Water-Energy Program Cost-Effectiveness Calculator

An energy efficiency program cost effectiveness calculation tool used to estimate the embedded electricity and natural gas savings and resultant avoided costs derived from the installation of water savings measures

Developed for the California Public Utilities Commission Energy Division by
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1. Overview of the Calculator

This spreadsheet tool was created for the CPUC to examine the details of water-saving measures as they apply to electricity and gas savings. The calculator determines the energy savings, the energy savings avoided cost and the TRC (total resource cost) of individual water conservation measures as well as utility programs that can consist of any number and combination of water measures. The current version of the tool in xls and xlsm formats can be found in the zip archives located at the following links:

ftp://deeresources.com/pub/Water-Energy/WaterEnergy-CEcalculator-v4B_XLSM.zip

ftp://deeresources.com/pub/Water-Energy/WaterEnergy-CEcalculator-v4B_XLS.zip

The tool relies on measure definitions that are supplied by the water conservation program designer and entered by the user. Utility and water-agency specific information is then applied to these measures to arrive at energy savings and avoided costs. A quick screening of all measures is provided in the first results table. A “best case scenario” can be investigated using this table

for a specific water agency to determine which measures can pass a measure-level TRC test. Those measures can be entered into a separate table that calculates the TRC for an entire program, made up of various rebate and direct install measures.

Figure 1 below illustrates the information that is utilized and the values that are calculated. The entries in **blue** are input by the user. The example inputs that are included in the calculator are from "BMP Costs & Savings Study" *California Urban Water Conservation Council, March 2005*. Other information, such as agency embedded energy or electric savings loadshapes, have default values available, but can be refined by the user with agency-specific information when available. These default embedded energy and loadshapes are from "Water Supply Related Electricity Demand in California" *Demand Response Research Center, Lawrence Berkeley National Laboratory, LBNL-62041, December 2006*.

The following sections of this report explain the contents and use of each of the tabs in the spreadsheet calculator.

New Features added in Version 3 and 4

- Gas Energy Savings – a new IOU was added (SoCalGas) and calculations were expanded to determine gas energy savings associated with water use reductions.
- Multiple Program Analysis – up to five programs can be saved, compared and summarized.
- Freshwater and Wastewater Energy Profiles – hourly energy use profiles associated with pumping and treating freshwater and wastewater can now be assigned separately and can vary seasonally.
- Water Savings Profiles – a water savings profile that varies the expected water savings on a daily basis replaces the summer/winter water savings specification.
- Expanded Program Summary – the IOU Program Budget components have been redefined to make their meaning more clear, and "Other TRC Component Costs" have been added to the summary. One important change here is that "partner" contributions to the IOU program which offset or reimburse non-measure IOU administration costs can now be specified (whereas previously these were added to rather than subtracted from the IOU costs.)
- Error checking that provides immediate feedback to the user regarding improper entries, pull-down lists that display only legitimate choices and "protected" worksheets make defining measures and programs more robust.

