

NAVIGANT

ENERGY

Water-Energy Cost Effectiveness Analysis

*Public Workshop Presentation of Future Water Supply
Selection*

April 25, 2014

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Content of Report

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April 25, 2014

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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.*”
- » Past water-energy studies have focused on a “snapshot” of water infrastructure and its energy requirements at that point in time.
- » This analysis looks to the future: what future costs associated with water and energy infrastructure can be avoided as a result of water conservation?

California IOUs can already rebate high efficiency clothes washers ...



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



Our core objective is to recommend modifications to existing Cost Effectiveness (CE) frameworks to include consideration of water.

- » Existing cost effectiveness frameworks value “Site Energy” savings using the avoided cost (AC) of energy.
- » Avoided cost of energy is based on the characteristics of California's marginal energy supply.

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

Where:

$$\textit{Site Energy AC} = \textit{Site Energy Savings} \times \textit{Avoided Cost of Energy}$$

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

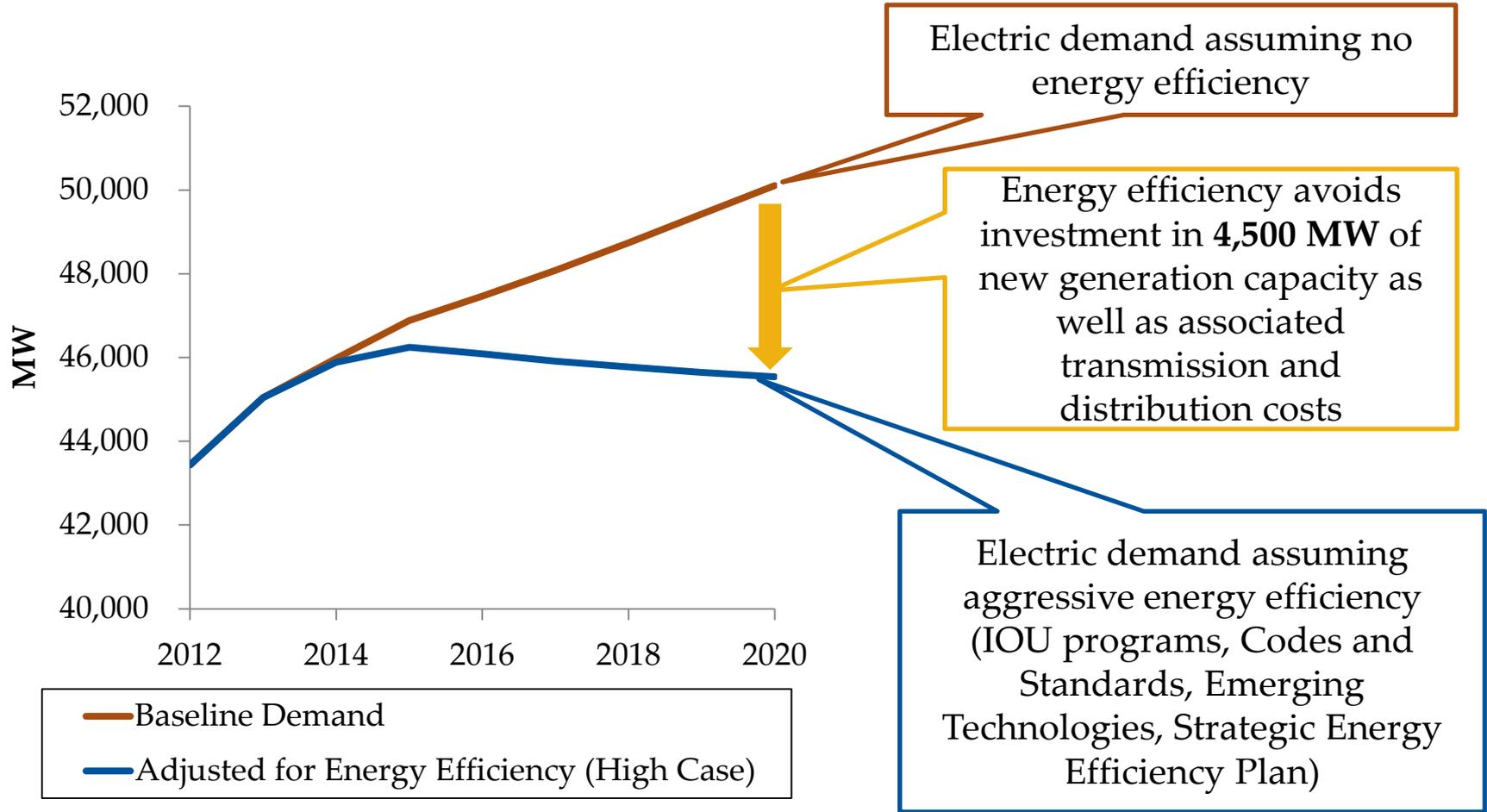
Benefit Cost Ratio =

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

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First, we look to California's electric sector to understand how energy efficiency is valued (we present a simplified interpretation).



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

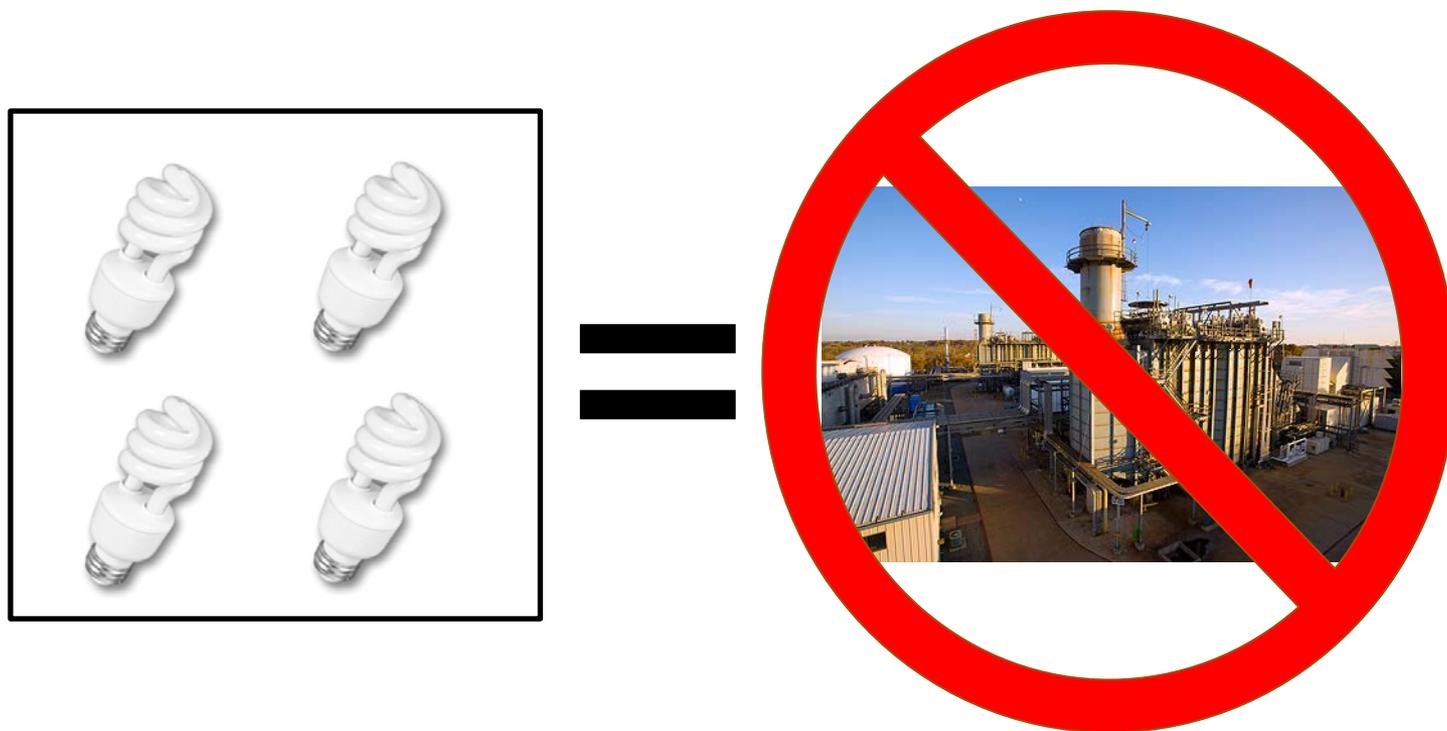
The avoided cost of energy places an economic value on each unit of energy saved (avoided investment in generation, transmission, etc.)

