NRDC Comments on the 2016 Title 24 Building Energy Standards – 45-Day Language
Docket #15-BSTD-01
March 30, 2015

On behalf of our 1.4 million members and online activists, 250,000 of whom are in California, the Natural Resources Defense Council respectfully submits the following comments on the 45-day language for the 2016 Title 24 Building Energy Standards ("the Code") proposed in February 2015. NRDC appreciates the opportunity to comment.

The Title 24 Building Energy Standards assure that all new buildings and renovations in California meet minimum levels of efficiency, providing cost-effective energy savings for Californians, reducing energy demand, and cutting greenhouse gas emissions. NRDC has participated in the proceedings to develop Title 24 since their inception because of these important consumer and environmental benefits. Title 24 has saved Californians over $30 billion on their energy bills since the first standards were adopted in 1975, in addition to cutting the associated pollution emissions.[1] These benefits do not even include the value of increased comfort in new homes, nor the benefits of decreases in gas and electricity prices that result from reducing demand. The CEC estimates that the 2016 Building Standards proposed in the 45-day language will result in net savings of almost $3 billion from homes and buildings permitted in 2017 alone. These savings will continue to grow in future years as new buildings continue to be built to the standards and beyond.

While NRDC is supportive of the CEC's efforts to update the standard and supports many of the specific measures proposed, we argue that the proposed standards continue to leave cost-effective energy savings on the table and urge the CEC to adopt the highest levels found to be cost-effective.

NRDC offers the following summary of our comments, followed by our detailed comments and appendices.

Summary

Residential

1. *Residential Water Heaters* – NRDC generally supports the proposed changes in the 45-Day Language related to tankless gas water heaters, quality insulation installation, compact hot water distribution systems, and pipe insulation. NRDC remains deeply concerned about the current barriers in the code that

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[1] http://www.energy.ca.gov/releases/2013_releases/2012_Accomplishments.pdf

inhibit the installation of heat pump water heaters despite their clear emissions benefits, as documented in our detailed comments below. To address this issue, the CEC should modify the 45-day language to:

<u>1. Use the same water heating fuel in the standard design as in the proposed design, regardless of gas availability.</u>

<u>2. Allow heat pump electric water heaters and solar-electric water heating systems to be installed under the prescriptive path and for retrofits and additions.</u>

NRDC has included suggested language in Appendix 1 which would remove the current barrier to heat pump water heaters and welcomes further discussion with the CEC on this issue.

2. *Residential Envelope and Ducts in Conditioned Space* – NRDC strongly supports the high performance attics/ducts in conditioned space measure. NRDC also strongly supports increased wall efficiency requirements, but urges the CEC to adopt the highest levels found to be cost-effective in the CASE analysis.

3. *Residential Lighting* – In general, NRDC strongly supports the proposed changes to the residential lighting requirements. The proposed requirements will provide flexibility to builders while ensuring that there is a quality, high efficacy bulb in every socket. As discussed below, NRDC has concerns with the proposed requirement of a minimum color rendering index (CRI) of 90, given the lack of data showing consumer dissatisfaction with CRI 80 and the energy and cost penalty of CRI 90. NRDC recommends that the CEC align the Title 24 standards with the proposed Title 20 CRI requirement of 84.

4. *Photovoltaic Credit* – NRDC supports a PV credit that is limited in both time and scope. A limited PV credit will enable greater levels of efficiency in the code by providing flexibility to the builders. The credit should be limited so as not to allow tradeoffs below the 2013 Standards efficiency levels. The credit should be evaluated in future code cycles and the efficiency floor should continue to be raised to at least the 2016 Standards level to ensure all cost-effective energy efficiency opportunities are captured. Given the importance and potential magnitude of this credit, is important that the CEC maintain an open and transparent process in its development. Our understanding is that this will happen through the ACM Reference Manual development process, which we look forward to participating in.

Nonresidential and High-rise Residential

5. *Indoor Lighting* – NRDC recommends changes to the lighting alterations language that better balances the needs of retrofit programs and continued code stringency. Specifically, we support the language submitted by PG&E in the March 19, 2015 CASE report. NRDC generally supports the indoor lighting power density requirements, but urges the CEC to reevaluate the requirements for space types not included in ASHRAE.

6. *Outdoor Lighting* – NRDC supports the changes to the general hardscape lighting power allowances but urges the CEC to reinstate the allowance for specific applications proposed in the November 2014 Draft Standards. These lighting power allowances represent one-third of the potential energy savings from this measure and are cost-effective, as described in our comments below.

7. *Envelope* – NRDC recommends that the CEC increase the U-factor requirement for wood-frame roofs so that they are equivalent to the ASHRAE Climate Zone 3 levels. Current proposed levels stop short of what is cost-effective.

8. Data Center and Server Room Submetering – NRDC recommends submetering requirements for data centers and server rooms.

9. Plug-in Equipment Definition – NRDC recommends modifying the definition of plug loads to better align with IOU and CPUC terminology.

Comments - Residential

1. Residential Water Heaters

The following comments discuss three issues related to residential water heaters. The first two, below, are areas in which we support the CEC's proposal in the 45-day language. The third, the unaddressed but urgent need to fix a bias in the Code against electric heat pump water heaters, comprises the bulk of our comments and is an area of great concern:

1. **Tankless Gas Water Heaters**. As NRDC submitted during the pre-rulemaking comment period, we support the CEC's proposal to allow for the use of a tankless gas water heater under the prescriptive path and as the baseline for the performance path *for homes using gas as a water heating fuel*. This will result in energy savings compared to the use of a storage gas water heater. However, we are concerned by the use of a tankless gas water heater as the baseline for homes that use electricity as the water heating fuel. We elaborate these concerns further below in the discussion of Electric Heat Pump Water Heaters.

2. **Quality Insulation Installation**, **Compact Hot Water Distribution Systems, and Pipe Insulation**. While we support the prescriptive options of a storage gas water heater with quality insulation installation (QII) and a compact hot water distribution system or hot water pipe insulation, we urge the CEC to make these measures mandatory in future editions of the code. These are common sense, cost-effective efficiency measures that should be installed in all homes. Furthermore, piping insulation and compact hot water distribution systems reduce wasted water, which is particularly important for California.

3. **Electric Heat Pump Water Heaters**. We remain deeply concerned that the Code inhibits the use of heat pump water heaters, despite the fact that heat pump water heaters are highly preferable from a greenhouse gas emissions perspective when compared to tankless gas or storage gas water heaters. Appendix 1 to these comments presents an effective, straightforward Code revision that would remedy the bias against heat pump water heaters.

Detailed Discussion of the Codes' Bias Against Heat Pump Water Heaters and of Their Superior Emissions Attributes

There are several specific barriers to heat pump water heaters in the code as proposed in the 45-day language that can and should be addressed.

a) **New construction – prescriptive path:** The proposed 45-day language prohibits the installation of a heat pump water heater under the prescriptive path for new construction. New construction wishing to install a heat pump water heater must use the performance path, which adds modeling time and cost.

b) **New construction – performance path:** The performance path uses a gas water heater in the reference building for all homes unless gas is unavailable, making it difficult to install a heat pump water heater under this path. In order to install a heat pump water heater, a home must also include additional efficiency measures to pass under the performance path if gas is available which inhibits the installation of heat pump water heaters.

c) **Retrofits and additions:** The current language for retrofits and additions requires that modeling be conducted to show that a heat pump water heater uses no more energy than a minimum efficiency gas water heater, if gas is available. This modeling is time-consuming and costly which acts as a barrier to the installation of heat pump water heaters in the retrofit market.

Illustrative example of the bias against HPWH, and the counterproductive result on greenhouse gas emissions:

To illustrate the issues and tradeoffs between water heater types, Table 1 summarizes the energy use, time dependent valuation (TDV) costs, and carbon dioxide emissions for different water heater types in a prototype home modeled in CBECC-Res. The numbers in Table 1 were developed using the 2100 square foot single story default prototype home in climate zone 12 in CBECC-Res 2013-2. The only change to the default prototype home was the water heater which was modified for each run as specified in Table 1. The water heater types include: standard gas, tankless gas, electric resistance and three heat pump electric water heaters including an energy factor (EF) of 2.0 (the minimum standard for electric water heaters greater than 55 gallons), an EF of 2.6 (the average EF in the ENERGY STAR certification database), and an EF of 3.0 (the highest EF allowable in CBECC-Res; notably lower than the highest EF available in the ENERGY STAR certification database). All storage water heaters were 50 gallon tanks. The detailed inputs and results from CBECC-Res are included in Appendix 2.

As can be seen from Table 1, the three heat pump water heaters all have higher TDV values than the tankless gas water heater. Furthermore, only the heat pump water heater with an EF of 3.0 has a lower TDV than the minimum efficiency storage gas water heater. Since the 45-day language proposes that a tankless gas water heater be the baseline water heater in the standard design, in order to install a heat pump water heater, additional efficiency features would need to be installed to make up for this discrepancy in TDV. This effectively discourages the installation of heat pump water heaters, which is opposite the effect that would be desired from an emissions perspective. Table 1 shows that the emissions for all three heat pump water heaters are lower than the emissions for both the minimum efficiency gas storage water heater and the tankless gas water heater. A description of the emissions rates used is included in Appendix 3. We note that heat pump water heaters are a potentially controllable load that could be utilized to store excess generation from renewables, resulting in even lower emissions than those in Table 1.

