A Comparison of Measure Avoided Cost Valuation using Hourly and TOU Load Shapes From Utility Filings versus DEER Hourly Measure Impact Load Shapes

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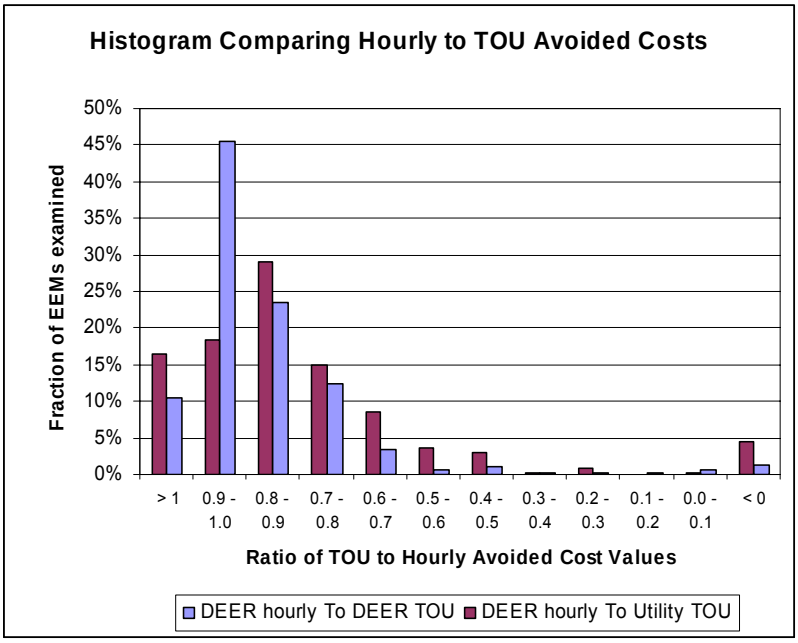
1.0 Overview of Work and Preliminary Conclusions

This document is an overview of the initial comparison of DEER and IUO load shapes as applied to the calculation avoided costs for energy efficiency measures (EEMs). The comparison done so far only examines the attribution of savings into avoided costs either by use of TOU time periods or hourly load shapes. This work does NOT examine or compare the magnitude of measure savings in the IOU filings vs. DEER savings for the same measure; this work only shows the relative avoided cost values when the SAME measure annual savings has an avoided cost calculated using the DEER hourly profile, or the IOU hourly or TOU profiles. It should be noted that quite often, for weather sensitive measures, the IOU measure savings used in the filings is different (usually higher) than the DEER savings.

The general conclusion is that the use of non-hourly load shapes with the hourly avoided costs is not recommended and that the IOU load shapes need to be updated, using the most recent DEER and/or EM&V data available, to represent accurate measure load shapes rather than older building load shapes. Until this update is completed the relative valuation of measures is very unreliable.

Preliminary conclusions of this work:

1. Use of TOU load shapes tends to under-predict the avoided cost of measures relative to hourly load shapes. The distribution of overall under- and over-prediction of the avoided cost when moving from hourly to TOU for DEER verses IOU values is shown below.



2. Use of IOU load shapes under-predicts the avoided cost of measures relative to DEER hourly load shapes by a larger margin than the conversion of DEER load shapes from hourly to TOU. This can be seen in the above figure by the maroon bars (with nearly twice the occurrences ration less than 0.8
3. Use of the IOU load shapes under-predicts the avoided cost for HVAC measures by a wider margin than lighting measures, up to a factor of two to four.
4. Building and end use load shapes, as used by the current E3 calculators, do not well represent measure impact shapes in most cases; the out-of-date building and end use load shapes used for the current filings amplify this difference (as seen in the above figures maroon bars.) Many measures have no single appropriate end use representation and therefore, no end use load shape can be developed which properly values those measures.
5. Data needed to develop measure load shapes for some important measures does not exist; the most important example is CFL's (reasonable residential end use load shapes exist for CFL's, but the base case data - the end use shape for the replaced bulb - do not exist)
6. Current DEER methods can be used to create much better load shapes and these methods may be improved with the use of future M&V impact study data, if those studies are well designed. The DEER methodology could also be extended to provide measure based impact "load factors" to allow the pairing of demand impacts with these hourly load shapes.
7. The currently available "load factors", which can be used to approximate the demand impact of a measure based upon its annual kWh savings, being either building or end use values, do not provide useful demand impact values; this is exactly the same issue as with using building/end-use load shapes rather than measure impact load shapes for the avoided cost calculation.
8. The currently available end use load shape categories are too narrow to be useful. Some examples: the HVAC category contains many measures whose impact load shapes are VERY different and should not have the same load shaped used to calculate avoided cost or demand impact values; for indoor lighting, the building type and area usage category (lobby, office, classroom, hallway, kitchen, etc.) will have a large influence on the load shape that should be used - sub-categories are needed, rather than a single category, and the number of required categories can only be determined through a well planned and executed research project.