- » Standard practice assumes energy efficiency reduces reliance of energy supply “on the margin” (i.e. the Marginal Electric Supply)
- » California has diverse electric generation options: natural gas, hydro, nuclear, solar, geothermal, coal, etc.
- » Need an assumption: which of these supply types is actually avoided as a result of energy efficiency (i.e. what is the Marginal Electric Supply)?



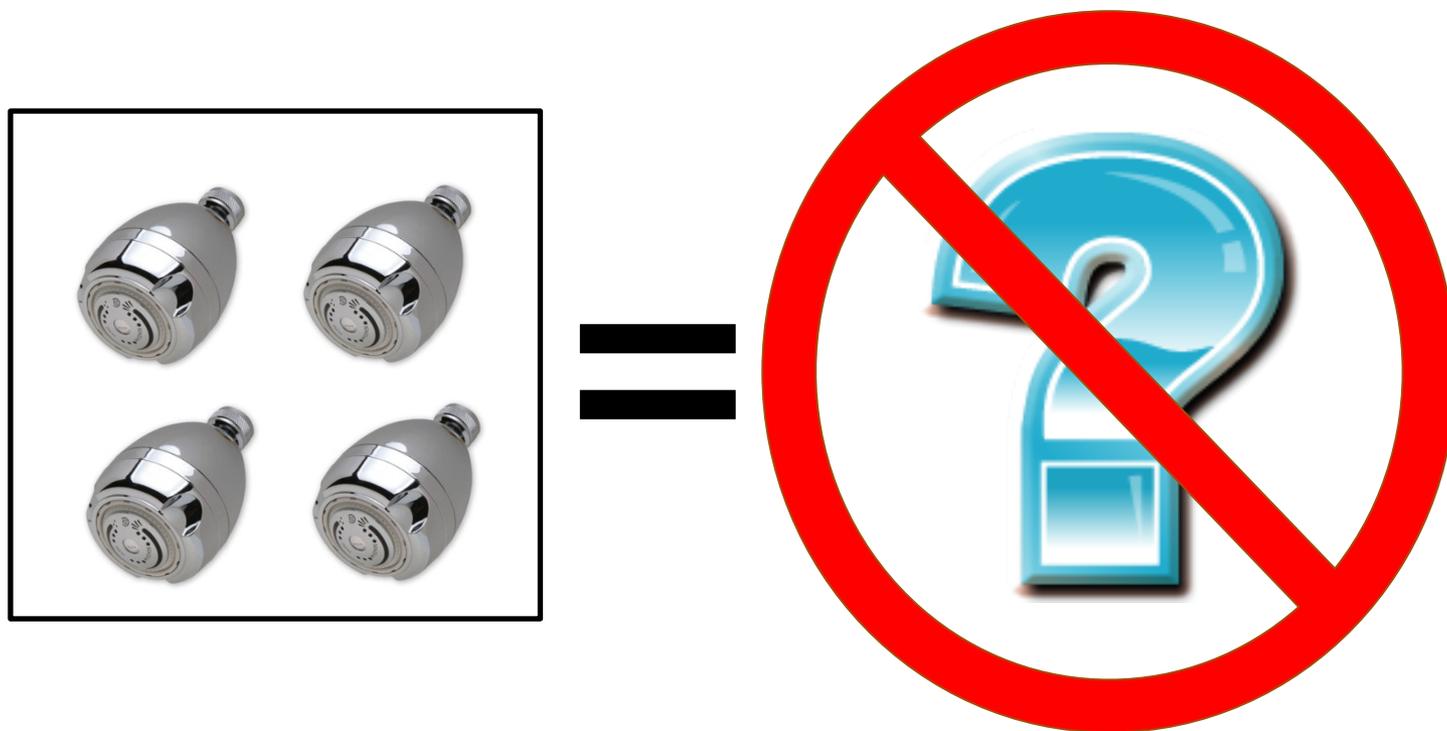
For example, the CPUC has determined a natural gas combined cycle power plant is the Marginal Electric Supply

Energy efficiency avoids development of the marginal supply.



Knowing the marginal supply allows us to value the economic benefit of energy efficiency (how much the marginal supply would have cost to build/expand and operate in the absence of energy efficiency).

We will follow a similar approach for water.



Like energy supplies, California has numerous water supply types (surface water, groundwater, imported water, recycled water, ocean desalination, brackish desalination, etc.)

We need to determine which supply type is the Marginal Water Supply.

We are applying the industry standard practice of energy avoided cost development to water avoided cost development.

- » The CPUC assumes that water efficiency reduces reliance of water supply “on the margin”
- » “Marginal Water Supply” refers to the future water supply we would otherwise need to develop in the absence of water conservation.
- » When we conserve water, the state can avoid:
 - Development of the marginal water supply
 - Expansion of potable treatment plants
 - (Possibly) investment in distribution systems
 - Expansion of wastewater systems

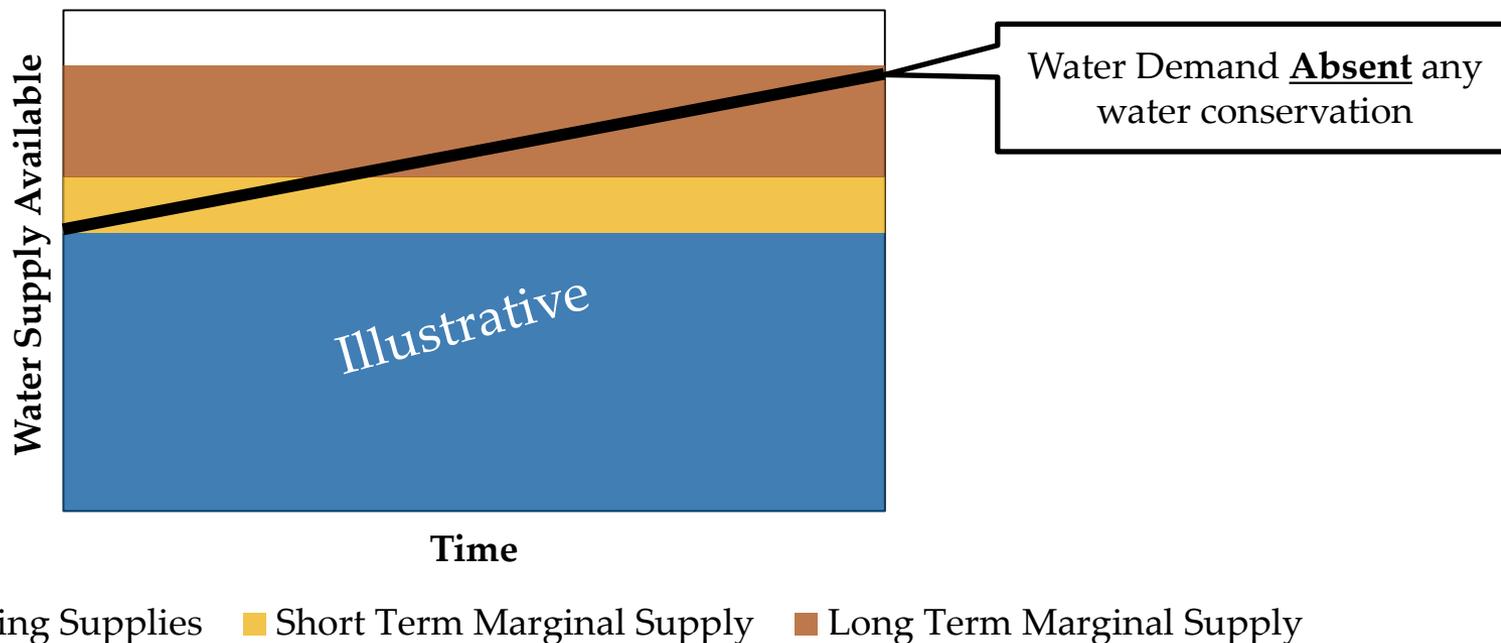


Determining the marginal supply is the most important aspect of our analysis.