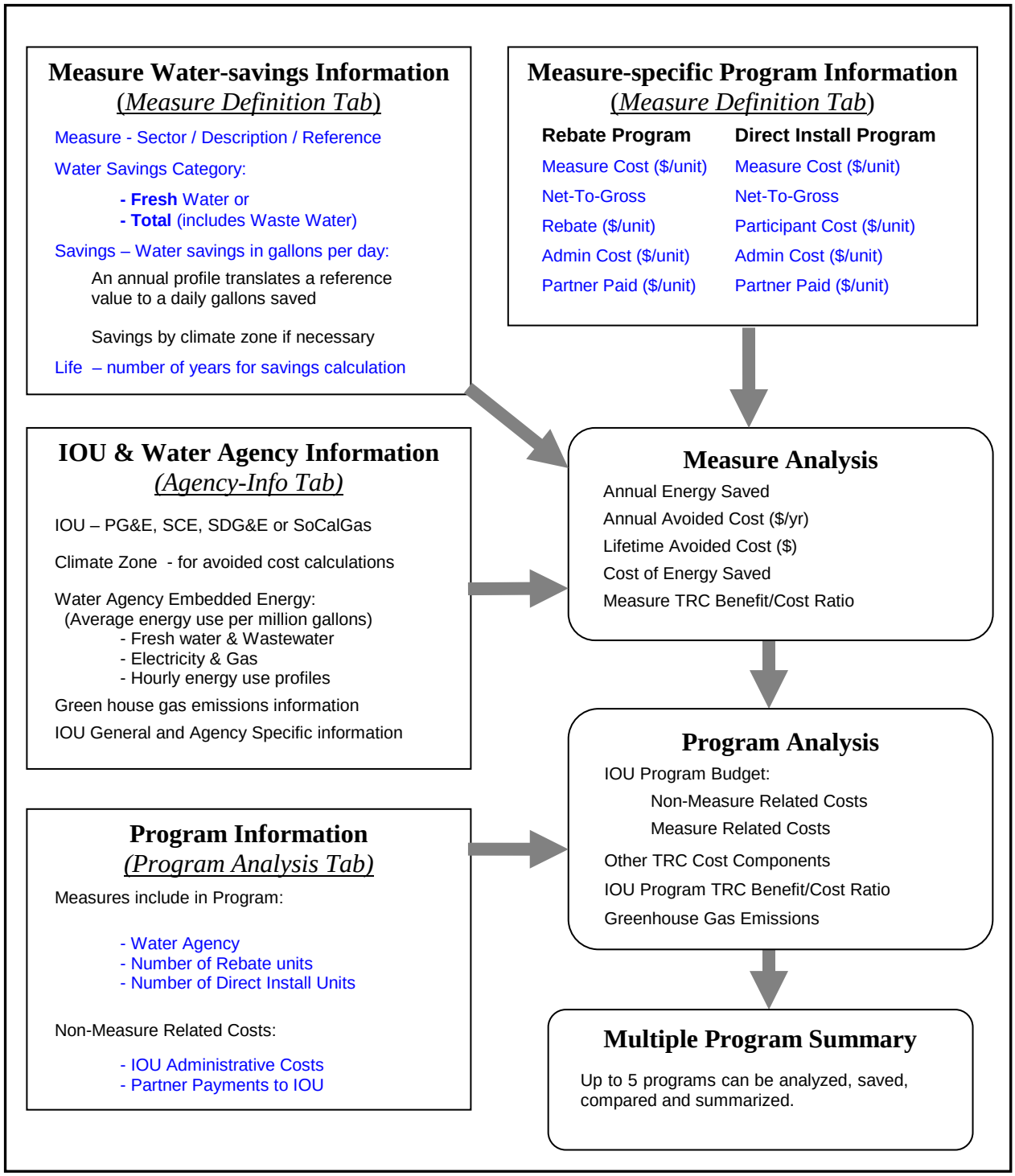


Figure 1. Calculator flow diagram

2. [Intro] tab

This tab provides a basic description of the spreadsheet and its use and contains a glossary of terms.

3. [Measure Definition] tab

The table on this tab defines each of the water-saving measures and associated program costs that will be analyzed. This information provides the foundation for all of the measure and program calculations. As such, each line of data should be carefully considered before including in the analysis.

3.1 Defining a Measure

To define a water-saving measure, three basic questions need to be answered:

1. What category of water will be saved?

The category of water savings is either "fresh water", "waste water" or "total" (fresh water and waste water). Measures that are assigned to the "fresh" water category will account for the energy required to deliver the water to the site of use, but will not include any energy for waste water treatment. This category is most applicable to outdoor water conservation measures such as evapotranspiration controllers where the water used is assumed not to return to the waste water treatment stream.

Measures assigned to the "total" category will account for both delivery and wastewater treatment energy use. Most indoor water conservation measures will be assigned to the total category. The third possibility, which is "waste water" only, would account for the reduction in wastewater treatment energy but with no associated reduction in delivery energy. This category would only apply to (those unusual) measures that deal with water obtained from the site and is added to the wastewater stream.

2. How much water will be saved?

The amount of water that is expected to be saved per installation is specified with a "reference water savings" value and an annual profile. The annual profile can account for differences in expected water savings due to varying seasonal requirements, such as for irrigation measures, and can account for differences in weekday versus weekend usage. Though the annual profile is hourly, it is only the ***daily*** total water savings that is altered by the water savings profile.

The user has a number of options for specifying a measure whose water savings is known to vary by climate zone. If only one climate zone is to be analyzed, then a note regarding the applicability of the measure to that specific climate zone should be entered into the description. If multiple climate zones are to be analyzed, then two options are available:

- Specify a separate measure for each climate zone, noting the applicable climate zone in the measure title, or
- Refer to a list of values that specifies the savings for each relevant climate zone.