2.0 Data Used in this Comparison Work

The comparison spreadsheet, which contains the details of this work, as well as the IOU load shapes and measure lists used for this comparison, can be found in the web directory:

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

The download directory contains three ZIP archives: the comparison spreadsheet,

http://www.doe2.com/download/AvoidedCost/Compare2006AvoidedCostCalcs_2006-03-10.zip

the IOU load shapes as were used in their EE filings for cost effectiveness calculations,

http://www.doe2.com/download/AvoidedCost/PGE-SCE-SDGE_LoadshapeViewers.zip

and the full list of measures for each IOU taken from their filings

http://www.doe2.com/download/AvoidedCost/PGE-SCE-SDGE_MeasureLists.zip

Only the comparison spreadsheet ZIP archive is needed to review the work we have done; download the ZIP to your hard drive and extract its entire contents into a single directory then open the spreadsheet (Compare2006AvoidedCostCalcs_2006-03-10.xls)

The Hourly Avoided Costs by Utility, Climate Zone and Measure Life were supplied to us by E3 and are those as used in the 2006 program filings. Utility TOU by Building Type, Measure and Climate Zone, for PG&E/SCE/SDG&E, were also supplied by E3 and are those as used in the IOU filings. 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.

Some issues, related to the assumptions of this comparison work, were identified within the IOU specific EE program E3 calculators and their load shapes used to create the measure avoided cost valuations included in the IOU filings. These issues include:

- The E3 calculators, as completed with measure inputs and submitted for the various IOU EE programs, often do not have the appropriate measure load shape selected from the IOU set available. For example, new construction (NC) measures using retrofit load shapes, refrigeration measures using HVAC load shapes. Also, many cases of incorrect NTG's (i.e, PG&E refrigerator recycling measures use 0.8 when the appropriate value is .35, SCE non-res NC is .7 when correct is .8), incorrect kW values (sometimes stated as DEER or workpaper values, but do not agree with either) and kWh values (sometimes listed as DEER values, but "scaled" up stating they will "target" customers of higher use.)

- Although PG&E has a “library” of hourly load shapes with a wider variety of selection than their TOU set, most all measures in all programs used the TOU selection even when appropriate hourly shapes are available. Additionally, the PG&E TOU load shapes are NOT created with, or consistent with, their hourly load shape counterpart.

- Almost all measures use TOU load shapes which are all building or end use load shapes rather than measure impact load shapes.

- Most non-DEER values used in the EE program E3 calculators do indeed have DEER values available; non-DEER workpaper values were used instead. Those measures for which DEER values are missing could easily have values developed for DEER if the CPUC made it a priority and directed the work to be done (since the budget exists.)

- Most of the "load research" TOU and hourly data are out-of-date but are tied back to the same basic methods used to create DEER values; it seems those load shapes were developed using older calibration data that may not well represent current building equipment, operation and/or use patterns.

3.0 Description of the Spreadsheet Tool Containing the comparison Results

The details of the results of this analysis are contained in the spreadsheet named "**Compare2006AvoidedCostCalcs_2006-03-10**". 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.