The team researched the short term (< 10 years) and long term (> 10 years) marginal water supply.

- » Like energy supplies, it takes time to develop additional water supplies
- » The long term marginal supplies may be more uncertain; but determining these supplies is necessary because efficiency measures are expected to last >10yrs.

Illustrative Relationships of Demand and Supply Options



The marginal supply directly informs two major aspects of the cost effectiveness test.

Benefit Cost Ratio =

$$\frac{\text{Site Energy AC} + \boxed{\text{Embedded Energy AC}} + \boxed{\text{Water Capacity AC}} + \text{Environmental Benefits}}{\text{Costs}}$$

Represents the avoided energy consumption that the marginal supply would have used.

Embedded Energy AC = Water Savings x **Marginal Energy Intensity** x Avoided Cost of Energy

Represents the avoided investment cost that would have been required to develop and operate the marginal supply.

Water Capacity AC = Water Savings x **Avoided Water Capacity Cost (Capital + O&M)**

The team is conducting analysis at the California Department of Water Resources Hydrologic Region level.

- » Types of supplies available to each region differ
- » Many water supply planning activities and data are available at this level; water supply options are relatively consistent within a hydrologic region.
- » The Navigant team leveraged the multitude of existing studies and reports that already document water supplies and their energy intensities at the hydrologic region.

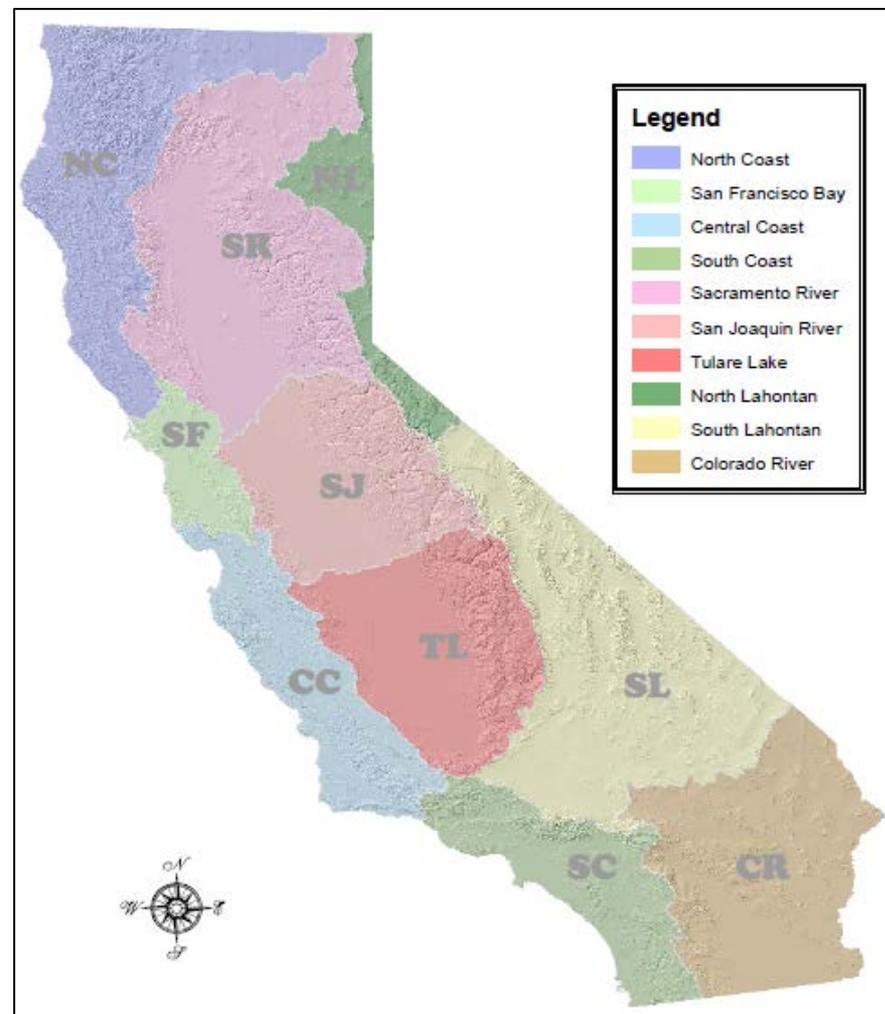


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California's Future: Water

“CALIFORNIA FACES GROWING WATER MANAGEMENT CHALLENGES...

California has made progress on water management. But population growth and climate change are likely to intensify the challenges, and solutions will require difficult and sometimes costly tradeoffs.”

By: Ellen Hanak,
PPIC, January 2014

Determining Future Supplies

Gather information from readily available public information such as DWR reports, IRWMPs and UWMPs

Identify the supply options available in each hydrologic region for the 0-10 year and 11-20+ year time frames

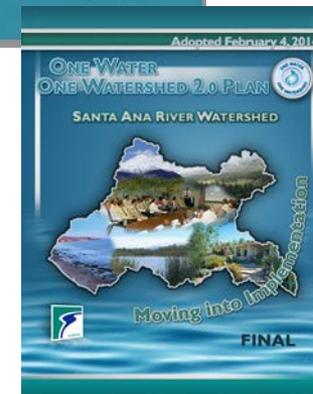
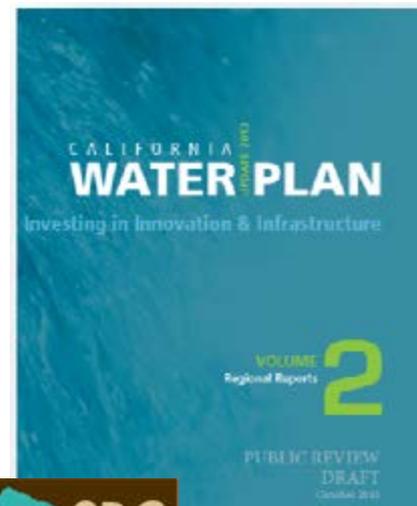
Evaluate the economic and physical characteristics of each supply as well as legal and institutional issues

Using supply characteristics, determine draft short and long term marginal supply for each region

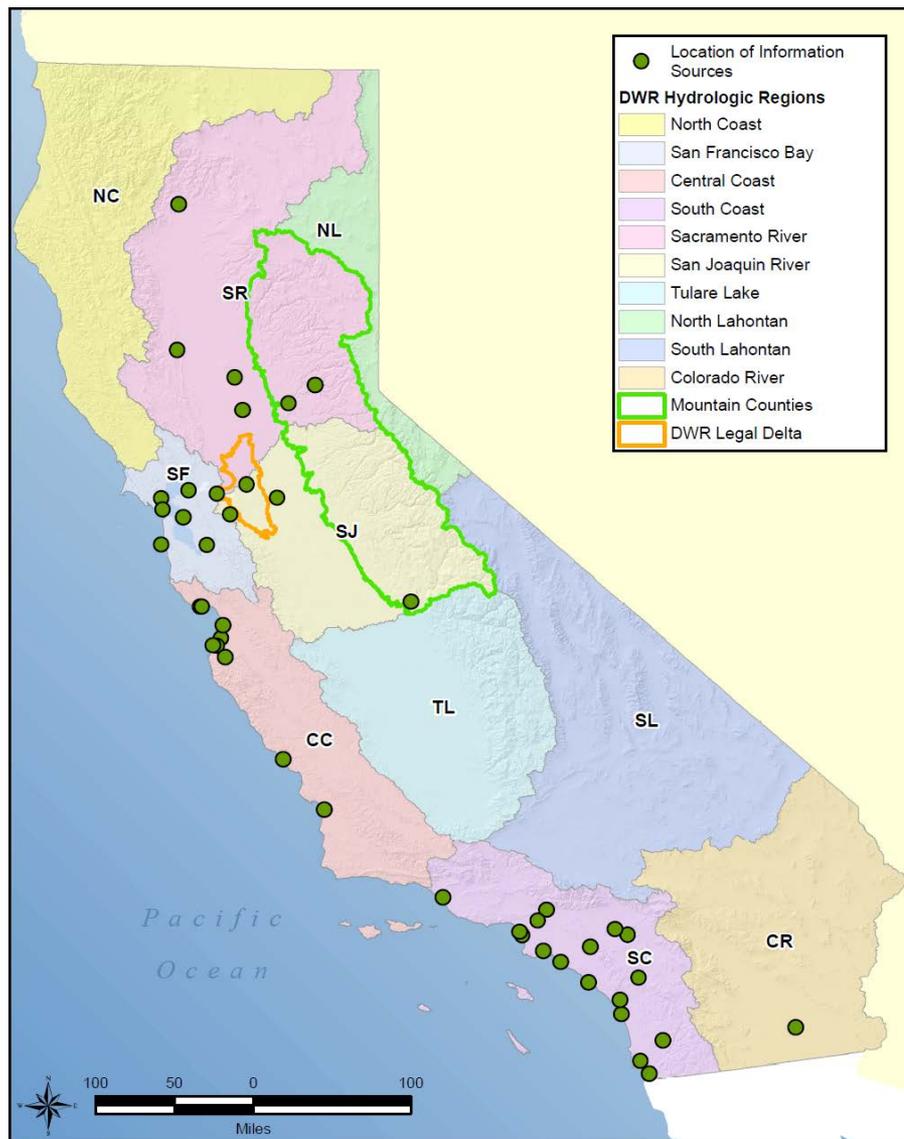
Vet marginal supply selections with the CPUC, PCG, and other experts such as DWR staff, regional water planners, and large wholesale and retail water agencies.

