DEER2017 and DEER2018 Update Summary

1 Finding the DEER2017 and DEER2018 update values and supporting documentation

The DEER2017 update, to be effective 1/1/2017, is limited to changes that are related to energy code requirements and changes due to corrections of errors in previous DEER versions. The DEER2018 update, to be effective 1/1/2018, encompasses changes due to program evaluation and market research.

1.1 DEER2017 and DEER2018 Measures and Impact Values

The DEER2017 and DEER2018 measures and associated energy impacts have been added to the Preliminary Ex Ante Review (PEAR) database for the review period. This database is accessible using the latest version of READI, found on the DEEResources.com web site. Measures impacted by this update have a value of either "DEER2017" or "DEER2018" in the version field and have a start date of either 1/1/2017 or 1/1/2018 respectively.

Following the review period, the final DEER2017 and DEER2018 data will be moved to the ex-ante database, also accessible using the latest version of READI.

1.2 Other Documents

This document along with support workbooks can be found on the DEEResources.com web page, under the menu DEER Versions => DEER2017 and DEER2018.

2 Non-residential Measure Updates Based on Energy Code

The commercial measures updated for DEER2017 are based on energy code changes, as described in the following sections.

2.1 Linear Fluorescent Code Baselines

Alignment with California Title 24 Lighting Power Density Updates

Since the 2013 update to Title 24, the CEC has been reducing allowances for lighting power based on the gradually increasing performance of linear fluorescent technologies. As discussed in Section 6.2.3 the office lighting power density (LPD) limits in 2013 Title 24 were developed assuming more efficient technologies than the current DEER code baseline of 2nd generation T8 lamps and normal light output (NLO) ballasts. However, 2016 Title 24 updates to non-office LPDs assumed technologies very similar to the DEER code baseline. Instead, the reduced 2016 Title 24 LPD values were developed by removing incandescent lights sources from typical lighting design assumptions. Furthermore, Title 24 offers flexibility in the use of optional lighting controls along with exceptions for small alterations. Because of varying assumptions made in the code development efforts along with the wide range of compliance approaches, the DEER team chose not to update any code baselines at this time. Instead, the DEER team believes these revisions are more appropriately incorporated into revisions to standard practice baselines covered in Section 6.2.

2.2 HVAC Equipment Measures

Alignment with California Title 24 and Federal Minimum Efficiency Requirements

Title 24 requires air-cooled package HVAC air conditioners and heat pumps greater than 65 kBtuh and all water chillers (except absorption chillers) to meet both minimum full-load and minimum integrated part-load efficiency requirements. Additionally, program administrators offer incentives that allow the customer to choose which efficiency metric, either the full- or part-load value, as the basis for the deemed savings and incentive. Previous versions of DEER did not include part-load efficiency values for heat pumps or chillers, and the part-load values for air conditioners were based on typical market averages rather than the characteristics of the simulated equipment. This version of DEER will update all measure definitions to include reference full- and part-load efficiency requirements for both the baseline and measure technologies. These revisions will bring the DEER measure definitions in line with all minimum efficiency requirements that will be in place on January 1, 2017. Furthermore, DEER will be revised to include scale-able values and methods that facilitate the PAs' development of non-DEER measure definitions without having to develop new savings values within workpapers.

2.2.1 Packaged Unitary Air Conditioning and Air Source Heat Pumps Measures for unit capacity of 65,000 Btu/h or greater

The 2016 Title-24 Energy Standard has new requirements for the Integrated Energy Efficiency Ratio (IEER) for packaged air conditioning equipment while full load efficiency values (EER) are unchanged from the previous standard. However, both the EER and IEER minimum requirements must be met not one or the other. The IEER values reported for the air conditioning baselines and measures for the DEER 2016 version were based on a survey of equipment available in the market place. These market average values provided typical IEER values for each EER based efficiency Tier. At the time of previous DEER releases, the IEER requirements of the Title 24 standard were relatively low. Based on the market average IEER values, it was clear that the DEER Standard level models would exceed these requirements. With the increased stringency of the new IEER requirements in the energy code, it is no longer certain that the IEER values of the DEER standard models are in compliance. Therefore, an activity was undertaken to determine the appropriate rated IEER values for each of the DEER standard and measure cases.

For a given air conditioning system, there will always be both a rated EER and a rated IEER. The selection of tier level must be based on both of these parameters, while any interpolation between DEER tiers must be based solely on the rated EER. If the rated EER and the rated IEER are both greater than or equal to the tier level values, then that tier is valid. It is not acceptable to move to the next tier if the rated IEER satisfies the minimum IEER threshold of the tier but the rated EER for the equipment does not satisfy the EER requirement for the tier. Interpolations can be performed between two DEER tier levels based on EER, but not IEER, and only if the IEER for the equipment meets the interpolated minimum IEER threshold. The two examples in the table below show units with the same rated EER value and with differing IEER values that both resolve to using the same DEER savings value developed for an interpolation between the two bounding DEER measures using the unit rated EER value.

Rated EER	Rated IEER	Tier Below EER/ min IEER	Tier Above EER/ min IEER	Selected Tier EER
12.2	14.1	12.0/13.8	12.5/14.1	12.0
12.2	15.2	12.0/13.8	12.5/14.1	12.0

The minimum IEER value for each DEER measure was developed from market data selecting the typical minimum IEER for each EER as shown in Figure 2 through Figure 4. These figures include both data collected by the DEER team as well as data provided by PG&E as part of their commenting on the DEER scope. The PG&E data was cleaned to exclude units not compliant with current code and also to exclude units that do not have IEER values reported for 2-speed fan operation. The DEER modeling for savings values, however, were calculated using typical unit performance maps for the range of equipment available at each EER level.

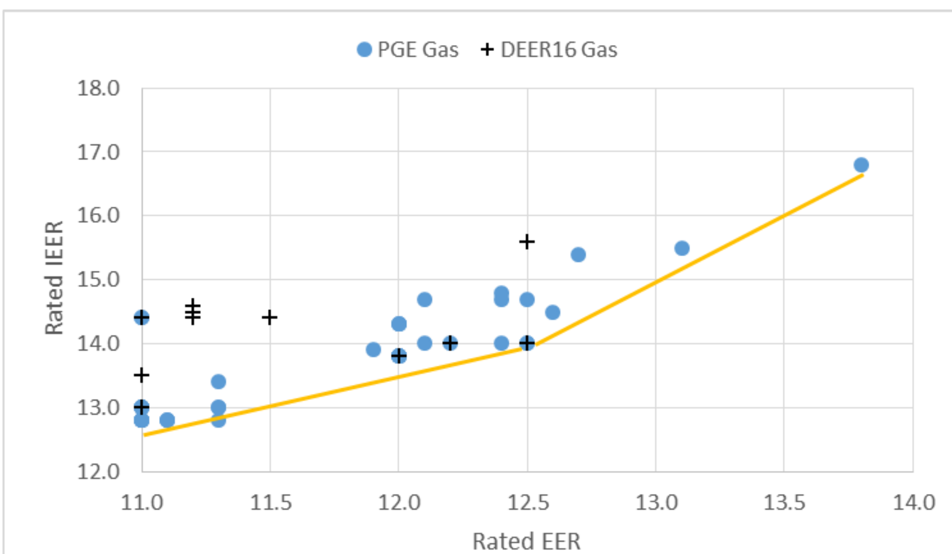

Figure 1. Relationship Between Rated IEER and Rated EER for Gas Air Conditioning Units 65 to <135 kBtu/hr Equipment Capacity Range

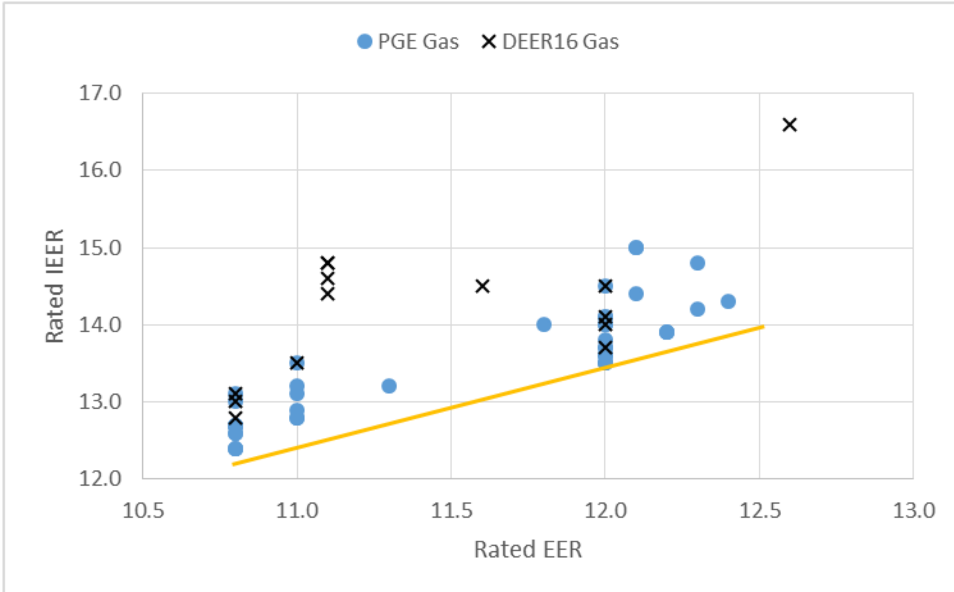

Figure 2. Relationship Between Rated IEER and Rated EER for Gas Air Conditioning Units 135 to <240 kBtu/hr Equipment Capacity Range

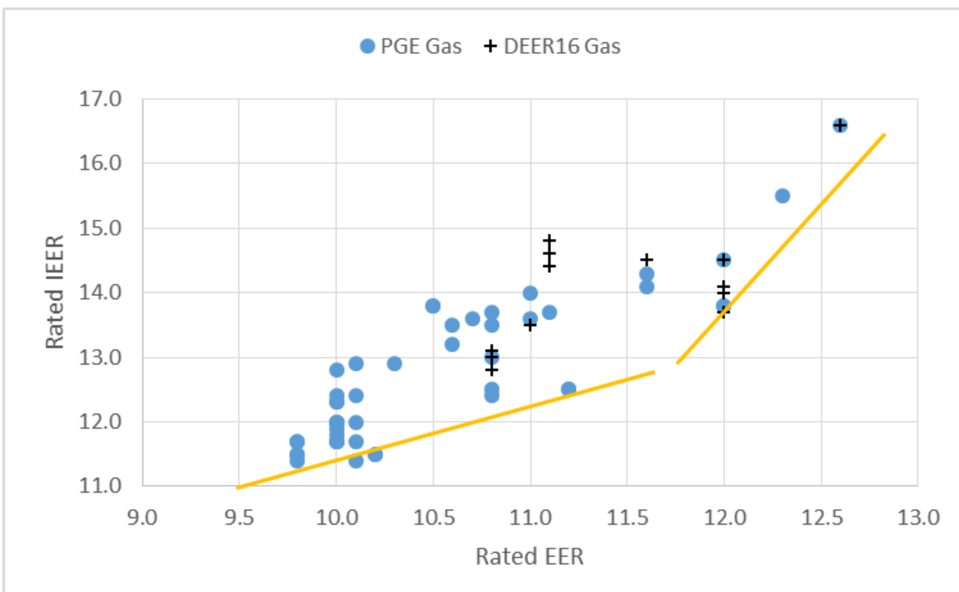

Figure 3. Relationship Between Rated IEER and Rated EER for Gas Air Conditioning Units 240 to <760 kBtu/hr Equipment Capacity Range

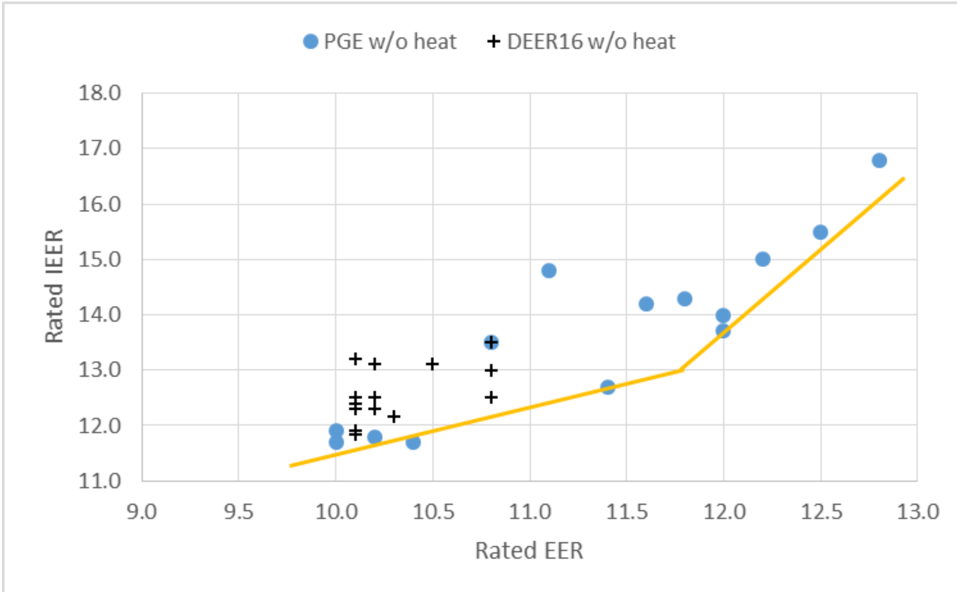

Figure 4. Relationship Between Rated IEER and Rated EER for Air Conditioning Units with No Heat or Electric Resistance Heat in the 240 to <760 kBtu/hr Equipment Capacity Range

Table 2 below provides an example of the EER and IEER minimum values required to be met for code compliance as well as to qualify for savings at the various DEER tier levels of performance. As noted above to qualify for savings treatment at a tier level both the minimum EER and IEER requirements must be met. Interpolation between tiers is performed using EER values only.

Capacity of 65 to <135 kBTU/hr with gas heating		
Tier	**Minimum Rated EER**	**Minimum Rated IEER**
Code	11	12.7
1	11.5	13
2	12	13.5
3	12.5	14
4	13	15
Capacity of 135 to <240 kBTU/hr with gas heating		
Tier	**Minimum Rated EER**	**Minimum Rated IEER**
Code	10.8	12.2
1	11.5	13
2	12	13.5
3	12.5	14
Capacity of 240 to <760 kBTU/hr with gas heating		
Tier	**Minimum Rated EER**	**Minimum Rated IEER**
Code	9.8	11.4
1	10.8	12.2

2	11.5	12.7
3	12.5	15.5
Capacity of >=760 kBTU/hr with gas heating		
Tier	**Minimum Rated EER**	**Minimum Rated IEER**
Code	9.5	11
1	10.2	11.6
2	11	12.3
3	12	13.8
Capacity of 240 to <760 kBTU/hr with no heating		
Tier	**Minimum Rated EER**	**Minimum Rated IEER**
Code	10	11.6
1	10.8	12.3
2	11.5	12.8
3	12.5	15.3
Capacity of >=760 kBTU/hr with no heating		
Tier	**Minimum Rated EER**	**Minimum Rated IEER**
Code	9.7	11.2
1	10.2	11.7
2	11	12.4
3	12	13.8

Table 1. EER and IEER Code and Tier Minimums for Packaged A/C units with Gas Heating

2.2.2 Water Chiller Measures

UPDATE NOTES: The code baseline value for water-cooled, constant speed, screw chillers less than 75 tons in the published draft DEER 2017 update was incorrect. The draft DEER uses 0.78 kW/ton, however, the 2016 Title 24 value is 0.75 kW/ton. Since the DEER measure definition is "Code + 10%", the measure definition is also incorrect. The draft DEER measure definition is 0.702 kW/ton, but, with the corrected code baseline, should be 0.675 kW/ton. This change will also cause savings to increase for the measure definition. Both the measure definition and impacts have been revised for the final version of the DEER 2017 update.