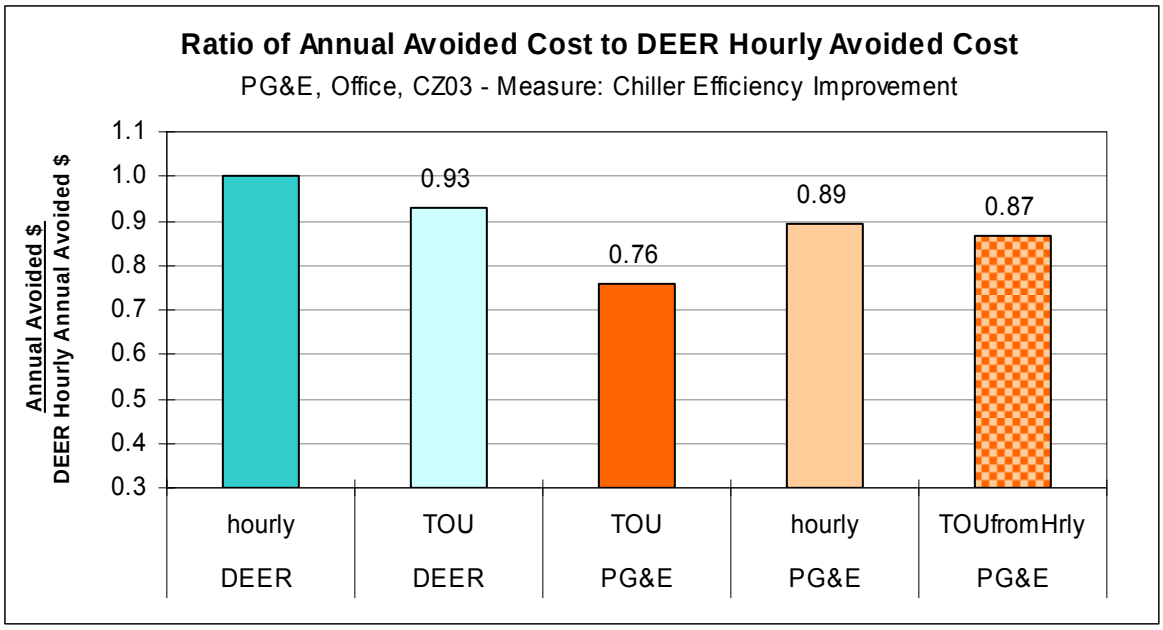
The five pick lists are used to set the current configuration:

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 Update Graphics 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!**

A series of six charts are located below the options settings. All of these charts are specific to the chosen options.

Chart 1: Ratio of Annual Avoided Cost to DEER Hourly Avoided Cost

The first chart presents a comparison of annual results derived from up to four different calculation methods.



The first bar is always 1.0, and merely sets the reference.

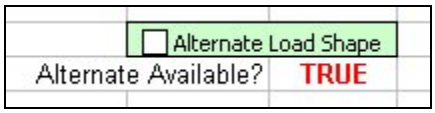
The second bar is the ratio of the annual avoided cost determined using seasonal TOU values derived from the DEER hourly results to the avoided cost calculated from DEER hourly results. This ratio shows the penalty suffered by averaging energy savings into the defined TOU periods and applying averaged avoided costs, versus using hourly energy savings and hourly avoided costs. The TOU periods used are defined for each utility and the TOU periods can be seen in column R starting in row 27.

> The DEER hourly avoided cost is calculated as the hourly energy savings determined from a DEER eQUEST run multiplied by the hourly avoided cost and summed over the entire year. The hourly avoided cost is a function of the utility, climate zone and measure life. The hourly avoided costs can be examined in column T, starting in row 27. The DEER hourly savings are listed in column AB, starting in row 27.
>
> Two alternative TOU periods were examined, just to see the impact they may have on this calculation. The first, called a "Super TOU" puts the 100 highest avoided cost hours of the summer on-peak period into a separate period. This should always lead to a TOU avoided cost estimate closer to the DEER hourly estimate. A second alternative creates 7 TOU periods each with equal avoided cost totals. This TOU definition sometimes leads to a better agreement with the hourly calculation.
>
> These alternative TOU calculations can be viewed by choosing a TOU definition from the pick list to the right of the graph. Note that only DEER results can be calculated from the alternative TOU periods.

The third bar is the ratio of the utility TOU calculated avoided cost to the DEER hourly

avoided cost. The TOU values are shown in column AJ beginning in row 15. A description of the utility TOU values used is shown just above the chart. Again, the annual energy savings is assumed to be the same as determined from the DEER eQUEST run.