Sources of Information

- » DWR California Water Plan Update 2013 (Public Review Draft, December 2013)
 - Bulletin 160-13: Volume 2 - Regional Reports. Draft 2013
 - IRWMPs, CIPs and other water management plans
- » Discussions/interviews with Water Managers and Analyst
 - DWR Staff
 - Local Water Agency Representatives
 - Non-governmental Organizations
 - Academics



Sources of Information: Regional Distribution



- » The team collected information from across the state
- » Efforts were made to collect data from a variety of hydrologic regions

Recognized Differences

- » Water Supply – the actual source of the water
 - Surface: fresh, impaired/contaminated, recycled, saline, ocean/sea
 - Ground: fresh, impaired, saline
 - Others?

- » Resource Management Strategies: “A project, program, or policy that helps federal, State or local agencies manage water and related resources.” - DWR
 - Reducing end-use water demand
 - Conjunctive management of surface and groundwater
 - Capture and storage
 - Improving water quality
 - Transfers

Total Water Demand

2005-2010 Annual Average Groundwater + Surface Water + Reused Water

2005-2010 Average	Agriculture	Urban
Hydrologic Regions	TAF	TAF
North Coast	736	152
San Francisco	103	1,146
Central Coast	996	298
South Coast	716	3,959
Sacramento River	7,612	906
San Joaquin	7,125	716
Tulare Lake	10,929	740
North Lahontan	447	44
South Lahontan	376	292
Colorado River	3,664	578
Statewide	32,703	8,830

Source: Department of Water Resources, April 2014

California's Groundwater Use

2005 – 2010 Average Annual

Hydrologic Regions	Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Total Water Use ⁴ Met by Groundwater	
	TAF ¹	% ²	TAF ¹	% ²	TAF ¹	% ²
North Coast	301.3	41%	60.0	40%	363.8	32%
San Francisco	76.1	74%	183.5	16%	259.5	21%
Central Coast	906.2	91%	211.3	71%	1,117.4	86%
South Coast	385.4	54%	1,219.6	31%	1,605.0	34%
Sacramento River	2,294.2	30%	428.6	47%	2,742.9	30%
San Joaquin	2,591.3	36%	414.1	58%	3,196.1	38%
Tulare Lake	5,662.5	52%	604.1	82%	6,295.5	54%
North Lahontan	118.4	27%	37.1	84%	166.2	32%
South Lahontan	270.6	72%	170.3	58%	440.9	66%
Colorado River	50.1	1%	329.7	57%	379.7	9%
2005-10 Ave. Total:	12,656.0	39%	3,658.1	41%	16,567	39%

Notes: 1) TAF = thousand acre-feet

2) Percent use is the percent of the total water supply that is met by groundwater, by type of use.

3) Statewide Precipitation for 2005-10 period equals 96% of the 30-yr average.

4) Total Water Use = Groundwater + Surface Water + Reuse

Supplies by Hydrologic Regions

Region	Supply Development Options	
	Short Term (0-10 years)	Long Term (10+ Years)
North Coast	Surface Water Groundwater	Surface Water Groundwater
	<u>Recycled/Reused Water</u>	<u>Recycled/Reused Water</u>
Sacramento River	Surface Water Groundwater Imports (SWP/CVP)	Surface Water Groundwater Imports (SWP/CVP)
	<u>Recycled/Reused Water</u>	<u>Recycled/Reused Water</u>
North Lahontan	Surface Water Groundwater	Surface Water Groundwater
	<u>Recycled/Reused Water</u>	<u>Recycled/Reused Water</u>

Draft marginal supplies indicated in **bold underline**. Based on available water planning information and interviews with water supply planners to date.

Supplies by Hydrologic Regions

Region	Supply Development Options	
	Short Term (0-10 years)	Long Term (10+ Years)
San Francisco Bay	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water
	<u>Brackish Surface + GW</u>	<u>Brackish Surface + GW</u>
San Joaquin River	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water
	<u>Brackish Groundwater</u>	<u>Brackish Groundwater</u>

Draft marginal supplies indicated in **bold underline**. Based on available water planning information and interviews with water supply planners to date.

Supplies by Hydrologic Regions

Region	Supply Development Options	
	Short Term (0-10 years)	Long Term (10+ Years)
Tulare Lake	Surface Water Groundwater Imports (SWP/CVP) Brackish Groundwater <u>Recycled/Reused water</u>	Surface Water Groundwater Imports (SWP/CVP) Brackish Groundwater <u>Recycled/Reused water</u>
South Lahontan	Surface Water Groundwater Imports (SWP) <u>Recycled/Reused water</u>	Surface Water Groundwater Imports (SWP) <u>Recycled/Reused water</u>

Draft marginal supplies indicated in **bold underline**. Based on available water planning information and interviews with water supply planners to date.

Supplies by Hydrologic Regions

	Supply Development Options	
Region	Short Term (0-10 years)	Long Term (10+ Years)
Central Coast	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water Brackish Groundwater	Surface Water Groundwater Imports (SWP/CVP) Recycled/Reused Water Brackish Groundwater
	<u>Ocean/Sea Water</u>	<u>Ocean/Sea Water</u>
South Coast	Surface Water Groundwater Imports (SWP/CVP/CR) Recycled/Reused Water Brackish Groundwater	Surface Water Groundwater Imports (SWP/CVP/CR) Recycled/Reused Water Brackish Groundwater
	<u>Ocean/Sea Water</u>	<u>Ocean/Sea Water</u>

Draft marginal supplies indicated in **bold underline**. Based on available water planning information and interviews with water supply planners to date.

Supplies by Hydrologic Regions

	Supply Development Options	
Region	Short Term (0-10 years)	Long Term (10+ Years)
Colorado River	Surface Water Groundwater Imports (SWP/CR) Recycled/Reused Water <u>Brackish Groundwater</u>	Surface Water Groundwater Imports (SWP/CR) Recycled/Reused Water <u>Brackish Groundwater</u>

Draft marginal supplies indicated in **bold underline**. Based on available water planning information and interviews with water supply planners to date.

Initial Input from Water Managers to date...

- » *Overall lists appear reasonable and fairly accurate.*
- » *Some have questioned why the short and long term appear to be the same list.*
 - For example, in the San Diego region surface, imports and groundwater may not be future supply options; only ocean desalination, and treated Contaminated and brackish groundwater.
- » *Why choose only one marginal supply (gets to the portfolio approach agencies – many things at once).*
 - Not a matter of can they avoid developing – it is a matter of what's available.
- » *Stormwater going to a salt sink or out to the ocean currently should be included as a new supply since it is neither part of surface nor groundwater.*

Initial Input from Water Managers to date...(continued)

- » *Define the appropriate simplifying assumptions that can be put in the model.*
- » *The order of supplies may need to be changed for some regions currently using imported resources.*
 - Areas such as SC, TL, SJ, and SL tend to use imported CVP, SWP and CRA before groundwater.
- » *Permits and regulatory mandates are restricting future use of surface and or groundwater resources, pushing regions to more expensive options such as ocean desalination and treatment of brackish/contaminated groundwater.*
- » *Some regions are planning no significant changes to water supplies in the defined time horizon.*
- » *Future imported supplies may not be available to certain region in the 11-20 year time frame (CC and CR).*

“Anyone who can solve the problems of water will be worthy of two Nobel Prizes – one for peace and one for science.”

