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On 2019 Time Dependent Value of Energy

Additional submitted attachment is included below.

McHugh Energy Consultants

efficiency research
analysis
policy

Friday, July 29, 2016

California Energy Commission
Dockets Office, MS-4
Re: Docket No. 16-BSTD-06
1516 Ninth Street
Sacramento, CA 95814-5512
e-mail: docket@energy.ca.gov

Re: 16-BSTD-06 Docket: 2019 Time Dependent Value of Energy

To CEC Staff and Commissioners:

My congratulations to the CEC staff and consultant team for developing the TDV factors well in advance of the 2019 Title 24 rulemaking. These TDV factors are critical for evaluating the life cycle savings of energy efficiency measures that reduce or shift the timing of energy consumption. The energy efficiency measures evaluated can last 30 years or longer and thus it is important to have a stable estimate of energy savings that are based on the physics of energy delivery and based on the forecasts of total utility costs to consumers in years to come.

This letter is sent into the record to highlight two issues:

- A recommendation to include hour demand factors in addition to the hours TDV factors for use by the CBECC-res and CBECC-com simulation tools so that precalculated outputs will include both TDV kBtu and system peak demand kW impacts. I have included a sample file that contains both the TDV factors and the demand factors.
- A correction to the electrification presentation given by E3 on July 15, 2016. The TDV kBtu results for the 50 gallon electric heat pump water heater are not for a 3.6 energy factor (EF) unit but rather for a unit that is modeled in hybrid mode which has an energy factor of 3.24.

TDV Demand Factors

The TDV demand factors are used to calculate system peak demand reductions from various measures. These hourly demand factors are multiplied by the hourly electric loads from an annual building simulation and then added up over the course of year to yield the system peak demand impact of the simulated load. Two building simulations are compared: a base case simulation without the energy efficiency measure(s) of interest and a proposed case that includes the energy efficiency measure(s) of interest. The demand savings from a given measure is simply the base case demand minus the proposed demand. These demand factors have been used in previous Title 24 proceedings to quantify the demand impact of the various efficiency efficiency proposals. The

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calculation does not replace the TDV calculations as TDV is used to calculate the present valued cost savings to the consumer resulting from the energy savings of various efficiency measures.

I contacted Brian Horii at E3 to discuss how to calculate demand factors for the 15 year and 30 year analyses that are used to determine the cost effectiveness of building code upgrade proposals. The demand factors are based on the hourly T&D allocators (peak capacity allocation factors) that are one component of costs used to build up the TDV costs. Because there are a number of hours during which system loads are near the system peak, several hours have a relatively high probability of being the peak hour that is the basis of sizing T&D components. The T&D allocators are the relative probabilities of a given hour being the peak hour. If these hourly allocators are summed up over 8,670 hours in a year these allocators sum up to 1.0. Most hours have a T&D allocators of 0; and depending upon climate zone, there are between 20 and 250 hours in a year where the allocators are greater than 0. These are the hours that could set system peak demand for that climate zone.

As shown in Table 1 below, the number of hours per year that loads contribute to peak can change over time. As an example, in climate zone 2 there are 73 hours in year 2020 with a non-zero T&D allocator and in 2030 this rises to 149 hours per year.

Table 1: T&D Allocators: Summary Statistics

	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
2020 Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2020 Count	250.00	73.00	250.00	20.00	250.00	147.00	250.00	20.00	20.00	20.00	20.00	20.00	20.00	146.00	250.00	20.00
2030 Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2030 Count	250.00	149.00	250.00	38.00	250.00	250.00	250.00	27.00	20.00	20.00	20.00	20.00	20.00	108.00	250.00	250.00

Steps for Creating Hourly Demand Factors.

1. Collect 2020 T&D Allocators and 2030 T&D Allocators from the "HourlyData"tab of the "TDV_2019Update_model7_13.xlsb" spreadsheet. There are 8,760 hourly T&D allocators for each climate zone. Most of these allocators are zeros. No more than 250 hourly allocators exist per climate zone.
2. Create T&D allocators for the time period 2020 to 2049. Years between 2020 and 2030 are linearly interpolated from the 2020 and 2030 data. After 2030 use the 2030 data.
3. Take the average over the period of interest. For demand factors used with the TDV factors for the 15 year period of analysis the results are averaged over the 2020 -2034 time frame. For demand factors used with the TDV factors for the 30 year period of analysis the results are averaged over the 2020 – 2049 time frame.[1]
4. Verify that the resulting 15 year and 30 year demand factors sum up to 1.0

[1] As Brian Horii noted this hourly demand factor, DF_h is equivalent to:

15 year $DF_h = ((AF_{2020,h} + AF_{2030,h})/2 * 11 + AF_{2030,h} * 4)/15$

30 year $DF_h = ((AF_{2020,h} + AF_{2030,h})/2 * 11 + AF_{2030,h} * 19)/30$

Where, $AF_{2020,h}$ is the 2020 T&D allocation factor and $AF_{2030,h}$ is the 2030 T&D allocation factor

I recommend that the demand factors are added to the TDV files so hourly simulation software can directly calculate peak demand impacts as well as TDV impacts. I have attached a sample MSExcel spreadsheet file with the needed data.