It was not always clear which utility TOU load shape to use for this calculation. In some cases two different utility TOU load shapes were potentially applicable for the given measure. When this happens, the alternative option can be viewed by clicking the "Alternative Load Shape" checkbox.

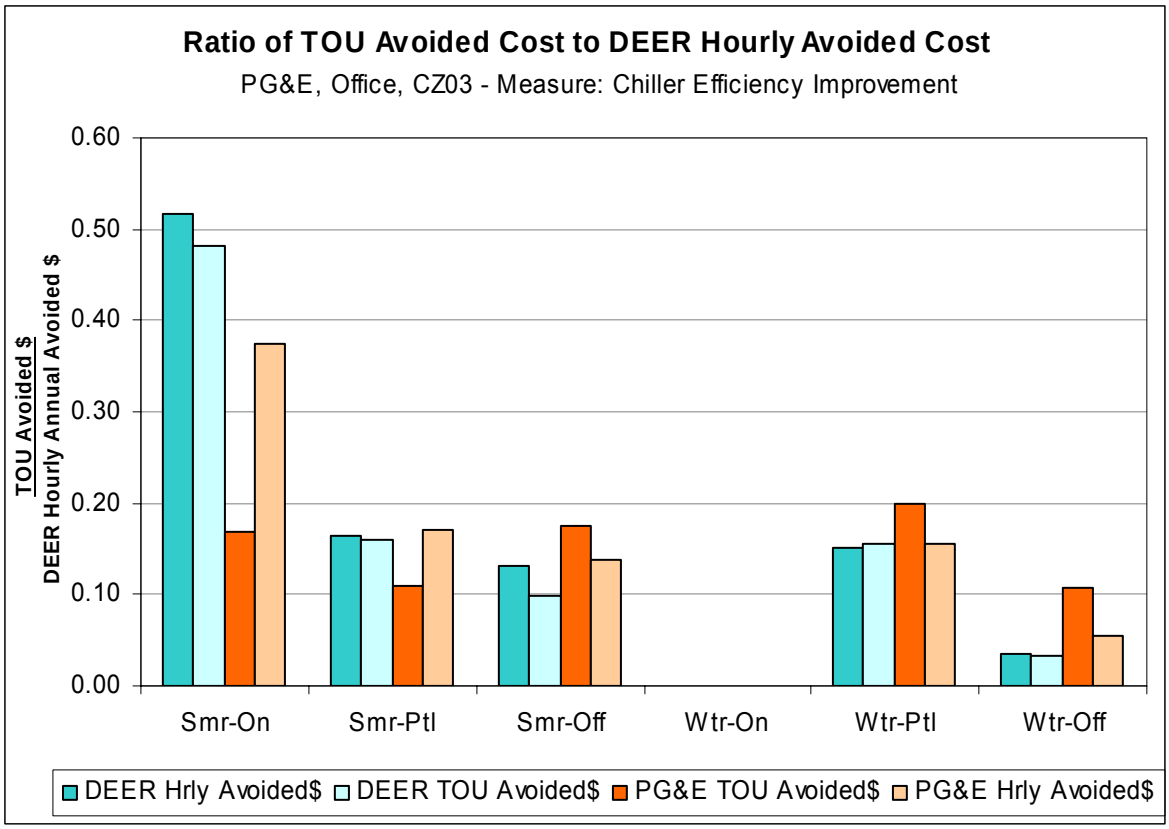


The fourth bar (only shown when available) is the ratio of the utility hourly avoided cost to the DEER hourly avoided cost. Utility hourly load shapes needed for this calculation were only available for PG&E, and were typically not used for reported avoided costs. This value is presented here to show how the value would compare to other avoided cost calculations ***if it were used***. The annual energy savings is assumed to be the same as determined from the DEER eQUEST run.

The last bar, only shown when utility hourly load shapes are available, calculates the utility avoided cost using a TOU loadshape derived from the utility hourly loadshape. Like the previous bar, this value is presented here only to show how the value would compare to other avoided cost calculations ***if it were used***.

Chart 2: Ratio of TOU Avoided Cost to DEER Hourly Avoided Cost

This chart expands the calculations of annual avoided cost presented in the first graph into each TOU period.