An example of the list of values is given in the spreadsheet. For the "ET-controllers" measure listed in the Measure Definition table, a name is given under the water savings column instead of a value. When the program needs to determine the water savings value for this measure, it looks for the specified list name and appropriate climate zone on the [Measure Savings by CZ] tab. *Note: if the user specifies a water-savings value using a name that does not exist in the "Measure Savings by CZ" table, the input will be shown in a white font with a red background, indicating an error.*

3. How many years is the measure expected to save water?

The number of years of expected water savings, or the "effective savings life" for a measure is a function of both the measure and the program that is associated with the measure. For an early retirement program that replaces existing, high water-use equipment with current code-compliant equipment, the effective savings life is the estimated average "remaining useful life" of the equipment that is replaced. For a "replace on failure" program that installs water-conserving equipment that goes beyond code requirements, the effective savings life is the number of years after which one-half of a population of installed devices would be expected to remain installed and in operation.

3.2 Rebate or Direct Install Measure Inputs

The same table used to define the measure inputs also defines the inputs associated with the Rebate or Direct Install program that promotes the measure.

Measure Cost

For a rebate program, the measure cost is the purchase price of the device or piece of equipment as seen by the participant. For a direct install program, the measure cost is the total price paid to a contractor to have the device or equipment installed. The total price paid to a contractor includes the cost paid by the utility and any cost paid by the participant. All costs in this table are "per unit" or per installation.

Net to Gross

The "net to gross" (equal to one minus the free rider fraction) must be estimated for each measure and its associated program. Data derived from econometric analysis of previous programs is most reliable, but some measures may need to rely on estimates from similar programs or best judgment.

Measure Rebate

This is the amount paid to the participant of a rebate program, in $ per unit. The fraction of participants that are expected to not apply for the rebate can be accounted for in the average rebate amount (effectively decreasing the average rebate per unit).

Participant Paid Cost

This is the amount of the measure cost that is paid by the participant in a direct install program, in $ per unit. This amount may be paid to the utility or directly to the installation contractor.

Administrative Cost

This is the utility's cost per unit measure that is associated with the administration of the rebate or direct install program. Typical values are some fraction (0.2 – 0.5) of the measure cost.

Partner Paid Cost

This is the amount paid by a third party partner (water agency) per measure unit. This amount may be paid to the utility or directly to the participant.

4. [Agency-Info] tab

This tab contains the water agency information that is used by the calculator to determine energy savings and GHG reductions based on reduced water use. The user can update or add new agency information to any of the cells with a brown background. Table 1 describes each of the water agency inputs.

Water Agency Information	
Agency	Name of agency will appear in pull-down lists
Utility Territory	controls which water agencies are available for a given IOU, must be one of: PG&E, SCE, SDG&E, SoCalGas
Climate Zone	CZ of agency location within the utility territory, required for electric avoided cost lookup
Pumping and Process Energy – Electricity Use:	
fresh (kWh/mgal)	kWh per million gallons for delivering freshwater to site
waste (kWh/mgal)	kWh per million gallons for processing waste water
combined (kWh/mgal)	Typically the sum of fresh and waste water kWh/mgal
Electricity Savings Profile:	
Freshwater	Annual profile that translates daily energy savings associated with freshwater savings into hourly demand reduction
Wastewater	Annual profile that translates daily energy savings associated with wastewater processing savings into hourly demand reduction
Include Electric Costs?	Flag for calculation to include electric costs in the avoided cost calculation; 1 means include, 0 means exclude
Pumping and Process Energy – Gas Use:	
fresh (therm/mgal)	therms per million gallons for delivering freshwater to site
waste (therm/mgal)	therms per million gallons for processing waste water
combined (therm/mgal)	Typically the sum of fresh and waste water therms/mgal
Gas Savings Profile:	
Freshwater	Annual profile that modifies the gas freshwater pumping and process energy (therm/mgal) as described above on a daily basis.
Wastewater	Annual profile that modifies the gas wastewater pumping and process energy (therm/mgal) as described above on a daily basis.
Include Gas Costs?	Flag for calculation to include electric costs in the avoided cost calculation; 1 means include, 0 means exclude
GHG Emissions - pounds per kWh reduced and pounds per million gallons reduced wastewater:	
CO2	Pounds of CO2 GHG emissions reduced per kWh saved
CH4	Pounds of CH4 GHG emissions reduced per kWh saved Conversion to CO2: times 21
N2O	Pounds of N2O GHG emissions reduced per kWh saved Conversion to CO2: times 310
GHG Emissions - pounds per therm of gas reduced	
CO2	Pounds of CO2 GHG emissions reduced per therm saved

Table 1. Water Agency inputs

New entries will be available from the pull-down menus on the [All Measure Analysis] and [Program Analysis] tabs.

