

# Correction Factors to Avoided Cost Valuation using TOU Load Shapes for Residential and Small Commercial Air Conditioning

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## 1.0 Overview of Work and Correction Factor Summary

This document provides a summary of correction factors proposed to be used to adjust the avoided cost valuation for residential and small commercial air conditioning hardware upgrade EEM's for the California IOU 2006-2008 Energy Efficiency portfolios. The work performed to develop the proposed correction factors was undertaken, at the direction of ALJ Gottstein, as a result of discussions during the March 14-15, 2006 CPUC workshop on the 2006 update to the avoided costs and E3 Calculator.

During this workshop, and within the draft report published prior to the workshop, materials were presented that illustrate how the conversion of hourly impact shapes to TOU impact "blocks" may undervalue measures with loads that vary greatly during the day. This undervaluing is a result of the TOU impact blocks providing an averaged value of the impact during each TOU period rather than an hourly profile; when the averaged impact for the TOU period is multiplied by the hourly avoided cost, the resultant value is lower than if the hourly impact shape was used for those measures which have higher hourly impact values during the times when the avoided cost hourly values are also high.

The long term approach to removing this issue will be the development of hourly impact shapes for use in the E3 calculators for future program cycles. The project to develop hourly impact shapes, however, will take up to 18 months to complete. To provide a short term temporary "fix" to this issue for residential (and possibly small commercial) air conditioning hardware improvement measures, it was directed that factors would be developed that correct for the averaging caused by the conversion of hourly impact shapes into TOU blocks. It was further directed that these correction factors would be based on an analysis using DEER residential and small commercial air conditioning hourly impact shapes converted to TOU block for each IOU's hourly avoided cost (excluding T&D costs) and appropriate climates.

A summary of the results of this analysis are presented below and the details can be found in the spreadsheet documented in Section 3 below and which can be obtained as described in Section 2 below. **The recommended correction factors resulting from this work can be found in Table 2 (residential) and Table 5 (small commercial) on the "Summary Tables" tab of the results spreadsheet and reproduced below.**

### Proposed Residential Correction Factors

To create the residential correction factors a three step process was used:

1. DEER analysis was performed for single family residences, new and retrofit (1990's vintage) AC upgrades to SEER 14, 15 and 16, for all climate zones with cooling (CZ's 2-16.) For each analysis a DEER hourly impact shape was captured. DEER TOU impact blocks were then calculated for each of these hourly impact shapes using the TOU period

definition for each utility. The annual avoided cost was calculated for the DEER hourly impact load shape using the hourly generation and environmental avoided cost values for each IOU as supplied by E3. The annual avoided cost was also calculated using the TOU impact blocks by applying the average avoided cost for each TOU period as determined from the same hourly avoided cost values. (If it is desired to examine these detailed results, they can be found in the results spreadsheet on the “Summary Tables” tab starting in row 107 in Table 7)

- The results of step 1 above were converted into ratios by dividing the avoided costs calculated using the hourly impact shape by the value calculated using the matching TOU impact block. These ratios were then averaged for each IOU by climate zone and SEER level; those results are presented below in Table 1 below (copied from the results spreadsheet on the “Summary Tables” tab)

**Table 1**  
**Residential**  
**Air-Conditioning Correction Factors by Air-Conditioner SEER level**

Climate	SEER 14			SEER 15			SEER 16		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
CZ02	1.16			1.14			1.14		
CZ03	1.06			1.05			1.08		
CZ04	1.21			1.15			1.15		
CZ05	1.07			1.07			1.11		
CZ06		1.16	1.21		1.15	1.19		1.15	1.20
CZ07			1.37			1.28			1.28
CZ08		1.18	1.26		1.15	1.21		1.15	1.21
CZ09		1.23	1.29		1.19	1.25		1.22	1.30
CZ10		1.29	1.38		1.24	1.31		1.23	1.32
CZ11	1.17			1.14			1.15		
CZ12	1.18			1.16			1.19		
CZ13	1.20	1.21	1.30	1.14	1.16	1.23	1.15	1.18	1.26
CZ14	1.23	1.23	1.31	1.20	1.20	1.28	1.16	1.17	1.25
CZ15		1.17	1.26		1.12	1.19		1.13	1.20
CZ16	1.13	1.11	1.10	1.13	1.13	1.14	1.18	1.20	1.23
<b>Wtd:</b>	<b>1.16</b>	<b>1.20</b>	<b>1.27</b>	<b>1.13</b>	<b>1.17</b>	<b>1.23</b>	<b>1.15</b>	<b>1.18</b>	<b>1.25</b>