This chart provides some insight into why the utility annual avoided cost may be different from the DEER calculation. In the example shown, the utility avoided costs are spread evenly across the TOU periods whereas the DEER avoided costs are heavily weighted toward the summer on-peak period. In this case, avoided costs determined using the utility hourly load shapes agree much more closely with the DEER values.

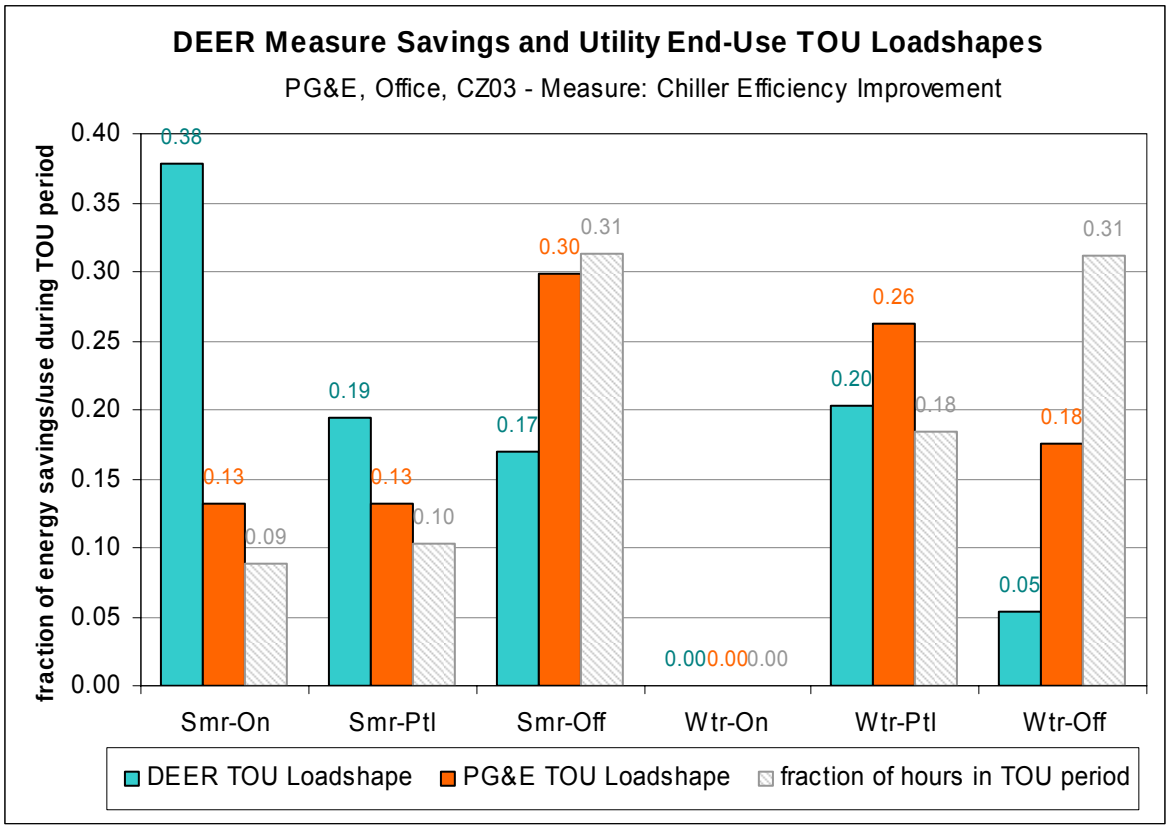
Note: only SDG&E uses a winter on-peak period. For the other utilities, these values will always be zero.

Chart 3: DEER Measure Savings and Utility End-Use TOU Loadshapes

Similar to chart 2, this chart examines the underlying differences between the DEER and utility avoided cost calculations. This time, the DEER measures savings TOU loadshape is compared with the utility TOU loadshape. These values are used in the same way when calculating the annual avoided cost, but are actually significantly different constructs. The DEER values represent how much of the annual ***energy savings*** falls into each of the TOU periods. The utility values represent how much of the annual energy end-use falls into each of the TOU periods.

For some measures, such as lighting demand reductions and equipment efficiency improvements, the energy savings and energy use TOU loadshapes will be very similar. This is because energy savings is realized whenever the component is operating. For other measures, however, such as economizer maintenance or orientation specific glazing

improvements, the savings loadshape will be very different than any energy end-use loadshape. One reason for this is that energy savings is not tied to when the component is used, but when conditions permit savings to be realized.