Since 2013, Title 24 has required water chillers to meet minimum full-load efficiency (kW/ton) and minimum integrated part-load efficiency (IPLV) values. Additionally, Title 24 also included alternate efficiency paths for chiller types. Path A requires a fairly high full-load efficiency. Path B[1]

[1] ASHRAE introduced Path B in Standard 90.1-2010 as way to establish equivalent efficiency for chillers equipped with variable speed drives on compressors. Commonly available VSD chillers have lower full-load efficiencies that often would not comply with

sets a lower minimum full-load efficiency than Path A, but requires a much higher minimum integrated part-load efficiency compared to Path A. Previous versions of DEER included measures based only on Path A efficiency requirements and did not include IPLV values in the measure definition.

Based on a review of PA's recently submitted workpapers, current programs offer incentives within Path A or Path B for the following categories:

1. Exceed Path A requirements for full-load efficiency
2. Exceed Path A requirements for integrated part-load efficiency
3. Exceed Path B requirements for full-load efficiency
4. Exceed Path B requirements for integrated part-load efficiency

For a given chiller, there will always be both a rated full-load efficiency (EER for air-cooled and kW/ton for water-cooled units) and a rated IPLV. The selection of an efficiency tier level must be based on both of these parameters, while any interpolation between DEER tiers must be based solely on the rated full-load efficiency. If the rated full-load efficiency and the rated IPLV are both greater than or equal to the tier level values, then that tier is valid. It is not acceptable to move to the next tier if the rated IPLV satisfies the minimum IPLV threshold of the tier but the rated full-load efficiency for the equipment does not satisfy the requirement for the tier. Interpolations can be performed between two DEER tier levels based on full-load efficiency, but not IPLV, and only if the IPLV for the equipment meets the interpolated minimum IPLV threshold. The complete list of updated DEER chiller measures is included in Table 6 in Section III.

The current version of DEER only supports measures defined using Path A full-load efficiencies. DEER2017 has been updated to include measure definitions that meet specific measure performance criteria within a specific efficiency path. For example, there is now a measure definition for a water cooled conventional centrifugal chiller that exceeds Path B full-load efficiency requirements by 15%. Additionally, DEER has been updated to include scale-able savings values for each of the four classes of measures listed above so that PAs can develop alternative non-DEER efficiency levels for chillers without having to develop new savings values in workpapers. Table 3 below shows the current DEER chiller measures that will expire at the end of 2016.

Path A requirements. However, VSD chillers typically have much higher efficiencies at part-load. The IPLV is weighted calculation of several part-load efficiency values. VSD chillers typically have much higher efficiencies at part-load compared to constant speed chillers, resulting in much higher IPLV ratings. Therefore, ASHRAE considers the lower full-load and higher part-load requirements of Path B to be equivalent to Path A.

MeasureID	Version	StartDate	ExpiryDate
NE-HVAC-Chlr-Screw-gte300tons-0p511kwpton	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-Cent-150to299tons-0p507kwpton-VSD	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-Cent-gte300tons-0p461kwpton-ConstSpd	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-Screw-150to299tons-0p574kwpton	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-Cent-150to299tons-0p507kwpton-ConstSpd	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-WtrRecip-lt150tons-0p672kwpton	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-AirScrew-AllSizes-1p008kwpton	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-WtrRecip-150to299tons-0p588kwpton	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-Cent-gte300tons-0p461kwpton-VSD	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-Cent-lt150tons-0p560kwpton-ConstSpd	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-Cent-lt150tons-0p560kwpton-VSD	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-Cent-lt150tons-0p700kwpton-1FrctnlsComp	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-Cent-lt150tons-0p700kwpton-gt1FrctnlsComp	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-WtrRecip-gte300tons-0p536kwpton	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-Screw-lt150tons-0p632kwpton	DEER2014	7/1/2014	12/31/2016
NE-HVAC-Chlr-AirPkgRecip-AllSizes-1p008kwpton	DEER2014	7/1/2014	12/31/2016

Table 2. DEER Chiller Measures updated for DEER2017

I. Summary of Measure Updates

All measures have been updated to reflect minimum efficiency requirements in 2016 Title 24, which required breaking chiller technologies into more size ranges. Furthermore, all measure impacts are based on improving the full load efficiency over the minimum code requirements. If adequate manufacturers data was available (such as with air-cooled chillers), then discreet full-load, and paired part-load measure values were determined. In all other cases, measures were defined assuming a fixed percentage improvement of full load efficiency over the minimum code requirement.

Efficiency measures for centrifugal chillers meeting Path B minimum code requirements were also updated. In past versions of DEER, these measures assumed a change in compressor technology type. Magnetic bearing (or frictionless) compressor chillers were assumed to have a conventional centrifugal compressor chiller as the baseline. This assumption has been revised so that the baseline and measure compressor technologies are identical, and the measure consists only of an increase in the full load chiller efficiency.

This DEER update does not include measures for air cooled chillers or water cooled positive displacement chillers meeting Path B minimum code requirements. In order to model these technologies, whole new performance maps (as discussed below in Section IIII) must be developed using manufacturers literature or chiller specification software. The modeling process developed by the DEER team for the updates to chiller measures can be adapted to utilize additional performance maps once they become available through future DEER or workpaper development efforts.

II. Development of Savings Estimation Methods

Savings estimates for chillers are developed by using energy simulation software to model specific chiller characteristics. Savings for a specific type of chiller are represented by the difference in simulation results for a specific code baseline chiller and a specific measure chiller. In order to correctly model a chiller using the DEER simulation software, a "performance map" which is a compilation of inputs to the simulation software, consisting of the following information:

Full-load efficiency: This is the efficiency of the unit when operating at full-load conditions as specified by the Air-Conditioning, Heating and Refrigeration Institute (AHRI)[2].

Capacity as a function of leaving chilled water temperature and entering condenser temperature (Cap-fT): This is a mathematical formula (or "curve-fit") that describes the capacity of the chiller as a function of the temperature of the water exiting the chiller evaporation and either:

- the temperature of the water entering the condenser for water-cooled chillers, or
- the ambient temperature of the air where air-cooled chiller condenser is located.

Efficiency as a function of part-load ratio and lift (EIR-fPLR&dT): This is a curve-fit that describes the chiller efficiency as a function of the chiller part-load ratio and the difference between the entering condenser temperature and the leaving chilled water temperature (often referred to as "lift").

Efficiency as a function of chilled water and condenser temperatures (EIR-fT): This is a curve-fit that describes the chiller efficiency as a function of leaving chilled water temperature and either:

- the temperature of the water entering the condenser for water-cooled chillers, or
- the ambient temperature of the air where the air-cooled chiller condenser is located.

IPLV is not an input to the DEER simulation software. IPLV is derived outside of the simulation software based on the performance map for a particular chiller. The IPLV is not a single point value like full-load efficiency. Rather, it is a calculated value, based on a weighting of efficiencies at four different sets of operating conditions. To calculate the IPLV, the operating conditions and the performance map are used in a manual calculation. It is important to note that, for any particular full-load efficiency and set of curve-fits, only a single IPLV value is possible.

[2] AHRI Standard 550/590 Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle

Additionally, if the full-load efficiency is increased or decreased, but the same curve-fits are used, then the IPLV will increase or decrease in the same proportion as the change in full-load efficiency. For a given set performance map, it is not possible to have different values for IPLV with the same full-load efficiencies. For example, two air-cooled chillers, both with a full-load EER of 10.1, but one with an IPLV of 15 and the other with an IPLV of 16, cannot be modeled using the same performance maps. The full-load efficiencies are identical, but the performance maps must be different in order to yield different IPLVs.

At this time, DEER includes only single sets of curve-fits for various types of water chillers. Therefore, the only input that can vary as part of the performance map is full-load efficiency. In most cases, code minimum full-load efficiencies resolve to higher IPLVs when using the current sets of performance curves for each technology type. The DEER team has investigated other resources, such as the Title 24 Alternative Calculation Methods Non-residential Reference Manual, and found that these methods also specify a single set of curve-fits for each chiller type. As a result, DEER and ACM manual methods can only model shifts in IPLV that are proportionate to the shift in full-load efficiency. Table 4 provides a comparison of minimum code requirements for IPLV and the IPLV resulting from the DEER curve-fits when using the code minimum full-load efficiency. In order to model improvements in IPLV that are not in proportion to an improvement in full-load efficiency, completely different performance maps are needed for each efficiency level.

Compressor Type	Condenser Type	Size Range	Efficiency Path	Title 24 Full- Load	Title 24 Part-Load	DEER Part-Load
Any	Air	<150 tons	A	≥10.1 EER	≥13.7 IPLV	13.7 IPLV
			B	≥9.7 EER	≥15.8 IPLV	- n/a -[3]
		≥150 tons	A	≥10.1 EER	≥14.0 IPLV	13.7 IPLV
			B	≥9.7 EER	≥16.1 IPLV	- n/a -
Positive Displacement (including screw, scroll, helical rotary)	Water	<75 tons	A	≤0.75 kW/ton	≤0.60 IPLV	0.574 IPLV
			B	0.78 kW/ton	≤0.50 IPLV	- n/a -[4]
		≥75 tons and <150 tons	A	≤0.72 kW/ton	≤0.56 IPLV	0.505 IPLV
			B	0.75 kW/ton	≤0.49 IPLV	- n/a -
		≥150 tons and <300 tons	A	≤0.66 kW/ton	≤0.54 IPLV	0.463 IPLV
			B	0.68 kW/ton	≤0.44 IPLV	- n/a -
		≥300 tons and <600 tons	A	≤0.61 kW/ton	≤0.52 IPLV	0.428 IPLV
			B	0.625 kW/ton	≤0.41 IPLV	- n/a -
		>600 tons	A	≤0.56 kW/ton	≤0.50 IPLV	0.393 IPLV
			B	0.585 kW/ton	≤0.38 IPLV	- n/a -
Centrifugal	Water	<150 tons	A	≤0.61 kW/ton	≤0.55 IPLV	0.538 IPLV
			B	0.695 kW/ton	≤0.44 IPLV	0.397 IPLV
		≥150 tons and <300 tons	A	≤0.61 kW/ton	≤0.55 IPLV	0.538 IPLV
			B	0.635 kW/ton	≤0.40 IPLV	0.363 IPLV
		≥300 tons and <400 tons	A	≤0.56 kW/ton	≤0.52 IPLV	0.494 IPLV
			B	0.595 kW/ton	≤0.39 IPLV	0.341 IPLV
		≥400 tons and <600 tons	A	≤0.56 kW/ton	≤0.5 IPLV	0.494 IPLV
			B	0.585 kW/ton	≤0.38 IPLV	0.341 IPLV
		≥600 tons	A	≤0.56 kW/ton	≤0.50 IPLV	0.494 IPLV
			B	0.585 kW/ton	≤0.38 IPLV	0.341 IPLV

Table 3 - Title 24 and DEER Chiller Efficiencies

Since only a single set of curve-fits are available for each chiller technology, savings must be estimated by varying the full-load efficiency input into the simulations. DEER includes "reference" measures with savings normalized by the difference of the baseline and measure full-load efficiencies. This supports the development of interpolated savings values for any pairing of baseline and measure full-load efficiencies when the desired measure efficiency is less then simulated reference measure efficiency and the desired baseline efficiency is greater than the

[3] At this time, DEER does not include "Path B" performance maps for air cooled positive displacement chiller types.

[4] At this time, DEER does not include "Path B" performance maps for water cooled positive displacement chiller types.

simulated reference baseline efficiency. Table 5 lists the reference DEER measure definition for each chiller type available in DEER.

Compressor	Condenser	Efficiency Path	Measure Efficiency		Baseline Efficiency	
			Full-Load	Part-Load	Full-Load	Part-Load
Frictionless VSD Centrifugal 2 Compressor	Water	B	0.439 kW/ton	0.223 IPLV	0.695 kw/ton	0.353 IPLV
Frictionless VSD Centrifugal 1 Compressor	Water	B	0.439 kW/ton	0.213 IPLV	0.695 kW/ton	0.337 IPLV
Conventional VSD Centrifugal	Water	B	0.439 kW/ton	0.251 IPLV	0.695 kW/ton	0.397 IPLV
Conventional Constant Speed Centrifugal	Water	A	0.420 kW/ton	0.370 IPLV	0.750 kW/ton	0.661 IPLV
Constant Speed Screw	Water	A	0.439 kW/ton	0.308 IPLV	0.790 kW/ton	0.554 IPLV
Constant Speed Screw	Air	A	13.47 EER	18.29 IPLV	9.23 EER	12.54 IPLV
Constant Speed Reciprocating	Water	A	0.439 kW/ton	0.379 IPLV	0.837 kW/ton	0.592 IPLV
Constant Speed Reciprocating	Air	A	13.47 EER	21.92 IPLV	9.23 EER	15.03 IPLV

Table 4 - DEER Reference Chiller Measures

III. Development of DEER Measure Definitions

As described in Section I, savings estimates must be based on the full-load efficiency of the chiller. A strict application of the scale-able savings values developed for this DEER update would mean that a measure or baseline could only be defined by a specific pairing of full-load efficiency and IPLV. In order to provide flexibility in the measure definitions, the DEER team reviewed available manufacturers literature and examined the range of IPLV values for a given full-load efficiency.

As an example, **Error! Reference source not found.** is a plot of IPLV versus EER for all chillers with manufacturers' data that included both values in its published literature for air-cooled positive displacement chillers less than 150 tons. For any full-load efficiency value there is a wide range of available IPLV ratings. Even for very high full-load ratings there are a few chillers that barely meet the Title 24 minimum IPLV requirement of 13.7. Conversely, for chillers that meet or barely meet the Title 24 minimum full-load requirement of 10.1 EER, there are a range of IPLV ratings from minimally compliant to over 17 IPLV.

