a common set of assumptions about the cost and operation parameters of the proxy resources
  - Outputs avoided costs, these avoided costs serve as inputs to the cost effectiveness calculator
- E3 Cost Effectiveness Calculator
  - Incorporates all costs and benefits to estimate cost effectiveness
  - Users input details about the efficiency measures (savings, cost, lifetime, etc.)
  - Calculator values energy savings using the avoided costs
- These existing tools do not consider the benefits of water savings

1. Overview of Study Goals
2. **Defining Cost Effectiveness**
   - A. Current Framework
   - B. **Updating to Include Water**
3. Overview of Methodology
4. Review Default Model Assumptions
5. The Water-Energy Calculator
6. Example Analysis

This study examines three added benefits of water efficiency, these benefits could be added to the existing Cost Effectiveness Calculator.

Avoided Embedded IOU Energy in Water

- The economic value (in dollars) from embedded energy savings.
- We focus only on IOU embedded energy savings as these savings will result in benefits to the energy IOU ratepayers.

Avoided Costs of Water Capacity

- The economic value (in dollars) from the avoided investment in new water capacity (capital costs plus fixed operation and maintenance costs).
- These benefits do not accrue to the energy IOU ratepayers; they accrue to the water utilities.

Environmental Benefits of Reduced Water Use

- The economic value (in dollars) of environmental services from water that is left in the environment to serve other purposes (e.g., wildlife habitats, instream flows, etc.).
- These benefits generally accrue to society but not to energy and water utilities.

Avoided Water Commodity Cost was not in our scope of work.

The CPUC is considering a multi-part cost-benefit test that is "viewed from multiple perspectives."

	TRC Perspective			
Component	**Energy**	**Water**	**Combined**	**Societal**
Administrative costs to energy utility	Cost		Cost	Cost
Administrative costs to water agency		Cost	Cost	Cost
Avoided costs of supplying electricity and natural gas	Benefit		Benefit	Benefit
Avoided costs of water capacity*		Benefit	Benefit	Benefit
Avoided embedded IOU energy in water*	Benefit	Benefit	Benefit	Benefit
Environmental benefits of reduced water use*				Benefit
Capital (measure) costs to participant	Cost	Cost	Cost	Cost
Capital (measure) costs to energy utility	Cost		Cost	Cost
Capital (measure) costs to water utility		Cost	Cost	Cost
Increased supply costs	Cost	Cost	Cost	Cost
Tax credits	Benefit	Benefit	Benefit	

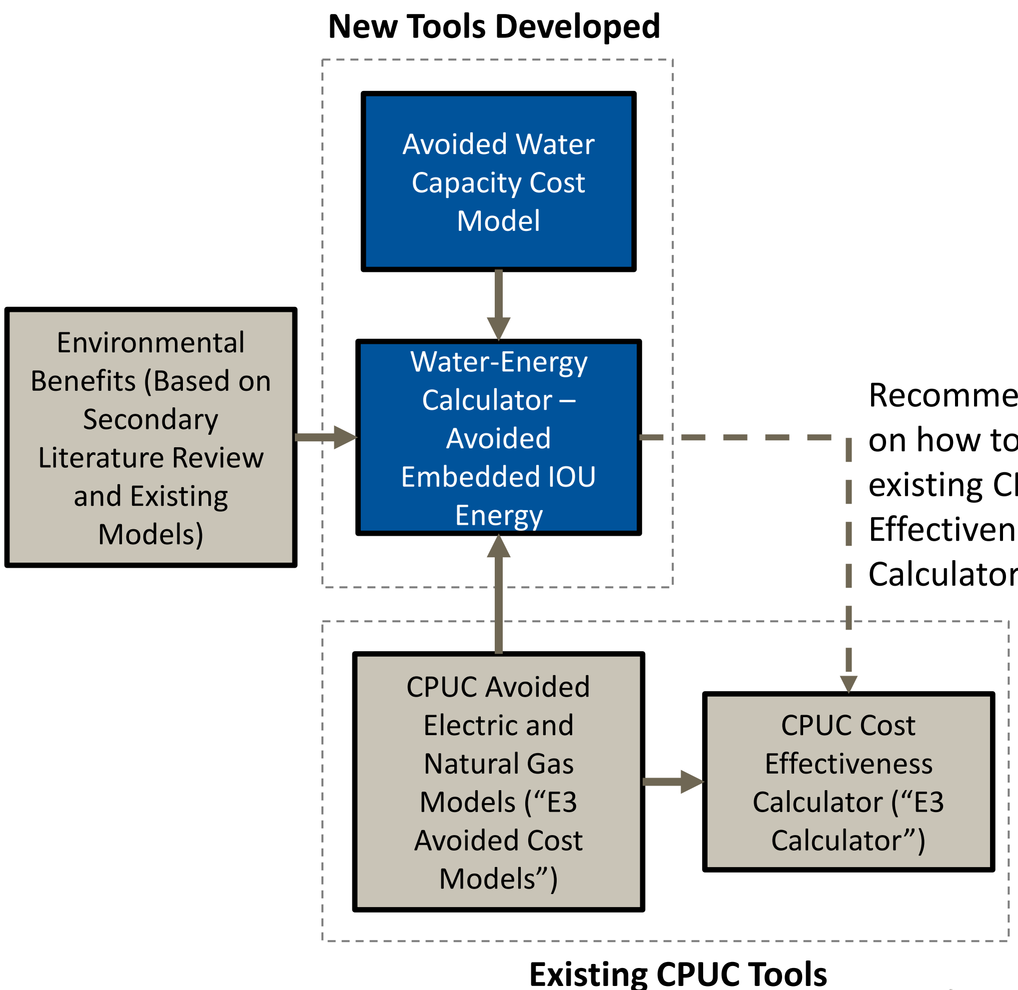
* New benefits being addressed by this study.

This study focuses on developing the tools and analysis to quantify the three water-related benefits in our scope.

» Three added benefits:
- Avoided Embedded IOU Energy in Water
- Avoided Costs of Water Capacity
- Environmental Benefits of Reduced Water Use

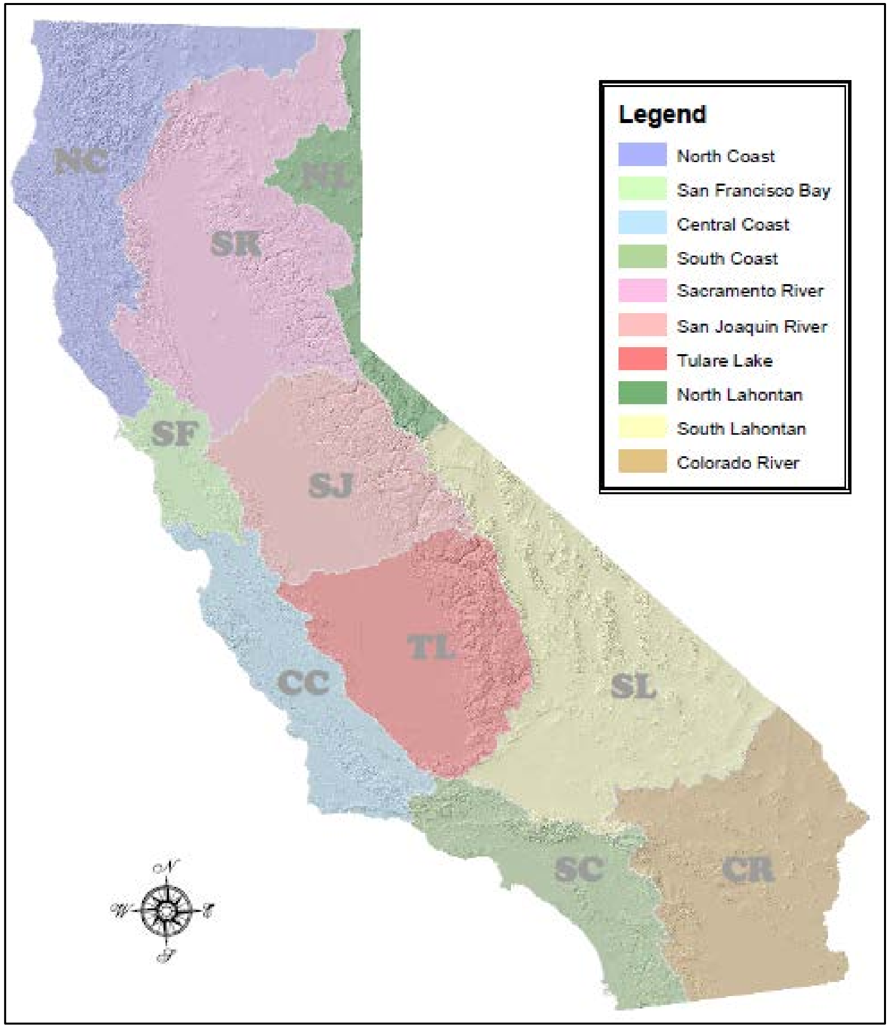
» Methodological similarities with California electric avoided cost analysis:
- Select a proxy marginal water supply
- Determine water avoided water capacity costs using similar methodologies used by avoided electric capacity cost calculations

All three water related benefits are combined into one tool that can be used for analyzing the water-related benefits of water efficiency measures: the Water Energy Calculator.