This example shows that much more of the energy savings falls in the summer on-peak and partial-peak periods than the utility TOU shape indicates. For reference, the gray bar indicates what fraction of the annual hours falls into each of the TOU periods.

Charts 4 - 6: Monthly Profiles

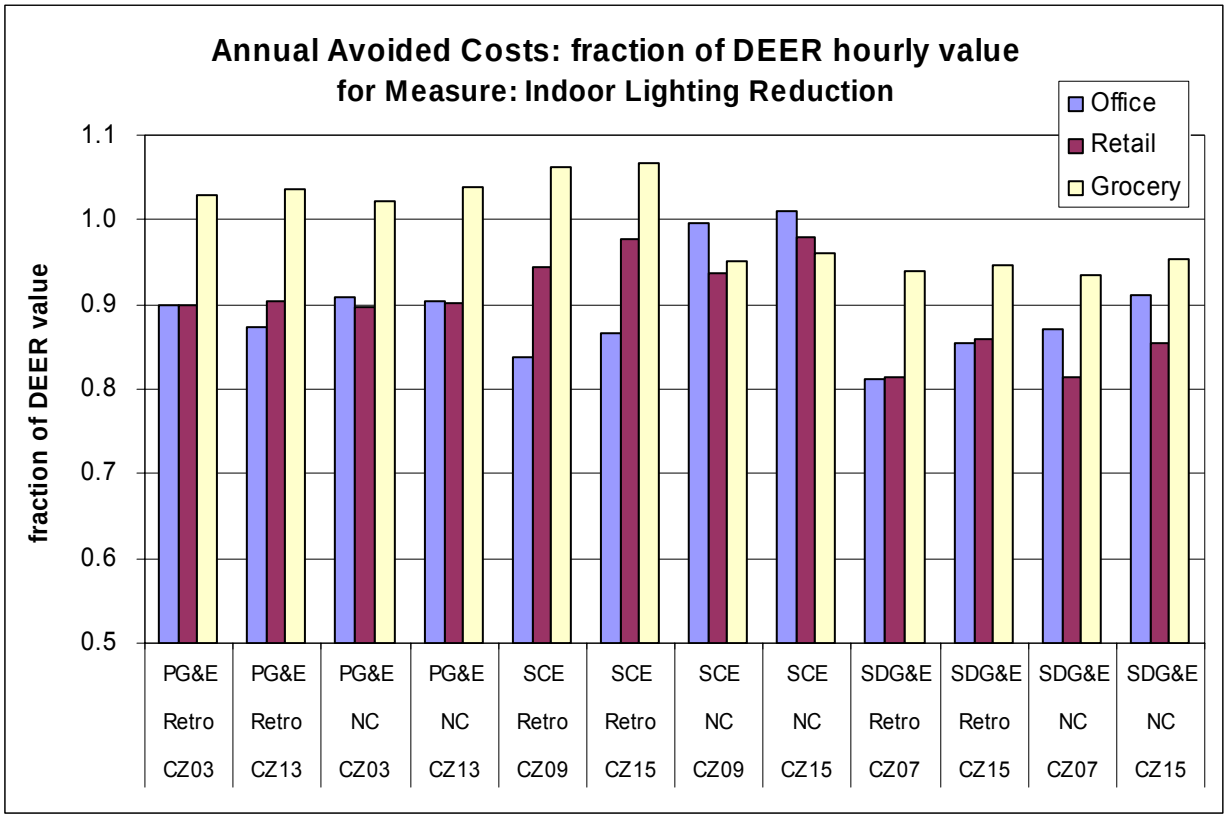
The first of these charts presents the monthly profiles of energy savings as calculated by the DEER eQUEST simulations. Only weekdays are included in the hourly averages. For the special case of the "Residential – Lighting" measure, the profile is actually CFL Lighting Usage. Savings for residential lighting measures were not determined using eQUEST. The savings are calculated independent of the building heating and cooling energy use.

The second of these charts presents the utility assumed hourly end-use profile. At this time, only PG&E has hourly load profiles for commercial buildings.

The last chart shows the monthly profiles for total building electricity use from the DEER eQUEST simulations. These charts are useful for understanding how the baseline buildings are assumed to operate.

