Avoided Cost Calculator User Manual

August 2016

Energy+Environmental Economics

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Table of Contents

1 Model Overview 1

2 Inputs 2

2.1 General Inputs 2

2.2 Hourly Inputs 3

3 Outputs 5

3.1 Summary Results 7

3.2 Hourly Results 9

3.3 Exporting Hourly Results 10

3.4 DR Reporting and PLS Tool Interface 11

4 Version Control 13

1 Model Overview

The "Avoided Cost Calculator" is an Excel-based spreadsheet model produced by Energy + Environmental Economics, Inc. (E3) for use in demand-side cost-effectiveness proceedings at the California Public Utilities Commission (CPUC). Specifically, the model produces an hourly set of values over a 30-year time horizon that represent costs that the utility would avoid if demand-side resources produce energy in those hours. These avoided costs are the benefits that are used in determining the cost-effectiveness of these resources.

This user manual focuses on how a user should interact with the model to change inputs and access results. For more specific information on the source of these inputs and model methodology, see the *Avoided Cost 2016 Update* documentation write up.

The Excel model consists of two input tabs, nine calculation tabs, and a dashboard tab where the user can control which outputs the model calculates as well as view these outputs. Additionally, there are two tabs that are compile specific outputs and can be directly copy/pasted into the DR Reporting Template which is used in demand response cost-effectiveness.

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2 Inputs

All model inputs are contained in the *General Inputs* tab and the *Hourly Inputs* tab.

2.1 General Inputs

The *General Inputs* tab contains all model inputs that do not have an hourly dimension. The specific inputs, cell locations, and general comments are documented in the table below.

Table 1: General Inputs

Input	Location	Comment
Real Discount Rate	C4	Real discount rate used to levelized costs over multiple years
Inflation	C5	Inflation rate used in conjunction with real discount rate to calculate nominal discount rate
Simple-Cycle Gas Turbine: Operations	C10:C14	Heat rate, lifetime, minimum margin (%) required for dispatch, scheduled outage factor, forced outage rate
Simple-Cycle Gas Turbine: Costs	C16:C20	Installed cost, fixed O&M, variable O&M, cost escalation, cost basis year
Simple-Cycle Gas Turbine: Financing	C22:24	Debt/equity ratio, debt cost, equity cost
Combined-Cycle Gas Turbine: Operations	C29:C30	Heat rate, lifetime

Combined-Cycle Gas Turbine: Costs	C32:C36	Installed cost, fixed O&M, variable O&M, cost escalation, cost basis year
Combined-Cycle Gas Turbine: Financing	C38:C40	Debt/equity ratio, debt cost, equity cost
Natural Gas Price Forecast	G4:AL15	Monthly natural gas price forecast (burnertip) for California power plants
Carbon Price Forecast	G20:U20	Annual carbon price forecast
Electricity Price Forecast	G25:N25	Annual electricity market forward prices
Resource Balance Year	C44	The year in which available resources are forecasted to be less than or equal to peak load requirements
Transmission and Distribution Losses	D57:F67	Time-of-use period loss factors
Emission Factors	C72:F77	Carbon, PM10, and NOx emission factors of natural gas and propane, high/low efficient power plant bounds
Renewable Costs	C81:C87	Marginal RPS resource cost, resource integration cost, incremental transmission cost
Transmission and Distribution Marginal Costs	C104:D107, D116:F135	Marginal costs for subtransmission and local distribution (PG&E further categorized by geographical zone)

2.2 Hourly Inputs

The *Hourly Inputs* tab contains all model inputs that have an hourly dimension.