*Wtd row applies population weights from Table 6 on the spreadsheet "Weights" tab*

- The results of Table 1 were then “weighted” into single AC correction factors using the portion of each SEER level expected to be the subject of an incentive during the 2006-2008 program cycle. The results are found in Table 2 below (copied from the results spreadsheet on the “Summary Tables” tab)

**Table 2  
Residential Air-Conditioning Average  
Correction Factors by Climate Zone**

Climate	Hrly/TOU avoided \$		
	PG&E	SCE	SDG&E
CZ02	1.16		
CZ03	1.06		
CZ04	1.20		
CZ05	1.07		
CZ06		1.15	1.19
CZ07			1.29
CZ08		1.16	1.22
CZ09		1.21	1.26
CZ10		1.26	1.32
CZ11	1.16		
CZ12	1.18		
CZ13	1.19	1.19	1.24
CZ14	1.23	1.21	1.28
CZ15		1.14	1.20
CZ16	1.13	1.13	1.14
<b>Wtd:</b>	<b>1.15</b>	<b>1.18</b>	<b>1.24</b>

*Values in this table are derived by weighting SEER level correction factors according to Table 5 on the spreadsheet "Weights" tab*

The weights used for combining SEER levels in Table 1 into the values in Table 2 were approximated by taking the unit counts for the related measures from the IOU compliance filings. These unit count percentages were adjusted, when a SEER level was not listed, to assign that unlisted SEER level 5% and reduce the otherwise largest listed SEER share by that amount. The weightings used are contained in Table 3 below (copied from the results spreadsheet on the "Weights" tab)

**Table 3  
Residential Weights by SEER measure**

Utility	SEER 14	SEER 15	SEER 16	sum
PGE	0.9	0.05	0.05	1.00
SCE	0.5	0.45	0.05	1.00
SDG&E	0.15	0.8	0.05	1.00

The above weights can be changed in the spreadsheet and will cause Table 2 to be regenerated using the new values. The results in Table 2 can be weighted into IOU service territory-wide correction factors if desired. An example of these values can be found in the last row of Table 2. Such weighted values, however, should be calculated by weighting each climate zone value by the ratio of the number of EEM's expected to be installed in that area over the total EEM's expected to be installed. Those weights can then be installed into Table 4 on the "Weights" tab; since these data were not readily available, Table 4 is populated with even weights and it is recommended that the climate

zone results be used unless reasonable values for these weights can be established.

**Table 4  
Residential Weights by CZ**

Climate	PG&E	SCE	SDG&E
CZ02	1.00		
CZ03	1.00		
CZ04	1.00		
CZ05	1.00		
CZ06		1.00	1.00
CZ07			1.00
CZ08		1.00	1.00
CZ09		1.00	1.00
CZ10		1.00	1.00
CZ11	1.00		
CZ12	1.00		
CZ13	1.00	1.00	1.00
CZ14	1.00	1.00	1.00
CZ15		1.00	1.00
CZ16	1.00	1.00	1.00
sum	9.00	8.00	9.00

**Proposed Small Commercial Correction Factors**

To create the small commercial correction factors a two step process, similar to the procedure described above for development of the residential factors, was used:

1. DEER analysis was performed for small office and small retail building types, new and retrofit (1990’s vintage) AC upgrades to a high efficiency 3 phase air-cooled package unit rated 13 SEER, for all climate zones with cooling (CZ’s 2-16.) Annual avoided costs were calculated based on hourly and TOU impact load shapes using the same process used for the residential building type. These detailed results can be found along with the residential results in Table 7 of the Summary Tables tab starting in row 107.
2. The results of step 1 above were converted into ratios by dividing the avoided costs calculated using the hourly impact shape by the value calculated using the matching TOU impact block. These ratios were then averaged by IOU and climate zone for each building type; those results are presented below in Table 5 below (copied from the results spreadsheet on the “Summary Tables” tab)