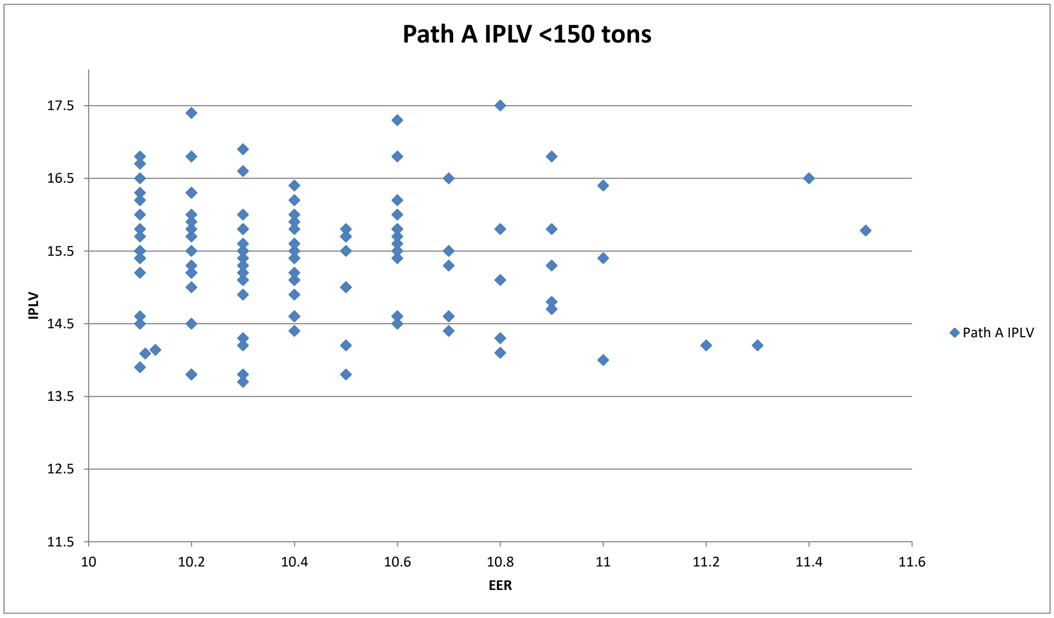

Figure 5. - IPLV vs. EER for Air Cooled, Positive Displacement Chillers (<150 tons)

In order to properly represent each of these efficiency levels, curve-fits as described in Section I would be required for all of the various combinations of full-load efficiency and IPLV. The data necessary to create these curve-fits is rarely if ever published for chillers and must be either obtained directly from the manufacturer or generated using specification software published by chiller manufacturers. The development of a larger set of curve-fits that represent various available full-load and IPLV pairings will likely be undertaken in future DEER updates. For this update, an alternative approach is needed that allows flexibility for varying IPLV ratings while still ensuring reasonable savings values.

This DEER update includes revised measure definitions for measures included in DEER along with minimum requirements for developing non-DEER measures. The most important of these requirements is that measures defined using only a single rating (either full-load efficiency or IPLV) will not be allowed. Moving forward, DEER and non-DEER chiller measures must have minimum full-load and IPLV requirements. Table 6 lists the revised measure definitions included in the DEER 2017 update.

Technology	Tech	Size Range	Path	Criteria	DEER EER	DEER IPLV	Max IPLV	Min IPLV	DEER Min IPLV
AirCldScrewChlr-2Cmp-lt150tons-10.5EER-14.26IPLV	Air Cooled Constant Speed Screw Chiller w/1 Compressor	<150 tons	A	10.5 EER	10.5	14.26	15.7	13.8	13.8
AirCldScrewChlr-2Cmp-lt150tons-11EER-14.94IPLV		<150 tons	A	11.0 EER	11.0	14.94	16.4	14.0	14.2
AirCldScrewChlr-2Cmp-lt150tons-11.5EER-15.62IPLV		<150 tons	A	11.5 EER	11.5	15.62	15.8	15.8	15.8

Technology	Tech	Size Range	Path	Criteria	DEER EER	DEER IPLV	Max IPLV	Min IPLV	DEER Min IPLV
AirCldScrewChlr-2Cmp-gte150tons-10.5EER-14.26IPLV		≥150 tons	A	10.5 EER	10.5	14.26	15.4	14.5	14.5
AirCldScrewChlr-2Cmp-gte150tons-11EER-14.94IPLV		≥150 tons	A	11.0 EER	11.0	14.94	15.3	14.0	14.5
AirCldScrewChlr-2Cmp-gte150tons-11.5EER-15.62IPLV		≥150 tons	A	11.5 EER	11.5	15.62	14.2	14.0	14.5
WtrCldScrewChlr-1Cmp-lt75tons-0.675kwpton-0.473IPLV	Water Cooled Constant Speed Screw Chiller w/1 Compressor	<75 tons	A	Code+ 10%	0.675	0.473			0.498
WtrCldScrewChlr-1Cmp-75to149tons-0.648kwpton-0.454IPLV		75-149 tons	A	Code+ 10%	0.648	0.454			0.478
WtrCldScrewChlr-1Cmp-150to299tons-0.594kwpton-0.417IPLV		150-299 tons	A	Code+ 10%	0.594	0.417			0.439
WtrCldScrewChlr-1Cmp-300to599tons-0.549kwpton-0.385IPLV		300-599 tons	A	Code+ 10%	0.549	0.385			0.405
WtrCldScrewChlr-1Cmp-gte600tons-0.504kwpton-0.353IPLV		≥600 tons	A	Code+ 10%	0.504	0.353			0.372
WtrCldCentChlr-Conv-1Cmp-lt150tons-0.519kwpton-0.457IPLV	Water Cooled Constant Speed Centrifugal Chiller w/1 conventional compressor	<150 tons	A	Code+ 15%	0.519	0.457			0.481
WtrCldCentChlr-Conv-1Cmp-150to299tons-0.519kwpton-0.457IPLV		150-299 tons	A	Code+ 15%	0.519	0.457			0.481
WtrCldCentChlr-Conv-1Cmp-300to399tons-0.476kwpton-0.42IPLV		300-399 tons	A	Code+ 15%	0.476	0.420			0.442
WtrCldCentChlr-Conv-1Cmp-400to599tons-0.476kwpton-0.42IPLV		400-599 tons	A	Code+ 15%	0.476	0.420			0.442
WtrCldCentChlr-Conv-1Cmp-gte600tons-0.476kwpton-0.42IPLV		≥600 tons	A	Code+ 15%	0.476	0.420			0.442
WtrCldCentChlr-NoFric-2Cmp-lt150tons-0.591kwpton-0.3IPLV-VarSpd-CndRlf	Water Cooled Centrifugal Chiller w/2 frictionless VSD compressors and condenser relief	<150 tons	B	Code+ 15%	0.591	0.300			0.316
WtrCldCentChlr-NoFric-2Cmp-150to299tons-0.54kwpton-0.274IPLV-VarSpd-CndRlf		150-299 tons	B	Code+ 15%	0.540	0.274			0.288
WtrCldCentChlr-NoFric-2Cmp-300to399tons-0.506kwpton-0.257IPLV-VarSpd-CndRlf		300-399 tons	B	Code+ 15%	0.506	0.257			0.270
WtrCldCentChlr-NoFric-2Cmp-400to599tons-0.497kwpton-0.252IPLV-VarSpd-CndRlf		400-599 tons	B	Code+ 15%	0.497	0.252			0.266
WtrCldCentChlr-NoFric-2Cmp-gte600tons-0.497kwpton-0.252IPLV-VarSpd-CndRlf		≥600 tons	B	Code+ 15%	0.497	0.252			0.266
WtrCldCentChlr-NoFric-1Cmp-lt150tons-0.532kwpton-0.258IPLV-VarSpd-CndRlf	Water Cooled Centrifugal Chiller w/1 frictionless VSD compressor and condenser relief	<150 tons	B	Code+ 15%	0.532	0.258			0.271
WtrCldCentChlr-NoFric-1Cmp-150to299tons-0.54kwpton-0.262IPLV-VarSpd-CndRlf		150-299 tons	B	Code+ 15%	0.540	0.262			0.275
WtrCldCentChlr-NoFric-1Cmp-300to399tons-0.506kwpton-0.245IPLV-VarSpd-CndRlf		300-399 tons	B	Code+ 15%	0.506	0.245			0.258
WtrCldCentChlr-NoFric-1Cmp-400to599tons-0.497kwpton-0.241IPLV-VarSpd-CndRlf		400-599 tons	B	Code+ 15%	0.497	0.241			0.254
WtrCldCentChlr-NoFric-1Cmp-gte600tons-0.497kwpton-0.241IPLV-		≥600 tons	B	Code+ 15%	0.497	0.241			0.254

Technology	Tech	Size Range	Path	Criteria	DEER EER	DEER IPLV	Max IPLV	Min IPLV	DEER Min IPLV
VarSpd-CndRlf									
WtrCldCentChlr-Conv-1Cmp-lt150tons-0.591kwpton-0.337IPLV-VarSpd-CndRlf	Water Cooled Centrifugal Chiller w/1 conventional VSD compressor and condenser relief	<150 tons	B	Code+ 15%	0.591	0.337			0.355
WtrCldCentChlr-Conv-1Cmp-150to299tons-0.54kwpton-0.308IPLV-VarSpd-CndRlf		150-299 tons	B	Code+ 15%	0.540	0.308			0.324
WtrCldCentChlr-Conv-1Cmp-300to399tons-0.506kwpton-0.289IPLV-VarSpd-CndRlf		300-399 tons	B	Code+ 15%	0.506	0.289			0.304
WtrCldCentChlr-Conv-1Cmp-400to599tons-0.497kwpton-0.284IPLV-VarSpd-CndRlf		400-599 tons	B	Code+ 15%	0.497	0.284			0.299
WtrCldCentChlr-Conv-1Cmp-gte600tons-0.497kwpton-0.284IPLV-VarSpd-CndRlf		≥600 tons	B	Code+ 15%	0.497	0.284			0.299

Table 5 - DEER 2017 Chiller Measures

3 Background: Residential Energy Code Changes Impacting DEER2017

There are a number of updates to the assumptions and methods based on adopted changes to the California Title 24 Building Standards which were adopted in 2015 and become effective 1 January 2017. Additionally, some previously effective code changes that were not correctly or appropriately considered in past DEER versions and are now updated. All of these changes impact the "code baseline" value results used in measure savings calculations. Some of these changes also impact the measure case value results (the model result for the building with the measure installed).

3.1 Attic Radiant Barrier Requirement

UPDATE NOTES: The radiant barrier update as described below and as included in the published draft DEER 2017 update was not applied to the multi-family building type. The error has a relatively small impact on measure energy savings. The energy impacts have been revised for the final version of the DEER 2017 update. The MASControl2 tool published with the draft DEER 2017 updates includes the correction.

Radiant barriers in attics of single-family and multi-family houses have been a Title-24 code requirement for most climate zones since 2003 as shown in **Error! Reference source not found.**. These requirements were not accurately included in previous DEER residential prototypes due to model limitations that did not allow separate specification of inside roof surface radiative and convective properties. Updates to the simulation program and DEER prototypes have been made to include the modeling of radiant barriers in all cases as required by code. The importance of this update was heightened and deemed necessary to the accuracy of the DEER values based on code changes related to roof insulation, duct insulation and whole house fans.

Vintage	CZ01	CZ02	CZ03	CZ04	CZ05-07	CZ08-15	CZ16
Pre-1978	NR	NR	NR	NR	NR	NR	NR
1978-1992	NR	NR	NR	NR	NR	NR	NR
1993-2001	NR	NR	NR	NR	NR	NR	NR
2002-2005	NR	REQ	NR	REQ	NR	REQ	NR
2006-2009	NR	REQ	NR	REQ	NR	REQ	NR
2010-2013	NR	REQ	NR	REQ	NR	REQ	NR
2014-2016	NR	REQ	REQ	REQ	REQ	REQ	NR
2017	NR	REQ	REQ	REQ	REQ	REQ	NR

Table 6. Radiant Barrier requirements by Vintage and Climate Zone

The properties assumed for the inside roof surfaces with and without radiant barriers are listed in Table 8. These were interpolated from values in the 1997 ASHRAE Fundamentals for a roof slope of 25 degrees with heat flowing down into the attic.

Inside Surface Condition	Convective Resistance	Emissivity	Total Film Resistance
No Radiant Barrier	4.0	0.9	0.86
With Radiant Barrier	4.0	0.05	3.35

Table 7. Radiant Barrier Properties for DEER2017 Simulations

3.2 Insulation Requirement for Ventilated Attics

UPDATE NOTES: The models used to develop the published draft DEER 2017 update energy values used a roof insulation R-value for single-family and multi-family models that was higher than required by the Title-24 update described below. The simulated insulation levels and resulting change in the energy impacts have been updated for the final version of the DEER 2017 update. This update has a very small impact on base case measure energy user values. The MASControl2 tool published with the draft DEER 2017 updates includes the correction.

A new section in the 2016 version of Title-24 requires roof insulation in ventilated residential attics that contain heating and cooling ductwork. Since the DEER single family and multifamily prototypes both have ducts in the attic, this requirement was applied to these building types for DEER 2017. The requirement is applicable to climate zones 4 and 8 through 16, and the path that applies continuous R-8 insulation above the roof rafter was implemented.

3.3 Framed Wall U-Value

The 2016 Title-24 increases the insulation level in exterior walls for all climate zones except CZ06 and CZ07. Previous versions of Title-24 described the framed wall insulation requirements in terms of the required R-value of fill insulation and continuous insulation. The new standard describes the requirement as an overall wall U-factor. Table 8 below lists the 2013 Title-24 requirements, the equivalent DEER prototype overall U-factor, and the 2017 required overall U-factor for each climate zone.

T-24	Parameter	CZ01-05	CZ06-07	CZ08-16
2013	Fill R-value	15	15	15
	Continuous R-value	4	4	4
	DEER $U_{overall}$	0.057	0.057	0.057
2017	$U_{overall}$	0.051	0.065	0.051

Table 8. Framed Wall U-value Requirements

3.4 Duct Insulation

The 2016 Title 24 increases the required level of duct insulation in most climate zones over the previous requirements as noted in Table 9 below.

	CZ01-02	CZ03	CZ04	CZ05	CZ06-07	CZ08	CZ09-13	CZ14-16
DEER2015	R-6.7	R-6.7	R-6.7	R-6.7	R-4.9	R-4.9	R-6.7	R-8.7
DEER2017	**R-8.7**	R-6.7	**R-8.7**	R-6.7	**R-6.7**	**R-8.7**	**R-8.7**	R-8.7

Table 8. Duct Insulation Requirements

3.5 Whole House Fan

UPDATE NOTES: The published draft DEER 2017 update for measures other than the whole house fan did not use the control strategy as described in the DEER2017 documentation and as implemented in the released MASControl2 simulation tool. This error mainly impacts lighting HVAC interactive effects; these values were updated on 7/20/2016 and documented on the PEAR change log. The error impacts all base case simulations to a small degree and the correction to this error has a small impact on all measure energy savings values. The control strategy has been updated and the energy impacts have been revised for the final version of the DEER 2017 update. The MASControl2 tool published with the draft DEER 2017 updates includes the correction.