	Natural Gas (therms/yr)	Electricity (kWh/yr)	TDV (kTDV/SF/yr)	Emissions (MT CO2/yr)[2,3]
Minimum Gas EF = 0.575, 50 gal	191.5		14.63	1.02
Tankless Gas EF = 0.82	121.2		9.3	0.64
Electric Resistance EF = 0.945, 50 gal		2976	30.26	0.85
Heat Pump WH EF = 2.0, 50 gal		1831	18.59	0.52
Heat Pump WH EF = 2.6, 50 gal		1473	14.91	0.42
Heat Pump WH EF = 3.0, 50 gal		1308	13.21	0.37

Table 1: Energy use, TDV, and Emissions of Different Water Heaters in a Prototype Home Modeled Using CBECC-Res

This discrepancy between TDV values and emissions is due to the relationship between gas and electric TDV values, which do not adequately reflect the emissions tradeoffs between gas and electric water heating.[4] NRDC submitted comments on the issues with TDV in its comments on the pre-rulemaking workshops in August, which are included here as Appendix 4. We recommend that the CEC work to address these issues with TDV in the 2019 standard update, since it is too late to make these changes in this round of the standard.

Since TDV does not adequately reflect the long-term emissions tradeoff between gas and electricity, we recommend that the CEC make the following changes to essentially remove the influence of TDV from the builder's decision of gas or electricity for water heating:

<u>1. Use the same water heating fuel in the standard design as in the proposed design, regardless of gas availability.</u>

<u>2. Allow heat pump electric water heaters and solar-electric water heating systems to be installed under the prescriptive path and for retrofits and additions.</u>

Appendix 1 includes recommended changes to the code language proposed in the 45-day language to implement these recommendations. Additional changes may also be required in the ACM Reference Manual. The language in Appendix 1 is one construction of how these problems could be addressed in the code. We are open to further discussion with the CEC on how the language might be modified.

Finally, this analysis revealed another bias in the Code against heat pump water heaters: the apparent difference in treatment in CBECC-Res of different water heater types in terms of water heater loads. Specifically, the delivered water heating loads appear to be different depending on water heater type, in a

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[2] Gas emissions rate is 0.00530576 MT CO2/therm; https://ethree.com/GHG/GHG%20Tool%20for%20Buildings%20in%20CA%20v2%20April09.pdf

[3] Electric emissions rate is 0.269 MT CO2/MWh which assumes that load growth is met by combined cycle gas turbine combined with a 33 percent renewable portfolio standard. See Appendix 3 for further description.

[4] The same is true for space heating.

way that penalizes heat pump water heaters significantly and gas storage water heaters partially. Table 2 below illustrates this concern. We emphasize again that nothing besides the water heater changed between these runs, so it is unclear why the delivered hot water load should vary. The effect of this difference is to further discourage heat pump water heaters. We would be interested in further discussing this issue with the CEC and think that modifications may be needed in the ACM Reference Manual to correct this concern.

	Water Heating Energy (therms/yr)	**Water Heating Energy (kWh/yr)**	**Water heating Energy in Consistent Units (therms/year)**	**Delivered hot water implied by CBECC – RES**
Description/Source:	*From CBECC-RES*	*From CBECC-RES*	*1 therm = 29.31 kWh*	*Therms delivered in heated water (= energy consumption * EF)*
Minimum Gas EF = 0.575, 50 gal	191.5		191.5	110.1
Tankless Gas EF = 0.82	121.2		121.2	99.4
Minimum Electric Resistance EF =0.945, 50 gal		2976	101.5	96.0
Heat Pump WH EF 2.0, 50 gal		1831	62.5	124.9
Heat Pump WH EF 2.2, 50 gal		1692	57.7	127.0
Heat Pump WH EF 2.6, 50 gal		1473	50.3	130.7

Table 2: Delivered Hot Water Implied by CBECC-Res for Different Water Heaters in Prototype Home

<u>Residential Water Heaters Summary</u>

In summary, we urge the CEC to modify the proposed 45-day language to facilitate the installation of heat pump water heaters in both new construction and retrofits. Heat pump water heaters have lower emissions impacts than gas water heaters and offer the potential of grid-interactivity to help balance variable loads.

Specifically the CEC should modify the 45-day language to:

<u>1. Use the same water heating fuel in the standard design as in the proposed design, regardless of gas availability.</u>

<u>2. Allow heat pump electric water heaters and solar-electric water heating systems to be installed under the prescriptive path and for retrofits additions.</u>

Recommended code language to implement these recommendations is included in Appendix 1.

2. Residential Envelope and Ducts in Conditioned Space

High Performance Attics and Ducts in Conditioned Space

NRDC strongly supports the proposed requirements for either high performance attics or ducts in conditioned space. These two measures have been identified as key measures to reach zero net energy goals and will provide cost-effective savings to consumers. According to the CASE report, this measure will save over 20 GWh/year in the first year the standards take effect and will save over $1.6 billion in TDV energy savings.[5] Providing builders with a choice between high performance attics and ducts in conditioned space will give builders flexibility and allow additional time for the industry to transition to these construction practices.

We support the modifications to the ducts in conditioned space language in the 45-day Language compared to the November 2014 Draft language. These modifications will ensure that the full energy savings potential of this measure will actually be achieved by not allowing ducts in any unconditioned spaces.

Residential Walls

NRDC strongly supports increasing the residential wall requirements. Highly insulating walls are a key measure to meet ZNE in homes, providing cost-effective savings for consumers and increased comfort. However, we are disappointed that the CEC's propose 45-day language stops short of the highest levels found to be cost-effective. The CASE report found that at least 33 percent higher TDV savings were achievable from the residential walls measure than those proposed by the CEC in the 45-day language.

We recommend that the CEC adopt the highest levels found to be cost-effective, as described below.

	First Year Statewide Savings			Statewide TDV Savings	
	Electricity Savings (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	TDV Energy Savings (Million kBTU)	TDV Dollar Savings (Million $)
U-factor=0.046	8.3	10.7	2.2	844	$145
QII	6.9	7.7	2.5	817	$141
U-factor=0.046 and QII	14.2	16.8	4.5	1,552	$268

Figure 1: Estimated first year savings for the CASE study proposed U-factor of U=0.046.[6]

[5] October 2014 CASE Report, "Residential Ducts in Conditioned Space/High Performance Attics"

[6] September 2014 CASE Report, "Residential High Performance Walls and QII"

	First Year Statewide Savings			Statewide TDV Savings	
	Electricity Savings (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	TDV Energy Savings (Million kBTU)	TDV Dollar Savings (Million $)
U-factor=0.051	6.5	8.6	1.8	675	$109

Figure 2: Estimated first year savings for the 45-day language proposed U-factor of U=0.051.

The CEC proposes increasing the wood-frame wall U-factor to U=0.051 in all climate zones. However, the CASE report found that a U-factor of U=0.044 would be cost-effective in almost all climate zone (except climate zones 6-8). The CASE report recommended a U-factor of U=0.046 which corresponded to the highest level evaluated using 2x4 studs. We recommend that the CEC modify the proposed standards to require a U=0.044. Stopping short of the highest levels found to be cost-effective is likely to impede efforts to reach zero net energy by 2020. Setting levels at the highest level that are cost-effective will allow builders to become more familiar with construction techniques to reach these levels, potentially leading to innovation and further cost-effective savings in the future. Alternatively, failing to adopt the highest cost-effective levels now could limit future savings opportunities.

Additionally, the CEC should require a U-factor of U=0.044 in all climate zones, even though the CASE analysis did not show it to be cost-effective in climate zones 6-8. There are several reasons for this. First, the CASE report does not take into account any reduced equipment costs from smaller equipment enabled by the reduced heating and cooling loads that come with increased envelope insulation. Therefore, the CASE report most likely overestimates the cost of reaching a given U-factor in all climate zones. If these costs were taken into account it is probable that a U=0.044 would be cost-effective in all climate zones. Secondly, the CEC would most likely find a U=0.044 to be cost-effective in all climate zones even without taking into account reduced equipment costs, if evaluated compared to historic practice (rather than the most recent standard), as the Warren-Alquist Act requires. Finally, the Warren-Alquist Act also requires that the standards be cost-effective in total, not that every proposed change be cost-effective. The increased cost of a U=0.044 in climate zones 6 through 8 will likely be offset by savings from other measures, resulting in standards that are cost-effective overall.

At a minimum, the CEC should adopt the highest cost-effective levels as the basis for the performance path. We understand that it may be too late to implement different requirements in the prescriptive and performance paths this cycle, but think the CEC should consider this approach for future code cycles. While there may be concerns with setting prescriptive levels that essentially require specific construction techniques, the performance path allows the builder the flexibility to trade these off with other measures in whatever way they see fit as long as the energy performance requirements are met. Given this flexibility, the performance path should not stop short of the highest levels found to be cost-effective.