**Table 5**  
**Commerical Buildings Small Packaged Air-Conditioning**  
**Correction Factors by Building Type and Climate Zone**

Climate	Office			Retail		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
CZ02	1.05			1.11		
CZ03	1.03			1.10		
CZ04	1.04			1.11		
CZ05	1.04			1.12		
CZ06		1.05	1.07		1.14	1.18
CZ07			1.09			1.20
CZ08		1.05	1.08		1.13	1.17
CZ09		1.06	1.09		1.13	1.18
CZ10		1.07	1.10		1.14	1.19
CZ11	1.06			1.11		
CZ12	1.07			1.13		
CZ13	1.06	1.08	1.12	1.11	1.15	1.20
CZ14	1.07	1.08	1.12	1.12	1.15	1.21
CZ15		1.06	1.09		1.10	1.15
CZ16	1.07	1.08	1.12	1.16	1.18	1.26
<b>Wtd:</b>	<b>1.05</b>	<b>1.07</b>	<b>1.10</b>	<b>1.12</b>	<b>1.14</b>	<b>1.19</b>

*Wtd row applies population weights from Table 7 on the spreadsheet "Weights" tab*

The results in Table 5 can be weighted into IOU service territory-wide correction factors if desired. An example of these values can be found in the last row of Table 5. Such weighted values, however, should be calculated by weighting each climate zone value by the ratio of the number of EEM's expected to be installed in that area over the total EEM's expected to be installed. Those weights can then be installed into Table 6 on the "Weights" tab; since these data were not readily available, Table 6 is populated with even weights and it is recommended that the climate zone results be used unless reasonable values for these weights can be established.

**Table 6**

Climate	Office Weights by CZ			Retail Weights by CZ		
	PG&E	SCE	SDG&E	PG&E	SCE	SDG&E
CZ02	1.00			1.00		
CZ03	1.00			1.00		
CZ04	1.00			1.00		
CZ05	1.00			1.00		
CZ06		1.00	1.00		1.00	1.00
CZ07			1.00			1.00
CZ08		1.00	1.00		1.00	1.00
CZ09		1.00	1.00		1.00	1.00
CZ10		1.00	1.00		1.00	1.00
CZ11	1.00			1.00		
CZ12	1.00			1.00		
CZ13	1.00	1.00	1.00	1.00	1.00	1.00
CZ14	1.00	1.00	1.00	1.00	1.00	1.00
CZ15		1.00	1.00		1.00	1.00
CZ16	1.00	1.00	1.00	1.00	1.00	1.00
<b>sum</b>	<b>9.00</b>	<b>8.00</b>	<b>9.00</b>	<b>9.00</b>	<b>8.00</b>	<b>9.00</b>

## 2.0 Obtaining the Details of this Work - Results and Data Used

The comparison spreadsheet, which contains the details of this work can be found in the web directory:

<http://www.doe2.com/download/AvoidedCost/>

The download directory contains the comparison spreadsheet:

[http://www.doe2.com/download/AvoidedCost/ACcorrectorSummary\\_2006-03-21.zip](http://www.doe2.com/download/AvoidedCost/ACcorrectorSummary_2006-03-21.zip)

Download the ZIP to your hard drive and extract its entire contents into a single directory then open the spreadsheet (ACcorrectorSummary\_2006-03-21.xls)

The Hourly Avoided Costs by Utility, excluding T&D costs, were supplied by E3. DEER hourly load shapes, were generated using the published DEER Measure Analysis Software (MAS) tool, however we made minor changes to eliminate a few known problems with DEER analysis as well as to capture the hourly whole building and end-use load shapes.

## 3.0 Description of the Spreadsheet Tool Containing the Results

The details of the results of this analysis are contained in the spreadsheet named “ACcorrectorSummary\_2006-03-21.xls”. This spreadsheet can also be used as a tool to examine individual results and hourly profiles. Below is a description of the important features of the spreadsheet.

### [Measure Details] tab

This tab contains the interactive portion of the spreadsheet and was used to calculate all of the individual results contained in the [Summary Table] tab.