-John F. Kennedy



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The purpose of the tool is to calculate the avoided cost of the embedded energy in water saved by conservation measures.

» The user will select an IOU, then input the following for each measure:

- Measure Name
- Annual Water Savings (gallons)
- Measure Life (years)
- Installation Year
- Hydrologic Region
- Water Quality
- Water Use
- Incremental Equipment Cost (\$)
- Installation Cost (\$)
- Program Administration Cost (\$)
- Rebate (\$)

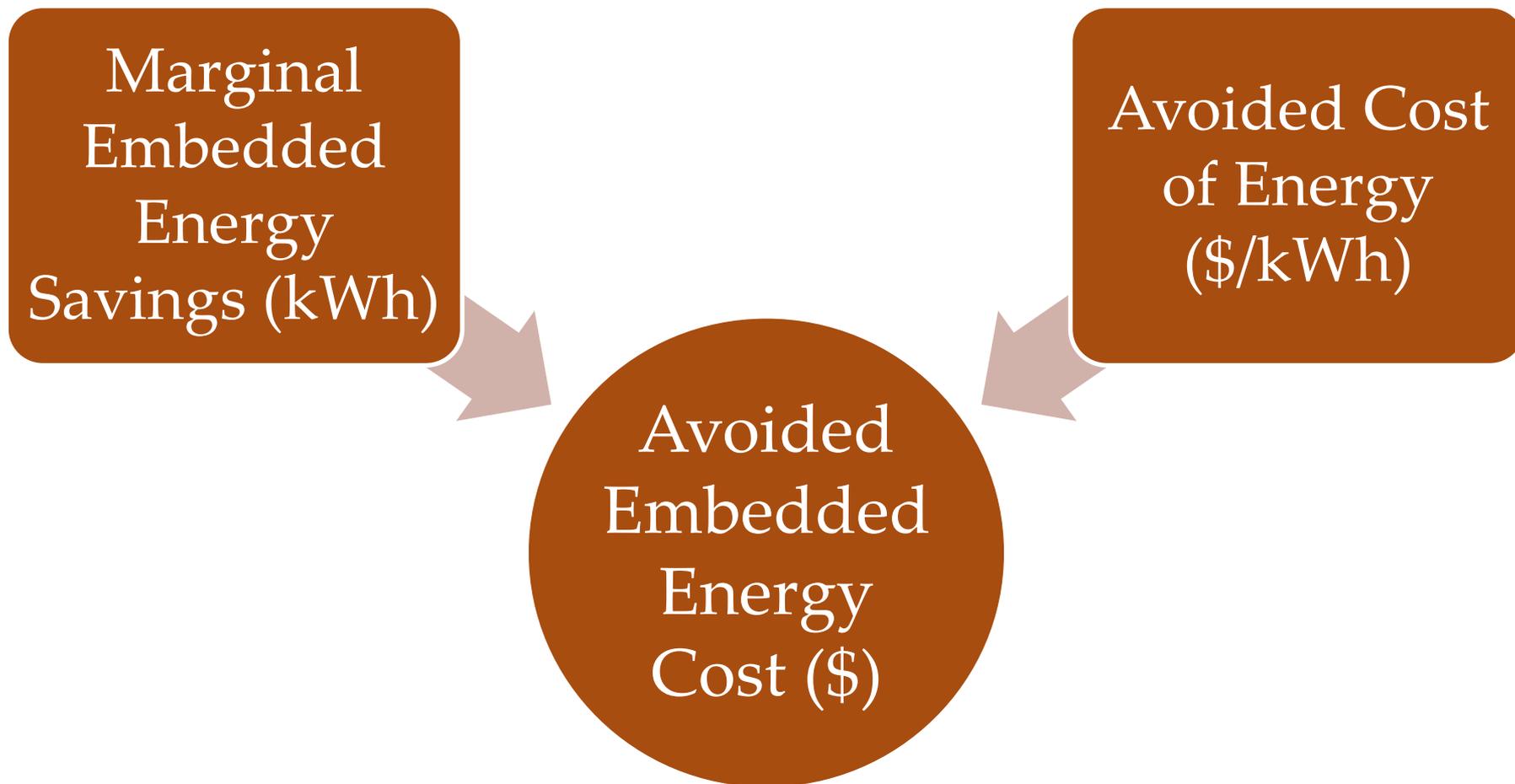
The Tool will:

Use the appropriate values for marginal supply energy intensity to determine a system-wide energy intensity value.

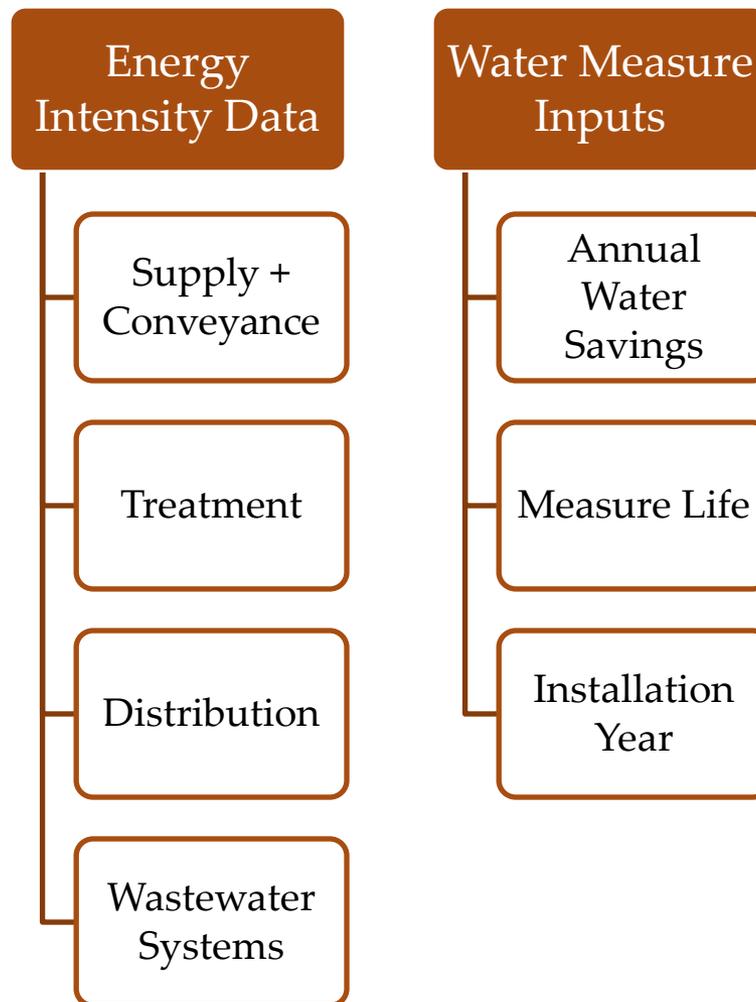
Combine that with the provided data on water savings to calculate embedded energy savings.

Multiply the amount of energy saved by the avoided cost of energy to calculate the total avoided cost of that embedded energy.