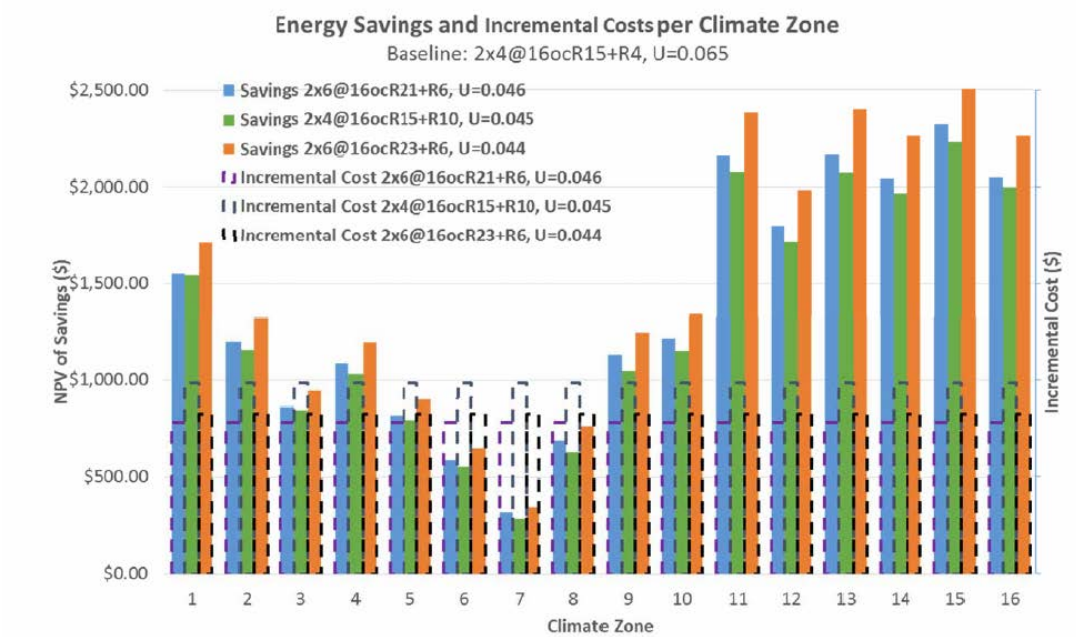

Figure 3: Energy Savings and Incremental Cost Analysis for assemblies with U=0.046 and below.[7]

3. Residential Lighting

In general, NRDC strongly supports the proposed changes to the residential lighting requirements. The proposal would simplify compliance with the standards, while ensuring that there is a high-efficacy, high-performance bulb in every fixture. This will result in significant energy savings: the changes to the residential lighting requirements have the largest projected energy savings of the residential measures considered in the CASE analyses, saving a projected total of 85 GWh in the first year. Put another way, according to the CASE analysis the proposed requirements have the potential to reduce a home's annual lighting energy use by an average of over 50 percent.

	First Year Statewide Savings[1]			TDV Savings[2]	
	Electricity Savings[3] (GWh)	Power Demand Reduction (MW)	Natural Gas Savings (MMtherms)	TDV Electricity Savings[4] (Million kBTU)	TDV Natural Gas Savings[4] (Million kBTU)
Recessed Luminaires	43.7	-	N/A	945.6	N/A
All Other Lighting	41.3	-	N/A	894.1	N/A
TOTAL	85.0	-	N/A	1,839.7	N/A

Figure 4: Estimated first year savings from residential lighting requirements.[8]

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7 September 2014 CASE Report, "Residential High Performance Walls and QII"

The proposal simplifies the current residential lighting requirements by requiring all light fixtures to be high-efficacy, removing the need to calculate the percentage of high-efficacy fixtures. Currently, low efficacy fixtures can be installed if they are installed with a dimmer or vacancy sensor and this option is widely utilized today. Eliminating this option will lead to significant energy savings. The proposal also provides greater flexibility by allowing screw-based fixtures to qualify as high efficacy as long as they meet the performance standards in Appendix JA-8. This is essential to the success of this proposal, as a homeowner who is not satisfied will simply unscrew these bulbs and may replace them with lower efficiency alternatives, negating the energy savings. Given the progress in both quality and decreased costs of LEDs, this requirement is feasible. Furthermore, the Energy Independence and Security Act (EISA) standards will take effect in 2018 in California and provide a backstop for any consumers who do replace screw-based bulbs. We offer the following comments on the details of the proposed requirements:

Recessed luminaires: <u>NRDC strongly supports the proposal to not allow the use of screw-based bulbs in recessed luminaires</u>. There are several reasons why screw-based bulbs should not be allowed in recessed luminaires. Recessed luminaires are commonly installed today and so it is important that high efficacy bulbs are installed and maintained in these fixtures. Since there is a higher price differential between high and low efficacy bulbs for the bulbs used in recessed fixtures, there is a bigger risk that the bulbs could be switched out between the final permit check and the time of occupancy, which would negate energy savings. Furthermore, the EISA standards that take effect in 2018, which will require most bulbs to be significantly more efficient, do not apply to directional bulbs used in recessed fixtures, so there is a larger risk of the consumer replacing with the bulb with a less efficient version. Finally, heat management is an important consideration for recessed fixtures and this can be better managed with a dedicated fixture. Since over half the savings for the residential lighting proposal comes from recessed luminaires, it is very important to maintain this requirement and prevent a potential loophole in the standards.

Elevated temperature requirements: NRDC supports the elevated temperature performance requirements proposed in Appendix JA-8 for bulbs installed in recessed cans and enclosed fixtures. These bulbs are subject to higher temperatures which can affect bulb performance. Bulbs that do not perform adequately at elevated temperatures could lead to consumer dissatisfaction and potentially negate energy savings if bulbs are switched out for less efficacious alternatives. <u>NRDC supports the requirement that bulbs that do not meet the elevated temperature requirements be labeled and recommend that the CEC require them to be labeled as “not for use in enclosed or recessed fixtures</u>.” This is a slight change from the current proposal which would allow the bulb to be labeled either “not for use in enclosed luminaires” <u>or</u> “not for use in recessed luminaires.” This labeling requirement will enable builders, consumers, and code inspectors to identify bulbs that are installed in the wrong type of fixture.

[8] October 2014 CASE Report, “Residential Lighting”

We also support the requirement in Section 150.0(k)1C that requires bulbs installed in recessed fixtures to meet these elevated temperature requirements. We recommend that the CEC add an additional requirement to Section 150.0(k) that requires bulbs in enclosed fixtures to meet the elevated temperature requirements of JA-8.

Disclosure: NRDC supports the proposal to require disclosure of installed lighting from the builder to the consumer in Part 11, Section 10-103(b)3. This is important because it creates accountability for the builder while also providing information to the consumer. Without this requirement, a builder might be tempted to switch out bulbs with cheaper, less efficacious alternatives between inspection and occupancy.

Dimmer requirements: NRDC supports the proposed requirement that dimmers meet NEMA SSL7A requirements. This will help ensure dimmer compatibility with the installed high efficacy fixtures and reduce potential consumer dissatisfaction from poorly matched dimmers and fixtures. This requirement is important because poor dimmer performance could lead consumers to switch out bulbs and replace them with lower efficacy alternatives.

Color Rendering Index: NRDC strongly supports the inclusion of a minimum color rendering index (CRI), as this will help prevent consumer dissatisfaction and lost energy savings. NRDC recommends that the CEC modify the proposed CRI requirement in Title 24 to align with the proposed Title 20 CRI requirements: specifically we recommend that the CEC set a CRI of 84. This would align with the Title 20 CRI value in effect at the time of the standard and could provide a compromise amongst stakeholders, some of whom have been advocating for 80 and others who have been advocating for 90 and above. NRDC does not support the CEC's proposed CRI of 90 at this time. As submitted in NRDC's October 24, 2014 comments on the Title 20 LED Lamp Proposal and in oral testimony in that proceeding, there is no data showing that consumers have been dissatisfied with CRIs in the low 80s that would indicate that this level of performance is not adequate for consumers. Furthermore, as submitted in the Title 20 proceeding, there is an energy and cost penalty associated with moving to a CRI of 90 and this penalty is not warranted, given the lack of consumer data supporting a higher CRI requirement. While we appreciate the data presented that indicate this cost penalty is shrinking, the cost gap still exists, as does the efficacy penalty. We support the proposal to also require a minimum R9 Value (red), given that this has been shown to be the most important color value to consumer.

Circuitry requirements: NRDC supports the separate circuitry requirement for under cabinet kitchen lighting. Homeowners often leave kitchen lights on even when the kitchen is not in use, sometimes as a form of night light or to indicate someone is present in the house. Given this tendency, it is important to allow consumers the flexibility to only leave some of the kitchen lights on by putting the under cabinet lighting on a separate switch, as under cabinet lighting is not likely needed for these purposes. This separate switching requirement will result in energy savings by allowing consumers to better control the level of lighting in the kitchen to meet specific needs.

4. Photovoltaic Credit

While not included in the 45-day language specifically, the CEC has indicated its intention to include a credit for on-site photovoltaic (PV) electric systems in the 2016 Code both in the pre-rulemaking workshops and in the March 2, 2015 lead commissioner meeting on the 45-day language. NRDC supports the inclusion of a PV credit that is limited in both time and scope. A PV credit will provide increased flexibility to builders as the code moves towards higher levels of efficiency and helps lay the ground work for ZNE in the 2019 code. The PV credit should be utilized to enable increasingly higher levels of efficiency in future editions of the code and as the code is updated in the future, the floor for this credit should continue to be raised to ensure that homes are more efficient in addition to having onsite PV. At a minimum, the credit should not allow tradeoffs below the efficiency of the 2013 code. In 2019, the floor should be raised similarly to not allow tradeoffs below the 2016 code as a minimum.