Whole house fans became a Title-24 code requirement in 2015 for single-family homes in climate zones CZ08 through CZ14. Whole house fans were modeled as a measure in DEER2005, but had not been added to the pre-existing or code case prototype DEER models. The investigation of whole house fan modeling necessary to meet the Title-24 requirement in the DEER single-family prototypes has led to the identification of a number of changes needed for the specification of whole house fan parameters including:

- revised flow rate to align with Title-24 requirements;
- revised fan power based on current standard practice;
- updated control sequence based on current standard practice;
- Increase in the amount of thermal mass in the residential models to better account for the transient effects of lower nighttime space temperatures possible with whole house fan controls.

To ensure accurate whole house fan results based upon the above considerations, the simulation tool was updated to improve modeling capabilities for whole house fan controls.

3.6 Window Model

All previous DEER modeling methods have incorporated simplified overall heat loss and solar gain models for glazing (the use of shading coefficients and center-of-glass u-values). This method was in agreement with the method used by the CEC in their development of Title 24 standards as well as CEC approved methods for calculating window impacts when using the performance method for showing compliance with Title 24. The DEER team demonstrated in previous work that the simplified glazing calculation method, for multi-pane and coated window glazing's, will overestimate solar gains at non-normal (90 degree) angles of incidence, which, in turn, may overestimate savings for measures that reduce cooling energy usage (such as high efficiency air conditioners) and underestimate savings from measures that reduce heating energy (such as high efficiency furnaces).

DEER2017 replaces the simplified heat loss and gain methods for windows with a more accurate layer-by-layer method that considers specific fenestration performance characteristics such as opaque frame thermal performance, impacts of different coatings and tints and solar gain with respect to angle of incidence. This method is consistent with the NFRC window rating method upon which code requirements are based. This update is also consistent with trends throughout the energy modeling industry to adopt more robust fenestration calculation methods. For example, the CEC recently adopted a simulation tool for residential compliance (CBECC-Res) that also uses a layer-by-layer approach to window modeling.

Code Maximum		DOE-2 model				Window parameters					
				Overall				Gap		Frame	
U-Factor	SHGC	Frame Type	Glass Code	U-Factor	SHGC	Category	Description	inches	Gas	fraction	U-value
1.09	0.8	Alum	1000	1.09	0.71	Single Pane	Single Clear	n/a	n/a	0.17	1
0.95	0.87	Vinyl	1001	0.96	0.67	Single Pane	Single Clear	n/a	n/a	0.17	0.3
0.9	0.87	Alum	1600	0.90	0.65	Single Low-e	Single Low-E Clear (e2=.4)	n/a	n/a	0.17	1
0.79	0.79	Vinyl	1600	0.78	0.65	Single Low-e	Single Low-E Clear (e2=.4)	n/a	n/a	0.17	0.3
0.77	0.79	Vinyl	1601	0.68	0.64	Single Low-e	Single Low-E Clear (e2=.2)	n/a	n/a	0.17	0.3
0.77	0.61	Vinyl	1601	0.68	0.64	Single Low-e	Single Low-E Clear (e2=.2)	n/a	n/a	0.17	0.3
0.77	0.4	Alum	2215	0.63	0.39	Double Pane	Double Tint Grey	0.25	Air	0.17	1
0.67	0.79	Alum	2000	0.64	0.63	Double Pane	Double Clear	0.25	Air	0.17	1
0.67	0.61	Alum	2004	0.57	0.58	Double Pane	Double Clear	0.50	Air	0.17	1
0.67	0.47	Alum	2203	0.63	0.41	Double Pane	Double Tint Bronze	0.25	Air	0.17	1
0.67	0.4	Vinyl	2636	0.41	0.32	Double Low-e	Double Low-E (e2=.1) Tint	0.25	Air	0.17	0.3
0.62	0.79	Vinyl	2000	0.52	0.63	Double Pane	Double Clear	0.25	Air	0.17	0.3
0.57	0.79	Vinyl	2000	0.52	0.63	Double Pane	Double Clear	0.25	Air	0.17	0.3
0.57	0.4	Alum	2660	0.52	0.37	Double Low-e	Double Low-E (e2=.04) Clear	0.25	Air	0.17	1
0.55	0.79	Alum	2610	0.55	0.60	Double Low-e	Double Low-E (e3=.2) Clear	0.25	Air	0.17	1
0.55	0.65	Alum	2610	0.55	0.60	Double Low-e	Double Low-E (e3=.2) Clear	0.25	Air	0.17	1
0.4	0.79	Vinyl	2601	0.39	0.61	Double Low-e	Double Low-E (e3=.4) Clear	0.50	Air	0.17	0.3
0.4	0.4	Alum	2665	0.36	0.35	Double Low-e	Double Low-E (e3=.04) Clear	0.50	Argon	0.17	1
0.4	0.35	Alum	2665	0.36	0.35	Double Low-e	Double Low-E (e3=.04) Clear	0.50	Argon	0.17	1
0.32	0.79	Vinyl	2612	0.30	0.61	Double Low-e	Double Low-E (e3=.2) Clear	0.50	Argon	0.17	0.3
0.32	0.25	Vinyl	2667	0.29	0.24	Double Low-e	Double Low-E (e2=.04) Tint	0.50	Air	0.17	0.3

Table 9. Window properties used for residential models

4 Residential Measure Updates Based on Energy Code

This section describes updates to DEER measures required by the energy code changes described above.

4.1 2017 residential vintage addition

A residential building vintage for 2017 is added as defined by the updated energy code requirements described in Section 3. The recent building vintage names and definitions have been updated to reflect the new vintage applications.

DEER2016 Vintages		DEER2017 Vintages	
Code	Description	Code	Description
1975	pre-1978	1975	pre-1978
1985	1978 - 1992	1985	1978 - 1992
1996	1993 - 2001	1996	1993 - 2001
2003	2002 - 2005	2003	2002 - 2005
2007	2006 - 2009	2007	2006 - 2009
2011	2010 - 2013	2011	2010 – 2013
2014	after 2013	**2015**	**2014 - 2016**
		2017	**2017**

Table 10. Vintages used in DEER2017

The addition of a new building vintage requires that all measures impacted by the building codes (i.e. all measures except exterior lighting measures) be updated for the new building vintage. In addition, the rolled-up Existing vintage, which is created by weighting all of the defined vintages together, is updated using residential building weights that encompass all eight DEER2017 residential vintages.

An assessment of the magnitude of both the new and the existing vintage values will be made on a measure-by-measure basis and the DEER team will make a recommendation as to whether the updated existing vintage results should be included in the final DEER2017 results or the older results should be retained.

The following chart compares the energy impacts for a residential furnace measure across the various building vintages. The DEER2017 version has results for vintages through 2017 whereas the residential furnace measure impacts prior to DEER2017 are from DEER2014 and only include vintages through 2014.

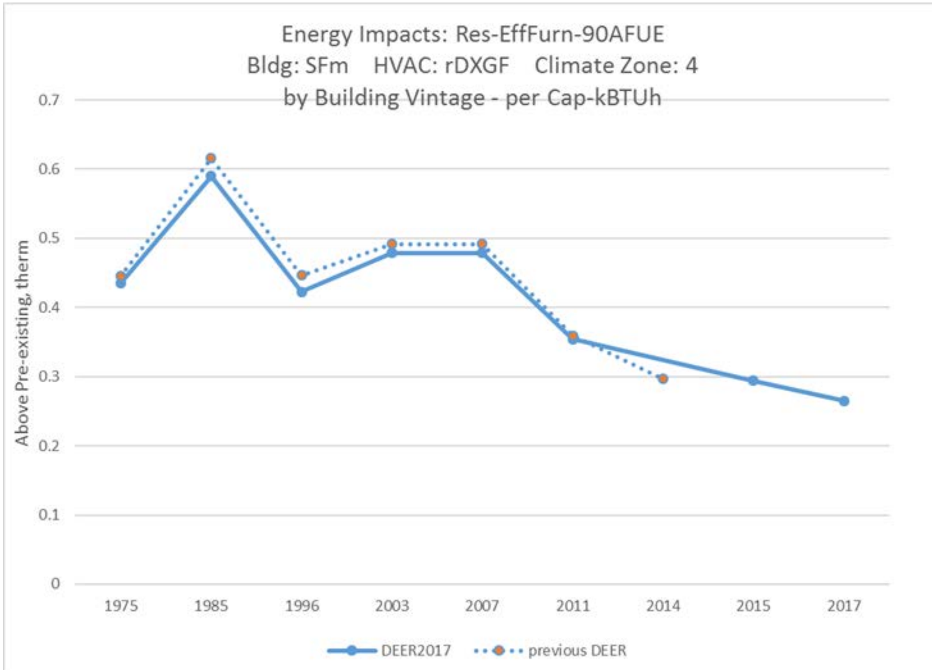

Figure 6. Example of the Vintage update for residential measures

4.2 Whole House Fan

As described above, the whole house fan measure has been redefined to comply with the current Title-24 codes. The whole house fan measure in DEER prior to DEER2017 was developed for DEER2005 (MeasureID = D03-441). This measure has been updated using new measure parameters and the latest building prototypes. The new whole house fan measures consider a range of capacities and fan efficiencies as summarized in Table 12 below. The basis for the fan power values is described in the file WholeHouseFanData_2016_05_31.xlsx.

DEER2017 Measure ID	Air Flow CFM/sq ft	Fan Power W/CFM	Fan Type
WHFan-0.7-PSC	0.7	0.15	PSC
WHFan-1.5-PSC	1.5	0.15	PSC
WHFan-2.0-PSC	2.0	0.15	PSC
WHFan-3.0-PSC	3.0	0.15	PSC
WHFan-0.7-ECM	0.7	0.124	ECM
WHFan-1.5-ECM	1.5	0.124	ECM
WHFan-2.0-ECM	2.0	0.124	ECM
WHFan-3.0-ECM	3.0	0.124	ECM

Table 11. Whole house fan measure parameters

The whole house fan is utilized in single-family homes and assumes that the fan is on when cooling is available, the cooling load can be met by the whole house fan, and the outdoor temperature is at least three degrees below the cooling thermostat setpoint. The whole house fan will cool the space down to 70 F if possible regardless of the actual cooling thermostat setpoint.

4.3 Lighting HVAC Interactive Effects

UPDATE NOTES: The HVAC interactive effects table published in the draft DEER 2017 update ("2017-Res-InLtg-CFL") incorrectly changed the coincident demand factor (CDF) values. Since the CDF values published in the previous DEER version already include the impact of the updated lighting profile, the coincident demand factors were not intended to change from the previous version of DEER; only the lighting profiles were intended to change. The support table and the energy impacts for residential indoor lighting measures have been revised for the final version of the DEER 2017 update. The correction to this error results in increased demand savings for residential indoor lighting measures over the published draft values.

The cumulative effects on the calculated residential lighting HVAC interactive effects of the above listed modeling updates due to code requirements as well as corrections to errors are documented in the DEER2017 Lighting IE workbook. The summary graphics below compare the IOU-territory weighted IE factors by PA and building type for the existing and new vintages.

Figure 7. Summary of changes in residential HVAC IE factors

4.4 Residential Dishwasher Measures

Measure updates were developed for the new Energy-Star criteria for dishwashers that became effective in early 2016. However, these updated values were found to not differ significantly from previous tier values and as such are not proposed to be included in the DEER2017 update. Similarly, updates for the clothes washer tier impacts were not incorporated due to their similarity to existing values.

5 Residential Measure Updates Based on Corrections to Errors

5.1 Lighting Use Profile

Analysis supporting DEER2011 resulted in revised lighting usage profiles, annual hours of use (HOU) and coincident demand factors (CDF). DEER2011 included updates to HOU and CDF values, which changed the overall savings values. However, the DEER2011 and subsequent updates neglected to include the lighting profiles advertised in the DEER2011 update documentation into the DEER prototypes. DEER2017 includes revisions to the interior lighting use profiles based on data used to update the lighting HOU and CDF values in DEER2011. Additional capabilities allow the specification of monthly profiles in DEER2017 as opposed to seasonal profiles used in earlier DEER versions. Figure 8. Comparison of Residential Lighting Profiles for DEER2017 Versus Previous DEER Versions below shows an example comparison between the previous profile and the updated profile. More complete data can be found in the "KEMA CFL load shape data.xls" workbook.

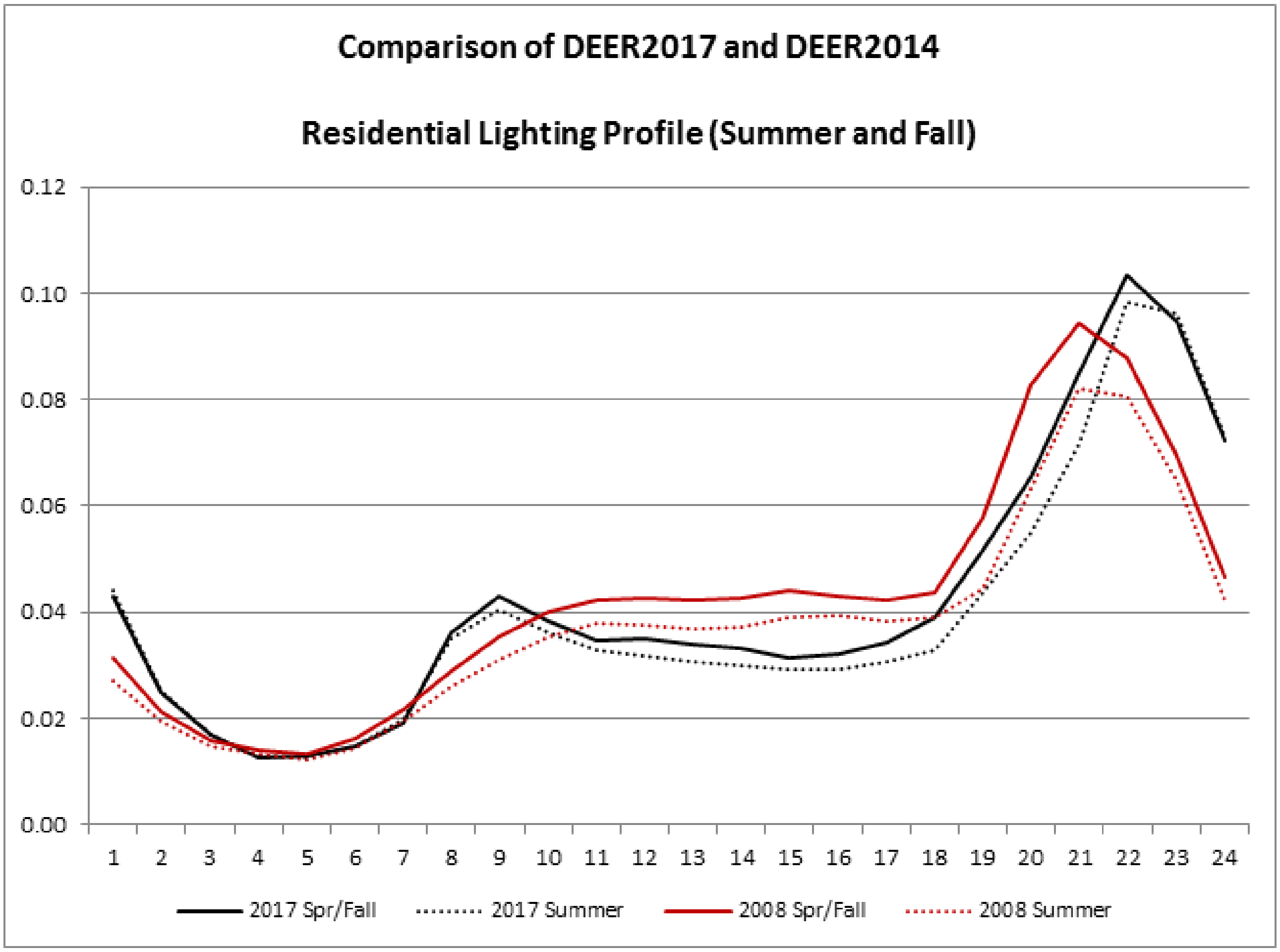

Figure 8. Comparison of Residential Lighting Profiles for DEER2017 Versus Previous DEER Versions

This correction contributes to the updated values for residential HVAC interactive effects factors described in the previous section. All residential indoor lighting measures are therefore impacted by this correction. No lighting direct impacts (lighting measure delta watts and hours of use) are impacted by this change, only the HVAC interactive effects are changed.