The models are set up to conduct analysis at the CA Department of Water Resources (DWR) Hydrologic Region level.

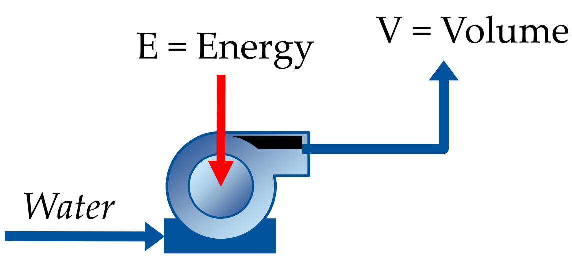
- Allows the analysis to leverage the multitude of existing studies and reports that already document water supplies and their energy intensities at the hydrologic region
- Allows flexibility in the model to test additional scenarios
- Allows the modeling of regional variations in energy use and supply options



Energy Intensity and Embedded Energy are two terms that are key to understanding the Water-Energy nexus

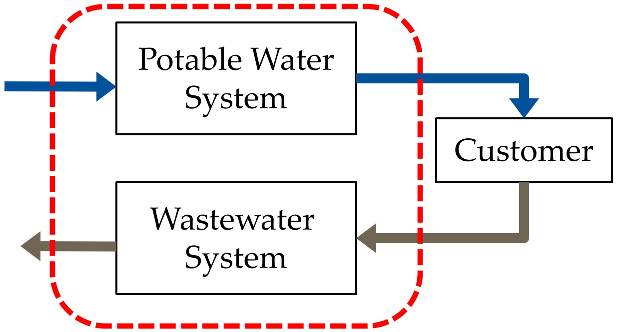
- **Energy Intensity (EI)**
  - The average amount of energy needed to transport or treat water or wastewater on a per unit basis (kilowatt hours per acre-foot of water [kWh/AF] or therms/AF)
  - Associated with a particular facility
  - EIs of successive facilities are additive
- **Energy Embedded in Water**
  - Captures the entire energy picture both upstream and downstream of an end use customer
  - Embedded energy is not associated with a particular facility but with the water itself
  - Calculated by multiplying energy intensity by a volume of water
  - Embedded energy savings = EI x Water Savings

Illustrative Energy Intensity Calculation for a Pump



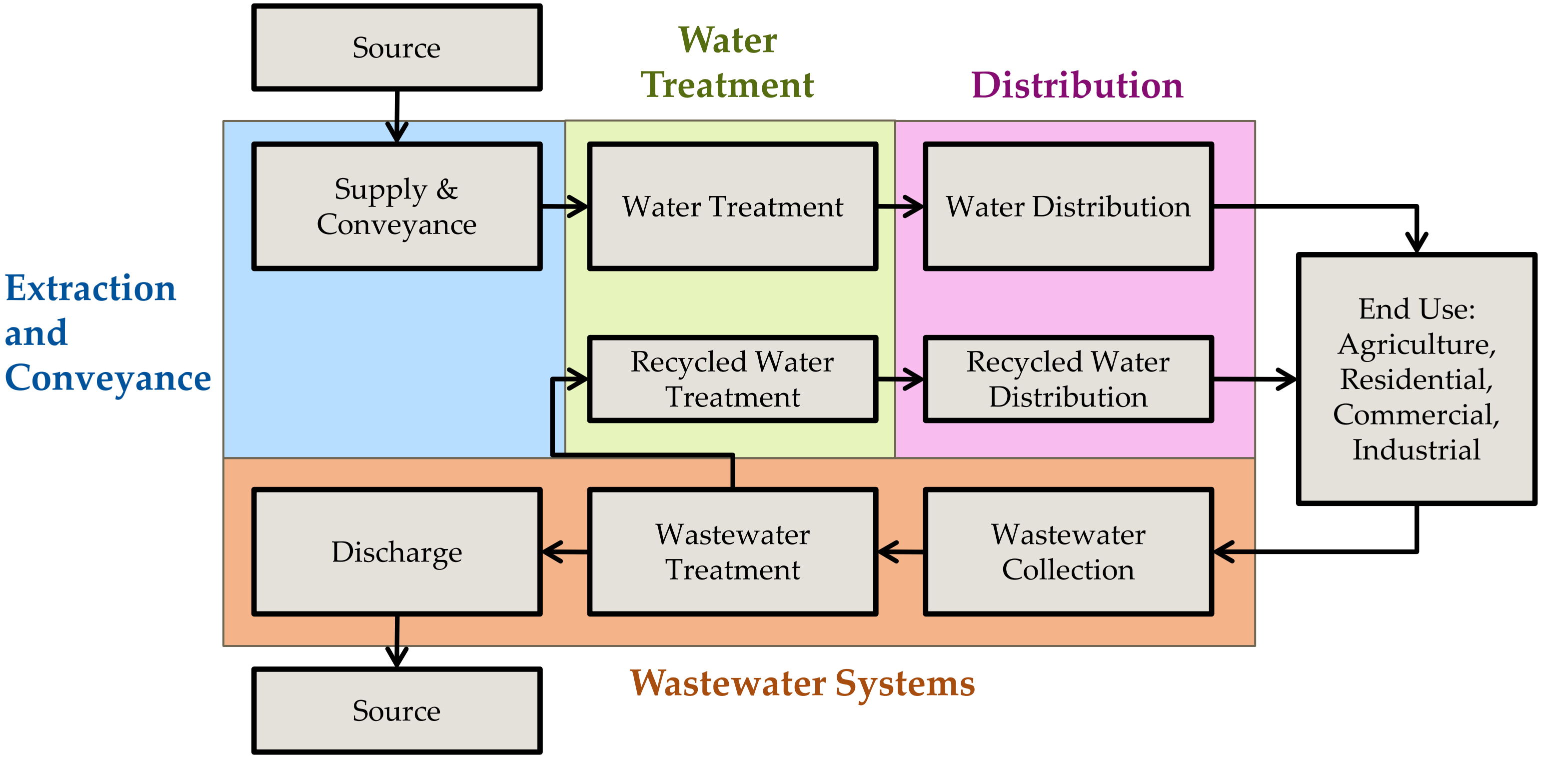
$$EI = \frac{E}{V}$$

Embedded Energy



Energy Use = Embedded Energy

Nomenclature for System Components



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The avoided embedded IOU energy in water is dependent on measure specific inputs; multiple outputs come from the analysis.

Inputs

- Energy IOU
- Hydrologic Region
- Measure Annual Water Savings (gallons)
- Measure Life (years)
- Measure Installation Year
- Sector (Urban vs. Agriculture)
- Water Use (Indoor vs. Outdoor)
- Water Use Profile