We support the concept presented in the March 2, 2015 meeting that a minimum size PV system would need to be installed to qualify for the tradeoff and that the value of the tradeoff would then be equal to that of high performance walls and attics. We are still evaluating whether 2 kW is the right minimum size system or whether the minimum should be higher. We also recommend that the CEC consider coupling other measures with the PV credit, such as grid-enabled appliances and equipment (e.g.) water heaters and storage. We would welcome further dialogue with the CEC on these issues going forward.

Our understanding is that the PV credit will be implemented as part of the ACM Reference Manual which will be finalized later this year. The CEC should clarify as part of this process that the credit will be time limited and reevaluated in future code cycles as the standards are updated. Given the importance and potential magnitude of this credit, it is important that it be developed in an open and transparent process. We look forward to continuing to work with the CEC on the implementation of this credit throughout the process.

<u>Comments - Nonresidential and High-rise Residential</u>

<u>5. Nonresidential and High-rise Residential Indoor Lighting</u>

a. Additions and Alterations Exemptions

The 2013 Building Efficiency Standards included significant updates to the lighting alterations provision, including an expansion of scope of the types of projects that are covered by the Code. These changes were estimated to lead to large energy savings: the California Investor Owned Utilities (IOUs) projected that the more stringent requirements would save 650 GWh/year for every year of construction complying with the code.

However, some stakeholders have since raised concerns that these changes are inhibiting lighting retrofits from occurring, primarily due to permitting costs and the costs of lighting controls where required. In the February 2015 45-day language, the CEC proposed changes to address these concerns. The CEC's proposal in the 45-day language was a blunt fix to this problem that proposed creating a broad exemption to the lighting alterations requirement. This would have created major loopholes and drastically reduced energy savings.

A more nuanced approached is necessary: one that better threads the needle between allowing retrofit programs to continue to provide energy savings, while also maintaining the stringency of the code. This is particularly true for projects that are broader in scope than just lighting retrofits, such as tenant improvements and gut rehabs.

To this end, the CEC staff have continued to work with stakeholders to fine tune this language since the publication of the 45-day language and we commend them on this effort.

<u>NRDC writes in support of the revisions proposed by PG&E in their March 19, 2015 Codes and Standards Enhancement Initiative (CASE) Report. These proposed changes strike the right balance between allowing for the continuation of retrofit programs and maintaining code stringency, maximizing overall energy savings</u>.

In particular, the following points should be addressed in the final language proposed by the CEC:

- NRDC agrees that there should be a two-part solution: one that addresses the short term concern with the 2013 standards and one for the 2016 standards. Some of the challenges with the 2013 code will be mitigated with the further advancement and availability of dimmable LED systems, which is expected by 2017, when the new code will take effect. The CEC should adopt a two-part approach that provides near-term relief, while continuing to capture the potential energy savings from dimmable LEDs in the future code.
- To this end, we agree that the exemption threshold of 20 percent energy savings compared to the existing luminaires is appropriate from the 2013 code. However we urge the CEC to require a savings of 30 percent or greater compared to existing luminaires in the 2017 code, which would better reflect the potential savings from LEDs.

- While not addressed in PG&E's proposal, NRDC remains concerned by the fact that the savings compared to previously installed luminaires is not auditable, as there is no way to check the previously installed lighting wattage after it has been removed. This is problematic because a project could claim that they fell under this exemption and a code official would have no way to verify that is indeed the case after the project has been completed. Including a lighting power density requirement would resolve this concern, but we understand that there are barriers to this due to the burden of calculating square footage. Another approach to address this concern would be to include a minimum average efficacy requirement in addition to the percent wattage reduction requirement. This minimum average efficacy could be checked after the fact and would provide an additional check that projects utilizing this exemption indeed meet the requirements of the exemption. At a minimum, the CEC should require projects using the exemption to maintain some record of the previously installed lighting (e.g. previously installed wattage, photo documentation). This documentation could be aligned with the required documentation for lighting retrofit rebate programs so as to avoid any additional burden on retrofit contractors.
- NRDC agrees with PG&E on the importance of not exempting gut renovations and tenant improvements from the requirements, as these represent major opportunities for energy efficiency and do not warrant an exemption due to the nature of the project type. We support the language submitted by PG&E that states that the exception should be limited to "projects consisting of only luminaire replacements."

b. Indoor Lighting Power Densities

NRDC generally supports the proposed nonresidential indoor lighting requirements, but urges the CEC to reevaluate the lighting power density requirements for space types that are not included in ASHRAE.

The CEC has proposed to align the nonresidential indoor lighting requirements with to the levels required by ASHRAE 90.1-2013, which NRDC supports. However, there are certain space types in Title 24 Tables 140.6- B (complete building method) and 140.6-C (area category method) that do not align with the ASHRAE space types and for which LPD values have not been updated since at least the 2001 Title 24 Standards(see categories highlighted in yellow below in Tables 3 and 4 below). These values are most likely not derived from the most recent technologies and therefore should be updated to reflect current technologies (high-performance T-8s and associated efficient ballasts, and LEDs for some applications that were based on technologies other than linear fluorescent). NRDC urges the CEC to evaluate these values and ensure they are based on current technologies. Additionally, there are some space types where the values proposed are less stringent than the ASHRAE values (see categories highlighted in orange in Tables 3 and 4). While we understand at this point in the process additional analysis likely cannot be conducted on these categories, we urge the CEC to reevaluate all of the values in the lighting power density tables in the 2019 standards update, as higher levels are likely to be cost-effective, particularly with the continued development of LEDs.

	Title 24 2005	Title 24 2016	ASHRAE 90.1-2013 Table 9.5.1	ASHRAE Building Area Type (if substantially different)
Auditorium Building	1.5	1.4	N/A	
Classroom Building	N/A	1.1	0.87	School/university
Commercial and Industrial Storage Building	N/A	0.6	0.66	
Convention Center Building	1.3	1	1.01	
Financial Institution Building	1.1	1	N/A	
General Commercial Building/Industrial Work Building	1.05	1	1.17	Manufacturing Facility
Grocery Store Building	1.5	1.5	N/A	
Library Building	N/A	1.2	1.19	
Medical Building/Clinic Building	1.1	1	1	Hospital and health care facility average
Office Building	1.1	0.8	0.82	
Parking Garage Building	0.4	0.2	0.21	
Religious Facility Building	1.6	1.5	1	
Restaurant Building	1.2	1.1	1.01	Dining: Bar lounge/leisure
School Building	1.2	0.95	0.87	
Theater Building	1.3	1.3	1.39	Performing Art Theater
All others buildings	0.6	0.5	N/A	

Table 3: Complete Building Method Lighting Power Density Values (Table 140.6 B)

		Title 24 2005	Title 24 2016	ASHRAE 90.1 -2013 Table 9.6.1	ASHRAE Building/Space Type (if substantially different)
Auditorium Area		1.5	1.4	0.63	Audience seating in an auditorium
Auto Repair Area		1.1	0.9	0.67	
Beauty Salon Area		N/A	1.7	N/A	
Civic Meeting Place Area		1.3	1.3	N/A	
Classroom, Lecture, Training,Vocational		1.2	1.2	1.24	
Commercial and Industrial Storage		0.6	0.6	0.58	Warehouse-storage area
Commercial and Industrial Storage		N/A	0.7	N/A	
Convention, Conference, Multipurpose		1.4	1.2	1.23	
Corridor, Restroom, Stair, and Support		0.6	0.6	0.66	
Dining Area		1.1	1	0.815	Average of dining area values
Electrical, Mechanical, Telephone		0.7	0.55	0.42	Electrical/mechanical room
Exercise Center, Gymnasium Areas		1	1	0.96	Average of exercise and play area
Exhibit, Museum Areas		2	1.8	1.05	
Financial Transaction Area		1.2	1	1.01	Bank activity Area
General Commercial and Industrial Work	Low bay	1.1	0.9	1.19	Manufacturing Facility
	High bay	1	1	1.23	
	Precision	1.3	1.2	1.29	
Grocery Sales Area		1.6	1.2	N/A	
Library Area	Reading areas	1.2	1.1	1.06	
	Stack areas	1.5	1.5	1.71	
Lobby Area	Hotel lobby	1.1	0.95	1.06	
	Main entry lobby	1.5	0.95	0.9	
Locker/Dressing Room		0.8	0.7	0.75	
Lounge Area		1.1	0.9	0.73	
Malls and Atria		1.2	0.95	1.1	
Medical and Clinical Care Area		1.2	1.2	1.18	Average of healthcare facility
Office Area	> 250 square feet	1.2	0.75	1.11	
	≤ 250 square feet	1.2	1	1.11	
Parking Garage Area	Parking Area	0.4	0.14	0.19	
	Dedicated Ramps	0.4	0.3	N/A	
	Daylight Adaptation Zones	N/A	0.6	N/A	
Religious Worship Area		1.5	1.5	1.53	
Retail Merchandise Sales, Wholesale Showroom Areas		1.7	1.2	0.9	Average of retail facilities: dressing/fitting room and mall
Theater Area	Motion picture	0.9	0.9	1.14	
	Performance	1.4	1.4	2.43	

Table 4: 140.6-C Area Category Method – Lighting Power Density Values

6. Outdoor Lighting

NRDC supports the proposed changes to the general hardscape lighting power allowances (LPA) proposed in Table 140.7-A. These lighting power allowances are achievable, cost-effective and will result in significant energy savings: the CASE analysis estimates approximately 30 GWh/year of savings from this measure alone.