The categories of inputs contained in this tab are:

Table 2: Hourly Inputs

Options	Location	Comment
Day-ahead energy profile	E21:AH8780	Normalized hourly day-ahead heat rate profiles for Northern and Southern California (NP-15, SP-15)

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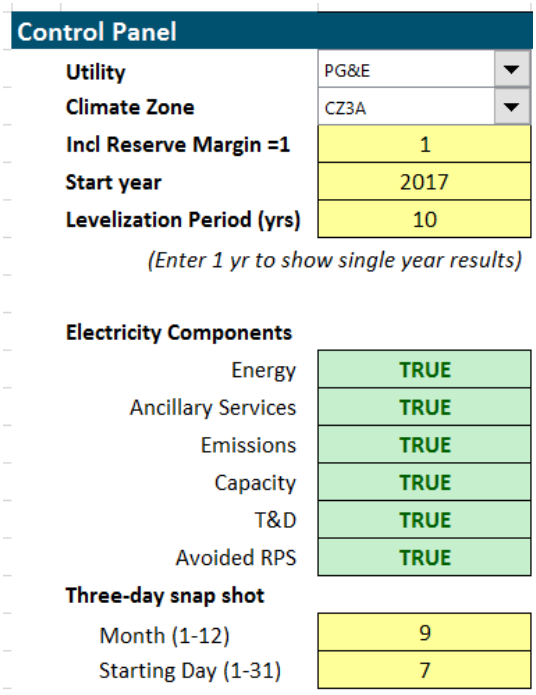
Real-time energy profile	BO21:BP8780	Normalized hourly real-time heat rate profiles for Northern and Southern California (NP-15, SP-15)
Marginal renewable resource profile	BT21:BT8780	Normalized hourly generation profile of the marginal renewable resource
Transmission cost allocators	BV21:DA8780	Normalized hourly transmission allocators by climate zone for 2020 and 2030
Distribution cost allocators	EH21:FM8780	Normalized hourly distribution allocators by climate zone for 2020 and 2030
Capacity generation cost allocators	GX21:HL8780	Normalized hourly generation capacity for the years 2016, 2020, and 2030
Time-of-use periods	IG21:IK8780	Time-of-use definitions used to map time-of-use loss factor information

3 Outputs

The avoided cost results are presented on the *Dashboard* tab. The Dashboard tab presents three summary graphics of the avoided costs, and 8760 hourly results disaggregated by component. The model calculates hourly avoided cost values for a single year or a levelized set of years, up to 30 years. The top left section of the Dashboard allows the user to customize the reported avoided costs using the selections listed in Table 3.

Figure 1: Avoided Cost Control Panel (Dashboard tab)



Control Panel	
Utility	PG&E
Climate Zone	CZ3A
Incl Reserve Margin =1	1
Start year	2017
Levelization Period (yrs)	10
(Enter 1 yr to show single year results)	
Electricity Components	
Energy	TRUE
Ancillary Services	TRUE
Emissions	TRUE
Capacity	TRUE
T&D	TRUE
Avoided RPS	TRUE
Three-day snap shot	
Month (1-12)	9
Starting Day (1-31)	7

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Table 3: Results Options

Options	Location	Comment
Utility	G3	PG&E, SCE, or SDG&E
Climate Zone	G4	Indicates the climate zone to use for T&D allocation factors and, for PG&E, area-specific T&D $/kW-yr capacity costs.
Incl Reserve Margin = 1	G5	(1 or 0). A value of 1 adds the value of reducing the reserve margin needs to the value of capacity reductions. This is appropriate for demand-side resources. A value of 0 should be entered if the avoided costs are to be used for supply-side resources, which would not reduce the reserve margin requirements.
Start Year	G6	(2017 – 2042, integer values) Note that the ACC only contains avoided costs through 2047, so the combination of this entry and the Levelization Period should not exceed 2047.
Levelization Period (yrs)	G7	(1 – 30, integer values) The model reports hourly costs on the dashboard. The costs can be for a single year (levelization period = 1), or for up to 30 years. The levelization is constant in real dollars.
Electricity Components	G11:G16	(TRUE, FALSE) Indicates which components to include in the avoided costs. Note that Losses are energy-related losses and are included or excluded based on the selection for Energy. Capacity-related losses are incorporated into the respective capacity avoided costs, and not reported separately.
Three-day shapshot Month(1-12)	G18	The Dashboard can graph the component avoided costs for any continuous three-day period. This is the month for the first day in that period.
Starting Day	G19	(1-31). This is the day of the month for the start of the three-day period.