Calculations and Outputs

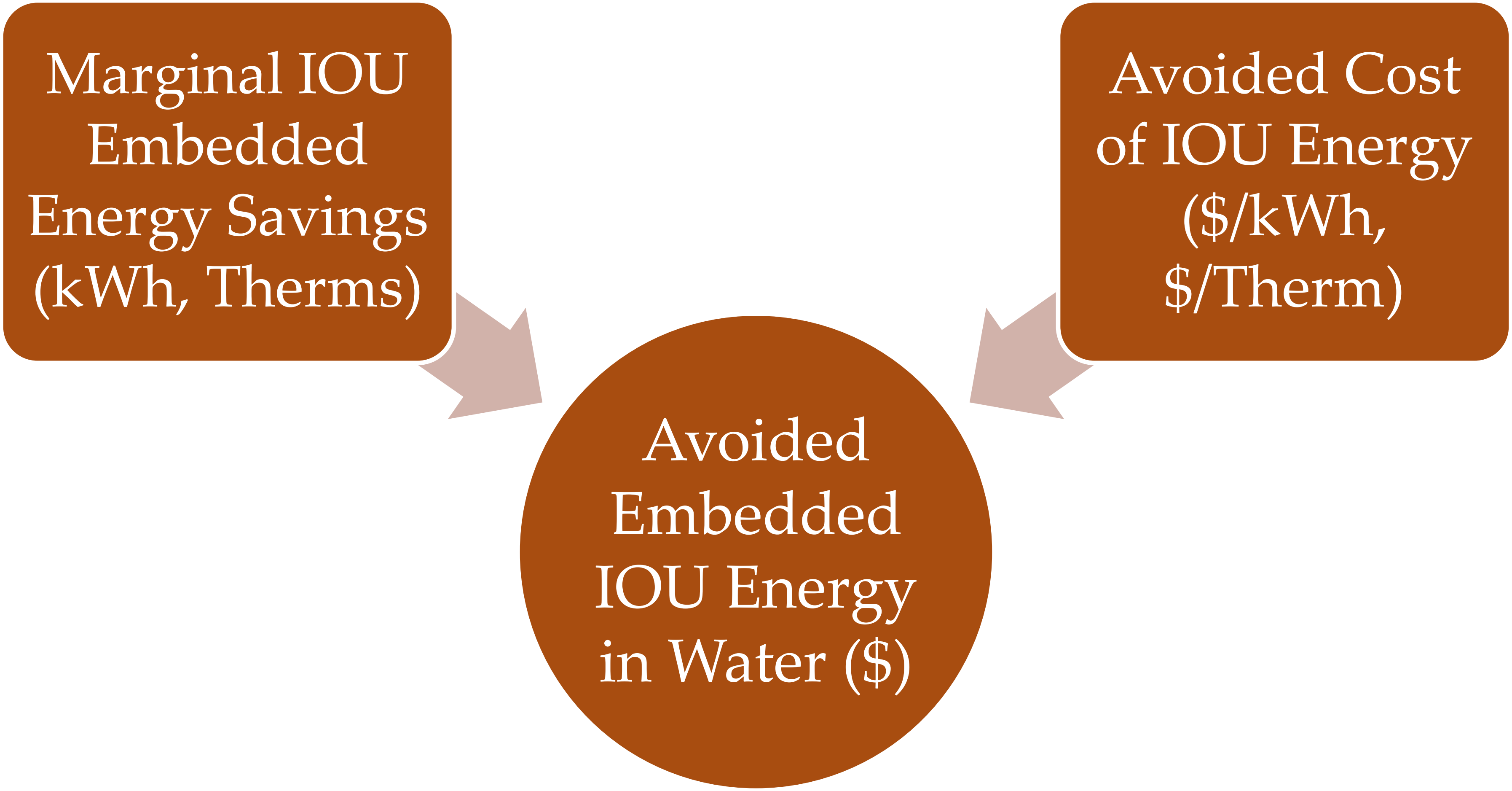
- Avoided Embedded IOU Energy in Water ($)
- IOU Average Embedded Energy Savings (kWh and Therms)

Average vs. Marginal Energy Intensity

- **Marginal Energy Intensity**
  - Energy intensity is the energy intensity of the selected marginal supply (plus appropriate treatment, distribution and wastewater EI)
  - Used to value the avoided embedded energy cost
  - Represents the energy use of the supply a region is avoiding developing
- **Average Energy Intensity**
  - Weighted average of the energy intensity of existing supplies within a region (plus appropriate treatment, distribution and wastewater EI)
  - Used to estimate, measure, and evaluate embedded energy savings (kWh or therms)
  - Better represents the actual energy savings that will occur
  - Analogous to estimating greenhouse gas savings from energy efficiency using an average carbon intensity of the electricity grid

- *The model further breaks down both of these into IOU and non-IOU components.*

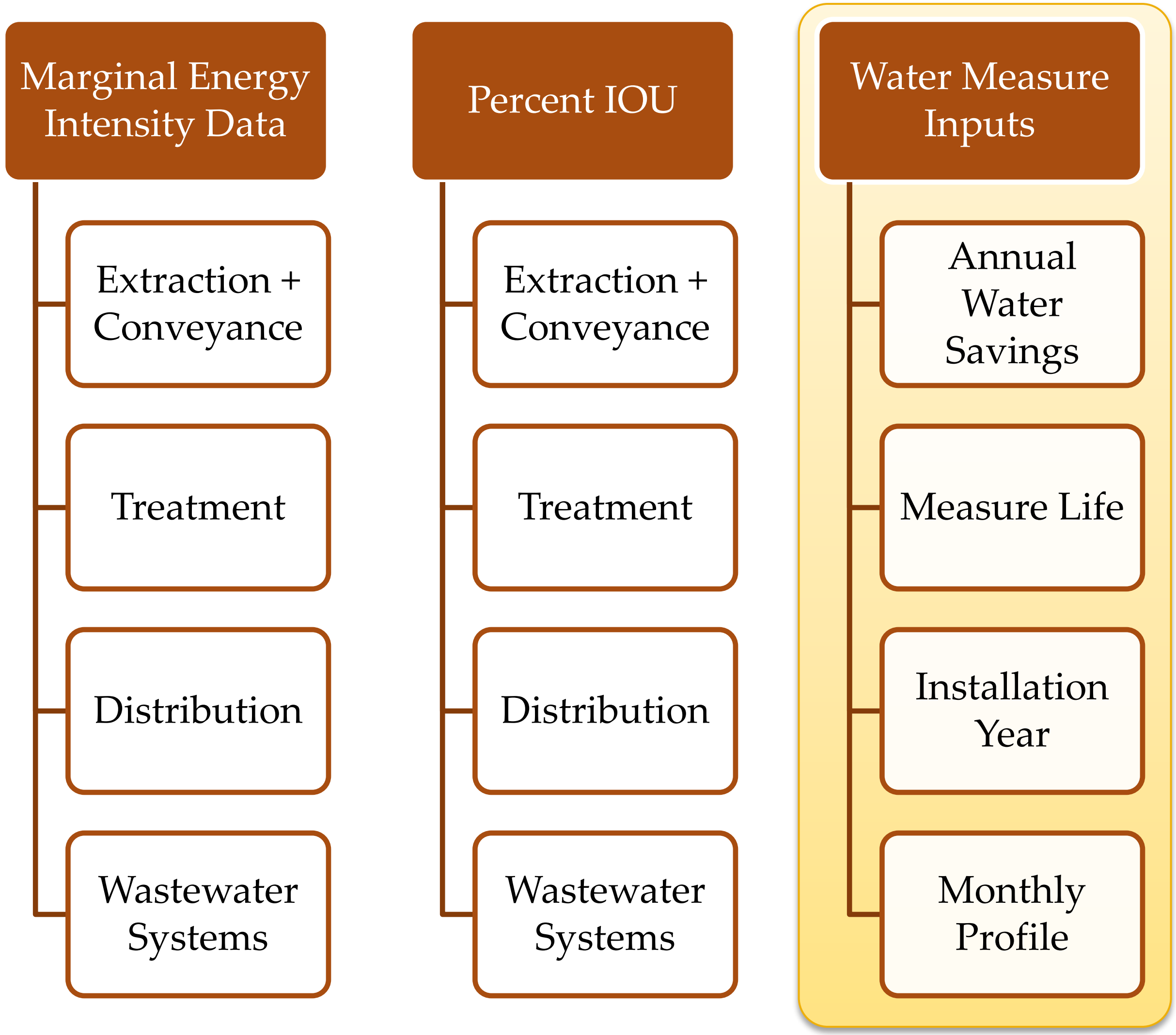
The Avoided Embedded IOU Energy in Water is calculated using energy savings and avoided energy cost data.



The marginal IOU embedded energy savings considers energy intensity data, IOU energy use, and water measure related data.

- **Marginal Energy Intensity Data**
  - Extraction + Conveyance
  - Treatment
  - Distribution
  - Wastewater Systems
- **Percent IOU**
  - Extraction + Conveyance
  - Treatment
  - Distribution
  - Wastewater Systems
- **Water Measure Inputs**
  - Annual Water Savings
  - Measure Life
  - Installation Year
  - Monthly Profile

Water measure inputs are key to determining the avoided IOU embedded energy in water.



Water measure inputs are used to generate a temporal distribution of water savings.