#### User-Controlled Options

The five pick lists are used to set the current configuration:

Utility	Building	Vintage	Climate	Measure	
SDG&E ▼	Residential ▼	1990s ▼	CZ09 ▼	SEER 14 ▼	Load Hourly Results

Note that the spreadsheet “Calculation” option should to be set to “Automatic”. This will allow the pick lists (“pull down” selection boxes) to change depending upon the current pick list options. For example, the Climate options will change depending upon which Utility is chosen. Once the desired configuration options have been set, the Load Hourly Results button **must** be pressed to update the results set and graphic presentations. **Even with “Calculations” set to automatic, you must press the update button to get new results!**

Three radio-button controls are used to set options that change how the avoided cost adjustment factors are calculated:

<p>Savings Calculation</p> <p><input type="radio"/> from Whole Building</p> <p><input checked="" type="radio"/> from Load Shapes</p>
<p>End-Use Load Shape</p> <p><input checked="" type="radio"/> use Base Building's</p> <p><input type="radio"/> use Measure Building's</p>
<p>Load Shape Fan Energy Options</p> <p><input type="radio"/> No Fan Energy</p> <p><input type="radio"/> Fan Energy During Cooling Only</p> <p><input checked="" type="radio"/> Include Fan Energy</p>

These options were used to explore how the hourly energy use profiles change between the base case and measure case. Part of the motivation for this exploration of the data was to develop confidence in the applicability of the simulations and results to this exercise

- **Savings Calculation:** When “from Whole Building” is chosen, the hourly savings of the high efficiency air-conditioning equipment is determined by subtracting the whole building electric energy use of the measure case from the whole building electric energy use of the base case. When the other button is chosen, the savings is determined by comparing the electric use of the load shapes. The load shapes are comprised of cooling equipment or cooling equipment plus ventilation (set by another radio-button control).
- **End-Use Load Shape:** This control determines whether the base or the measure simulation is used to create the end-use load shape graph.
- **Load Shape Fan Energy Options:** This control determines which end-uses make up the end-use load shape graph. Cooling equipment is always included in the end-use, and ventilation energy use can be included, excluded or included only when the cooling equipment is operating.

Results presented in the tables above were created with the options shown. Note: you do not need to re-load the hourly results file when new radio-button options are chosen.

### Individual Results

The following table of results is created based on the hourly data file and options chosen by the various controls.

Current Configuration				Meas Hrly	Meas TOU	Meas Hrly
Annual Avoided Cost \$				Meas TOU	EndUse TOU	EndUse TOU
Meas LS hourly	Meas LS TOU	EndUse LS hourly	EndUse LS TOU	Meas TOU correction	EndUse TOU correction	EndUse TOU correction
\$ 39	\$ 30	\$ 37	\$ 29	<b>1.296</b>	<b>1.022</b>	1.325

1. Annual Avoided Cost \$, Meas LS – hourly: this value is calculated as the sum of the hourly savings times the hourly avoided costs for the entire year.
2. Annual Avoided Cost \$, Meas LS – TOU: this value is determined based on the average avoided cost for each TOU period times the average electricity savings in each TOU period. The TOU avoided costs and energy savings are calculated from the hourly values.
3. Annual Avoided Cost \$, EndUse LS – hourly: this value is similar to the value in the first column, but is calculated based on the chosen load shape profile as opposed to the measure impact load shape.
4. Annual Avoided Cost \$, EndUse LS – TOU: this value is similar to the value in the second column, but is calculated based on the hourly load shape profile as opposed to the hourly measure impact load shape.
5. Meas Hrly/Meas TOU correction: this factor adjusts annual avoided costs for end-use load shape based TOU calculations. The adjustment accounts for the difference in hourly and TOU avoided cost results.
6. Meas TOU/EndUse TOU correction: this factor also adjusts annual avoided costs for end-use load shape based TOU calculations. This adjustment factor accounts for the difference in results when using an end-use load shape based TOU versus a measure impact TOU.
7. Meas Hrly/EndUse TOU correction: this factor is the sum of the first two factors. This adjustment factor accounts for the difference in results when using an end-use load shape based TOU versus hourly measure savings.