5.2 Building shell insulation measures

During the investigation of the above listed Title 24 standards changes related to insulation levels, errors were discovered in the specification of some existing ceiling and wall insulation measures. The error associated with measures that add insulation to existing ceiling insulation levels caused energy savings values to be underestimated in most vintages and climate zones. Savings for the wall insulation measure were underestimated in all cases. A total of four measures were updated to correct the specification errors. The updated methodology was also used to add higher level ceiling insulation measures as requested by program administrators.

MeasureID	Description
RB-BS-BlowInIns-R0-R13	Wall Blow-In R-0 to R-13 Insulation
RB-BS-CeilIns-VintR-AddR11	Ceiling - Add R-11 batts on top of vintage-specific existing insulation
RB-BS-CeilIns-VintR-AddR19	Ceiling - Add R-19 batts on top of vintage-specific existing insulation
RB-BS-CeilIns-VintR-AddR30	Ceiling - Add R-30 batts on top of vintage-specific existing insulation

Table 12. Residential Insulation Measures updated in DEER2017

Additional Measures:

MeasureID	Description
RB-BS-CeilIns-VintR-AddR38	Ceiling - Add R-38 batts on top of vintage-specific existing insulation
RB-BS-CeilIns-VintR-AddR44	Ceiling - Add R-44 batts on top of vintage-specific existing insulation
RB-BS-CeilIns-VintR-AddR50	Ceiling - Add R-50 batts on top of vintage-specific existing insulation

Table 13. Additional residential Insulation Measures

The following two charts show example comparisons for the "add R-19" ceiling insulation measure and the wall blow-in insulation measures. The increase in energy savings in DEER2017 over DEER2014 is largely due to a fix in the measure R-value specification.

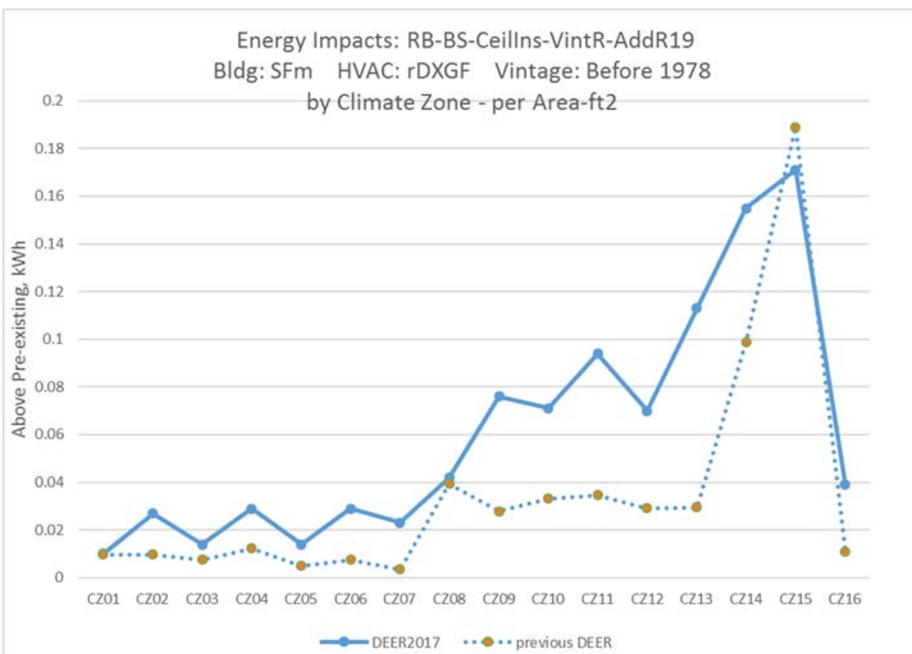

Figure 9. Example of energy impact changes in a residential ceiling insulation measure

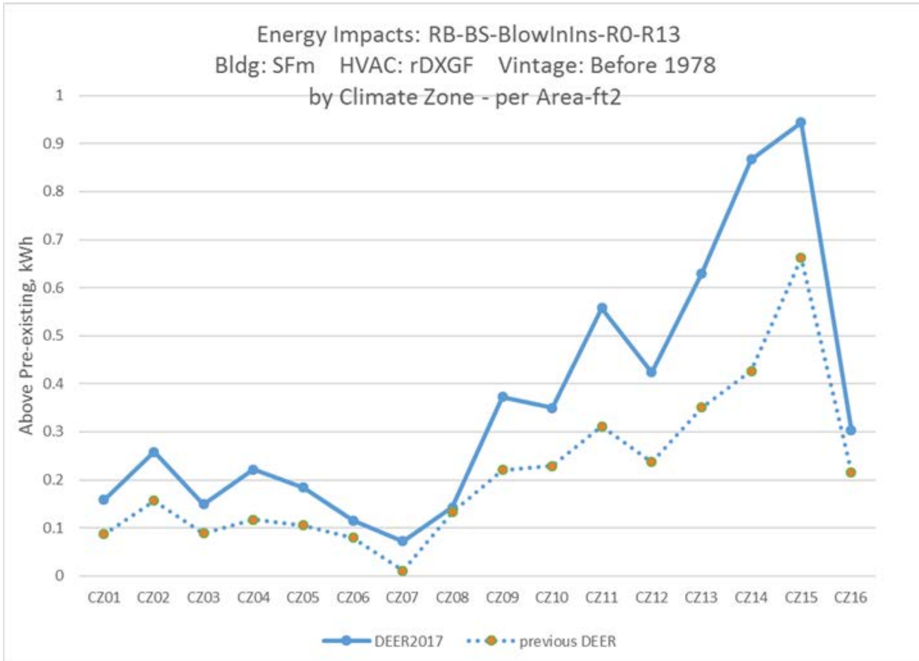

Figure 10. Example of energy impact changes in a residential wall insulation measure

5.3 HVAC sizing Correction

The residential HVAC systems use pre-determined sizes based on building size, location and vintage. DEER2015 incorrectly applied commercial sizing factors to these values, resulting in system fans that were 30% larger than intended and cooling capacities that were 7% below the intended sizes. Savings for HVAC measures that are normalized by capacity used the intended capacity when calculating the unit energy savings. As a result of these two issues, the savings per ton of the HVAC cooling measures are overstated in DEER2015. The following two charts show example comparisons for a SEER 16 air conditioner measure and a SEER 18 heat pump measure. The savings decreases in DEER2017 largely due to the correction of the HVAC sizing factors.

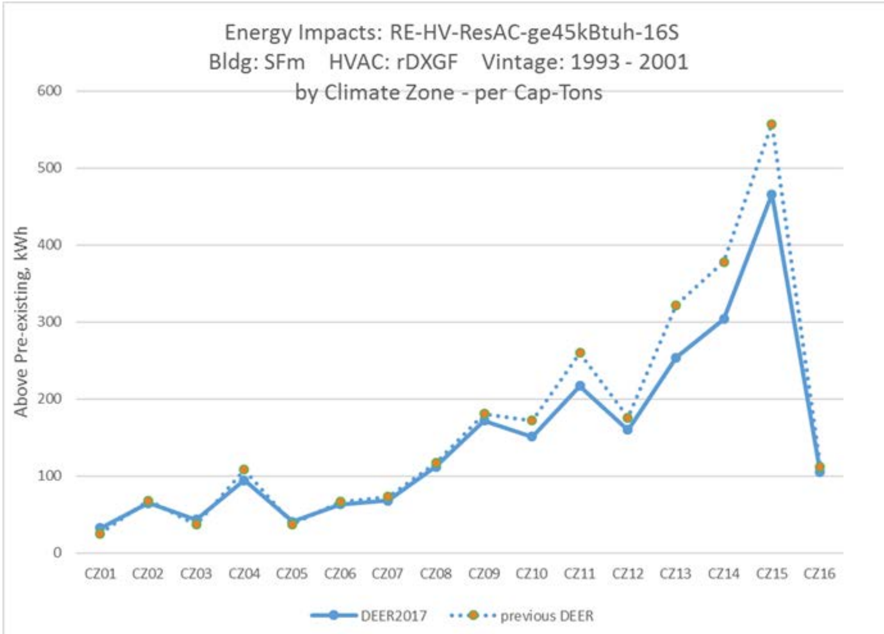

Figure 11. Example of energy impact changes in a residential air-conditioner measure

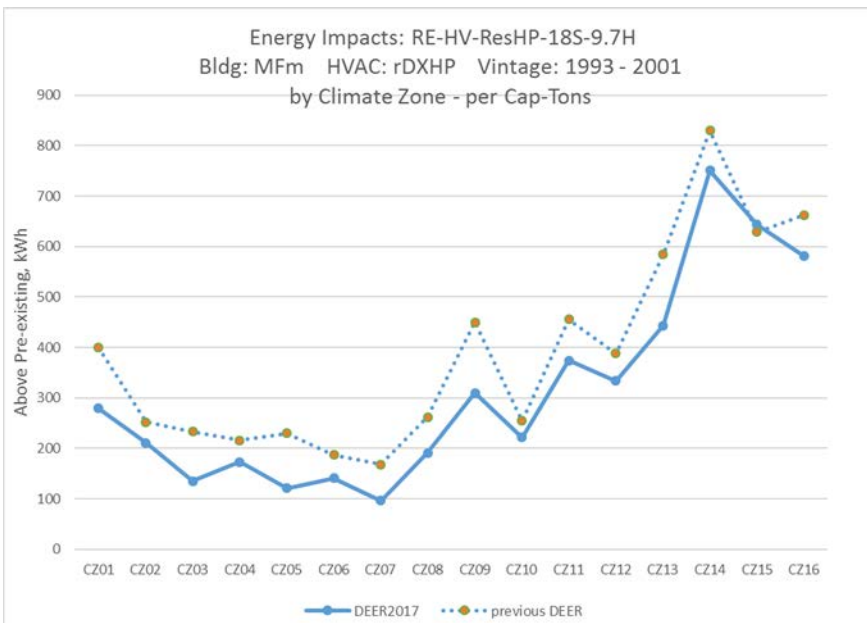

Figure 12. Example of energy impact changes in a residential heat pump measure

6 DEER2018 Updates Based on Newly Available Evaluation Results and Related Market and Technology Research

These DEER2018 updates have a start date of 1/1/2018. There is some expectation, based on Decision language and 10-12 workpaper dispositions, that measures will be updated as evaluation results become available, however, these changes are proposed to be effective in 2018.

6.1 Refrigerant Charge Adjustment

UPDATE NOTES: Based upon comments on the Draft Resolution filed by Robert Mowris & Associates (RMA) on the refrigerant charge measure update the measure assumptions were reviewed and modified. Some assumptions as described in the draft documentation were not implemented correctly which resulted in savings being under-estimated. Additional information from RMA also allowed updating of the measure assumptions to be more typical of expected field conditions based on historical data on refrigerant charge adjustments. RMA also pointed out that for a refrigerant charge adjustment to be performed correctly so as to result in the expected energy savings the service must be performed using appropriate methods and tools that allow the identification and correction of all system "fault" conditions that affect the refrigerant system measurements prior to proceeding with a charge state measurement and then any indicated appropriate charge adjustment. RMA points out that technicians performing HVAC system fault diagnosis and correction must have all the proper tools, must follow the appropriate procedures, and have been trained by and experienced an qualified professional on the procedures and use of the tools. Commission staff agrees with these comments and has previously indicated to the Program Administrators the importance of proper technician training, use of a "fault" diagnosis and correction sequence and procedure as well as a continuous verification activity to assure the work is being performed properly.

The DEER2018 refrigerant charge measure parameters were updated based on recent EM&V data[5, 6] and new refrigerant charge measures were created from these updated measure results. The recent data included both laboratory and field data. The laboratory data was used to update the HVAC equipment performance changes expected due to a change in the charge state from either an under or over charge condition to the recommended refrigerant charge for units with either TXV or non-TXV expansion devices. The field data was used to determine the typical under- or

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[5] Draft Evaluation Report: Lab Tests of a Residential 3-Ton Split System Air Conditioner under Typical Installed Conditions, CPUC, 2012.

[6] Revised Comments of Robert Mowris & Associates, Inc, Regarding Resolution E-4795 for Approval of the Database for Energy-Efficient Resources (DEER) Updates for 2017 and 2018 in compliance with D.15-10-028.

over-charged condition as well as the expected fraction of units with the two general classes of expansion devices.

Field data[7] indicates that typically systems diagnosed as requiring a charge adjustment result in the addition or removal of an amount of refrigerant that represents approximately eight percent of the total recommended charge amount. This information was used to inform the change in the typical refrigerant charge adjustment measure listed below. The distribution of refrigerant charge adjustments observed in the field data is presented in ten percent bins in Figure 13. Over eighty percent of charge adjustments were to add refrigerant to a system having been diagnosed as being in an undercharged state and seventy-five percent of charge additions were noted to be ten percent or less of the recommended total charge. For undercharged units 88.7% were observed to have non-TXV expansion devices while for the overcharged units the non-TXV devices were observed in 84.3% of the cases. This information was used to weight the laboratory performance data for TXV and non-TXV tests into expected typical measure parameters.