Water Measure Inputs

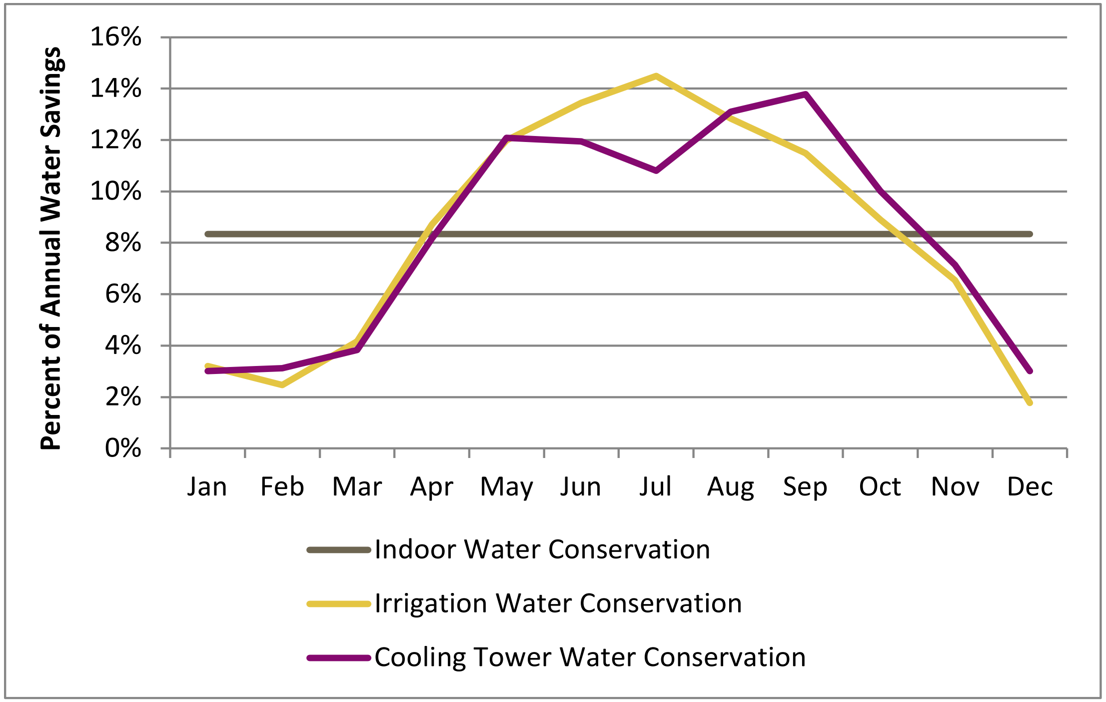
Measure	Annual Water Savings (gallons)	Measure Life (years)	Installation Year
#1	1000	9	2015
#2	500	6	2018
#3	1000	6	2015

Annual Water Savings by Measure (gallons)

Measure	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
#1	-	1000	1000	1000	1000	1000	1000	1000	1000	1000
#2	-	-	-	-	500	500	500	500	500	500
#3	-	1000	1000	1000	1000	1000	1000	-	-	-

Marginal IOU embedded energy savings is tracked at the monthly level

- Embedded energy savings at different times of the year have different associated benefits
- Users select from default monthly water use profiles
  - Indoor water use from appliances and fixtures are likely to have a relatively constant monthly water use
  - Irrigation water use peaks in the summer
  - Water use for cooling towers peaks during the summer
- Users can enter their own monthly water use profiles

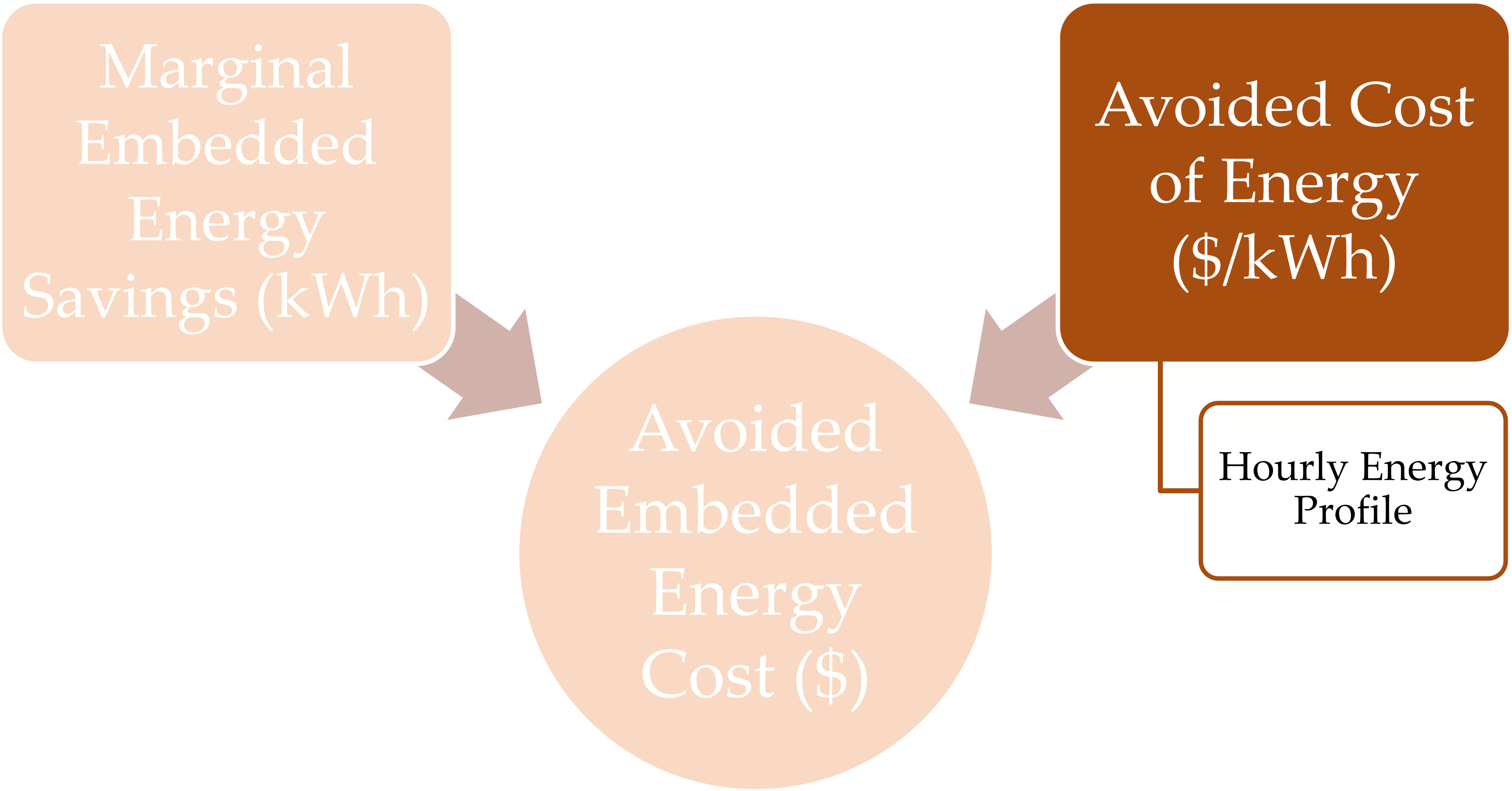


Adapted from California Sustainability Alliance.

Other key assumptions and inputs

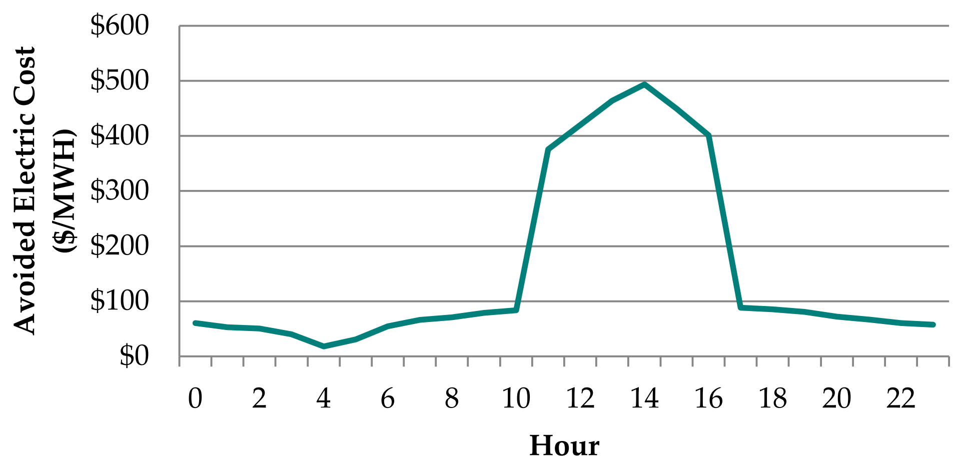
- Extraction, conveyance, water treatment, distribution and wastewater system energy intensities are used where appropriate
  - Wastewater system EI only applies to urban indoor water uses
  - Treatment technology depends on supply type
  - Wastewater treatment EI is based on secondary treatment processes
- For CPUC cost effectiveness tests, only IOU energy use is considered
  - Embedded energy savings the occurring within the State Water Project provide no benefits to the IOUs
  - IOU energy use is considered in both the analysis of average embedded energy savings and avoided embedded energy savings
  - Total energy savings are tracked (IOU and non-IOU)