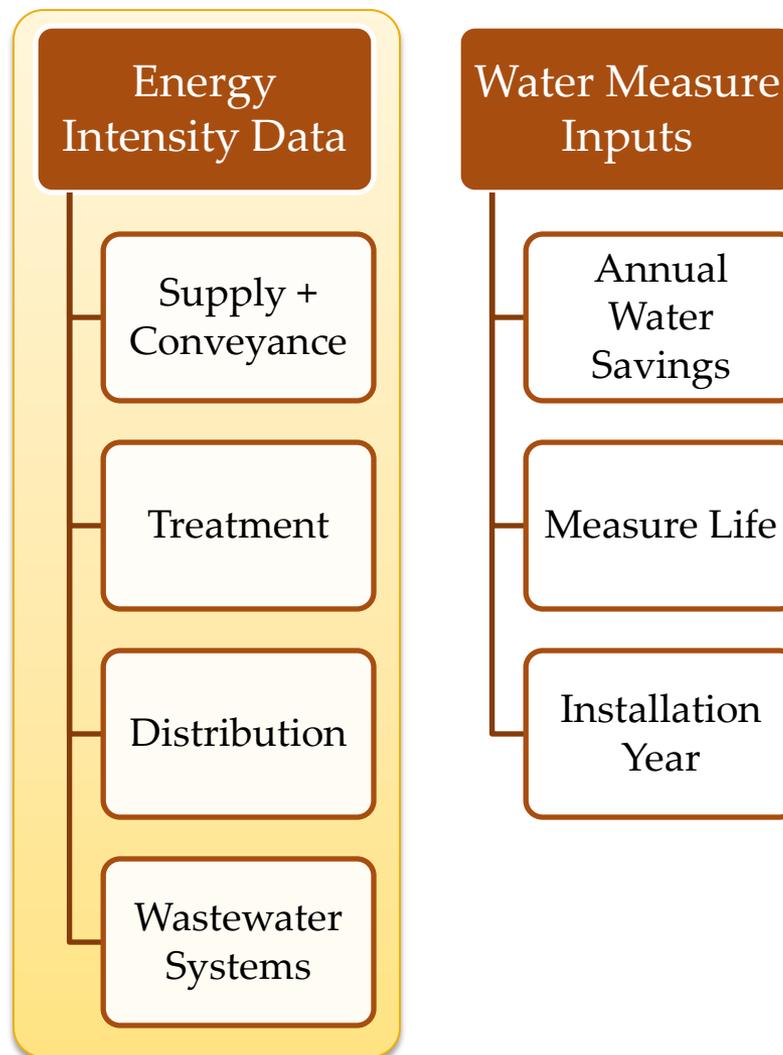
The avoided embedded energy cost is calculated from an energy and a cost component.



This tool will calculate the embedded energy savings from a water conservation measure from the following components.



Energy intensity (EI) is calculated for each component of the water system.



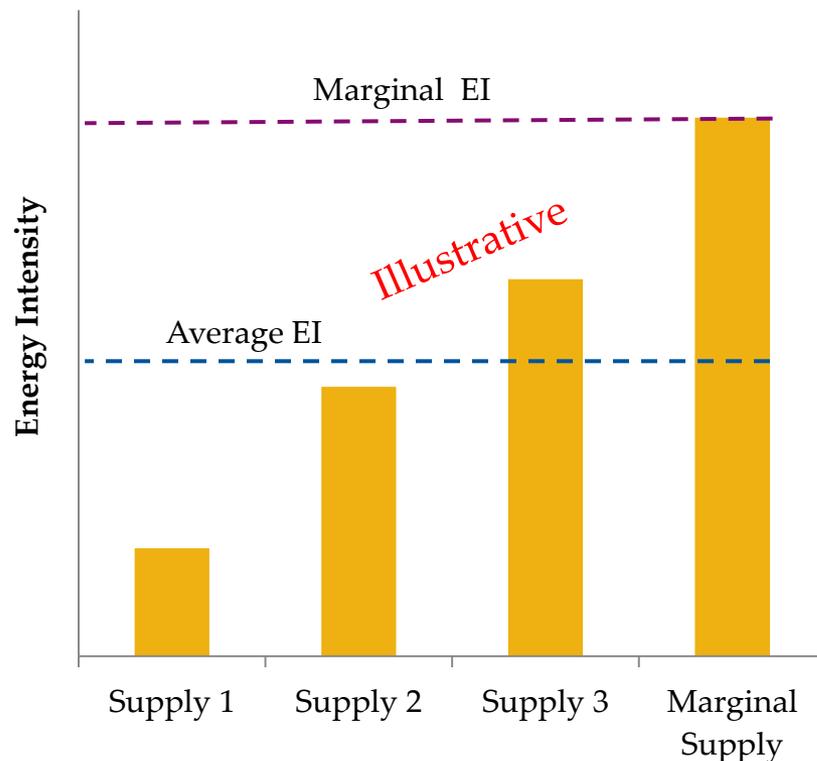
Supply EI is represented by the EI of the marginal supply; Average EI will also be calculated.

» **Marginal EI**

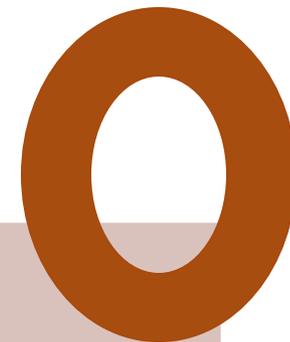
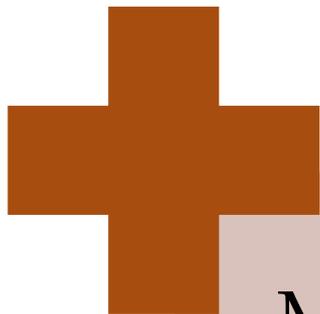
- The EI of the selected marginal supply for the region.
- May be time-dependent if short and long term marginal supply differ

» **Average EI**

- Represents the weighted average present-day EI value of the regions' water



Treatment EI is a function of the quality of the water being conserved and the supply type.



- Measure saves treated water
- Supply type produces water that needs further treatment

- Measure saves untreated water

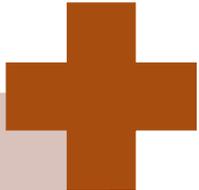
Distribution EI is dependent on region topography; each region is assigned a topography and thus a set EI value for the distribution component of the water system.



Wastewater system EI is a function of the use environment of the water being conserved.



- Water use is indoors



- Water use is outdoors



EI data is aggregated based on the specifics of each measure being analyzed.

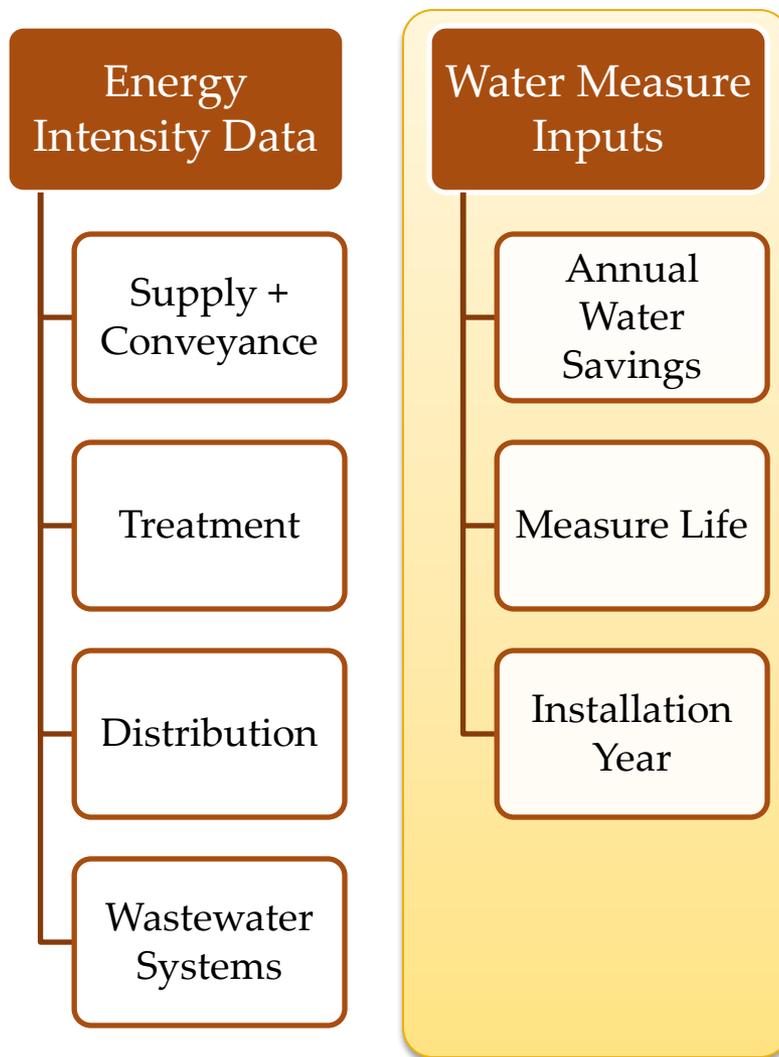
Illustrative Example: Water Quality = Potable, Water Use = Indoor

	2014	2015	...	2023	2024	2025	2026	...
Supply	1000	1000	...	1000	2000	2000	2000	...
Treatment	300	300	...	300	300	300	300	...
Distribution	500	500	...	500	500	500	500	...
Wastewater	1500	1500	...	1500	1500	1500	1500	...
Total (kWh/AF)	3300	3300	...	3300	4300	4300	4300	...