3.1 Summary Results

The model produces several charts summarizing the avoided costs. At the top of the Dashboard tab as charts showing the avoided costs by component averaged by month and by hour.

Figure 2: Average Avoided Cost by Month

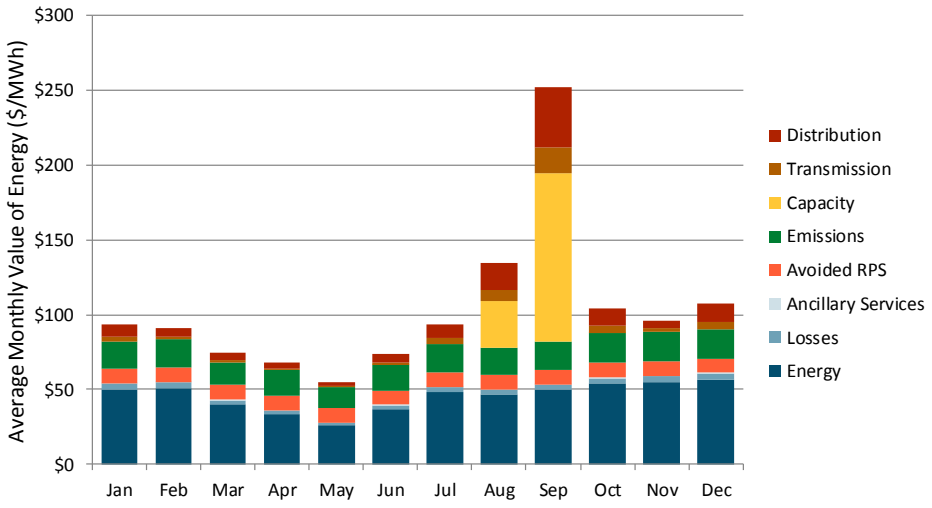

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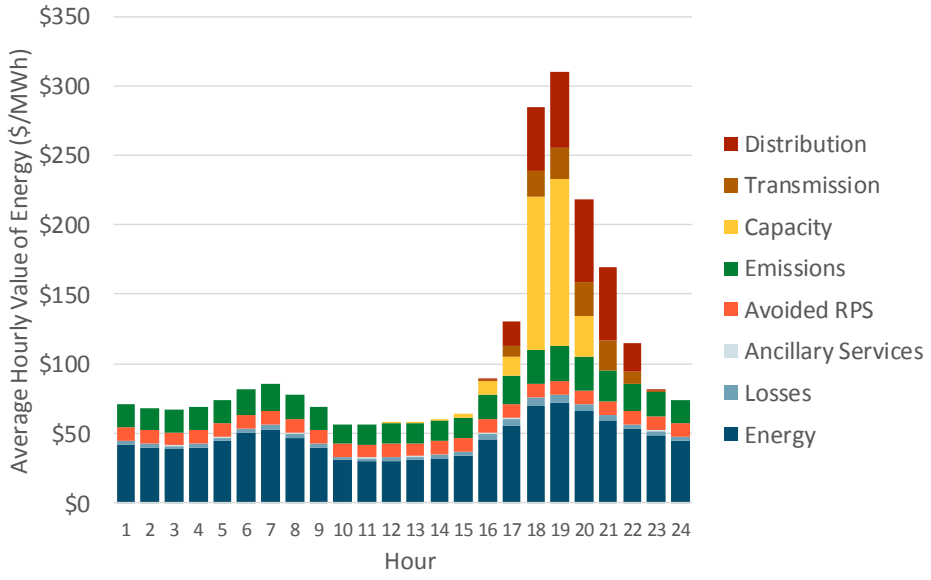
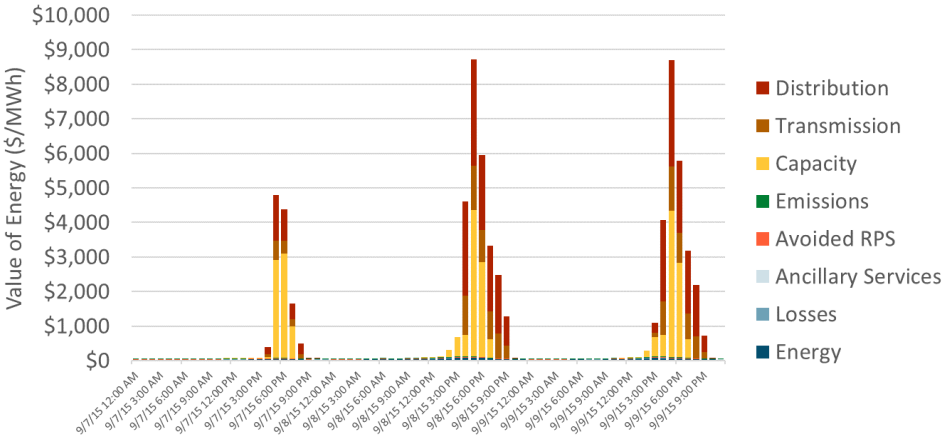
Figure 3: Average Avoided Cost by Hour