However, NRDC is very disappointed in the significant rollback between the outdoor lighting power allowances for specific applications proposed in Table 140.7-B in the November 2014 Draft Standards and the proposed the values proposed in Table 140.7-B in the 45-day language. We urge the CEC to reinstate the values proposed in the Draft Standard, which would provide significant, cost-effective energy savings: approximately 15 GWh/year in additional savings.

The CEC's rationale for rolling back the values proposed in the November 2016 Draft Standards was the analysis documented in Table 37 of the December 2014 CASE report for this measure, which showed that the proposed levels were not cost-effective. However, the values in this table are flawed in several ways: if corrected, the analysis would show that the levels proposed by the IOUs in the CASE report are indeed cost-effective.

The primary flaw in the analysis stems from the fact that even deeper reductions in lighting power allowances than the values proposed in the November 2014 Draft Standards would be cost-effective, but the IOUs chose to propose more modest improvements to the lighting power allowances in order to give the industry time to transition. Despite the fact the IES RP 20 light levels published at the time of the analysis could have been met using lower wattage, the analysis was conducted using the full LPA allowance, which, when using LED-based efficacies, results in significantly higher lighting levels than required. This both overestimates the cost and underestimates the likely energy savings from this measure.

We recommend that the analysis be revised to be based on meeting the IES RP 20 lighting level requirements using LED-based efficacies. This analysis would prove that the proposed lighting levels can indeed be met in a way that is very cost-effective. It is immaterial if this results in a lower LPA than what is allowed by Title 24.

If the CEC insists on using the full LPA as the basis for the analysis, then it should update the assumptions in the analysis as follows. The current analysis uses worst case assumptions in a way that results in a double hit to the cost-effectiveness analysis: decreased energy savings and increased costs. Furthermore, the increased cost hit is two-fold: costs increase both because the installed lumens are higher than needed and also because LED costs are a non-linear function of wattage (i.e. higher wattage LEDs cost more per watt). The analysis documented in Table 37 assumes that LEDs exclusively are used to meet the LPA, however 100 percent LEDs are not needed to meet the IES requirements if the full LPA is used. Assuming 100 percent LEDs is, in fact, the most costly way to meet the LPA. A lower cost alternative would be to use a combination of LEDs and lower efficacy sources (which would have zero incremental cost) to meet the IES requirements and also remain within the LPA. While the energy savings would be lower than our preferred analysis approach based on the IES criteria, as discussed above, the costs would also be lower and a more realistic documentation of the least-cost method to meet both the

IES criteria and use up the full LPA. If the analysis was rerun in this way, it would likely show to the values proposed in the November 2014 Draft Standards in Table 140.7-B to be cost-effective.

In summary, we urge the CEC to request a revision of the analysis using the IES standard as the design criteria and update the values in Table 140.7-B to those proposed in the November 2014 Draft Standards.

7. Nonresidential and High-rise Residential Envelope

NRDC recommends increasing the efficiency of the opaque envelope requirements proposed in the 45-day language for nonresidential wood-frame roofs. The CEC has proposed levels that are lower than ASHRAE despite the fact that higher levels would be cost-effective.

For the 2019 code, we urge the CEC to conduct further analysis on increased nonresidential and high-rise residential envelope requirements. We also urge the CEC to implement a single requirement for each roofs, walls, and floors, based on the most efficient construction type – rather than breaking out requirements by construction type as done currently – as the baseline in the performance path. This will ensure that the highest cost-effective efficiency reductions are achieved while also providing builders flexibility to use whatever construction type they see fit. We would welcome further discussion with the CEC going forward on how to implement these changes in the 2019 code.

Nonresidential Wood Frame Roofs

For non-residential wood frame roofs, the CEC has proposed levels in the 45-day language (ranging from U=0.034 to U=0.067) that are below the ASHRAE climate zone 3 levels despite the fact that the ASHRAE climate zone 3 levels (U=0.027) appear to be cost-effective in the CASE analysis in almost all climate zones, even without considering additional benefits.[9] For climate zone 8 in particular, the CEC does not propose to change the required U-value at all (currently U=0.067) despite the fact that the CASE analysis found that a U-values of 0.027 would be cost-effective. The CEC should consider adopting the the ASHRAE climate zone 3 level (U=0.027) in all climate zones where it is shown to be cost-effective by the CASE report: 2, 3,4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16. We understand that the CASE report analysis may not fully account for the increased framing costs and so may overstate cost-effectiveness, we recommend that at a minimum the CEC update the requirements in Climate Zone 8 and reevaluate the requirements in Climate Zones 6 and 7 to see if higher levels than the proposal would indeed be cost effective.

[9] This was determined taking the TDV savings for the levels proposed (U=0.034) and dividing them by the incremental cost of going to U=0.027 documented in the CASE report. Actual benefit to cost ratios would be higher when taking into account the full TDV benefits.

CZ	Current Assembly	Current U-Value	Current Cost	Assembly Choosen	U Value Choosen Assembly	Cost Chosen Assembly	TDV Benefit	Incremental Cost	B/C	Highest Assembly Analyzed	U-factor of Highest Assembly Analyzed	Incremental Cost	B/C (not counting additional benefits)
1	R-19	0.049	$ 1.08	R-30	0.034	$ 2.60	$ 2.01	$ 1.38	1.46	R-38	0.027	$ 2.55	0.8
2	R-25	0.039	$ 2.16	R-30	0.034	$ 2.60	$ 3.18	$ 1.38	2.30	R-38	0.027	$ 1.47	2.2
3	R-25	0.039	$ 2.16	R-30	0.034	$ 2.60	$ 2.07	$ 1.38	1.50	R-38	0.027	$ 1.47	1.4
4	R-25	0.039	$ 2.16	R-30	0.034	$ 2.60	$ 2.90	$ 1.38	2.10	R-38	0.027	$ 1.47	2.0
5	R-19	0.049	$ 1.08	R-30	0.034	$ 2.60	$ 1.90	$ 1.38	1.38	R-38	0.027	$ 2.55	0.7
6	R-11	0.075	$ 0.81	R-19	0.049	$ 1.58	$ 4.51	$ 0.42	10.80	R-38	0.027	$ 2.82	1.6
7	R-13	0.067	$ 1.01	R-19	0.049	$ 1.58	$ 2.71	$ 0.21	13.10	R-38	0.027	$ 2.62	1.0
8	R-25	0.039	$ 2.16	R-25	0.039	$ 2.16	$ 3.13	$ 1.38	2.27	R-38	0.027	$ 1.47	2.1
9	R-25	0.039	$ 2.16	R-30	0.034	$ 2.60	$ 3.75	$ 1.38	2.72	R-38	0.027	$ 1.47	2.6
10	R-25	0.039	$ 2.16	R-30	0.034	$ 2.60	$ 3.76	$ 1.38	2.73	R-38	0.027	$ 1.47	2.6
11	R-25	0.039	$ 2.16	R-30	0.034	$ 2.60	$ 4.66	$ 1.38	3.38	R-38	0.027	$ 1.47	3.2
12	R-25	0.039	$ 2.16	R-30	0.034	$ 2.60	$ 4.04	$ 1.38	2.93	R-38	0.027	$ 1.47	2.7
13	R-25	0.039	$ 2.16	R-30	0.034	$ 2.60	$ 5.02	$ 1.38	3.64	R-38	0.027	$ 1.47	3.4
14	R-25	0.039	$ 2.16	R-30	0.034	$ 2.60	$ 4.89	$ 1.38	3.55	R-38	0.027	$ 1.47	3.3
15	R-25	0.039	$ 2.16	R-30	0.034	$ 2.60	$ 6.02	$ 1.38	4.36	R-38	0.027	$ 1.47	4.1
16	R-25	0.039	$ 2.16	R-30	0.034	$ 2.60	$ 4.67	$ 1.38	3.38	R-38	0.027	$ 1.47	3.2

Figure 10: Cost-effectiveness of CASE analysis proposed assembly by climate zone and of the highest efficiency assembly analyzed by climate zone for nonresidential wood-frame roofs.[10]

8. Data Center and Server Room Submetering

NRDC recommends that Section 130.5(a) include a new requirement for multitenant or “colocation” data centers to install electrical metering systems for individual cages that are occupied by different customer tenants. Currently, many multitenant data centers do not have metering equipment installed on each individual customer’s cage in the data center, and therefore cannot bill customer by energy usage. This decreases a customer’s likelihood of implementing energy efficiency measures for their IT equipment such as powering down unused servers: when the data center’s customers do not know how much energy their equipment is using, and when they are not charged for energy use on a per kilowatt-hour basis, they have no incentive to invest in energy efficiency that would reduce their consumption. This is one of the major barriers to improving the energy efficiency of multitenant data centers. NRDC recommends that electrical metering systems be installed on each cage in a data center to facilitate the adoption of usage-based energy billing in the data center industry. Separate metering for each cage should at least be required for new construction of data centers, and should eventually be required for retrofit projects as well.

Furthermore, NRDC recommends that server rooms in nonresidential buildings, also known as “embedded data centers”, also be metered separately from the rest of each tenant’s space. Small and medium server rooms accounted for nearly half of the electricity use of all data centers in 2011.[11] Many server rooms are not metered separately from the rest of an organization’s rented space. This lack of information on how much energy a server room is responsible for is a barrier for IT and facilities

[10] October 2014 CASE Report “Nonresidential Opaque Envelope”.