Illustrative Example: Water Quality = Non-Potable, Water Use = Outdoor

	2014	2015	...	2023	2024	2025	2026	...
Supply	1000	1000	...	1000	2000	2000	2000	...
Treatment	0	0	...	0	0	0	0	...
Distribution	500	500	...	500	500	500	500	...
Wastewater	0	0	...	0	0	0	0	...
Total (kWh/AF)	1500	1500	...	1500	2500	2500	2500	...

The region, water quality, and water use are only a few of the required measure inputs related to water savings.



For calculating marginal embedded energy, water measure inputs are used to generate a temporal mapping of the water savings.

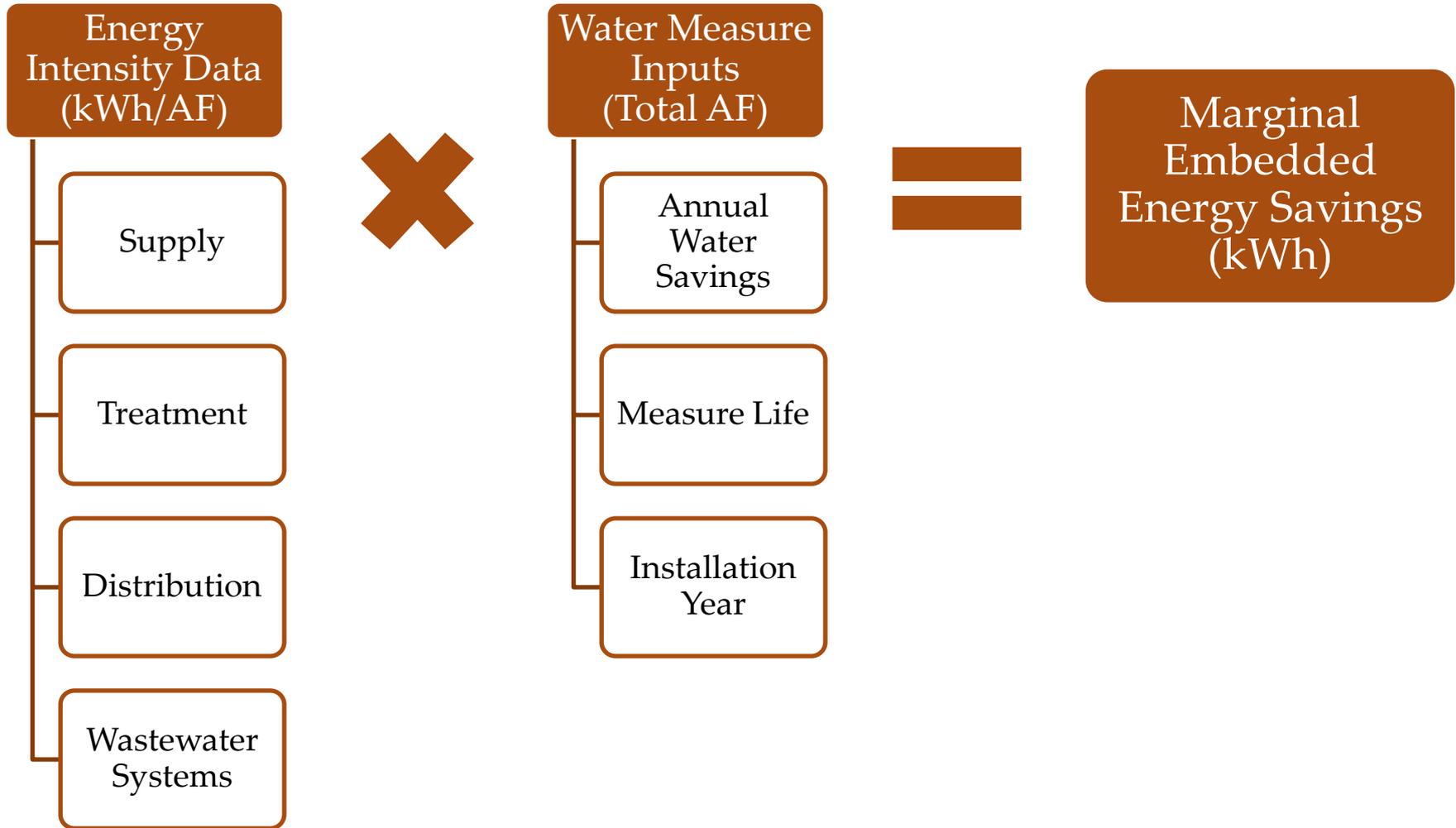
Water Measure Inputs

Measure	Annual Water Savings (gallons)	Measure Life (years)	Installation Year
#1	1000	9	2015
#2	500	6	2018
#3	200	6	2015

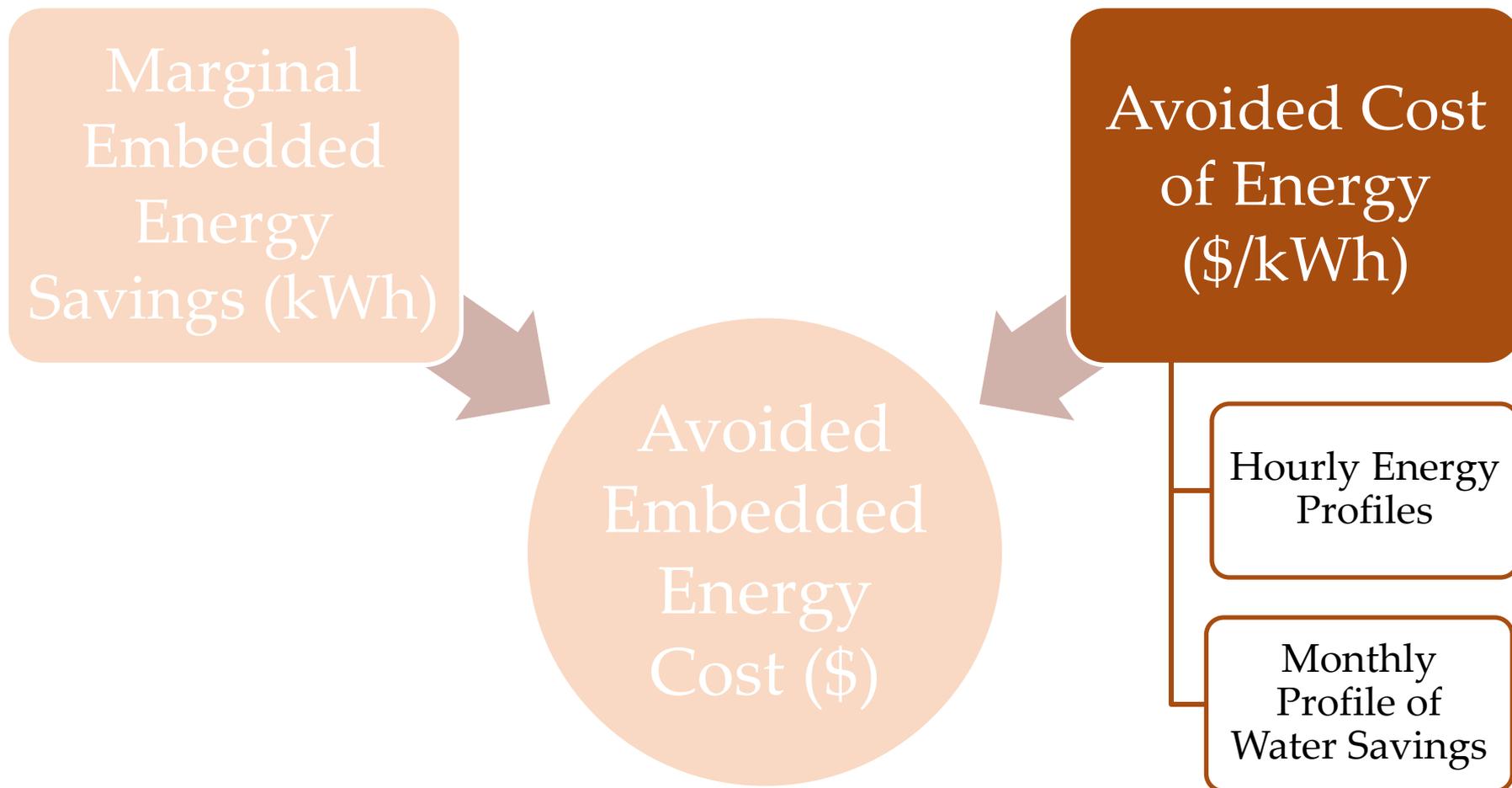
Annual Water Savings by Measure (gallons)

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	-	200	200	200	200	200	200	-	-	-

The energy intensity and water savings are combined to calculate embedded energy savings.