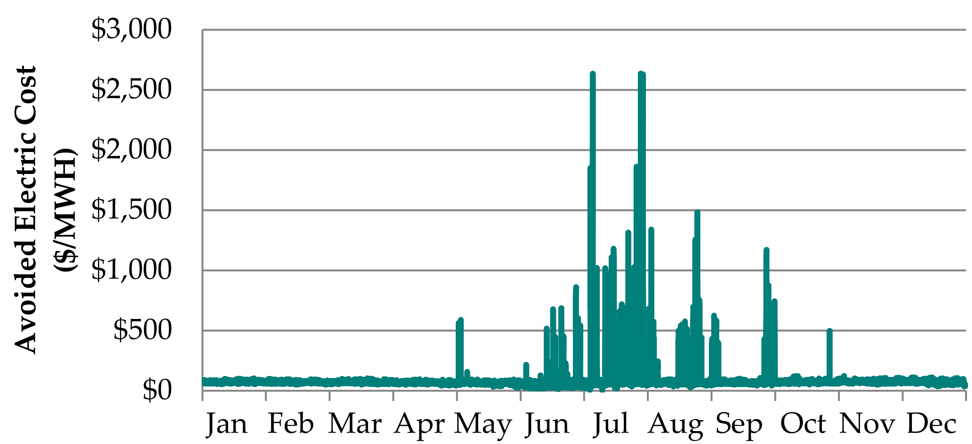
The avoided cost of energy are sourced from existing CPUC avoided cost models and incorporate water-related load profiles.



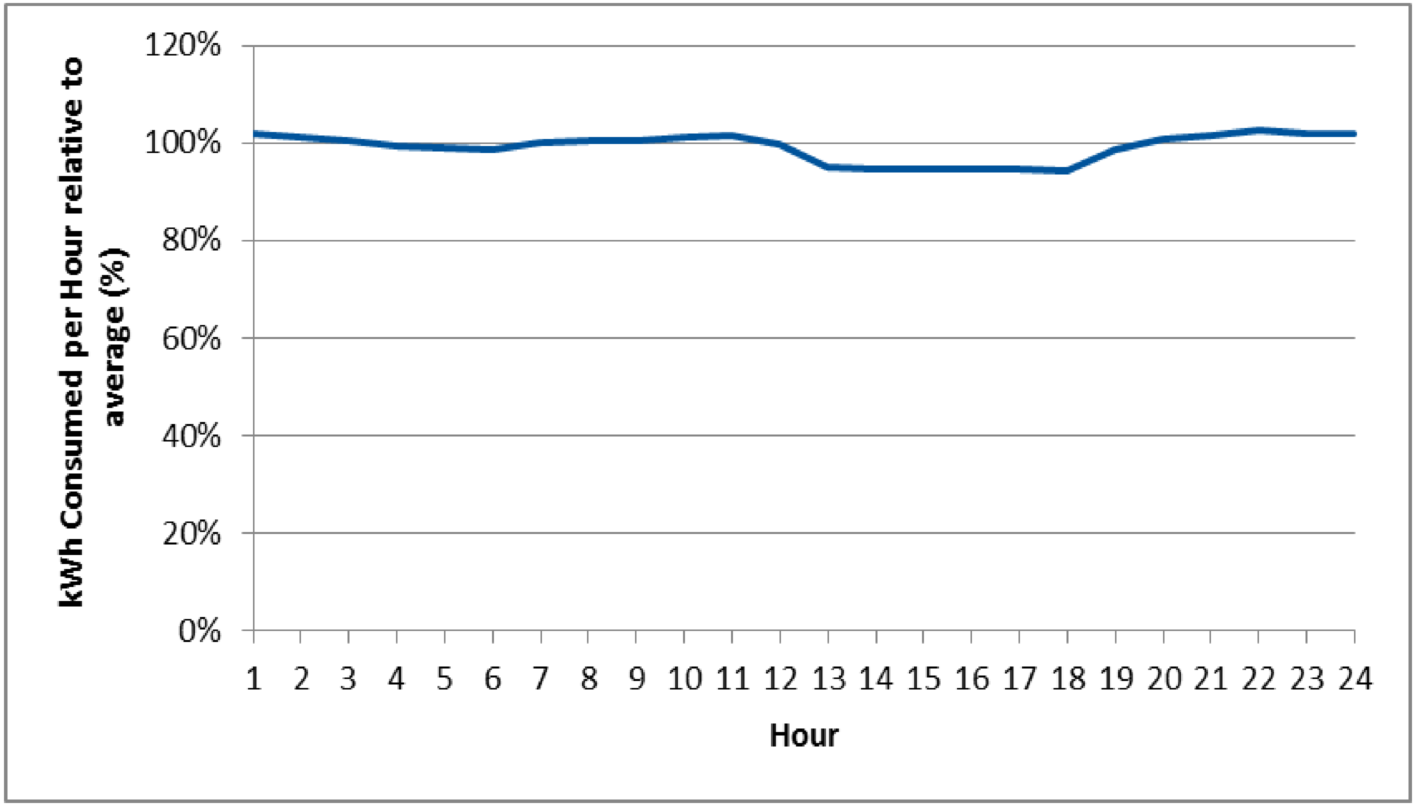
Embedded energy savings during the summer months and peak hours can provide higher benefits.

- Generally, the avoided cost of energy is higher during peak hours of the day
  - Embedded energy savings during peak hours result in higher benefits
- Avoided cost of energy is higher in the summer months (June through September).
  - Embedded energy savings during the summer months result in higher benefits
- Future benefits are discounted to present data value





Weighted Average Hourly Electric Profile for Retail Water System Components



Source: Navigant team analysis based on CPUC Embedded Energy in Water Study 2 and Water-Energy Pilot Evaluations data (Water-Energy Load Profiling Tool)

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Dual Goals of the Avoided Capacity Cost Methodology

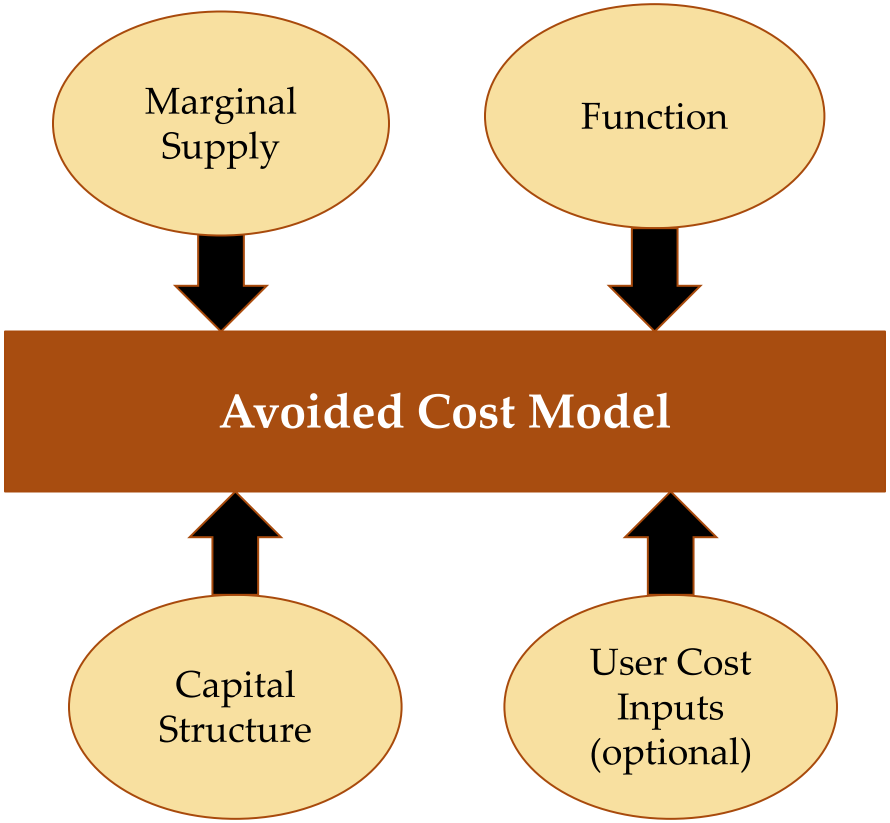
- **Develop an Avoided Capacity Cost Model**
  - Develop a model which is flexible enough to address future study needs
  - Capable of capacity cost calculation by Hydrologic Region – with the capability of additional regions
  - Calculation by function
  - Ability to toggle between IOU and municipal financial structures

- **Perform an Avoided Capacity Cost Study**
  - Use data from this study to perform a study of avoided water capacity costs in California
  - Preliminary focus of the study is Supply which is the primary resource challenge in California
  - Assumed that the marginal cost of conveyance and distribution are zero

The goal of the model is to develop a flexible tool that can service the needs of stakeholders in California in future studies. The goal of the avoided capacity cost study is to establish an initial estimate of avoided capacity costs.