[11] NRDC, *America’s Data Centers Are Wasting Huge Amounts of Energy,* August 2014, available at http://www.nrdc.org/energy/files/data-center-efficiency-assessment-IB.pdf

managers to justify and implement efficiency improvement projects. Separate metering of server rooms should be required for both new construction and retrofit projects.

NRDC proposes that CEC add a definition for server rooms in Section 100.1(b) and include new items 3 and 4 in Section 130.5(a). We suggest the following language:

Section 110.1(b) **SERVER ROOM** is a room that does not meet the definition of a DATA CENTER, and whose primary function is to house electronic equipment and that has a design equipment power density exceed 20 watts/ft^2 of conditioned floor area.

Section 130.5(a) 3. For multitenant data centers, the distribution systems shall be separately monitored for the total building and for each individual cage used by a customer. The metering equipment installed for each individual cage must be of the standard required by utilities for nonresidential sub-metering to enable the data center to charge customers for per unit of energy used.

Section 130.5(a) 4. For all server rooms, the distribution systems shall be separately monitored from the rest of the space. Additionally, any HVAC and conditioning equipment dedicated to the server room must be included in the separate monitoring of the server room.

9. Plug-in Equipment Definition

In section 100.1 (b) the CEC proposes a new definition for "plug loads" for the purpose of Section 130.5. We support the addition of a definition but propose that the CEC use the term "plug-in equipment" instead of "plug loads". The definition as written includes both appliances and other electronic devices that can be plugged in. We support this broad definition, but note that currently the IOUs and CPUC define the term plug loads as separate from appliances. The term "plug-in equipment" is inclusive of both appliances and plug loads and would better align with the terms currently used by the IOUs and CPUC. Additionally, we suggest a small change to the language to indicate that appliances covered under "plug-in equipment" are generally plugged in, but in some cases may be hard-wired (e.g. dishwashers). We suggest the following definition:

"**Plug-in equipment** is any electrical equipment of a type that is typically plugged into a receptacle or receptacle outlet. Plug-in equipment are not related to general lighting, heating, ventilation, cooling, and water heating, domestic and service water system, renewable power, and electric vehicle charging."

Thank you for the opportunity to submit these comments.

Sincerely,

Meg Waltner
Manager, Building Energy Policy
Natural Resources Defense Council

Appendix 1. Proposed Code language to correct bias against electric heat pump water heaters

NRDC proposes the following changes to the 45-day language:

Strike outs and underlines in black text represent CEC's proposed changes in the 45-day language.

Red text with yellow highlighting indicates NRDC proposed changes to the 45-day language.

1) New Construction - Section 150.1 (c) 8

8. **Domestic Water-Heating Systems.** Water-heating systems shall meet the requirements of either A, B, or C~~, or D~~. For recirculation distribution systems serving individual dwelling unit, only Demand Recirculation Systems with manual control pumps shall be used:

~~A. For systems serving individual dwelling units, a single gas or propane storage type water heater with an input of 75,000 Btu per hour or less, and that meets the tank insulation requirements of Section 150.0(j) and the requirements of Sections 110.1 and 110.3 shall be installed. For recirculation distribution systems, only Demand Recirculation Systems with manual control pumps shall be used.~~

A. For systems serving individual dwelling units, the water heating system shall meet the requirement of either i, ii, iii, iv, or v:
i. ~~For systems serving individual dwelling units, a~~A single gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank, and that meets the requirements of Sections 110.1 and 110.3 shall be installed.
~~For recirculation distribution systems, only Demand Recirculation Systems with manual control pumps shall be used.~~

ii. A single gas or propane storage type water heater with an input of 105,000 Btu per hour or less, rated volume less than or equal to 55 gallons and that meets the requirements of Sections 110.1 and 110.3. The dwelling unit shall meet all of the requirements for Quality Insulation Installation (QII) as specified in the Reference Appendix RA3.5, and in addition one of the following shall be installed:

a. A Compact Hot Water Distribution System that is field verified as specified in the Reference Appendix RA4.4.16; or

b. All domestic hot water piping shall be insulated and field verified as specified in the Reference Appendix RA4.4.1, RA4.4.3 and RA4.4.14.

iii. A single gas or propane storage type water heater with an input of 105,000 Btu per hour or less, rated volume of more than 55 gallons, and that meets the requirements of Sections 110.1 and 110.3, and in addition one of the following shall be installed:

a. A Compact Hot Water Distribution System that is field verified as specified in the Reference Appendix RA4.4.16; or

b. All domestic hot water piping shall be insulated and field verified as specified in the Reference Appendix RA4.4.1, RA4.4.3 and RA4.4.14.

iv. A heat-pump water heater.

v. An electric storage or instantaneous water heater located within the building envelope and a solar water-heating system meeting the installation criteria specified in the Reference Residential Appendix RA4 and with a minimum solar savings fraction of 0.50 is installed. The solar savings fraction shall be determined using a calculation method approved by the Commission. Recirculation pumps shall not be used.

B. For systems serving multiple dwelling units, a central water-heating system that includes the following components shall be installed:

i. Gas or propane water heaters, boilers or other water heating equipment that meet the minimum efficiency requirements of Sections 110.1 and 110.3; and

ii. A water heating recirculation loop that meets the requirements of Sections 110.3(c)2 and 110.3(c)5 and is equipped with an automatic control system that controls the recirculation pump operation based on measurement of hot water demand and hot water return temperature and has two recirculation loops each serving half of the building; and

EXCEPTION to Section 150.1(c)8Cii: Buildings with eight or fewer dwelling units are exempt from the requirement for two recirculation loops.

iii. A solar water-heating system meeting the installation criteria specified in Reference Residential Appendix RA4 and with a minimum solar savings fraction of 0.20 in Climate Zones 1 through 9 or a minimum solar savings fraction of 0.35 in Climate Zones 10 through 16. The solar savings fraction shall be determined using a calculation method approved by the Commission.

~~D. For systems serving individual dwelling units, an electric-resistance storage or instantaneous water heater may be installed as the main water heating source only if natural gas is unavailable, the water heater is located within the building envelope, and a solar water-heating system meeting the installation criteria specified in the Reference Residential Appendix RA4 and with a minimum solar savings fraction of 0.50 is installed. The solar savings fraction shall be determined using a calculation method approved by the Commission. Recirculation pumps shall not be used.~~

2) Additions -- Section 150.2 (a) 1.D

D. **Water Heater**. When a second water heater is installed as part of the addition, one of the following types of water heaters shall be installed and assumed to comply:

i. A natural gas or propane water-heating system that meets the requirements of Section150.1(c)8; or

ii. If no natural gas is connected to the building, an electric water heater that has an energy factor equal to or greater than required under the Appliance Efficiency Regulations. ~~Recirculation pumps~~

~~shall not be used~~For recirculation distribution systems, only Demand Recirculation Systems with manual control pumps shall be used; or

iii. A heat-pump water heater.

iv. An electric storage or instantaneous water heater located within the building envelope and a solar water-heating system meeting the installation criteria specified in the Reference Residential Appendix RA4 and with a minimum solar savings fraction of 0.50 is installed. The solar savings fraction shall be determined using a calculation method approved by the Commission. Recirculation pumps shall not be used.

iv. A water-heating system determined by the Executive Director to use no more energy than the one specified in Item 1 above; or if no natural gas is connected to the building, a water-heating system determined by the Executive Director to use no more energy than the one specified in Item 2 above; or.

v. Using the existing building plus addition compliance or addition alone compliance as defined in Section 150.2(a)2 demonstrate that the proposed water heating system uses no more energy than the system defined in Item 1 above regardless of the type or number of water heaters installed.

3) Alterations -- Section 150.2 (b) 1.G

G. Water-Heating System. Replacement service water-heating systems or components shall: Meet the requirements of Section 150.0(j)2 and either be:

i. A natural gas or propane water-heating system that meets the requirements of ~~150.1(c)8.~~ Section 110.1 and 110.3. ~~No recirculation system shall be installed~~For recirculation distribution systems, only Demand Recirculation System with manual control pumps shall be used; or
ii. If no natural gas is connected to the building, an electric water heater that ~~has an energy factor equal to or greater than required~~meets the requirements of ~~under the Appliance Efficiency Regulations~~Section 110.1 and 110.3. For electric resistance storage type water heaters, the capacity shall not exceed 60 gallons. ~~No recirculation system shall be installed~~For recirculation distribution systems, only Demand Recirculation System with manual control pumps shall be used; or

iii. A heat-pump water heater.

iv. An electric storage or instantaneous water heater located within the building envelope and a solar water-heating system meeting the installation criteria specified in the Reference Residential Appendix RA4 and with a minimum solar savings fraction of 0.50 is installed. The solar savings fraction shall be determined using a calculation method approved by the Commission. Recirculation pumps shall not be used.

v. A water-heating system determined by the executive director to use no more energy than the one specified in Item 1 above; or if no natural gas is connected to the building, a water-heating system determined by the executive director to use no more energy than the one specified in Item 2 above; or

vi. Using the existing building plus addition compliance approach as defined in Section 150.2(b)2 demonstrate that the proposed water heating system uses no more energy than the system defined in Item 1 above regardless of the type or number of water heaters installed

EXCEPTION to Section 150.2(b): Existing inaccessible piping shall not require insulation as defined under 150.0(j)2A iii.