Results

This calculation was contained in a large file called "DemandFactor.xlsx" and then more compactly calculated using the simplified equations suggested by Brian Horii in the file"DemandFactor2.xlsx." The results were identical, both files were sent to CEC staff and E3 for their review.

All the demand factors add up to 1 as they should. Since the 2020 and 2030 T&D allocation factors can shift over time, the number of non-zero average demand factors increases. This reflects the broadening of the possible period of peak demand. This is indicating that the time of peak demand is changing over time and thus the number of hours that could be the time of system peak is greater but correspondingly the probability of any particular hour being the peak hour is decreasing as the annual sum of the peak demand factors must still be 1.0.

Table 2: Summary Statistics for 15 tear and 30 year demand factors

	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
15 year sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
15 year count	250.00	161.00	271.00	39.00	250.00	307.00	325.00	32.00	21.00	29.00	23.00	24.00	23.00	153.00	305.00	250.00
	CZ1	CZ2	CZ3	CZ4	CZ5	CZ6	CZ7	CZ8	CZ9	CZ10	CZ11	CZ12	CZ13	CZ14	CZ15	CZ16
30 year sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
30 year count	250.00	161.00	271.00	39.00	250.00	307.00	325.00	32.00	21.00	29.00	23.00	24.00	23.00	153.00	305.00	250.00

Demand Factor Next Steps

So all this data is in one place, the calculated demand factors for all 16 climate zones for both the 15 year and 30 year period of analyses have been merged with the TDV factors. The TDV factors are from the MSExcel file "2019_TDV_Results_20160713.xlsx" and this new merged file with both TDV and demand factors is given the name "2019_TDV_Results_20160713wDF.xlsx.

We recommend that the CBECC-com and CBECC-res software incorporate both the TDV factors <u>and the system demand factors</u> so annual building simulations of hourly electrical loads can be directly used to calculate annual electric TDV kBtu and annual average system peak demand. This would reduce the effort needed to calculate peak demand impacts of various measures. Alternatively, the hourly electrical consumption results from these simulation programs can be exported and separately post-processed with these demand factors to yield the demand impacts.

Modelling of Electric Heat Pump Water Heater in Electrification Example

During the TDV presentation on July 15, 2016, E3 had also presented a number of scenarios on the impacts of the new 2019 TDVs.[2] This included as discussion of how a heat pump water heater would compare to the default water heater, a tankless gas fired water heater with an energy factor of 0.82.

[2] http://docketpublic.energy.ca.gov/PublicDocuments/16-BSTD-06/TN212440_20160725T110215_E3_2019_TDV_Lead_Commissioner_Workshop_Presentation.pdf

The presentation indicates that the comparison heat pump water heater (AO Smith HPTU 50N) has an energy factor of 3.6, when in actuality it is listed with the CEC as a 3.24 EF heat pump water heater in the CEC's Appliance efficiency database.

The manufacturer lists the energy factor in three different modes as follows:

Energy Factor:

3.61 (Efficiency Mode)

3.24 (Hybrid Mode)

0.93 (Electric Mode)

Efficiency mode is with the electric resistance element in the water heater locked out. Hybrid mode uses the heat pump to generate hot water but will turn on the electric resistance element if the water temperature in the tank is too low (maintaining amenity for the user). Electric mode is the energy factor when only the resistance element is used.

The water heaters are shipped in hybrid mode and thus the CBECC-com software models the water heater in hybrid mode. Thus it is more accurate to describe this heat pump water heater as a 3.24 EF water heater.

It is also worth noting that the water heater selected is one that has been tested in accordance with NEEA Advanced Water Heater Specification.[3] This more comprehensive test procedure better captures the details of how a HPWH operates, providing detailed data so that the CBEEC-res program can more accurately simulate water heater operation. If the heat pump water heater had not been tested to this detailed specification, the water heater performance would have been more conservatively modeled in CBECC since less information is known regarding actual performance.

The end result is for a similar type of heat pump water heater with a 3.6 EF in hybrid mode, the TDV energy results would be approximately 10% lower and would show the heat pump water heater being equivalent or lower TDV energy consumption than the tankless gas water heater in most climate zones (except perhaps CZs 1, 3, 5 and 16).

I would like to acknowledge the assistance I received from Brian Horii and Snuller Price at E3 and Marc Hoeschele and Bill Dakin at Davis Energy Group.

Sincerely,

Jon McHugh, PE

Principal, McHugh Energy Consultants Inc.

[3] Formerly known as the Northern Climate Specification. For more details see: http://neea.org/docs/default-source/northern-climate-heat-pump-water-heater-specification/northern-climate-specification.pdf?sfvrsn=18