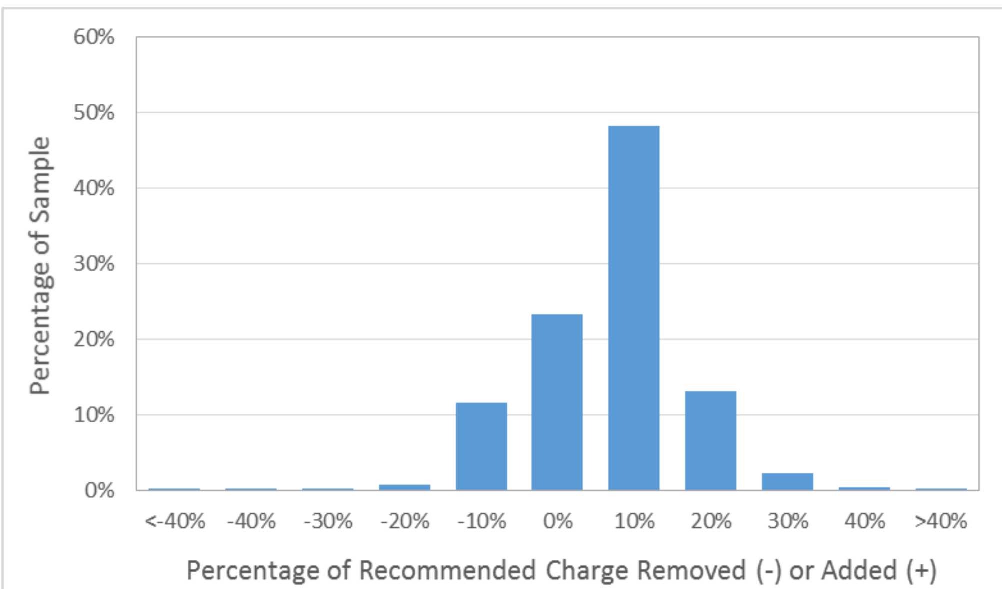

Figure 13. Observed Frequency of Refrigerant Additions, Removals, and No Change Cases

Of the charge additions and removals observed in the field data, 30% are four percent or less with the refrigerant additions being less than three and one half ounces. The difficulty in precise measurements and diagnosis in the field for these small off-charge states makes it difficult to establish that small charge adjustments will result in any improved system state or performance. Additionally, as can be seen in Figure 14, the largest number of charge adjustments overall is in the

[7] Ibid.

above three up to four percent charge addition range. This is troublesome and possibly indicates a problem in the implementation activity. For these reasons the DEER savings values are only to be utilized for charge adjustments of four percent or greater and shall only be allowed if the technicians are utilizing approved methods and tools and have undergone approved training by a qualified professional. Additionally, the implementation activities, in order to utilize the DEER savings values, must include a continuous verification element that ensures that the approved system fault diagnosis and correction protocols are being followed and that any charge adjustments are necessary and correct.

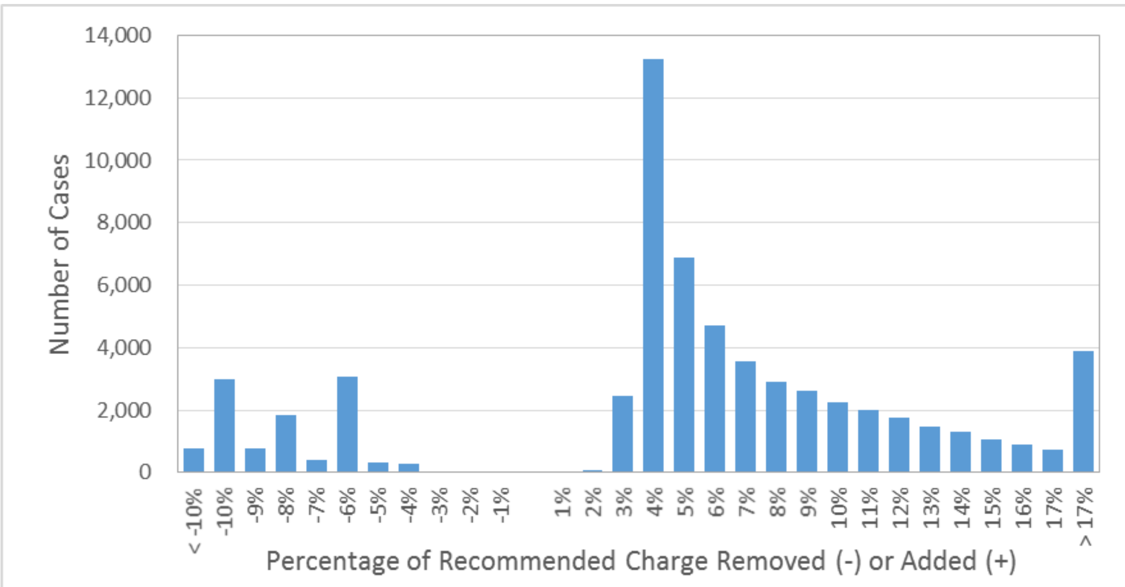

Figure 14. Counts of Observed of Refrigerant Additions and Removals

DEER2018 includes four refrigerant charge measures based on scenarios derived from monitored data discussed above along with a weighted measure that combines the results of the two typical scenarios into a single measure. Supporting calculations are provided in a workbook posted on the DEEResources.com website on the DEER2018 page. The technology specifications based on the state of charge are summarized in Table 15 and the measure descriptions are provided in **Table 16**.

Technology Criteria	% Charge Adjustment		Capacity Multiplier		EIR Multiplier		Sens Cap Multiplier	
	prev	2018	prev	2018	prev	2018	prev	2018
High Over-Charge	>20	n/a	0.83	n/a	1.35	n/a	0.89	n/a
Typical Over-Charge	5-20	8	0.894	1.003	1.16	1.031	0.947	1.025
Standard	0	0	1.00	1.00	1	1.00	1.00	1.00
Typical Under-Charge	<5-20	8	0.887	0.874	1.11	1.087	0.91	0.816
Low Under-Charge	n/a	4	n/a	0.994	n/a	1.031	n/a	0.917
High Under-Charge	>20	16	0.84	0.748	1.16	1.246	0.91	0.663

Table 14. Residential refrigerant charge specifications

MeasureID	Description
RE-HV-RefChrg-Dec-typ	Decrease Refrigerant Charge - Typical (any adjustment >= 4%, typical value of 8%)
RE-HV-RefChrg-Inc-high	Increase Refrigerant Charge - High (> 10% rated charge, typical value of 16%)
RE-HV-RefChrg-Inc-typ	Increase Refrigerant Charge - Typical (any adjustment>= 4%, typical value of 8%)
RE-HV-RefChrg-Inc-low	Increase Refrigerant Charge - Typical (>=4% and <5% rated charge)
Res-RefrigCharge-wtd	Adjusted Refrigerant charge – Any charge adjustment >= 4%

Table 15. Updated residential refrigerant charge measures

The energy impacts for the typical and high increase in refrigerant charge measure go up with this update, whereas the energy impacts for the decrease in charge measure decreases significantly.

The update to the refrigerant charge adjustment measures are also incorporated into the combined duct sealing plus refrigerant charge adjustment measures that were part of the previous DEER version.

MeasureID	Description
RB-HV-RefChrg-DecTyp-DuctLoss-24To12pct	Single and Multi-Family: Typical decrease in refrigerant charge and duct sealing (Total Leakage Reduced from 24% of AHU flow to 12%)
RB-HV-RefChrg-DecTyp-DuctLoss-25To15pct	Mobile Home: Typical decrease in refrigerant charge and duct sealing (Total Leakage Reduced from 25% of AHU flow to 15%)
RB-HV-RefChrg-IncTyp-DuctLoss-24To12pct	Single and Multi-Family: Typical increase in refrigerant charge and duct sealing (Total Leakage Reduced from 24% of AHU flow to 12%)
RB-HV-RefChrg-IncTyp-DuctLoss-25To15pct	Mobile Home: Typical increase in refrigerant charge and duct sealing (Total Leakage Reduced from 25% of AHU flow to 15%)

Table 16. Updated residential refrigerant charge + duct sealing measures

The charts below show example energy impact results to two of the refrigerant charge cases. As noted above, relative to the previous DEER values, savings increase for the typical increase in refrigerant charge measure.

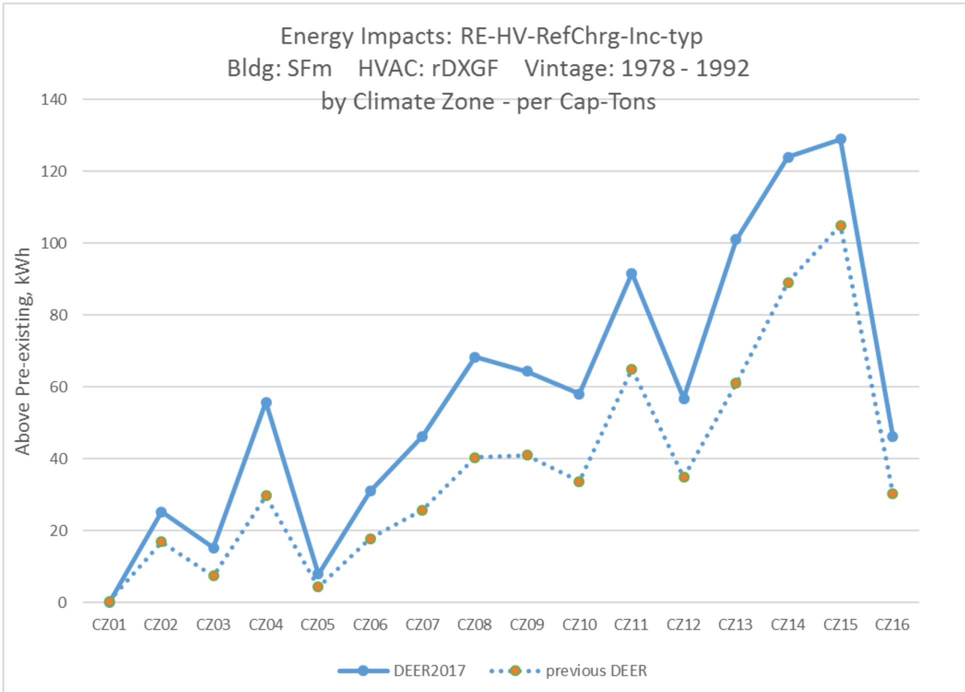

Figure 15. Example energy impacts for a typical increase in refrigerant charge – Single Family, 1978 – 1992 Vintage

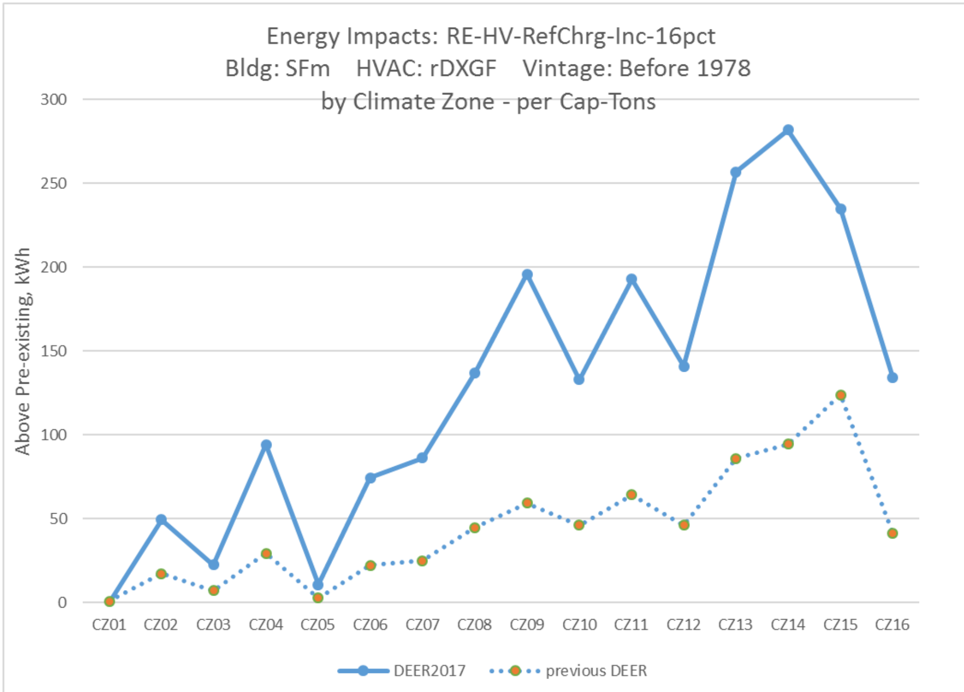

Figure 16. Example energy impacts for a high increase in refrigerant charge – Single Family, pre-1978 Vintage

6.2 Standard Practice for Early Retirement Lighting Measures

6.2.1 Summary of DEER Revisions to Standard Practice Baseline for Outdoor Lighting Measures

UPDATE NOTES: SCE recommends that the CPUC not adopt the proposed change to LED technologies as the standard practice baseline for exterior lighting[8] on the basis that California Energy Commission and CPUC use different methods for evaluating cost-effectiveness. In response to this comment, CPUC staff has updated this section to include more background on CPUC policies covering standard practice. CPUC staff has also added clarification to how this DEER update will cause revisions to currently approved exterior lighting measures. Furthermore, CPUC clarifies that these revisions apply to all exterior lighting use categories, including nonresidential applications of the DEER use sub-category covering Outdoor General Lighting ("OutGen"), and non-DEER use sub-categories for Outdoor Common Areas ("OutCommon") and

[8] See Comments of Southern California Edison Company on Draft Resolution E-4795 Approval of the Database for Energy-Efficient Resources updates for 2017 and 2018, in Compliance with Decision15-10-028 @ 2

Outdoor Dusk-to-Dawn ("OutDuskDawn"). The proposed DEER revisions do not apply to residential applications of the DEER use sub-category OutGen.

During the development of 2016 Title 24, the CEC concluded that it was cost-effective to update lighting power allowances (LPAs) for general hardscape[9] exterior lighting applications assuming LED technologies. As discussed in the 2016 CASE Outdoor Study[10], costs of exterior LED technologies are decreasing while performance is increasing. Due to the long EUL of most exterior lighting technologies, RUL for most exterior lighting measures will be five years, at which time price and performance will have continued to improve. Therefore, the DEER standard practice baseline for outdoor lighting early retirement measures has been revised to be LED technologies. The specific baseline technologies need to be developed through workpapers or custom project supporting documentation as new exterior lighting measures are introduced into programs. This second baseline will be applicable to all non-residential measures covering outdoor general ("OutGen" use subcategory) lighting measures. As a result of the change in standard practice baseline to LED technologies, all currently approved outdoor lighting measures (except screw-in CFLs) will no longer be approved for early retirement measures after December 31, 2017. These measures have been updated in the ex ante database to have an expiration date of December 31, 2017. At this time DEER only includes exterior lighting measures for CFL fixtures. There are no DEER measures for HID technologies such as Pulse Start Metal Halide. In consideration of the revised DEER baseline, PAs may submit workpapers where the measure technology meets or exceeds the current DEER code baseline (Pulse Start Metal Halide). For these measure and code baseline technologies shall be identical, resulting savings for RUL period only.