[Commercial by Measure] tab

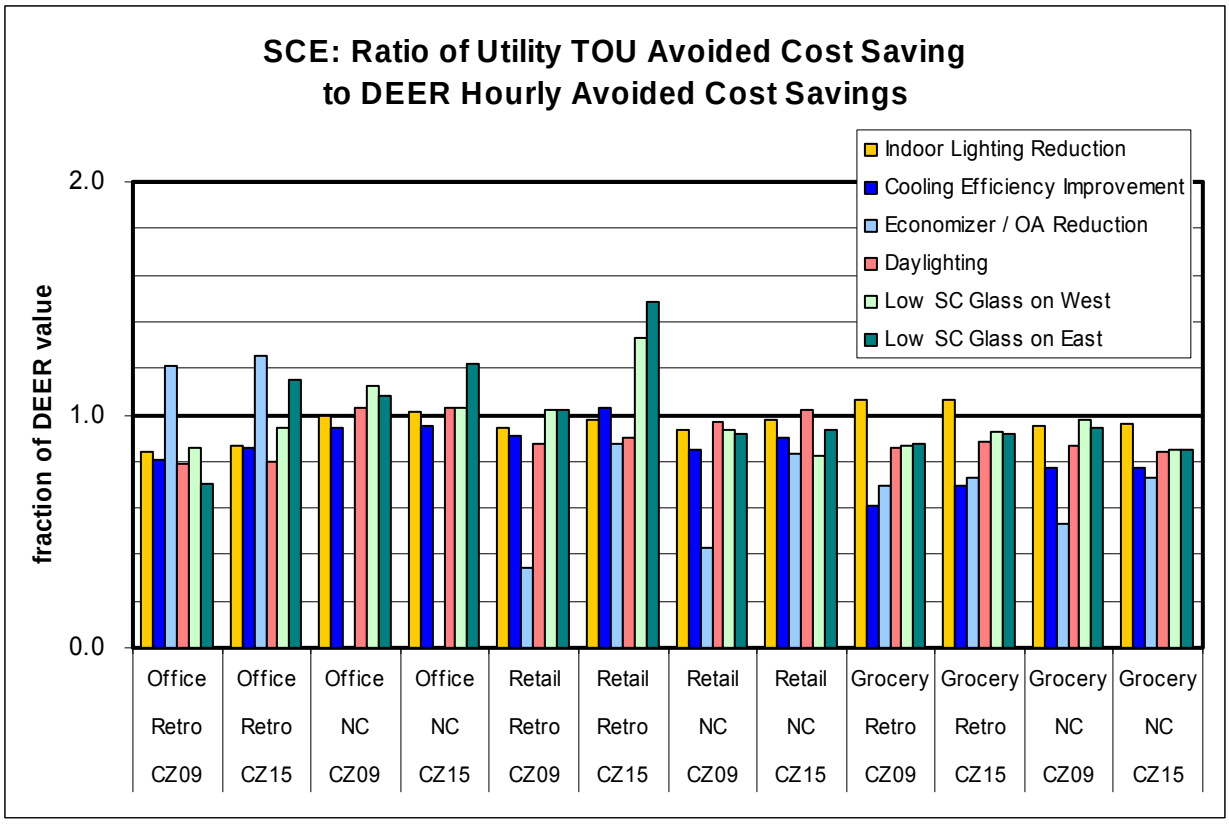
This tab shows a summary of all of the utility TOU avoided cost savings compared to the DEER hourly avoided cost savings for commercial measures. Each of the commercial measures is presented in a single graph, with the utility, vintage and climate zone variations along the X-axis. In these charts, **a value less than one indicates that, *for a given energy savings (kWh/year),* the assumed utility TOU load shape underestimates the annual avoided cost**. Conversely, and rarely as it turns out, a value greater than one indicates that, for a given energy savings (kWh/yr), the utility TOU load shape overestimates the annual avoided cost.



The example shown above presents the results for an indoor lighting reduction measure.