**All of the summary results are based on the first correction factor only.**

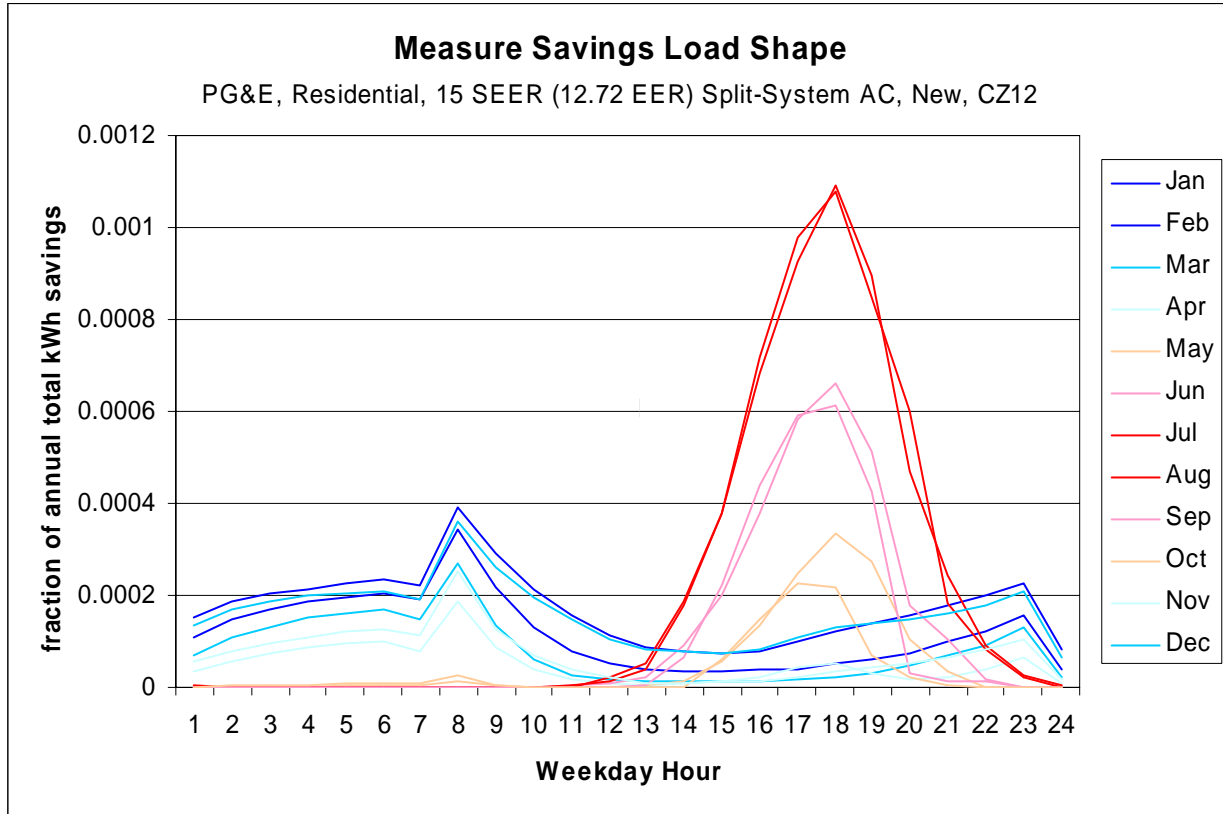
Graphics

Two charts are located below the options settings. The data for these charts is based on the last loaded hourly results file and the radio-button options described above.