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[9] See 2016 Title 24 Section 140.7(d)1.A for the definition of outdoor general hardscape: *"The general hardscape area of a site shall include parking lot(s), roadway(s), driveway(s), sidewalk(s), walkway(s), bikeway(s), plaza(s), bridge(s), tunnel(s), and other improved area(s) that are illuminated. In plan view of the site, determine the illuminated hardscape area, which is defined as any hardscape area that is within a square pattern around each luminaire or pole that is ten times the luminaire mounting height with the luminaire in the middle of the pattern, less any areas that are within a building, beyond the hardscape area, beyond property lines, or obstructed by a structure. The illuminated hardscape area shall include portions of planters and landscaped areas that are within the lighting application and are less than or equal to 10 feet wide in the short dimensions and are enclosed by hardscape or other improvement on at least three sides."*

[10] "Codes and Standards Enhancement Initiative (CASE) Non-residential Outdoor Lighting Power Allowance" Measure Number: 2016-NR-LTG3-F, prepared by TRC Energy Services for California Utilities Statewide Codes and Standards Team, December 2014

6.2.2 Summary of DEER Revisions to Standard Practice Baseline for Interior Linear Fluorescent Lighting Measures

UPDATE NOTES: In consideration of SCE's comments noted in Section 6.2.1 CPUC staff recognized that the proposed measure updates did not address the early retirement cases where the measure case was identical to either the current DEER code baseline or the proposed DEER standard practice baseline. These early retirement measures will have savings for the RUL period only.

The current DEER code baseline for linear fluorescent measures assumes 2nd generation T8 lamps with normal light output ballasts. However, recent market, technical and codes and standards research, along with 2013 and 2016 Title 24 updates (all described in Section 6.2.3) provide substantial support for a shift in this baseline to more efficient technologies, especially for standard practice (second) baseline in early retirement applications. The DEER standard practice baseline for 4-foot linear fluorescent early retirement measures has been revised to assume 3rd generation T8 lamps (3,100 initial lumens) and reduced light output ballasts. For a conventional, two-lamp fixture with a single ballast, this reduces the standard practice fixture power from 59 to 48 watts.
As a result of the change in standard practice baseline for early retirement to more efficient technologies, all current indoor lighting measures using four-foot linear T8 lamps will no longer be approved for early retirement measures after December 31, 2017. These measures have been updated in the ex ante database to have an expiration date of December 31, 2017. A limited number of new measures have been added in the following categories:

1. Replace-on-burnout, normal replacement and new construction: Any current DEER measures using technologies that exceed the DEER code baseline (2nd generation T8 lamps with normal light output ballasts) have been revised to have no pre-existing technology and DEER code baseline technologies. With these revisions, these measures will have no above customer average savings and therefore can only be used in ROB/NR/NC measure applications.
2. Early retirement: Any current DEER measures using technologies that exceed the DEER 2018 standard practice baseline (3rd generation T8 lamps with reduced light output ballasts) have been revised to have 2nd baseline technologies that meet the DEER 2018 standard practice baseline requirements.
3. Early retirement (RUL savings only): Any current DEER measures using technologies that match the proposed DEER 2018 standard practice baseline (3rd generation T8 lamps with reduced light output ballasts) or the current DEER code baseline (2nd generation T8 lamps with normal light output ballasts) have been revised to have identical measure and code baseline technologies. This results in measures that can be claimed as early retirement but will have savings for the RUL period only.

6.2.3 Background and Applicable Research for Standard Practice Baselines for Lighting Measures

At this time, DEER baselines for normal replacement ("NR", also called Replace-on-Burnout or "ROB") are the same as second baselines for early retirement ("ER") measures. For NR projects, the baseline is the standard practice or code baseline in place at the time the project is commenced. For ER projects, the second baseline is the likely standard practice or code baseline that will be in place at the end of the remaining useful life (RUL) of the pre-existing lighting equipment. For early retirement lighting projects the RUL is approximately five years, except for projects replacing T12 linear fluorescent lamps where the EUL is rarely greater than two years.

D.12-05-015 Ordering Paragraph 151 directed that typical installation baselines be investigated as an alternative to code and/or standards baselines when appropriate. There are several recent evaluation and code development efforts that indicate increasing efficiency of standard practice baselines that are being influenced by many factors including improvements in technology, changes in design practice and the gradually increasing stringency of energy codes.

Commercial Market Share Tracking Study: The Commercial Market Share Tracking[11] study (CMST) indicated that by 2012, showed that selection and installation of "high efficiency" linear fluorescent lamps[12] was nearly a standard practice. Figure 17[13] is from the CMST study showing that "non-participants" (survey respondents who did not receive IOU incentives or participate in IOU programs as a means of financial support for projects) installed "high efficiency" linear fluorescent lamps in 67% of their projects. CMST does not include any information on ballasts. Since the light output rating of the ballast is necessary to estimate fixture power, the CMST findings provide qualitative evidence of change in standard practice to lower power lighting sources. However, Figure 17 also shows that reduced wattage lamps make up 52% of non-participant installations. The most common available wattages for these lamps are 25 and 28 watts.

[11] Commercial Market Share Tracking Study (CMST), prepared for California Public Utilities Commission, Energy Division, Itron, Inc., July 18, 2014

[12] CMST classifies high performance (or 3rd generation) T8, reduced wattage T8 (typically 25 or 28 watt) and T5 linear fluorescent lamps as "high efficiency."

[13] See page 4-30 of CMST

Table 4-16: CMST-Linear Fluorescent Efficiency Distribution by Participation in the LF HIM, Fixture Count Shares*

	2009				2010				2011				2012			
	Participants		Non-Participants		Participants		Non-Participants		Participants		Non-Participants		Participants		Non-Participants	
Efficiency Level	Per-cent	Relative Precision	Per-cent	Relative Precision	Per-cent	Relative Precision	Per-cent	Relative Precision	Per-cent	Relative Precision	Per-cent	Relative Precision	Per-cent	Relative Precision	Per-cent	Relative Precision
Base Efficiency	23%	47%	46%	32%	24%	25%	76%	8%	27%	20%	46%	21%	17%	33%	33%	37%
High Efficiency	77%	14%	54%	27%	76%	8%	24%	26%	73%	8%	54%	18%	83%	7%	67%	18%
Base Efficiency Tiers Distribution																
T12	0%		1%		<1%		<1%		<1%		1%		0%		<1%	
Std 700 T8	13%		21%		10%		61%		14%		39%		8%		27%	
Std 800 T8	10%		25%		13%		15%		13%		7%		9%		5%	
High Efficiency Tiers Distribution																
High Performance T8	21%		41%		35%		12%		28%		20%		23%		7%	
Reduced Wattage T8	33%		2%		25%		5%		35%		29%		56%		52%	
T5	23%		10%		16%		7%		9%		5%		4%		7%	
LED	<1%		<1%		0%		0%		0%		<1%		0%		1%	
n	6,207		28,506		19,802		25,492		32,868		9,627		24,363		8,280	

* **The results presented above have been weighted by site weight.** The fixture counts represent two light equivalent fixtures.

Figure 17 - Fluorescent Lamp Practices

2013 Codes and Standards Study – Indoor Lighting Controls: As part of the 2013 update to Title 24, the IOU’s Codes and Standards Enhancement “Measure Information Template” (2013 CASE study) [14] developed revised lighting power density requirements for office buildings and office space types. The analysis to develop these reductions assumed the use of high performance lighting technologies including “high performance” linear fluorescent lamps (with higher initial and mean lumen output ratings than lamps that comply with minimum federal standards) and reduced light output ballasts. Figure 18 is from the 2013 CASE study and shows the results of several prototypical lighting models used to develop the revised LPD levels. Fixture tags RF1, RF2, RF3, PF1, PF2 and PF3 represent the predominant linear fluorescent fixtures used in the model. Each of these fixtures shows initial lamp lumens of 3,100 (or a 3rd generation, high performance, T8 lamp) and a ballast factor of 0.71 (which is at the low range of ballast factors for reduced lighting output ballasts). The current DEER code baseline consists of 2nd generation T8 lamps (approximately 2,950 initial lumens) and normal light output ballasts (ballast factors of about 0.9).

[14] “CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE) Measure Information Template – Indoor Lighting Controls 2013 California Building Energy Efficiency Standards”, California Utilities Statewide Codes and Standards Team, October 2011

Open Office Area, [sf]	21,680

Scenario	Luminaire Type		Input Watts per Luminaire, [W or W/ft]	Luminaire Quantity, [unit or lf]	Total Watts, [W]	Ballast Factor	Light Loss Factor (LDD * LLD)	Initial Lumens per Lamp	Installed LPD, [W/sf]	Average Maintained Illuminance on Desk Surfaces, [fc]	Average Initial Illuminance on Desk Surfaces, [fc]
T24 Baseline - Recessed SK-1 Series	General Overhead	RF1	72	221	15,912	0.71	0.903	3,100	0.87	43.9	48.7
		RF4	28	47	1,316	0.88	0.817	1,710			
		RF5	28	58	1,624	0.88	0.817	1,710			
T24 Baseline - Suspended SK-2 Series	General Overhead	PF1	47	344	16,168	0.71	0.903	3,100	0.90	42.2	45.8
		RF4	28	67	1,876	0.88	0.817	1,710			
		RF4a	28	32	896	0.88	0.817	900			
		RF5	28	23	644	0.88	0.817	1,710			
Task/Ambient - Recessed SK-3 Series	General Overhead	RF2	47	222	10,434	0.71	0.903	3,100	0.51	40.0 (43.3 total at task areas, 25.9 ambient)	46.1 (49.7 total at task areas, 28.7 ambient)
		RF4b	20	7	140	0.88	0.817	1,150			
		RF5a	20	28	560	0.88	0.817	1,150			
	Task	TL1	11	151	1,691	1.00	0.808	479	0.13		
		TL2	7	151	1,027	1.00	0.808	270			
Task/Ambient - Suspended SK-4 Series	General Overhead	PF2	47	330	15,510	0.71	0.903	3,100	0.75	41.1 (44.2 total at task areas, 27.3 ambient)	47.3 (51.22 total at task areas, 30.2 ambient)
		RF4b	20	16	320	0.88	0.817	1,150			
		RF5a	20	17	340	0.88	0.817	1,150			
	Task	TL1	11	151	1,691	1.00	0.808	479	0.13		
		TL2	7	151	1,027	1.00	0.808	270			
High Efficiency - Recessed SK-5 Series	General Overhead	RF3	72	151	10,872	0.71	0.903	3,100	0.52	40.5	44.8
		RF4b	20	15	300	0.88	0.817	1,150			
		RF5a	20	8	160	0.88	0.817	1,150			
High Efficiency - Suspended SK-6 Series	General Overhead	PF3	94	151	14,194	0.71	0.903	3,100	0.68	42.7	47.4
		RF4b	20	15	300	0.88	0.817	1,150			
		RF5a	20	8	160	0.88	0.817	1,150			

Figure 18 **- 2013 CASE Office Lighting Model**

<u>2016 Codes and Standards Study – Non-residential Outdoor Lighting Power Allowance:</u> As part of the 2016 update to Title 24, the IOU's Codes and Standards Enhancement (CASE) program proposed revisions to Title 24 outdoor lighting power allowances (2016 CASE Outdoor Study). The report proposed that all lighting power allowances (LPA values) in Title 24 be reduced based on the standard practice usage of LED technologies. The final adopted Title 24 requirements only incorporated the recommendations for general hardscape lighting and did not reduce allowances for additional specialty lighting use categories such as vehicle service stations, outdoor sales lots, building facades, canopies and tunnels. Nevertheless, the report notes that many "many manufacturers expect this to be mostly complete in all outdoor lighting product categories by 2017."

<u>CPUC Decision D.12-05-015: This decision states:</u>

> *For new equipment choices that are subject to existing regulations, codes or standards, our current policy provides that the baseline equipment be determined by the regulation, code, or standard requirements. However, there may be instances where there is sufficient evidence or documentation that the efficiency or energy use of equipment that meets the requirements of the regulation, code, or standard does not represent the efficiency or energy use of equipment that is typically installed. In those cases it may be appropriate to assign a baseline that equals or exceeds the typical installation in place of the regulation, code, or standard.*

The 2016 CASE Outdoor Study supports the rapid move in standard practice of using LED technologies in outdoor lighting applications, and provides a case-in-point of the scenario suggested in the decision language noted above. The proposed DEER standard practice baseline applies only to early retirement measures and does not apply to normal replacement measures. This change would be effective for the second baseline, which for most projects, would start four to five years after the measure installation. The proposed effective date of this change is January 1, 2018, which means the standard practice being addressed, is what would be occurring in the year 2022 at the earliest.

2016 Codes and Standards Study – Non-residential Lighting: Indoor LPDs: As part of the 2016 update to Title 24, the IOU's Codes and Standards Enhancement (CASE) program proposed revisions to Title 24 indoor lighting power allowances for many non-office building and space types (2016 CASE Indoor Study).[15] The primary change in the 2016 analysis compared to previous efforts appears to be the assumption that all lighting sources consist of linear or compact fluorescent lamps. Previous analyses included some consideration for the use of incandescent lamps for a limited number of specialty applications. Normal light output ballasts were assumed for all modeled linear fluorescent fixtures, which differs from the assumptions in the 2013 Case Study where, for offices, reduced light output ballasts were assumed.

2016 Title 24 Updates for Alterations (interior): There are two significant revisions to Title 24 Section 141.0(b)2I covering lighting system alterations:

1. Replacement lighting fixtures, where the entire lighting system is not being redesigned, in office, retail and hotel occupancies must have at least 50 percent, and all other occupancies at least 35 percent lower rated power at full light output compared to the replaced luminaires.

2. Lighting fixture retrofits (such as lamp and ballast replacements or LED kit retrofits) with at least 70 modified fixtures in office, retail and hotel occupancies must have at least 50 percent, and all other occupancies at least 35 percent lower rated power at full light output compared to the original, unmodified luminaires. Generally, in order to avoid these power reduction requirements a project would likely cover less than 6,000 square feet of floor space[16].

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[15] "Codes and Standards Enhancement Initiative (CASE) Non-residential Lighting: Indoor LPDs" Measure Number: 2016-NR-LTG1-F, prepared by TRC Energy Services for California Utilities Statewide Codes and Standards Team, October 2014

[16] For a typical 8'x10' grid of linear fluorescent fixtures (or 80 square feet per fixture), 70 fixtures would light about 5,600 square feet of floor area.

The two requirements (one for lighting fixtures, one for fixture modifications) present challenges for early retirement projects by making the code baseline dependent on the pre-existing technology. When a pre-existing fixture utilizes T12 lamps, then many commonly available T8 technologies will meet these requirements. However, if the pre-existing fixtures include T8 lamps, LEDs are likely the only technologies that can meet the 35-50% power reduction requirements. Title 24 allows any alteration to comply with new construction LPD limits. However, following the new construction requirements also invokes other requirements for multi-level output controls, occupancy/vacancy sensors, and day-lighting. In order to bypass the most burdensome control requirements, projects may meet LPD levels that are 15% less than the new construction requirements as allowed in Table 141.0-D.