General Capabilities of the Model

- Capable of defining costs by Hydrologic Region
- Analyses each function separately
  - Supply
  - Water Treatment
  - Wastewater Treatment
- Capabilities for estimating IOU and municipal capital structures



Water avoided capacity costs are defined as the change in cost triggered by the change in quantity.

- Navigant has developed approaches that are methodologically similar to that which have previously been adopted in California (for electric capacity avoided cost analysis) but account for the specific circumstances unique to water service.
- A water avoided capacity cost input data set was not available.
- Side note on avoided commodity cost (not covered by this study)
  - Commodity cost defined on a volumetric basis (i.e. dollars per acre foot) whereas water capacity cost is defined on a daily production basis (i.e. dollars per Million Gallons/Day [MGD]).
  - For some water agencies the avoided commodity cost is the cost of purchasing of water from a state or regional water wholesaler; such data is readily available.

The relevant unit of measure is triggered by demand, which is defined by gallons per day (or million gallons per day [MGD]).

» Water is traditionally measured volumetrically (e.g., in units of hundred cubic feet, gallons, or acre-feet) commonly used in water system planning and the development of tariff pricing.

» For the purposes of estimation of marginal capacity costs, the use of a volumetric unit (i.e. acre-feet) is inappropriate.

	Units of Commodity	Units of Capacity	Units of Capacity Cost
Electric	kWh, MWh, GWh	kW, MW	$/kW
Gas	Cubic Feet	Cubic feet/day	$/Cubic feet/day
Water	Gallons, Cubic Feet, AF	MGD, Gal/day	$/MGD

Marginal capacity costs are associated with different components of the water system.

Water Supply (Our Primary Focus of the Study)

» Supply is the key component in estimating marginal capacity costs

» The marginal supply technology could vary by region

» Many of the other water supply service functions are characterized as being fixed

Water Treatment

» Recognize that treatment may differ dependent upon the source of supply

» Assumed capital costs of supply treatment were similar across regions for the same technology

Wastewater Treatment

» Recognize that treatment may differ depending on region

» For the purposes of the study we assumed that wastewater treatment plants in each hydrologic region were identical

For some components, the marginal costs are not relevant.

Conveyance

» Few significant conveyance projects have occurred in several decades

» Many of the water supply technologies anticipated in the future will not rely upon distant water supplies

» Some projects in planning are to increase reliability of existing systems, not add new capacity

» ***Conclusion: Marginal conveyance capacity costs have been set to zero.***

Distribution

» The cost structure of distribution systems differs significantly from region to region

» In many parts of California per capita usage on distribution systems has decreased as opposed to increased

» Distribution investment appears to be driven by interconnection of customers and not the demand / quantity of water delivered

» ***Conclusion: Navigant concluded that avoided water distribution systems capacity costs are fixed costs.***

The Navigant team prepared estimates of the avoided cost of providing water and wastewater service to consumers by calculating marginal capacity cost.

- Navigant used an Accounting (Real) Fixed Charge Rate (FCR) approach to estimate marginal capacity costs.
- FCR accounts for the capital investments and fixed O&M expenses associated with an investment
  - Provides an annualized cost over the useful life of the investment
  - The Net Present Value (NPV) of the revenue requirement is calculated and then recovered as a level payment over the useful life of the asset
  - The annual level payment is considered the annual avoided cost of capacity for the length of time a certain measure causes additional capacity to be avoided
- The FCR includes the following components:
  - Depreciation Expense
  - Return on Equity
  - Interest Expense
  - Fixed O&M Expense
  - Asset Lifetime

Costs of capital assumptions were prepared for the two common ownership structures: IOUs and Municipal-Owned Utilities (MOUs).

» Investor-Owned Water Utilities

- Calculated using the CPUC decisions for large and small water utilities for the periods 2011–2014 and 2012–2015, respectively
- ***Weighted Average Cost of Capital (WACC) Assumption: 8.62%***

» Municipal Water Utility

- Calculated the default assumption for municipal cost of debt using the tax equivalent bond yield equation
- Municipal debt is often tax exempt, so the yield on municipal debt is lower than taxable debt by the average marginal tax rate of its investors, all else equal.
- Because the cost of debt for water utility IOUs reflects the business and systemic risk inherent in water utility investments, we made this adjustment for tax exempt status to our estimate of the IOU cost of debt.
- Our implied yield on municipal debt falls within the generally observed range municipal bond rates (3-5%).
- ***Implied Yield on Municipal Debt: 4.51%***

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The Navigant team leveraged existing studies to value environmental benefits.

- Water efficiency and conservation provide a number of environmental benefits.
  - increase water availability in rivers and streams diluting pollutants
  - maintaining flows for fish populations
  - providing habitat for fish and wildlife
  - sustaining freshwater and nutrient inflows in coastal and estuarine systems
  - conserving water decreases withdrawals from groundwater aquifers, reducing salt water intrusion in coastal areas, and providing base flow for rivers and streams.
- While there are rarely any direct market values for these services, there is growing recognition that they have an economic value and should be included in policy- and decision-making processes.
- The Navigant team leveraged the California Urban Water Conservation Council (CUWCC) framework for estimating the economic value of environmental benefits of conserved water.
- While the CUWCC provides values for surface water and groundwater, it does not include environmental benefits of conserving other water supplies, i.e., recycled water, brackish surface water, and ocean water.

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Having established a methodology for tools, the Navigant team sought out estimates of default data to populate the tools.

- The Navigant team's scope was to primarily develop tools and methodology
- Inputs serve as reasonable default values based on available secondary data
- Many inputs can be edited by users to conduct custom analysis

- Key energy intensity data sources include:
  - CPUC Study 1 and Study 2
  - DWR Draft Water Plan
  - Water-Energy Simulator (WESim) Model
- Key avoided water capacity cost data sources include:
  - Integrated Regional Water Management Plans (IRWMP)
  - Capital Improvement Plans (CIPs)
  - California Department of Water Resources (DWR)
  - State and Local Agency Engineering Reports
  - Investor Owned Water Utility reports filed to the CPUC
- Environmental benefits data was sourced completely from the CUWCC Model

Proxy Marginal Supply Selection

- Selected a default proxy marginal supply of recycled water (wastewater treated to tertiary, unrestricted standards) applicable to all regions in California.
- Using recycled wastewater as the default proxy marginal supply is reasonable based on several facts:
  - All regions currently are developing and have available recycled water supplies. Although the predominant use of these supplies is currently for irrigation, these supplies are approved for numerous other uses.
  - Many utilities include recycled wastewater as a key element of their future supply portfolios.
  - More conservative supply option than ocean water, which addresses concerns raised by some stakeholders who question the availability of treated ocean supplies to more inland water utilities.
  - Consistent with the State Water Resources Control Board (SWRCB) goals which encourage water agencies to significantly increase the development and use of these supplies.
- The selected proxy marginal supply affects the results of all three benefits. However, the Navigant team developed flexible tools irrespective of the selected marginal supply.

Additional default assumptions were made about treatment facilities.

- Energy and cost data for the selected marginal supply (recycled water) already include the treatment component. Similarly, desalination treatment costs are already "bundled" with supply costs.
- Other supplies require treatment, should users select these other supplies, the model uses the appropriate treatment technology

Marginal Supply Technology	Additional Marginal Treatment Technology
Ocean water – membrane desalination	None
Brackish groundwater – membrane desalination	None
Recycled water – membrane treatment	None
Recycled water – tertiary treatment + disinfection	None
Fresh groundwater	Chlorine Disinfection
Surface water – imported or local	Contaminant Removal Plus Disinfection

- Navigant team identifies secondary treatment as the marginal wastewater treatment technology

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Not all water systems are powered by an IOU; thus, the IOUs may not be able claim credit for all embedded energy savings.

» Default values in the Water Energy Calculator were derived from the Water Energy Load Profiling Tool, as augmented for use in the CPUC Water-Energy Pilot Evaluations.