5. [All Measure Analysis] tab

The main table on this tab provides a quick screening of all defined measures on the Measure Definition tab for a water agency scenario (up to 50 measures). This allows the comparison of all measures if installed in the same locale. The controls near the top of the page (figure 2) are used to choose the options that define the water agency energy use and the electricity avoided cost hourly values.

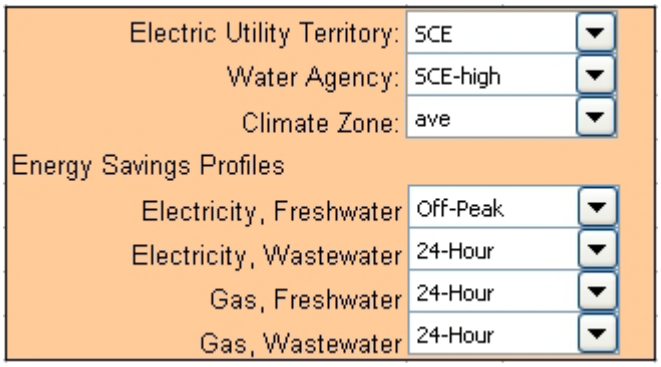


Figure 2. "All Measure Analysis" options.

5.1 Electric Utility Territory

There are four IOU electric utility territories to choose from: PG&E, SCE, SDG&E and SoCalGas. The choice of IOU defines the available water agencies and climate zones and, along with the climate zone for electric utilities, determines which hourly avoided cost values will be used.

5.2 Water Agency

The choice of water agency determines the amount of energy associated with a unit of water savings. For the electric utilities, the first three choices are always the low, medium and high levels of water agency electricity use as defined for the chosen IOU. The gas utility includes only a typical value, as the low range is essentially zero and the high range is better defined by specific water agencies that use gas for their base load pumping. All specifically defined agencies associated with the IOU are also available. The choice of water agency defines the particular fresh-water and waste-water electricity and gas values that will be used in the calculation of energy savings. These values are displayed at the top of the screen for the currently chosen water agency:

Water Agency Information pumping & process energy			
	Fresh-water	Wastewater	
Electricity	1589	1974	kWh/Mgal
Gas	0.0	0.0	therm/Mgal

5.3 Climate Zone

The choice of IOU determines which forecasting climate zones are available. All forecasting climate zones for the utility are displayed. The climate zone is used to determine the proper hourly electricity avoided cost values. The average of all the climate zones is also available. If "Ave" is chosen, then the average hourly avoided costs for all climate zones with the utility territory are used in the calculations.

PG&E	SCE	SDG&E	SoCalGas
average	average	average	average
CZ01	CZ06	CZ07	
CZ02	CZ08	CZ10	
CZ03A	CZ09	CZ14	
CZ03B	CZ10	CZ15	
CZ04	CZ13		
CZ05	CZ14		
CZ11	CZ15		
CZ12	CZ16		
CZ13			
CZ16			

Table 2. Forecasting climates zones by IOU

5.4 Energy Savings Profiles

The energy savings profiles perform two functions: they describe how the daily "energy use per million gallons" may change of the course of a year and for electricity, they describe how daily energy savings translates into hourly electric demand reductions at the water agency. Total cost savings is highly sensitive to the assumed electricity savings profile since the calculation uses hourly avoided cost values to determine cost savings.

Three default energy savings profiles are always available from the pull-down menu along with any custom profiles that the user has defined. Figure 3 shows the daily profile of the three default profiles and an example of a custom profile.