**Chart 1: Measure Savings Load Shape**

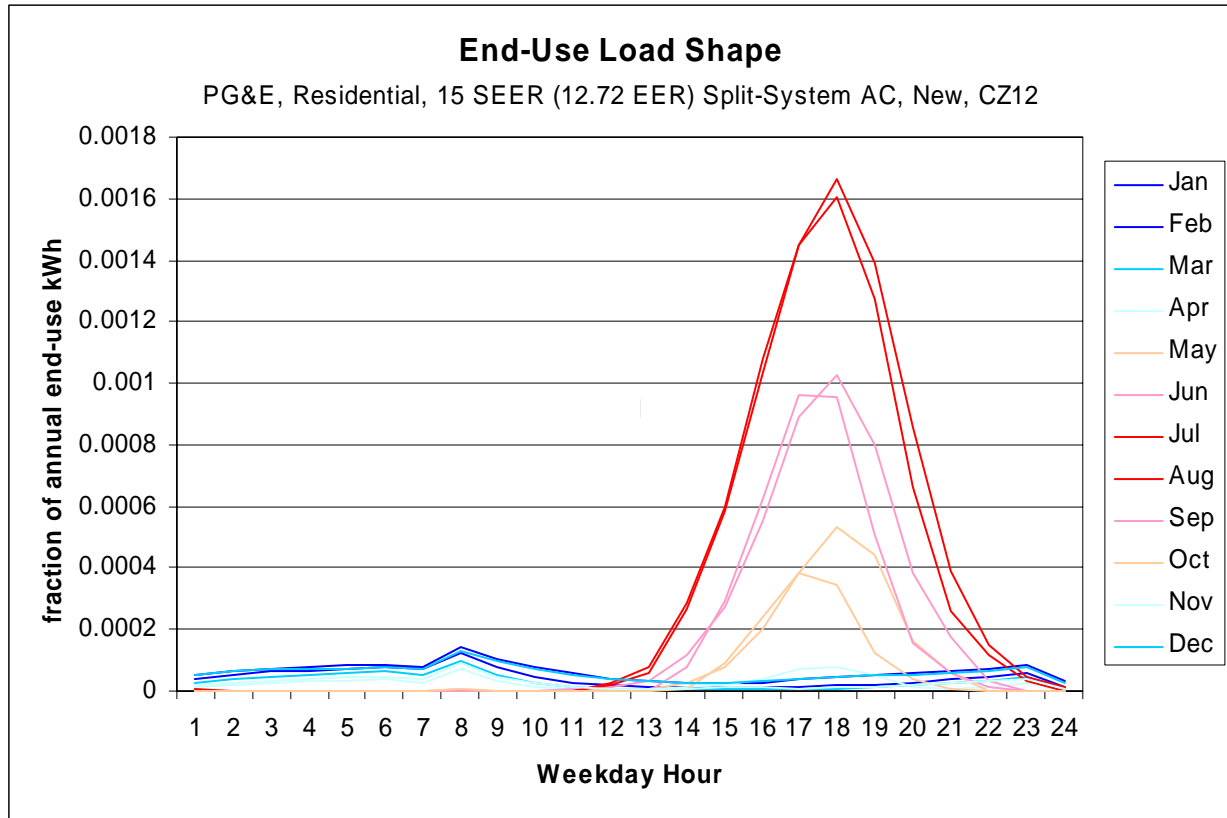
The first chart presents the normalized profile of weekday **electric energy savings** for each month.



If the [Savings Calculation] radio-button group is set to “from Load Shapes”, then this chart will change depending on which option is chosen for the radio group [Load Shape Fan Energy Options].

**Chart 2: End-Use Load Shape**

The second chart presents the normalized profile of weekday **end-use electric energy consumption** for each month. This chart changes based on the options chosen for the last two radio-button groups.



**[Summary Tables] tab**

This tab contains the summary tables (1, 2 and 5) that are presented in Section 1. These tables are derived from the complete set of results located at the bottom of the page (Table 7). These results are not affected by changes to the [Measure Details] tab, but will change based on any alterations to the tables of weights located on the next tab.

**[Weights] tab**

The tables on this tab are used to weight the individual results. The first table (Table 3) assigns weights to three levels of SEER improvement for each utility. These values are used to create the summary Table 2 from Table 1. The values used do not have to add to 1 for each utility; the relative magnitude of the values within each row is used to weight the results.

The other tables on this tab assign weights to each climate zone for a particular utility and building type. Currently only even weights are assigned each climate zone.

**[HrlyAvoided Costs] tab**

Hourly avoided costs and utility TOU period definitions are stored here. These values were supplied by E-Three. The first tab copies the appropriate column of hourly avoided costs for use in the detailed calculations.

**[Key] tab**

This tab contains the lookup values for all of the controls.

**[hrly] tab**

This tab contains the hourly electric use values from the DEER eQUEST runs. The data is only updated when the “Update Graphics” button is pressed on the first tab.