System Component	Supply Type	% IOU
Extraction and Conveyance	Ocean Water Desalination	94%
	Brackish Desalination	94%
	Recycled Water	97%
	Groundwater	59%
	Local Deliveries	27%
	SWP, CRA, CVP and Other Federal Deliveries	0%
	Local Imported Deliveries (e.g. LA Aqueduct, SFPUC)	27%
Treatment		94%
Distribution		95%
Wastewater Systems		97%

Source: Navigant team analysis based on CPUC Embedded Energy in Water Study 2 and Water-Energy Pilot Evaluations data (Water-Energy Load Profiling Tool)

Marginal Energy Intensity Data – IOU only (kWh/AF)

Region	Extraction and Conveyance	Treatment	Distribution	Wastewater Collection + Treatment	Outdoor (Upstream of Customer)	Indoor (All Components)
NC	0	490	470	1,245	961	2,206
SF	0	490	918	1,245	1,408	2,653
CC	0	490	470	1,245	961	2,206
SC	0	490	470	1,245	961	2,206
SR	0	490	51	1,245	541	1,786
SJ	0	490	51	1,245	541	1,786
TL	0	490	51	1,245	541	1,786
NL	0	490	51	1,245	541	1,786
SL	0	490	470	1,245	961	2,206
CR	0	490	51	1,245	541	1,786

Source: Navigant team analysis. Assumes tertiary treated recycled water is the marginal supply.

To inform average embedded energy savings calculation, an average existing supply mix was developed for each hydrologic region.

Supply Type	NC	SF	CC	SC	SR	SJ	TL	NL	SL	CR
Ocean water Desal.	0%	<1%	0%	0%	0%	0%	0%	0%	0%	0%
Brackish Desal.	0%	<1%	0%	2%	0%	0%	0%	0%	0%	0%
Recycled Water	20%	3%	8%	10%	20%	23%	12%	34%	16%	11%
Groundwater	29%	19%	79%	31%	20%	31%	50%	22%	64%	9%
Local Deliveries	28%	15%	3%	4%	31%	29%	16%	44%	7%	<1%
Local Imported Deliveries	2%	38%	0%	5%	0%	<1%	<1%	0%	0%	<1%
CRA	0%	0%	0%	21%	0%	0%	0%	0%	0%	79%
CVP and Other Federal Deliveries	22%	12%	8%	<1%	29%	16%	15%	0%	0%	0%
SWP	0%	12%	3%	27%	0%	0%	8%	0%	14%	1%

Source: Navigant team analysis based on DWR's 2013 Draft Water Plan

Average Energy Intensity Data – Total IOU + Non IOU (kWh/AF)

Region	Extraction, Conveyance, and Treatment	Distribution	Wastewater Collection + Treatment	Outdoor (Upstream of Customer)	Indoor (All Components)
NC	391	495	1,284	886	2,170
SF	614	966	1,284	1,580	2,864
CC	558	495	1,284	1,053	2,337
SC	1,948	495	1,284	2,443	3,727
SR	417	53	1,284	470	1,754
SJ	416	53	1,284	470	1,753
TL	498	53	1,284	552	1,835
NL	417	53	1,284	470	1,754
SL	904	495	1,284	1,399	2,683
CR	520	53	1,284	573	1,856

Source: Navigant team analysis.

Average Energy Intensity Data – IOU Only (kWh/AF)

Region	Extraction, Conveyance, and Treatment	Distribution	Wastewater Collection + Treatment	Outdoor (Upstream of Customer)	Indoor (All Components)
NC	343	470	1,245	813	2,058
SF	394	918	1,245	1,312	2,557
CC	316	470	1,245	787	2,032
SC	446	470	1,245	916	2,161
SR	372	51	1,245	423	1,668
SJ	351	51	1,245	401	1,646
TL	338	51	1,245	388	1,633
NL	375	51	1,245	425	1,670
SL	301	470	1,245	771	2,016
CR	414	51	1,245	465	1,710

Source: Navigant team analysis.

Water supply capital and fixed O&M costs were developed based on publicly available data; they serve as default estimates.

Region	Ocean Water Desalination Plant Costs ($M/MGD)		Brackish Water Desalination Plant Costs ($M/MGD)		Recycled Water Plant Costs – Tertiary Plus Disinfection ($M/MGD)		Recycled Water Plant Costs – Membrane Treatment ($M/MGD)		Groundwater Facility Costs ($M/MGD)	
	Capital	Fixed O&M	Capital	Fixed O&M	Capital	Fixed O&M	Capital	Fixed O&M	Capital	Fixed O&M
NC	$33.38	$0.79	$6.45	$0.48	$3.19	$0.09	$7.15	$0.27	$3.25	$0.01
SF	$33.38	$0.79	$5.77	$0.47	$3.19	$0.09	$7.15	$0.27	$3.25	$0.01
CC	$33.38	$0.79	$6.45	$0.48	$3.19	$0.09	$7.15	$0.27	$3.25	$0.01
SC	$16.23	$0.42	$6.45	$0.48	$3.19	$0.09	$7.15	$0.27	$3.25	$0.01
SR	-	-	$6.45	$0.48	$3.19	$0.09	$7.15	$0.27	$3.25	$0.01
SJ	-	-	$6.45	$0.48	$3.19	$0.09	$7.15	$0.27	$3.25	$0.01
TL	-	-	$6.45	$0.48	$3.19	$0.09	$7.15	$0.27	$3.25	$0.01
NL	-	-	$6.45	$0.48	$3.19	$0.09	$7.15	$0.27	$3.25	$0.01
SL	-	-	$6.45	$0.48	$3.19	$0.09	$7.15	$0.27	$3.25	$0.01
CR	-	-	$6.45	$0.48	$3.19	$0.09	$7.15	$0.27	$3.25	$0.01

Source: Navigant and GEI Analysis: *Water System Component Cost Assumptions* August 2014

Water treatment and wastewater treatment costs were developed based on publicly available data; they serve as default estimates.

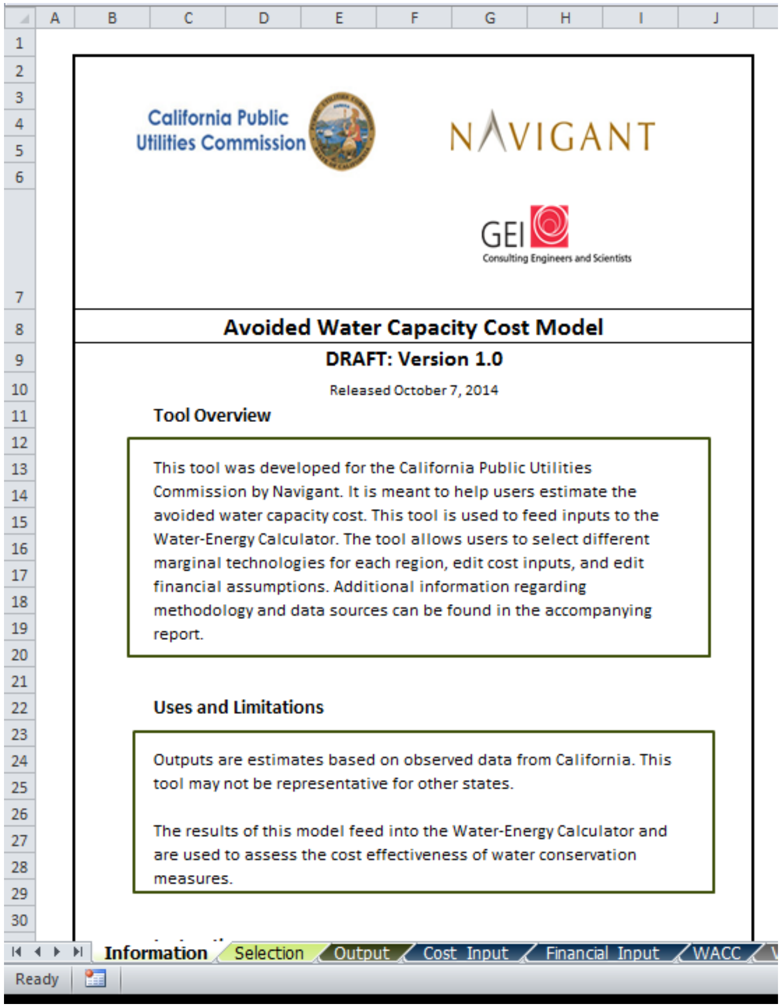
Region	Potable Treatment - Chlorine Disinfection Costs ($M/MGD)		Potable Treatment - Contaminant Removal Plus Disinfection Plant Costs ($M/MGD)		Wastewater Treatment Plant Costs ($M/MGD)	
	Capital	Fixed O&M	Capital	Fixed O&M	Capital	Fixed O&M
NC	$0.06	$0.01	$4.23	$0.06	$17.98	$0.70
SF	$0.06	$0.01	$4.23	$0.06	$17.98	$0.70
CC	$0.06	$0.01	$4.23	$0.06	$17.98	$0.70
SC	$0.06	$0.01	$4.23	$0.06	$17.98	$0.70
SR	$0.06	$0.01	$4.23	$0.06	$17.98	$0.70
SJ	$0.06	$0.01	$4.23	$0.06	$17.98	$0.70
TL	$0.06	$0.01	$4.23	$0.06	$17.98	$0.70
NL	$0.06	$0.01	$4.23	$0.06	$17.98	$0.70
SL	$0.06	$0.01	$4.23	$0.06	$17.98	$0.70
CR	$0.06	$0.01	$4.23	$0.06	$17.98	$0.70