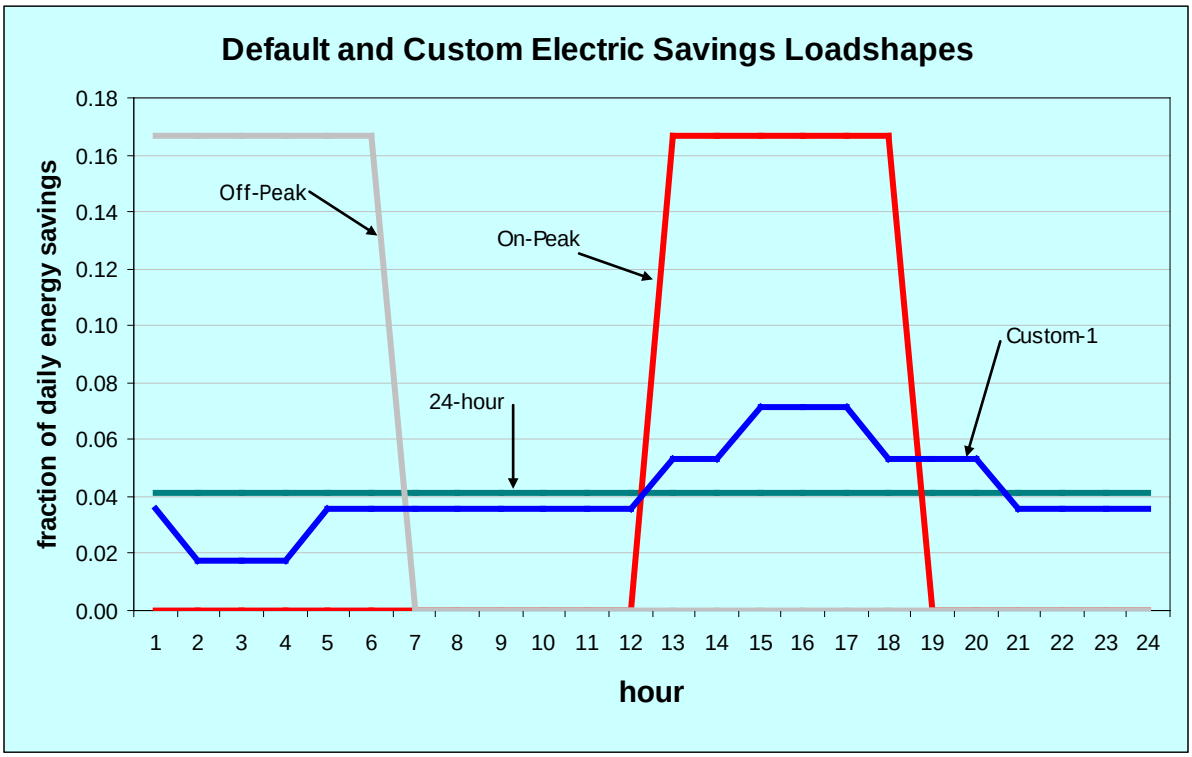


Figure 3. Profiles for the Electric Savings Loadshapes

The "Off-Peak" load shape is representative of a water agency that is able to pump all marginal water volume needs during off-peak hours, from midnight to 6 a.m. in this case. As a response to less water demand, this agency will pump less water into storage at night and will see no effect on its daytime electricity requirement. This loadshape will lead to the lowest possible avoided cost per unit of water savings.

The "On-Peak" load shape is representative of a water agency that can respond to a decrease in water use by decreasing peak period pumping. This loadshape will lead to the highest possible avoided cost per unit of water savings since avoided cost are highest during this same period.

The "24-hour" load shape assumes that a decrease in water use may lead to a pumping energy decrease during any time of the day and therefore uses a constant decrease in electricity use.

"Custom" profiles can be created on the [ProfileCalc] tab and added to the library of available profiles.

5.5 All Measure Results

The table of results on this tab is updated automatically whenever a new option is selected. The table displays energy and cost savings for each measure, along with the individual measure TRC and cost of saved energy for the rebate and direct install programs. Measures that have a TRC greater than or equal to the value in cell J17 are highlighted in a bold font; measures that have a

TRC greater than or equal to 1.0 are highlighted in a bold blue font. Table 3 below describes each of the columns of the table on the tab.