In addition, the model can show the detailed hourly results for a three-day period, as specified in cells G18 and G19 of the Dashboard.

Figure 4: Three-Day Period Hourly Avoided Costs



3.2 Hourly Results

The hourly avoided costs are reported in tabular format by component and by hour starting in row 25 of the Dashboard tab.

Figure 5: Example hourly output on Dashboard Tab

Hourly Levelized Value of Electricity ($/MWh)									
Date/Time Stamp	Energy	Losses	Ancillary Services	Emissions	Capacity	Transmission	Distribution	Avoided RPS	Total Levelized Value
Jan-01 00:00	$34.94	$2.14	$0.24	$10.55	$0.00	$0.00	$0.00	$14.78	$62.65
Jan-01 01:00	$32.62	$2.00	$0.23	$10.15	$0.00	$0.00	$0.00	$14.78	$59.77
Jan-01 02:00	$31.02	$1.90	$0.22	$9.97	$0.00	$0.00	$0.00	$14.78	$57.88
Jan-01 03:00	$29.31	$1.79	$0.21	$9.80	$0.00	$0.00	$0.00	$14.78	$55.89
Jan-01 04:00	$31.39	$1.92	$0.22	$10.01	$0.00	$0.00	$0.00	$14.78	$58.31
Jan-01 05:00	$34.63	$2.12	$0.24	$10.48	$0.00	$0.00	$0.00	$14.78	$62.25
Jan-01 06:00	$36.21	$2.22	$0.25	$10.87	$0.00	$0.00	$0.00	$14.78	$64.32
Jan-01 07:00	$35.99	$2.20	$0.25	$10.81	$0.00	$0.00	$0.00	$14.78	$64.03
Jan-01 08:00	$32.12	$1.97	$0.22	$10.08	$0.00	$0.00	$0.00	$14.78	$59.17
Jan-01 09:00	$27.63	$1.69	$0.19	$9.78	$0.00	$0.00	$0.00	$14.78	$54.07
Jan-01 10:00	$24.41	$1.49	$0.17	$9.78	$0.00	$0.00	$0.00	$14.78	$50.63
Jan-01 11:00	$22.78	$1.39	$0.16	$9.78	$0.00	$0.00	$0.00	$14.78	$48.88
Jan-01 12:00	$21.00	$1.28	$0.15	$9.78	$0.00	$0.00	$0.00	$14.78	$46.98
Jan-01 13:00	$20.24	$1.24	$0.14	$9.78	$0.00	$0.00	$0.00	$14.78	$46.17
Jan-01 14:00	$22.13	$1.35	$0.15	$9.78	$0.00	$0.00	$0.00	$14.78	$48.19
Jan-01 15:00	$28.34	$1.73	$0.20	$9.78	$0.00	$0.00	$0.00	$14.78	$54.82
Jan-01 16:00	$41.74	$2.55	$0.29	$12.36	$0.00	$0.00	$0.00	$14.78	$71.72
Jan-01 17:00	$48.26	$2.95	$0.34	$14.29	$0.00	$0.00	$0.00	$14.78	$80.61
Jan-01 18:00	$56.47	$3.46	$0.40	$16.42	$0.00	$0.00	$0.00	$14.78	$91.52
Jan-01 19:00	$49.64	$3.04	$0.35	$14.70	$0.00	$0.00	$0.00	$14.78	$82.50
Jan-01 20:00	$50.11	$3.07	$0.35	$14.84	$0.00	$0.00	$0.00	$14.78	$83.14
Jan-01 21:00	$45.15	$2.76	$0.32	$13.34	$0.00	$0.00	$0.00	$14.78	$76.34
Jan-01 22:00	$42.79	$2.62	$0.30	$12.67	$0.00	$0.00	$0.00	$14.78	$73.16
Jan-01 23:00	$36.13	$2.21	$0.25	$10.85	$0.00	$0.00	$0.00	$14.78	$64.22
Jan-02 00:00	$35.19	$2.15	$0.25	$10.61	$0.00	$0.00	$0.00	$14.78	$62.97
Jan-02 01:00	$32.53	$1.99	$0.23	$10.14	$0.00	$0.00	$0.00	$14.78	$59.66
Jan-02 02:00	$32.45	$1.99	$0.23	$10.13	$0.00	$0.00	$0.00	$14.78	$59.57