[Commercial by IOU] tab

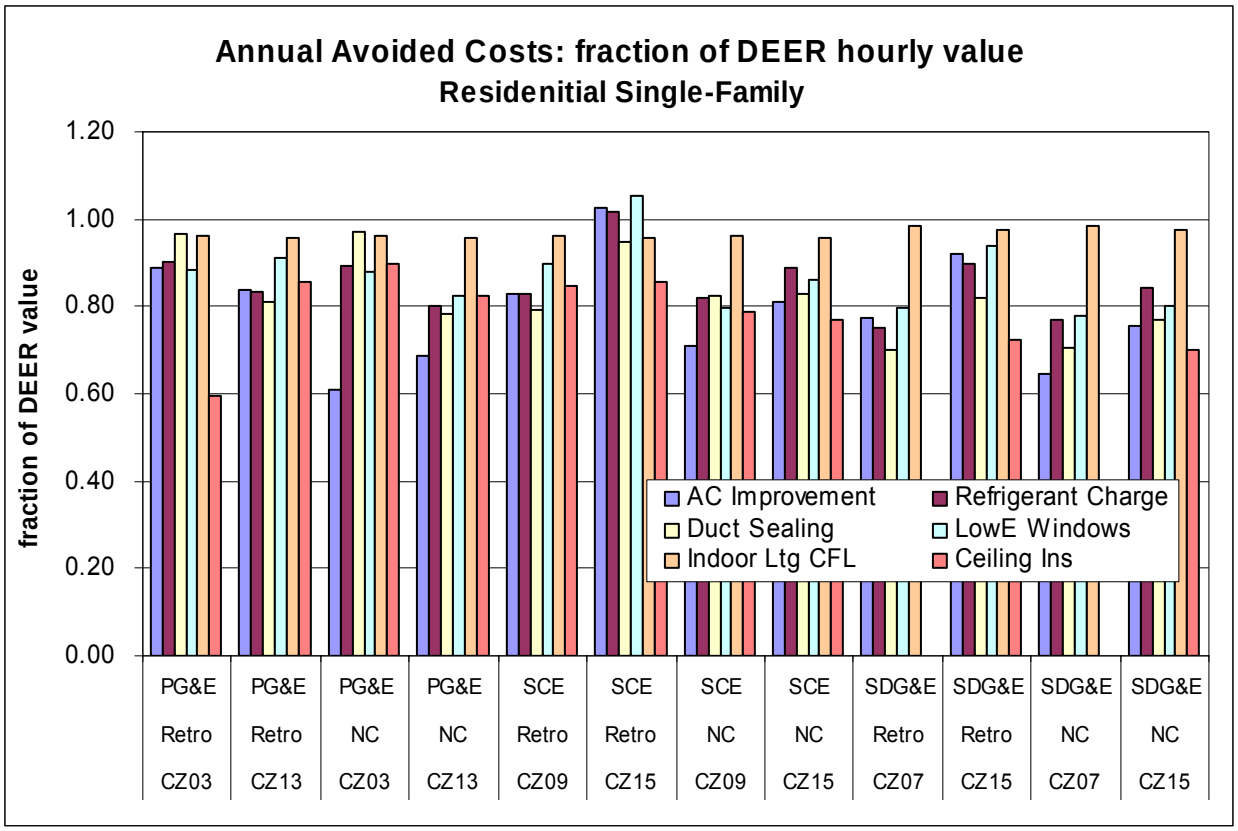
The charts on this tab rearrange the data in the previous tab to present the result by utility. The relative avoided cost savings between measures are more readily compared in these charts.



This example shows the ratio of Utility TOU avoided costs to DEER values for the indoor lighting measure as being relatively stable across all building types, vintages and climate zones while other measures vary significantly.

[Res Measures] tab

The same type of data presented for commercial buildings in the previous two tabs are shown here for the residential single-family building.



[Summary Table] tab

The large table on this tab preserves all of the data calculated on the {Measures Detail] tab except for the hourly profiles. Each utility, building, vintage, climate and measure combination is included. The data for the graphs in the previous three tabs is organized to the right of the large table. These data are static and must be copied from the first tab if any new values are used in the detailed calculations.

[HrlyAvoided Costs] tab

Hourly avoided costs are stored here. These values were derived from the spreadsheet: "cpucAvoided26.xls" for a subset of climate zones and measure life values. 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 as well as the utility TOU load shapes.

[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.

[PG&E-LS] tab

This tab contains the PG&E Load shapes used for the calculations.