All Measure Analysis Result	Description
Annual Water Saved (gallons/yr)	Water savings for the measure, based on the reference water savings per day and the water savings profile.
Annual Electricity Saved (kWh/yr) and Annual Gas Saved (kWh/yr)	Annual electricity and gas savings due to water saving measure; calculated based on water savings and the water agency energy use specifications.
Annual Avoided Cost ($/yr)	Avoided cost of energy savings levelized over the life of the measure; calculated via a macro using avoided cost values *f*(fuel, IOU, CZ, yrs), and the hourly profile of energy savings.
Total Avoided Cost ($)	Present value of annual avoided costs over the lifetime of the measure; calculated using IOU specific discount rates: (PG&E = 8.79%; SCE = 8.77%; SDG&E = 8.23%; SoCalGas = 8.48%)
Rebate or Direct Install, Cost of Energy Saved ($/kWh)	Cost of energy saved over lifetime of measure (see below for definition)
Rebate or Direct Install, TRC	Total Resource Cost test, see formula below
GHG Reductions	Lifetime reduction of green house gases due to the measure, expressed in pounds of CO2 equivalent

Table 3. Description of "All Measure Analysis" Results

The individual measure TRC values are calculated as described below.

TRC = Benefit / Cost

Benefit = Total Avoided Cost * NTG **eq. 1**

where NTG = Net-To-Gross

Cost is dependent on the type of program.

Cost (rebate program) = (Measure Cost – Partner Paid Cost) * NTG
+ (1-NTG) * Rebate Amount + Admin Cost **eq. 2**

Cost (Direct Install program) = Measure Cost - Partner Paid Cost
- (1-NTG) * Participant Paid Cost + Admin Cost **eq. 3**

6. [Program Analysis] tab

This tab allows for the definition and energy analysis of a water conservation program, or group of water-saving measures. The user must design the program by choosing the measures to

include in the program, the geographic location of the measure installations and the target number of installations for a rebate and/or direct install campaign.

> Note: This process can involve a number of steps and it may be advantageous to the user to maximize the spreadsheet window and, if necessary, to use the "zoom" feature in Excel to show at least columns A through Q. The "freeze panes" feature is likely turned on and set to scroll only rows below the main table headings. Depending on your computer screen resolution, this may or may not help in viewing this tab. If you need to turn off this feature, point to the Excel "Window" menu at the top of the screen and choose "Unfreeze Panes".

6.1 Program Inputs

Since multiple programs can be defined, it is important to enter a descriptive name and status for the current program being defined. These descriptors are used to identify the program in the [Program Summary] tab.

Defining the measures associated with a program involves many of the same choices that were described for the [All Measures] tab. The main difference is that the water agency is chosen for each measure, instead of for all the measures as a group. The energy savings profiles are not entered for each measure, but are associated with the chosen water agency.

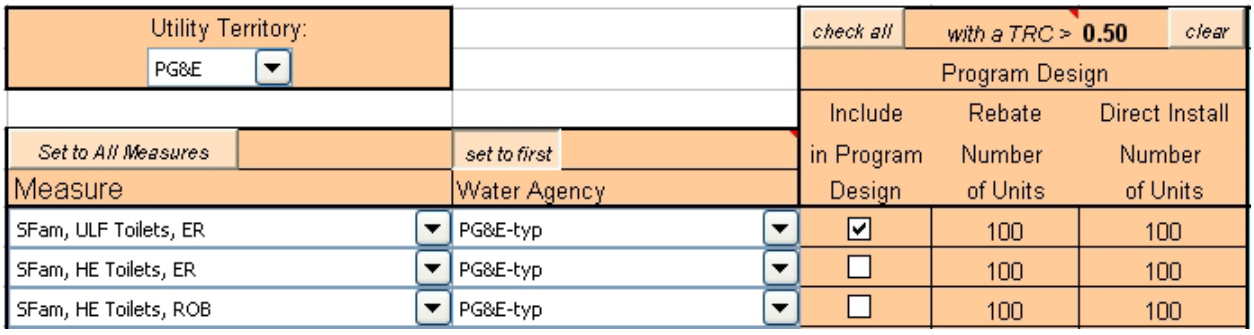


Figure 4. Program Analysis Options

In addition to the measure options already described, the user must also indicate whether the measure is to be included in the program using the checkbox and indicate how many of each measure are to be included in the program using the entries below the columns labeled "Rebate Number of Units" and "Direct Install Number of Units".