If a single year Levelization Period is selected by the user, then the hourly results will be for the Start Year, and no levelization is applied. If more than one year is entered for the Levelization Period, then each hourly value will represent the present value of the avoided costs for that component in that hour (beginning in the Start Year), multiplied by an annualization factor that is constant in real dollars (in Excel parlance, the annualization factor uses a PMT function with a real discount rate instead of a nominal discount rate).

The levelized results are in nominal dollars, with the Start Year as the base. For example, using 2020 as the Start Year, and 10 years as the levelization period,

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the results will be for the avoided costs from 2020 through 2029, and are shown in 2020 dollars.

3.3 Exporting Hourly Results

In addition to the levelized or single year results discussed above, the Avoided Cost Calculator can produce hourly avoided costs for 2017 through 2047. Because the amount of data associated with 31 years of hourly avoided costs, these results are output to separate Excel files, rather than added to the model itself. In addition, the results are written to the output files as the total avoided cost by year and hour, but not by avoided cost component[1]. The output files are written to a subfolder in the same directory as the Avoided Cost Model. The subfolder is named according the date the macro is run.

There are three macros included in the Avoided Cost Calculator. The buttons for each macro are located below Cell F20 on the Dashboard tab. Each macro is described below.

Macro	Comment
Export Annual Avoided Costs – All CZ	Using the user-selected utility, the macro will iterate through each climate zone that applies to the utility. The macro will write the total hourly avoided costs for the components indicated by the *Electricity Component* inputs, and will include or exclude the planning reserve margin

[1] Costs by component could be generated by running the export macros with only the desired component set to TRUE in the Dashboard Electricity Components section.

	benefit base on the user input for *Incl Reserve Margin*. Note that because the macro is outputting results by year for all years, instead of levelized results, the Levelization Period and the Start year are ignored.
Export Annual Avoided Costs – One CZ	Same functionality as the macro above, but only outputs results for the user selected Climate Zone.
Export Gen & Env for EE	This is a specialized macro used to create output files used for the E3 Calculator and CET. It overrides the user selections to generate the needed transfer file for the selected utility. This should not be used by the general user of the model.

3.4 DR Reporting and PLS Tool Interface

Finally, the model aggregates specific outputs for input into the DR Reporting Tempate which is used to determine the cost-effectiveness of demand response.