Appendix 2: CBECC-Res Water Heater Inputs and Results

Min Gas – 0.575 EF

Water Heater Data

Currently Active Water Heater: Min 50 Gal

Name:	Min 50 Gal
Heater Element Type:	Natural Gas
Tank Type:	Small Storage
Energy Factor:	0.575
Tank Volume:	50 gal
Input Rating:	40,000 Btu/hr
Recovery Efficiency:	70 % (only needed for Hydronic Space Heating)

Energy Use Details | Summary

North Facing End Use	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	207	240.6	22.70	223	259.7	24.36	-1.66
Space Cooling	414		14.11	251		7.70	6.41
IAQ Ventilation	112		1.13	112		1.13	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		181.4	13.86		191.5	14.63	-0.77
PV Credit						0.00	0.00
Compliance Total			51.80			47.82	3.98
Inside Lighting	1,045		11.16	1,045		11.16	Result:
Appl. & Cooking	958	52.5	13.80	958	52.5	13.80	PASS
Plug Loads	2,206		22.73	2,206		22.73	
Exterior	117		1.16	117		1.16	
TOTAL			100.65	4,911	503.7	96.67	

Tankless Gas – EF .82

Water Heater Data

Currently Active Water Heater: Tankless 82 EF

Name:	Tankless 82 EF
Heater Element Type:	Natural Gas
Tank Type:	Small Instantaneous
Energy Factor:	0.82
Tank Volume:	0 gal
Input Rating:	195,000 Btu/hr
Recovery Efficiency:	70 % (only needed for Hydronic Space Heating)

Energy Use Details | Summary

North Facing End Use	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	207	240.6	22.70	223	259.7	24.36	-1.66
Space Cooling	414		14.11	251		7.70	6.41
IAQ Ventilation	112		1.13	112		1.13	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		181.4	13.86		121.2	9.30	4.56
PV Credit						0.00	0.00
Compliance Total			51.80			42.49	9.31
Inside Lighting	1,045		11.16	1,045		11.16	Result:
Appl. & Cooking	958	52.5	13.80	958	52.5	13.80	PASS
Plug Loads	2,206		22.73	2,206		22.73	
Exterior	117		1.16	117		1.16	
TOTAL			100.65	4,911	433.4	91.34	

Electric Resistance

Water Heater Data

Currently Active Water Heater: Electric Resistance

Name: Electric Resistance

Heater Element Type: Electric Resistance

Tank Type: Small Storage

Energy Factor: 0.945

Tank Volume: 50 gal

Input Rating: 8,000 watts

Energy Use Details | Summary

North Facing End Use	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	207	240.6	22.70	223	259.7	24.36	-1.66
Space Cooling	414		14.11	251		7.70	6.41
IAQ Ventilation	112		1.13	112		1.13	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		181.4	13.86	2,976		30.26	-16.40
PV Credit						0.00	0.00
Compliance Total			51.80			63.45	-11.65
Inside Lighting	1,045		11.16	1,045		11.16	Result:
Appl. & Cooking	958	52.5	13.80	958	52.5	13.80	FAIL
Plug Loads	2,206		22.73	2,206		22.73	
Exterior	117		1.16	117		1.16	
TOTAL			100.65	7,887	312.2	112.30	

Heat Pump EF 2.0

Water Heater Data

Currently Active Water Heater: Heat Pump 2.0

Name: Heat Pump 2.0

Heater Element Type: Heat Pump

Tank Type: Small Storage

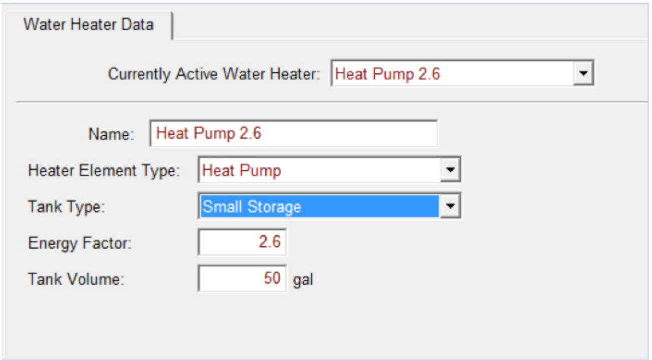
Energy Factor: 2

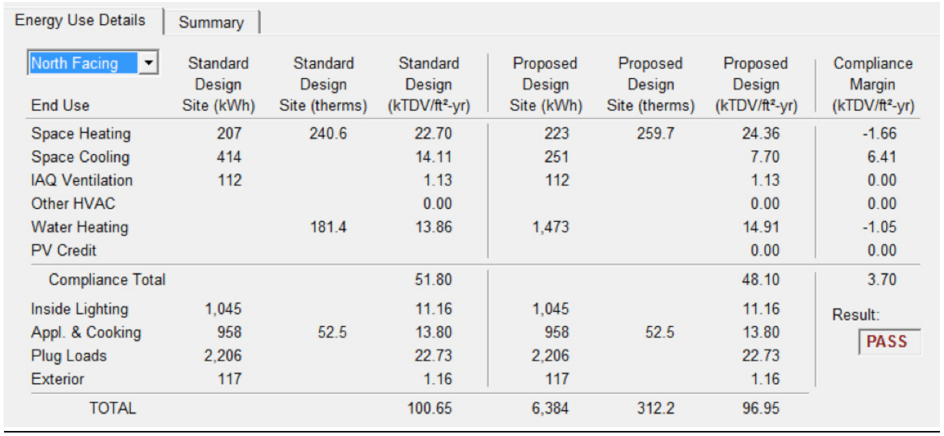
Tank Volume: 50 gal

Energy Use Details | Summary

North Facing End Use	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	207	240.6	22.70	223	259.7	24.36	-1.66
Space Cooling	414		14.11	251		7.70	6.41
IAQ Ventilation	112		1.13	112		1.13	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		181.4	13.86	1,831		18.59	-4.73
PV Credit						0.00	0.00
Compliance Total			51.80			51.78	0.02
Inside Lighting	1,045		11.16	1,045		11.16	Result:
Appl. & Cooking	958	52.5	13.80	958	52.5	13.80	PASS
Plug Loads	2,206		22.73	2,206		22.73	
Exterior	117		1.16	117		1.16	
TOTAL			100.65	6,742	312.2	100.63	

Heat Pump 2.6





Energy Use Details | Summary

North Facing

End Use	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	207	240.6	22.70	223	259.7	24.36	-1.66
Space Cooling	414		14.11	251		7.70	6.41
IAQ Ventilation	112		1.13	112		1.13	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		181.4	13.86	1,473		14.91	-1.05
PV Credit						0.00	0.00
Compliance Total			51.80			48.10	3.70
Inside Lighting	1,045		11.16	1,045		11.16	Result:
Appl. & Cooking	958	52.5	13.80	958	52.5	13.80	PASS
Plug Loads	2,206		22.73	2,206		22.73	
Exterior	117		1.16	117		1.16	
TOTAL			100.65	6,384	312.2	96.95	

Heat Pump EF 3.0

Water Heater Data

Currently Active Water Heater: Heat Pump 3.1

Name: Heat Pump 3.1

Heater Element Type: Heat Pump

Tank Type: Small Storage

Energy Factor: 3.1

Tank Volume: 50 gal

Energy Use Details | Summary

North Facing

End Use	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	207	240.6	22.70	223	259.7	24.36	-1.66
Space Cooling	414		14.11	251		7.70	6.41
IAQ Ventilation	112		1.13	112		1.13	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		181.4	13.86	1,308		13.21	0.65
PV Credit						0.00	0.00
Compliance Total			51.80			46.40	5.40
Inside Lighting	1,045		11.16	1,045		11.16	Result:
Appl. & Cooking	958	52.5	13.80	958	52.5	13.80	PASS
Plug Loads	2,206		22.73	2,206		22.73	
Exterior	117		1.16	117		1.16	
TOTAL			100.65	6,219	312.2	95.25	

Appendix 3: Emissions Rate Discussion

To compare the CO_2 emissions of a natural gas water heater with an electric water heater, we need to estimate the emissions of the power plants likely to be built over time to serve this new electricity load. This is the obverse of the typical question in energy efficiency (usually asked to determine cost effectiveness): what is the resource we are avoiding when we save energy. It is common, when analyzing the long-term impacts of a change in load, to use the expected variable costs of the resource likely to be built if the energy efficiency were not put in place.[12]

For an electric water heater, which has a variable usage pattern that does not specifically coincide with peak demand, it is reasonable to assume that the plants that will be built to serve this new load are a combination of combined cycle gas plants, which provided 67% of California's natural gas generation in 2013, and whose electricity output grew by 230% between 2004 and 2013,[13] and a portfolio of renewable energy resources sufficient to meet California's renewable portfolio standard (now, 33%).This is a conservative assumption, given that an electric water heater is also a potentially controllable load, which would lead to an even lower emissions factor.

This blended marginal emissions rate is equal to:

.385 MTCO2/kWh(3)[14]*.66 = .254 MTCO2/kWh

Taking into account distribution and transmission system losses of 11% [15], the recommended blended marginal emissions rate is:

.254 MTCO2/kWh/.89 = .286 MTCO2/kWh

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12 See, for example, National Action Plan for Energy Efficiency, Understanding Cost-Effectiveness of Energy Efficiency Programs, November 2008, Table 4-2.