6.3 DEER definition of Peak Demand

UPDATE NOTES: In consideration of CAISO[17] and PG&E[18] comments relating to the possible update of the DEER definition of peak demand reductions, an analysis of CAISO data on grid load was undertaken to determine if the DEER definition relating to weather conditions can accurately forecast when the grid peak loads occur as well as how specific changes in the time period portion of the definition would impact typical measure peak demand savings values.

First, we clarify that the DEER peak definition was developed to allow the selection of a sequence of days for any given year of weather conditions (either typical or actual) when a grid peak load is expected to occur and then, within those days specify how to calculate the peak demand reduction by averaging the energy efficiency measure energy impacts over a specified period. The DEER peak demand definition is based on a selection of hours during which the grid demand will actually occur as opposed to being based on the demand reduction during a given set of hours averaged over one or more summer months. The definition was developed to provide a reasonable estimate of the peak grid load impact of installing an energy efficiency measure at a facility and it not intended to provide an average load impact.

The current DEER peak demand definition, adopted by D.12-05-015, is as follows:

> The three-day demand periods for the new weather data were chosen based on these criteria:
>
> - occurs between June 1st and September 30th,
> - does not include weekdays or holidays,

[17] California Independent System Operator Corporation Comments on Draft Resolution E-4795, 1 August 2016.

[18] Comments of Pacific Gas and Electric Company on Draft Resolution E-4795, 1 August 2016, page 1.

- has the highest value for
  - average temperature over the threeday period +
  - the average temperature from noon to 6 p.m. over the threeday period +
  - the peak temperature over the threeday period.

To test the ability of this definition to accurately select the days when the grid peak loads occur, the DEER team utilized the one-minute and hourly energy consumption data for 2015 referenced in the CAISO comments[19] combined with the weather history for 2015 in five California population centers[20] served by the three electric IOUs. Applying the DEER selection criteria to all these locations resulted in the same date selection: September 8th to 10th. Examining the CAISO one-minute data for 2015 and locating the minute the grid peak load occurred results in the identification of September 10th at 4:53:00 PM being the peak grid load of 47,353 MW. Thus the DEER definition date range and time selection criteria for the grid peak load appears to be an accurate selection criterion. We also note that the peak grid load less solar and wind was 44,335 MW and occurred the same day at 6:22PM. However, this value is not coincident with the somewhat earlier T&D peak load represented by the grid peak that is a 6.8% higher.

Table 18, Table 19, and Table 20 below show the average grid load components during three different hour ranges for the peak demand calculation. It should be noted that while the shift of the DEER period definition by one hour, as shown in the second table below, results in a slight increase in the average grid peak load during the period, the alternate expansion and shift shown in the third table results in a more significant decrease in the average grid load.

We can compare these three day sequences with the values averaged over all 2-5 PM and 4-9 PM periods in each month by reviewing Table 21 and Table 22. Note that even using this method it appears that the peak selection criteria must include September but that June can likely be dropped. Note that using an average monthly value rather than the three-day heat wave criteria results in an incorrect indication that the peak might occur in August rather than September.

[19] R1512012_CAISO_TOU period_backup_2015.xlsx for one-minute data and R1512012_CAISO TOU period backup_IOU data_2015.xlsx for hourly data.

[20] Bakersfield, Fresno, Los Angeles, San Diego and San Francisco 2015 weather data for June through September was retrieved from http://www.accuweather.com

September 2015 Day/Hour	Average of Load	Average of Wind	Average of Solar	Average of net_load 2015
8	**44,991**	**245**	**4,317**	**40,429**
15 (2PM - 3PM)	43,769	197	5,116	38,456
16	45,418	245	4,350	40,822
17 (4PM - 5PM)	45,787	293	3,486	42,008
9	**45,727**	**579**	**2,793**	**42,354**
15 (2PM - 3PM)	45,681	535	3,427	41,719
16	46,069	487	2,847	42,735
17 (4PM - 5PM)	45,431	716	2,106	42,608
10	**46,468**	**408**	**4,050**	**42,010**
15 (2PM - 3PM)	45,496	300	4,441	40,755
16	46,652	423	4,222	42,007
17 (4PM - 5PM)	47,257	501	3,487	43,269
9 Hour Average	**45,729**	**411**	**3,720**	**41,598**

Table 17. 2015 Grid Peak Load for Current DEER Peak Period Definition of 2-5 PM

September 2015 Day/Hour	Average of Load	Average of Wind	Average of Solar	Average of net_load 2015
8	**45,556**	**267**	**3,452**	**41,838**
16 (3PM - 4PM)	45,418	245	4,350	40,822
17	45,787	293	3,486	42,008
18 (5PM - 6PM)	45,464	262	2,519	42,682
9	**45,516**	**682**	**2,124**	**42,710**
16 (3PM - 4PM)	46,069	487	2,847	42,735
17	45,431	716	2,106	42,608
18 (5PM - 6PM)	45,049	844	1,418	42,787
10	**46,846**	**519**	**3,300**	**43,028**
16 (3PM - 4PM)	46,652	423	4,222	42,007
17	47,257	501	3,487	43,269
18 (5PM - 6PM)	46,629	632	2,191	43,807
9 Hour Average	**45,973**	**489**	**2,958**	**42,525**
Change from 2-5PM	244 0.52%	78 19.10%	-762 -20.48%	927 2.23%

Table 18. 2015 Grid Peak Load for Shifted DEER Peak Period Definition to 3-6 PM

September 2015 Day/Hour	Average of Load	Average of Wind	Average of Solar	Average of net_load 2015
8	**44,307**	**476**	**1,326**	**42,505**
17 (4PM - 5PM)	45,787	293	3,486	42,008
18	45,464	262	2,519	42,682
19	44,203	422	644	43,137
20	43,487	655	-3	42,835
21 (8PM - 9PM)	42,593	750	-17	41,860
9	**44,603**	**566**	**790**	**43,248**
17 (4PM - 5PM)	45,431	716	2,106	42,608
18	45,049	844	1,418	42,787
19	44,278	454	399	43,425
20	44,371	356	14	44,002
21 (8PM - 9PM)	43,888	461	10	43,417
10	**45,479**	**710**	**1,220**	**43,548**
17 (4PM - 5PM)	47,257	501	3,487	43,269
18	46,629	632	2,191	43,807
19	45,239	630	447	44,161
20	44,796	892	-10	43,914
21 (8PM - 9PM)	43,472	897	-16	42,591
15 Hour Average	**44,796**	**584**	**1,112**	**43,100**
Change from 2-5PM	-932 -1.97%	174 34.65%	-2,608 -74.80%	1,502 3.47%

Table 19. 2015 Grid Peak Load for Shifted and Expanded DEER Peak Period Definition to 4-9 PM

Month	Average of AGCISO .iso TOTAL LOAD_AGC _MWX .AV	Average of AGCISO .PGAE TOTAL LOAD_AGC _MWX .AV	Average of AGCISO .Sce TOTAL LOAD_AGC _MWX .AV	Average of AGCISO .SDG TOTAL LOAD_AGC _MWX .AV
1	25,771	11,600	11,662	2,455
2	25,980	11,674	11,804	2,454
3	27,238	11,951	12,671	2,565
4	27,176	12,162	12,455	2,506
5	26,917	12,309	12,158	2,392
6	34,696	15,932	15,809	2,860
7	36,441	16,649	16,600	3,096
8	38,925	16,627	18,629	3,564
9	37,272	15,424	18,109	3,649
10	32,234	13,650	15,342	3,182
11	25,862	11,618	11,664	2,525
12	26,181	11,909	11,684	2,524
Average	**30,430**	**13,478**	**14,066**	**2,817**

Table 20. Average Monthly Grid Load 2-5 PM weekdays

Month	Average of AGCISO .iso TOTAL LOAD_AGC _MWX .AV	Average of AGCISO .PGAE TOTAL LOAD_AGC _MWX .AV	Average of AGCISO .Sce TOTAL LOAD_AGC _MWX .AV	Average of AGCISO .SDG TOTAL LOAD_AGC _MWX .AV
1	28,023	12,692	12,547	2,720
2	27,696	12,554	12,422	2,666
3	28,060	12,467	12,848	2,691
4	27,820	12,637	12,531	2,598
5	27,427	12,753	12,136	2,480
6	34,568	16,201	15,420	2,858
7	36,223	16,811	16,246	3,076
8	38,380	16,782	17,990	3,511
9	36,754	15,680	17,413	3,578
10	32,361	14,025	15,055	3,224
11	27,902	12,710	12,380	2,749
12	28,965	13,094	12,892	2,903
Average	**31,218**	**14,052**	**14,173**	**2,924**

Table 21. Average Monthly Grid Load 4-9 PM weekdays

We must also examine how the peak period selection relates to energy efficiency measure impacts. To estimate this, several DEER measure for residential and commercial building were re-run and the peak demand reductions were calculated for the three alternative peak demand hour ranges (2-5P M, 3-6 PM and 4-9 PM). For single family residential building type, Table 23 shows an estimate of how the peak demand would change from the current DEER values for a lighting (i.e., LED) measure and a representative HVAC SEER improvement measure. Table 24 and Table 25 show similar estimates for non-residential lighting and HVAC measures.

Location	Lighting Measure		SEER 17 Measure	
	3p to 6p	4p to 9p	3p to 6p	4p to 9p
CZ01	7%	67%	-48%	-90%
CZ02	-3%	23%	16%	14%
CZ03	3%	30%	15%	10%
CZ04	-1%	30%	8%	-3%
CZ05	5%	42%	13%	-19%
CZ06	2%	38%	7%	-7%
CZ07	4%	47%	3%	-10%
CZ08	5%	59%	-2%	-15%
CZ09	3%	63%	-1%	-26%
CZ10	3%	61%	2%	-18%
CZ11	-2%	33%	9%	1%
CZ12	-5%	25%	14%	15%
CZ13	0%	40%	11%	16%
CZ14	3%	53%	-1%	-15%
CZ15	4%	53%	2%	3%
CZ16	5%	38%	3%	-5%

Table 22. Estimated Change to DEER peak Demand Values for Residential Lighting and HVAC Measures

	Small Office		Large Office		Small Retail		3-Story Large Retail	
Location	3-6 pm	4-9 pm	3-6 pm	4-9 pm	3-6 pm	4-9 pm	3-6 pm	4-9 pm
CZ01	-6.3%	-46.2%	-8.9%	-45.1%	-3.0%	-24.8%	1.1%	-8.6%
CZ02	-5.3%	-48.8%	-9.6%	-47.1%	-3.1%	-24.8%	0.4%	0.5%
CZ03	-9.1%	-50.2%	-13.9%	-49.4%	-9.3%	-42.3%	-0.8%	-19.6%
CZ04	-6.9%	-50.7%	-15.0%	-22.0%	-7.7%	-37.1%	-0.3%	-18.0%
CZ05	-6.0%	-52.5%	-11.4%	-49.4%	-4.5%	-30.7%	-0.9%	-7.1%
CZ06	-6.3%	-51.5%	-11.3%	-49.4%	-4.5%	-27.4%	0.2%	-4.6%
CZ07	-3.9%	-48.1%	-9.4%	-48.0%	-3.6%	-23.0%	0.1%	1.4%
CZ08	-3.7%	-49.0%	-9.6%	-25.3%	-3.1%	-23.5%	0.5%	1.7%
CZ09	-7.9%	-53.4%	-11.1%	-49.6%	-4.8%	-27.6%	-0.1%	-5.0%
CZ10	-5.3%	-49.8%	-8.8%	-31.6%	-3.4%	-24.0%	0.1%	1.2%
CZ11	0.7%	-46.1%	-12.2%	-16.5%	-8.0%	-36.3%	-0.6%	-17.7%
CZ12	-5.3%	-48.8%	-8.2%	-31.8%	-3.4%	-23.7%	0.6%	2.0%
CZ13	-6.0%	-51.8%	-12.9%	-50.3%	-7.2%	-36.3%	-0.4%	-17.8%
CZ14	-6.0%	-52.5%	-10.9%	-37.2%	-5.8%	-27.2%	0.5%	-3.8%
CZ15	-5.7%	-50.9%	-11.1%	-29.2%	-4.0%	-26.9%	0.0%	-4.8%
CZ16	-4.0%	-51.5%	-11.1%	-49.9%	-4.1%	-27.2%	0.1%	-4.5%

Table 23. Estimated Change to DEER peak Demand Values for Non-Residential Lighting

	Small Office		Large Office		3-Story Large Retail	
CTZ	3-6 pm	4-9 pm	3-6 pm	4-9 pm	3-6 pm	4-9 pm
CZ01	0.0%	-70.0%	-6.0%	-67.8%	-4.5%	-40.0%
CZ02	-2.0%	-62.0%	-0.1%	-36.3%	3.4%	-7.0%
CZ03	0.0%	-60.0%	12.4%	-42.7%	-3.8%	-33.8%
CZ04	4.9%	-50.2%	-5.1%	-38.5%	-1.9%	-26.7%
CZ05	-9.4%	-66.3%	-11.4%	-57.6%	-11.9%	-30.6%
CZ06	-3.6%	-62.9%	-5.0%	-53.4%	0.2%	-18.6%
CZ07	-8.2%	-64.6%	-7.7%	-61.7%	-1.8%	-3.8%
CZ08	-7.5%	-64.8%	-7.7%	-62.2%	-0.6%	-13.6%
CZ09	-6.6%	-63.7%	-4.4%	-49.2%	-1.5%	-16.5%
CZ10	-6.7%	-64.0%	-6.1%	-51.3%	-2.4%	-11.0%
CZ11	-3.0%	-55.2%	0.5%	-31.2%	-0.4%	-18.2%
CZ12	0.0%	-61.2%	-2.6%	-46.3%	2.8%	0.2%
CZ13	9.0%	-51.6%	0.8%	-35.6%	3.8%	-18.3%
CZ14	-2.1%	-61.6%	0.1%	-44.6%	4.2%	-7.0%
CZ15	-1.9%	-61.1%	-2.4%	-40.9%	3.1%	-6.5%
CZ16	-1.9%	-61.9%	-1.7%	-43.0%	1.7%	-8.9%

Table 24. Estimated Change to DEER peak Demand Values for Non-Residential HVAC

The above discussion and examples point out that shifting the peak demand period to a later time from the current period will result in mild to dramatic reduction in peak demand values for most HVAC and non-residential lighting measures and minimal to dramatic increases for residential lighting measures. It would be expected that many industrial and agricultural measures may have changes more like the non-residential lighting and HVAC measures in those situations where energy use is higher during the day than during the evening and nighttime.

One concern is that a devaluing of non-residential peak demand reductions for most non-residential measures as well as non-lighting residential measure may negatively impact energy efficiency support for the progress toward net zero buildings.

The DEER analysis suggests that a shift is not warranted to capture actual grid peaks and if a shift is warranted in the future, care should be taken to prevent the devaluation of the bulk of the energy efficiency portfolio.