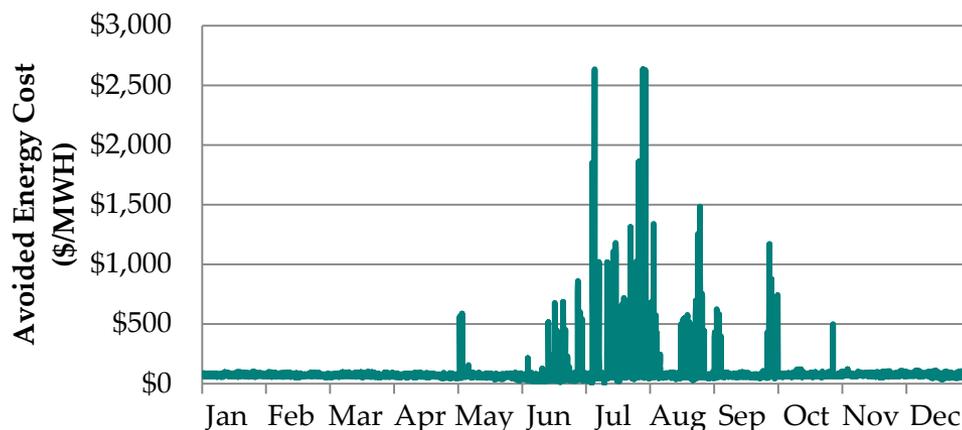
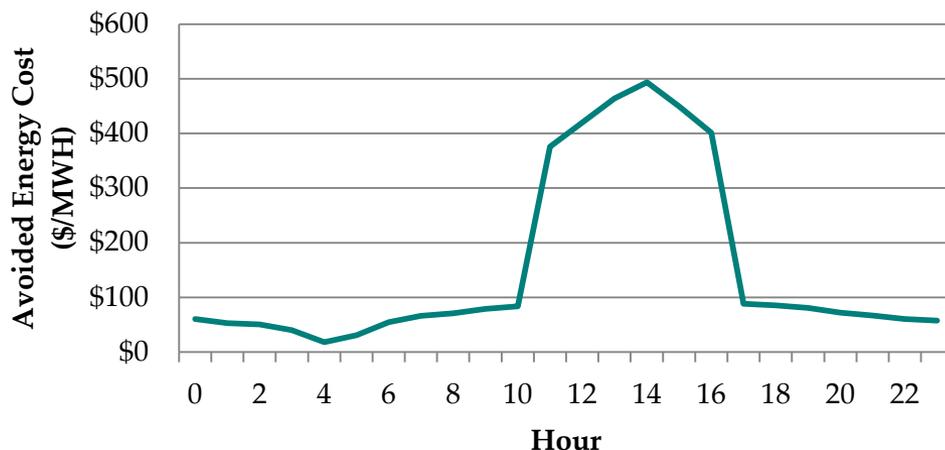
The avoided cost of energy will be sourced from existing CPUC avoided cost models and will incorporate water-related load profiles.



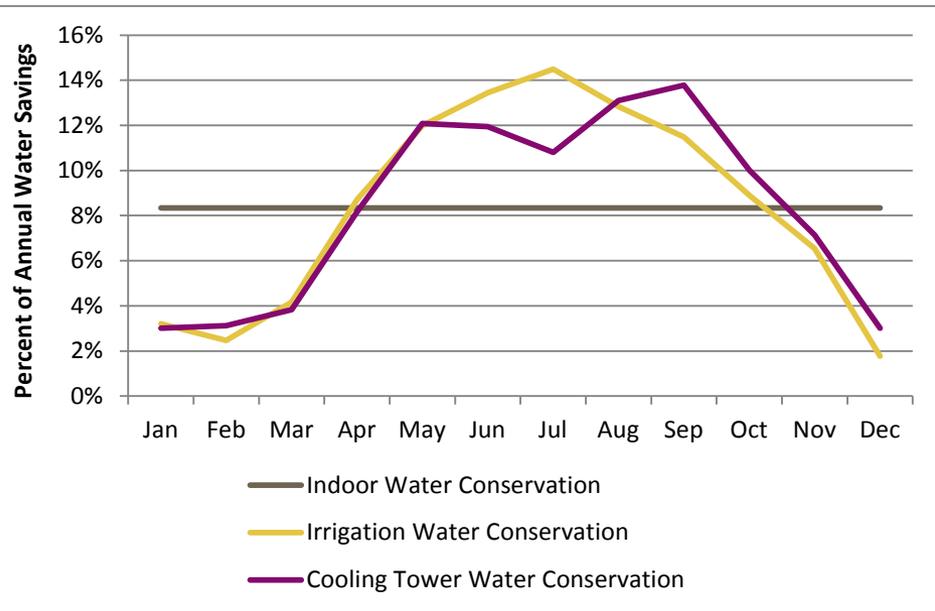
Embedded energy savings during the summer months and peak hours can provide higher benefits.

- » 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.

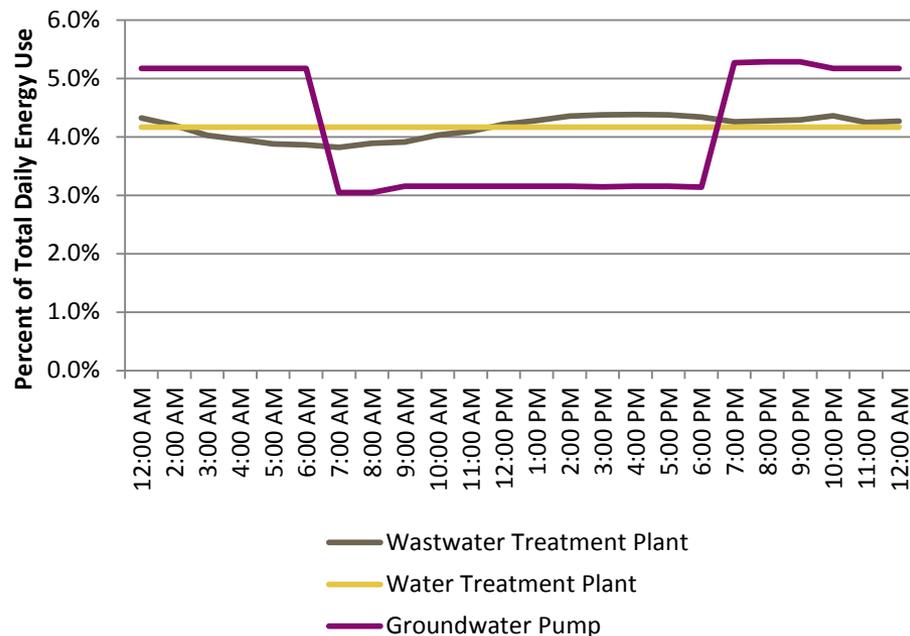


Monthly and hourly profiles are available from secondary data sources.



Illustrative monthly water savings for various end uses. Adapted from California Sustainability Alliance.

Illustrative hourly energy consumption of water system components. Adapted from CPUC Embedded Energy in Water Study 2.



Discussion

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The following sources were reviewed as part of the marginal supply selection process.

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The following sources were reviewed as part of the marginal supply selection process.

- » Bay Area Regional Desalination Project (BARDP). (2010). Pilot Testing at Mallard Slough Pilot Plant Engineering Report: Appendix H Design Criteria. Oakland, CA: Ebmud, Contra Costa Water District, SFPUC, Santa Clara Water District
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