13 Thermal Efficiency of Gas-Fired Generation in California: 2014 Update, California Energy Commission, CEC-200-2014-005, September, 2014, Table 5

14 http://www.energy.ca.gov/2014publications/CEC-200-2014-003/CEC-200-2014-003-SD.pdf

15 See: Comparison of Loss Factors, A Review of Transmission Losses in Planning Studies, August 2011, California Energy Commission, CEC-200-2011-009, p. 24;Derived from in-state and import line loss factors assuming 30% imports.

Appendix 4: Failure of TDV to account for societal value in greenhouse gas reduction.

While we recognize the TDV values cannot be substantially modified at this point in the 2016 code cycle, we offer the following comments for consideration for the development of subsequent TDV values as well as for how these TDV values are applied in the current code cycle.

TDV values should adequately account for the total societal value of energy use, taking into account long term greenhouse gas reduction targets. However, the current TDV values do not accurately reflect the long term societal costs of natural gas versus electricity, in particular as we move towards a target of 80 percent reduction in greenhouse gases by 2050.

The below graph shows the TDV values of electricity and gas for climate zone 12, adjusted to a common denominator of site Btu. The TDV value of electricity is roughly three times that of gas in off-peak hours and over 100 times that of gas in the highest peak hour. This is questionable, and may have material impacts. For example, it has the effect of highly favoring the use of gas over electricity, especially for space and water heating equipment, where gas equipment is used in the reference design. This wasn't a material issue in the past due to the clear superiority of gas for heating. However, there are now updated heat pumps, and a growing capability for grid-interactive water heaters to dynamically avoid high-cost periods in real time. These developments offer a potentially significant benefit which requires further consideration.

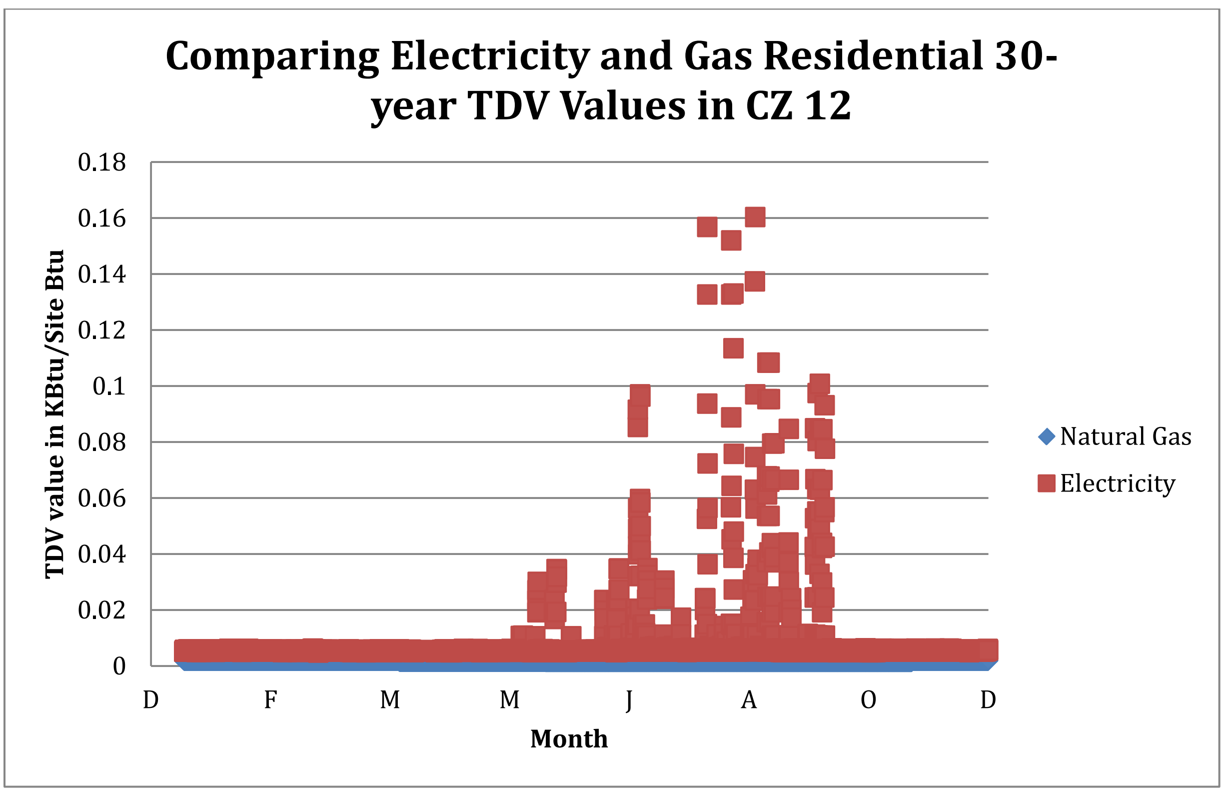

Figure 3: Comparison of Gas and Electric TDV values in Climate Zone 12[16]

This difference could set up a self-inconsistent process, in which the TDV values cause homebuilders to prefer end-use gas to electricity, and result in a shortfall in meeting 2050 emissions goals. The consequence of this shortfall will be a large increase in the cost of carbon, which will affect the cost of gas a lot more than the cost of electricity (since by 2030 or later, the electric system will be based mostly on renewables or very-high efficiency gas generation).

In the short term, *the CEC should address this issue this code cycle by using the same fuel type in the reference and proposed design, which would make the standards fuel neutral.* For residential, the CEC should use a large electric heat pump water heater in the reference design and a minimally compliant heat pump space heater. In the long term, the CEC should work to make sure that TDV better encompasses full environmental costs and benefits, consistent with achieving the state's 2050 carbon emissions reduction goal, in next TDV update.

One reason for the large difference in current gas and electric TDV values is the method for valuing renewables in the electricity TDV calculations. Under the current methodology, renewables are considered as an additional avoided cost, calculated by multiplying the percentage RPS by the MWh avoided and the $/MWh factor for renewables (See Figure 4). This means that the higher the assumed penetration of renewables, the higher the value of avoided electricity and the higher the cost of electricity compared to gas. This is counter to the result that would lead to the best societal outcome: the more renewables are used to generate electricity for new homes, the more TDV encourages gas rather than the renewables-heavy electric option. Clearly, the outcome should be the reverse: the more renewables used to generate electricity, the more favored electricity should be as a fuel choice.

Furthermore, the current assumption that the marginal fuel is always a natural gas turbine is inaccurate and fails to take into account the increasing prevalence of zero marginal cost variable resources.

While we support the use of the TDV metric and evaluating the time-value of energy savings, we urge the CEC to fully evaluate the changing landscape of marginal and variable resources as well as the emergence of high efficiency electric space and water heating equipment in its future updates of TDV values.

In the past, this time variation within one fuel was the only factor that made a big difference. But now with the improvement in efficiency of heat pumps, the TDV values affect the fuel choice tradeoff. Some evidence suggests that electricity is a better choice for meeting California's climate goals. While more detailed analysis might refute this evidence, for the time being, Title 24 should be neutral between gas and electricity for water and space heating applications. This neutrality can easily be accomplished by establishing separate reference houses based on fuel choice. The IECC and the RESNET HERS Standard (currently ANSI/RESNET Standard 301-2014) have done this for years.

[16] Developed using data presented in July 9, 2014 workshop.

We urge the CEC to address this issue in the next TDV update. In doing so, CEC should use best available estimates for renewable penetration and efficiency. We think that the current estimates used for the 2016 TDV are conservative and that other assumptions would be more appropriate.

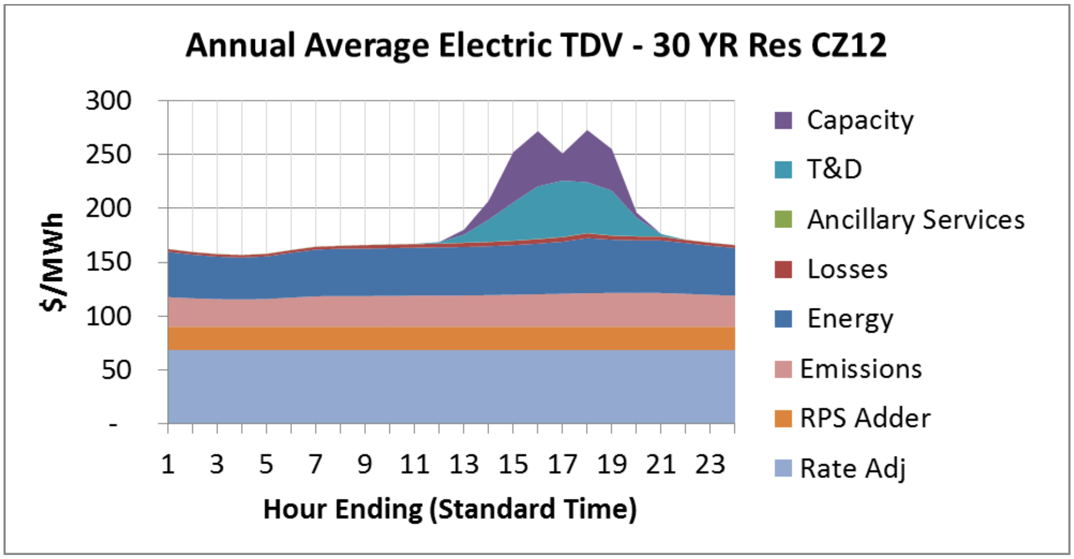

Figure 4: Average Annual Electric TDV Values for CZ12 show the constant RPS adder.[17]

[17] Title 24, 2016 TDV Methodology Report, Figure 7; July 9, 2014