Because of the potentially large number of options that need to be specified, a few buttons have been added that may aid in the process. These buttons and their actions are described below:

Button	Action
Set to All Measures	Pressing this button will set the table to include one instance of each of the measures defined in the Measure Definition table.
set to first (above Water Agency)	Pressing this button will set all of the controls under the Water Agency to the choice shown in the first row.
check all	Pressing this button will place a checkmark next to those measures that have a TRC (either rebate or direct install TRC) greater than the value in to the right of the button.
clear	Pressing this button will clear all of the checkmarks.

Choosing a new option using the pull-down menus or pressing a button that causes these options to change will require that the values in the table be recalculated. Whenever the values need to be recalculated the button that initiates the calculation will turn from

Update All Measures to **Update All Measures**.

Since many options may be changed to define a program, this worksheet does not automatically update whenever needed. Instead, the user should press the Update button when they have completed a set of changes. Note: altering the checkboxes or changing the number of units for a rebate or direct install program ***does not*** require a recalculation of the annual avoided costs; all results update automatically when these inputs change.

The only other inputs that define the program are the non-measure related costs listed in the IOU Program Budget table.

IOU Program Budget		
Non-Measure Related Costs:		
IOU Paid Administrative Costs:	$	20,000
Partner Payments to IOU Program:	$	5,000
Measure Related Program Paid Costs:		
IOU Administrative Costs:	$	52,500
IOU Rebate Costs:	$	78,000
IOU Direct Install Costs:	$	54,000
Total Program Budget:	$	199,500

Figure 5. IOU Program Budget Table – Use Inputs

These two non-measure related entries are defined as:

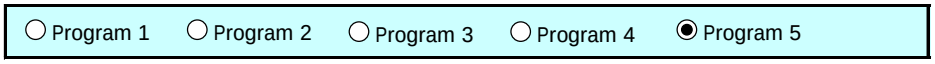
IOU Paid Administrative Costs

Costs paid by the IOU to administer the program are entered here. These are costs not accounted for by the values entered for measure administrative costs per unit in the measure selection area of the tab. This value increases the program TRC cost.

Partner Payments to IOU Program

Payments made by a third-party partner to the IOU to offset program costs are entered here. These are partner contributions to the program operating cost which reimburse dollars actually paid by the IOU which are not accounted for by the values entered for partner measure related contributions per unit in the measure selection area of the tab. This value is subtracted from the overall program TRC cost.

Up to five separate program definitions can be saved using the buttons provided. To select a program to view and/or edit you click on the program number in the selection at the top of the tab:



One you have completed the program input or edits and wish to save the changes (or replace any other program number with the program data current displayed on the program analysis tab) you select the program number to update from the "save program setup" control to the right of the above program selection control (using the up/down scroll keys) then press the "save" button. You can also clear the data for a saved program selected in this control by pressing the "clear" button.

6.2 Program Results

The overall results of the program are displayed in the tables at the top of the worksheet.. The following table describes each of these results:

Result	Description
IOU Program Budget Table	
Measure related costs: IOU Administrative Costs	For all measures included in the program (both rebate and direct install): **# of measures * admin cost per unit**
Measure related costs: IOU Rebate Costs	For all rebate measures included in the program: **# of measures * measure rebate**
Measure related costs: IOU Direct Install Costs	For all direct install measures in the program: **# of measures *** **(measure$ – participant paid$ - partner paid$)**
  Total Program Budget	All Measure related costs + Non-Measure related IOU Paid Admin Costs – Partner Payments to IOU Program
Other TRC Cost Components	
 Gross Measure Costs	For all measures included in the program: **# of measures * measure cost**
 Partner Measure Payments	For all measures included in the program: **# of measures * partner paid$**
  Participant Net TRC Cost	For all measures included in the program: **# rebate measures * (measure $ - partner paid$) * NTG** **+ # direct install measures * participant paid $ * NTG**
 Rebates to Freeriders	For all rebate measures included in the program: **# of measures * measure rebate * (1 – NTG)**
IOU Program TRC	
 Summed Benefit	For all measures included in the program: **# of measures * lifetime avoided $ * NTG**
 Summed Cost	For all measures included in the program: **# of measures * measure cost (according to eq. 2 & 3)**
Program TRC	Summed Benefit / Summed Cost

Table 4. Description of the Program Summary Results

7. [Program Summary] tab

This tab displays summary information for the five possible programs. Programs can be included or excluded from the overall summary by using the checkboxes next to the program descriptions.