The *DR Outputs* tab is an exact replica of the Inputs tab in the DR Reporting Template. Thus, the tab can be directly copy/pasted into the DR Reporting Template. A screenshot of this tab is shown below.

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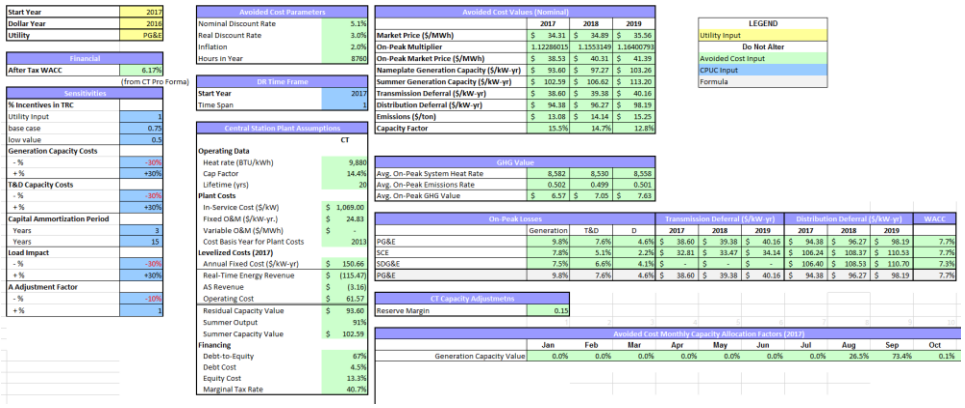
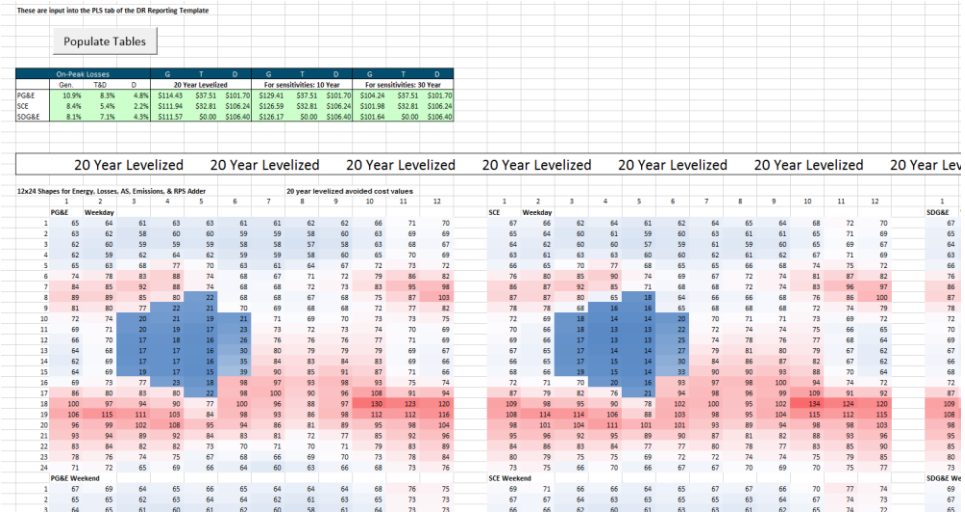
Figure 6: DR Outputs Tab in Avoided Cost Calculator



Additionally, the *PLS Outputs* tab organizes outputs of the Avoided Cost Calculator that can be copy/pasted as inputs into the *PLS Inputs* tab of the DR Reporting Template. A screenshot of this tab is shown below.

Figure 7: PLS Outputs tab in Avoided Cost Calculator



4 Version Control

The Avoided Cost Calculator is updated on an annual basis to reflect the latest market data and California system conditions. Interannual updates may be completed as needed for minor adjustments and correction of errors.

The naming convention for the Avoided Cost Calculator is ACC_Year_Version (e.g. ACC_2016_v1). The active version of the calculator will be the version with the most recent year and the latest version.

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