Source: Navigant and GEI Analysis: *Water System Component Cost Assumptions* August 2014

1	Overview of Study Goals
2	Defining Cost Effectiveness
3	Overview of Methodology
4	Review Default Model Assumptions
5	**The Water-Energy Calculator**
6	Example Analysis

The Water-Energy Calculator is designed to be simple to use.

- More advanced users have the option to customize the analysis.
- Default values are provided to enable those who may not have detailed system knowledge.
- A users guide is contained in the appendix of our final report.



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Live Calculator Demonstration

1 Water-Energy System Inputs

Select your IOU: Electric: PG&E Gas: PG&E Water Utility: Non-IOU

2 Measure-Specific Inputs

Note: all metrics are on a per unit basis (Example: per low-flow shower head)

Measure ID#	Measure Name	Annual Water Savings (gallons)	Measure Life (years)	Installation Year	Savings Profile	Hydrologic Region	Sector	Water Use	Rebate ($)	Installation Cost ($)	Incremental Equipment Cost ($)	Program Administration Cost ($)
1	Toilet											
2	Toilet											
3	Toilet											
4	Toilet											
5	Toilet											
6	Toilet											
7	Toilet											
8	Toilet											
9	Toilet											
10	Toilet											
11												
12												
13												
14												
15												
16												
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18												
19												
20												

Information | Inputs | Glossary | Summary Outputs | Avg Embedded Electric Svgs | Avg Embedded Gas Svgs | AC Marginal Embedded Elec | AC Marginal Embedded Gas | AC Water Capacity

Ready

1. Overview of Study Goals
2. Defining Cost Effectiveness
3. Overview of Methodology
4. Review Default Model Assumptions
5. The Water-Energy Calculator
6. **Example Analysis**

The Navigant team conducted an example calculation of the savings and benefits.

- » Savings and benefits from an EPA WaterSense high-efficiency toilet
  - 1.28 gallons per flush
  - 8,000 gallons per year savings
  - $200 average cost
  - 20 year measure life
- » This analysis assumed
  - The measures are installed in PG&E territory
  - The measures are installed within a non-IOU water utility territory
  - Water savings follows a constant monthly profile
  - All other inputs in the models are set to their default values

Savings source:
http://socalwatersmart.com/qualifyingproducts/hets.

The example analysis shows the measure is cost effective (TRC > 1.0) from a combined utility perspective.

Region	Equipment Cost	Program Admin Cost	Annual IOU Embedded Energy Savings (kWh)	Annual Non-IOU Embedded Energy Savings (kWh)	Net Present IOU Avoided Electric Embedded Energy Benefits (2014$)	Net Present Avoided Water Capacity Benefits (2014$)	Combined Total Resource Cost Test Result
NC	$200	$10	50.54	2.74	$70.63	$700.95	3.67
SF	$200	$10	62.83	7.52	$84.96	$700.95	3.74
CC	$200	$10	49.86	7.47	$70.63	$700.95	3.67
SC	$200	$10	53.10	38.44	$70.63	$700.95	3.67
SR	$200	$10	40.96	2.11	$57.19	$700.95	3.61
SJ	$200	$10	40.42	2.62	$57.19	$700.95	3.61
TL	$200	$10	40.09	4.95	$57.19	$700.95	3.61
NL	$200	$10	41.01	2.04	$57.19	$700.95	3.61
SL	$200	$10	49.50	16.37	$70.63	$700.95	3.67
CR	$200	$10	41.94	3.59	$57.19	$700.95	3.61

Source: Navigant team analysis.

Discussion

Key
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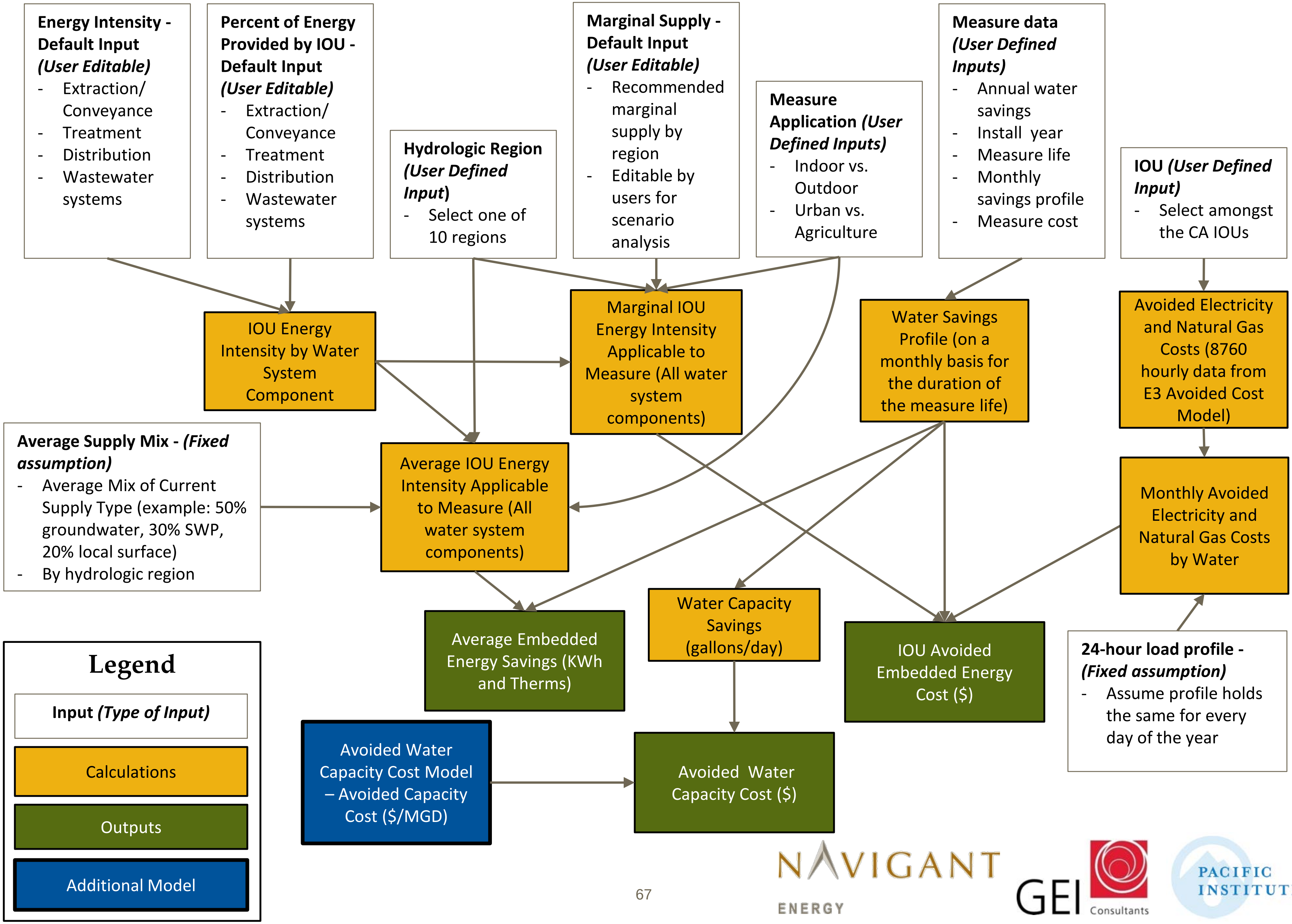
Appendix: Water-Energy Calculator – Avoided Embedded Energy Model



Appendix: Avoided Water Capacity Cost Model