8. [ElecGasProfiles] tab

This tab contains all of the defined Energy Saving Profiles that can be used when specifying the information for a water agency. New profiles can be added starting in column J. The specified "name" for the new profile will be automatically added to the list of available energy savings profiles (table 2b on the [Agency-Info] tab).

As described above, the energy savings profiles perform two functions: they describe how the daily "energy use per million gallons" may change of the course of a year and for electricity, they describe how daily energy savings translates into hourly electric demand reductions at the water agency.

The typical profile will be normalized based on daily energy savings (or daily water savings times the average energy per volume of water savings). As such, the values for the annual profile should sum to 365.

The [ProfileCalc] tab provides an easy method of creating a normalized annual profile based on relatively simple inputs.

9. [MeasProfiles] tab

This tab contains all of the defined Water Saving Profiles that can be used when defining a water-saving measure. A number of examples are provided starting in column H. New profiles can replace these examples or can be added to the columns to the right. The specified "name" for the new profile will be automatically added to the list of available water savings profiles (table 1c on the [Measure Definition] tab).

As described above, these profiles account for differences in expected water savings due to varying seasonal requirements, such as for irrigation measures, and can account for differences in weekday versus weekend usage.

The typical profile will be normalized based on a reference daily water savings value. For example, an ET controller may be specified to save 45 gallons a day during typical summer days, with water savings known to be significantly less during the other seasons. The water saving profile specified in the measure definition for this measure should have daily profiles that sum to 1.0 during the summer and to values much less than 1.0 during the other seasons. In this case, the values for the annual profile should sum to much less than 365.

The [ProfileCalc] tab provides an easy method of creating a annual profile that is normalized to a reference savings.

10. [ProfileCalc] tab

This tab provides a quick and easy method of created annual profiles for use as Energy Savings Profiles in the Agency-Info table and as Water Savings Profiles in the Measure Definition table.

A detailed guide to this process will be provided separately.

11. [Measure Savings by CZ] tab

As discussed previously, the table on this tab defines the water savings by climate zone (CZ) for any measure whose savings varies by climate zone. The list of savings is associated with a measure via the "list name" in the first column.

12. [Program Data] tab

This tab stores all of the data for the five water measure programs that can be defined and saved. The calculator stores only summary information and the details needed to reproduce the program results. The user does not need to interact with any of the information on this tab.

13. [AvoidedCost] tab

This tab contains the hourly calculations for the annual avoided cost. No user interaction is required on this tab.

14. [ElecAV$] tab

This tab contains the levelized hourly avoided cost data for electricity for 125 scenarios of number of years, IOU and CZ. The scenarios are made up of a utility district, a climate zone within that district and a measure number of years. All values are the CPUC adopted avoided costs from the E3 spreadsheet "cpucAvoided26-1_update3-20-06.xls" with corrected discount rates by IOU and with the following specifications:

Division:	Weighted Average
Voltage:	Secondary
Measure Start Year:	2007
Discount Rate:	PG&E: 8.79%
	SCE: 8.77%
	SDG&E: 8.23%
Results in:	2007 dollars
Inflation Rate:	2%

Components Included in Hourly Avoided Cost Calculation:

Market:	TRUE
T&D:	TRUE
Environment:	TRUE

No user interaction is required on this tab.

15. [GasAV$] tab

This tab contains the levelized monthly avoided cost data for gas for the three gas utilities, for 5 sets of measure lifes and for two cost scenarios. All values are the CPUC adopted avoided costs from the E3 spreadsheet "gasModel9_6-1-06.xls " with corrected discount rates by IOU and with the following specifications:

Class:	Commercial
End Use:	Large Boiler
Emission Control:	Low NOx Burner
Measure Start Year:	2007
Discount Rate:	PG&E: 8.79%
	SCG: 8.68%
	SDG&E: 8.23%
Results in:	2007 dollars
Inflation Rate:	2%

Components Included in Hourly Avoided Cost Calculation:

Market:	TRUE and FALSE
T&D:	TRUE
Environment:	TRUE

One table on this tab includes market costs along with T&D and environment costs. This table is appropriate for “Core” water agencies. Another table includes only T&D and environment costs for use with “non-Core” water agencies.

No user interaction is required on this tab.

16. [key] tab

This tab contains the lists used by the various pull-down menus throughout the calculator. No user interaction is required on this tab.