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NRDC Comments on Draft Residential ACM Reference Manual

Additional submitted attachment is included below.

NRDC Comments on the 2016 Draft Residential Alternative Calculation Method Reference Manual
Docket #15-BSTD-04
August 20, 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 2016 Draft Residential Alternation Compliance Method (ACM) Reference Manual. NRDC appreciates the opportunity to comment.

The Title 24 Building Energy Standards can be met through either the prescriptive or performance path, the latter of which is documented using compliance software. The ACM Reference Manual specifies the rules that this software must follow when determining the building model proposed and standard design. Given the large percentage of new buildings that comply with Title 24 using the performance path, the details of how the performance path is implemented through the ACM Reference Manual are very important.

In June, the California Energy Commission adopted updated Title 24 Building Standards that will take effect January 1, 2017. These new standards will cut energy use in homes by approximately 28 percent, saving homeowners an average of $7400 on their energy bills over the course of a 30-year mortgage. NRDC commends the CEC for adopting these updated standards, which take a large step forward toward achieving the goal of zero net energy new residential construction by 2020 and add to the over $30 billion that Title 24 has saved Californians on their energy bills since the first standards were adopted in 1975.[1]

Our comments on the 2016 Draft Residential ACM Reference Manual focus on two issue areas that we have raised throughout the 2016 Title 24 development process: the implementation of the solar PV credit and the treatment of heat pump electric water heaters. Our comments are as follows:

Solar PV Credit

Throughout the 2016 Title 24 development process, NRDC has supported the concept of a PV credit that is limited in scope and direction. We support the concept of a solar PV credit because we see it as a way to ease the pathway for increased energy efficiency in the building standards over time. The PV credit provides increased flexibility for builders as they learn how to implement cost-effective efficiency measures; this increased flexibility allows the CEC to set higher levels of efficiency in the standards. However, the PV credit should be limited in scope and duration to ensure that the bar for efficiency continues to be increased over time. California's loading order specifies that energy efficiency should be the primary energy resource. The PV credit should therefore be utilized as a method to achieve the highest

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

levels of efficiency that are cost-effective in the building standards, rather than as a substitute for efficiency. We recognize that both deep energy efficiency savings and solar PV will play important roles in achieving California's ZNE goal for residential construction by 2020.

NRDC has emphasized from the beginning of the Title 24 process that the details of how the PV credit is implemented are very important and we continue to have some concerns with and recommendations on the current proposal. We offer the following specific comments on the proposed credit in the Draft ACM Reference Manual:

NRDC is concerned with the lack of publically available analysis behind the credit and with the percentage based structure. Our understanding is that the CEC's intent is to allow a PV credit that would be equal in amount to the time dependent valuation (TDV) energy savings achieved by the high performance wall and attic measures required by the 2016 Title 24 Standards. However, this is not how the credit appears to be implemented. The ACM Reference Manual calculates the PV credit by first calculating the TDV energy use of a reference home constructed with high performance walls and attics and then multiplying this TDV energy use by a specific percentage value, depending on the climate zone, found in Table 2-1. The resulting value is the amount of TDV energy that can be offset using solar. NRDC has two major concerns with this approach:

1. *Lack of publically-available analysis supporting values in Table 2-1.* No analysis has been provided to date to support the values in Table 2-1. NRDC has asked for this analysis both in oral testimony and by email to staff. While staff has indicated they will publish this analysis, it was not published in advance of the comment deadline. Without this analysis, we do not know whether the values in Table 2-1 are valid.

2. *Percentage based methodology is flawed*. Second, and more importantly, this percentage based methodology does not accurately reflect the savings that will be achieved by high performance walls and attics in an individual home. The percent of total TDV energy attributable to high performance walls and attics will vary from home to home, depending on the home's size and geometry. Using the percentage based approach will result in a credit that is sometimes larger and sometimes smaller than the actual savings that would be achieved by high performance walls and attics in that home.

We propose an alternate approach, as follows. The software should develop two reference homes: one that determines the TDV energy budget that must be met with energy efficiency measures alone (reference home 1) and a second that determines the TDV energy budget that can be met with a combination of solar and energy efficiency (reference home 2). Reference home 1 would meet all the requirements of the 2016 Title 24 standards except for walls and attics; for walls and attics, the prescriptive requirements would be equivalent to the 2013 Standard levels (i.e. everything expect high performance walls and attics). Reference home 2 would include the full 2016 prescriptive requirements. This would both provide a more accurate way of giving a tradeoff equivalent to high performance wall/attic measures that would actually give a tradeoff equivalent to the savings from these measures for each individual home. It would also provide a framework for how to include PV in the code going forward as it moves toward net zero.

NRDC recommends that the PV credit sunset before the effective date of the 2019 standards. The stated intent of the PV credit is to provide flexibility to builders as they get up to speed on the high performance wall and attic measures required by the 2016 Title 24 standards. However, these measures, and additional efficiency measures, will be needed to reach the zero net energy goals by 2020. Many builders are likely to continue using the PV credit to offset these measures as long as it exists. If the credit does not have an end date specified, builders will not be motivated to scale up their abilities to implement the high performance wall and attic measures. We therefore recommend a sunset date of January 1, 2019 for the PV credit. This date would give ample time for the industry to get up to speed on how to implement these measures. Alternatively, the CEC could consider phasing out the credit in stages, for instance: in 2018, the credit could be reduced to just the high performance attics measure, and in 2019 sunset entirely.

Water Heating

NRDC continues to be concerned that the TDV values for gas and electricity do not adequately reflect the long-term emissions tradeoffs between gas and electricity. These concerns have been elaborated in our previous comments to the CEC during this proceeding, which are attached, in part, as Appendix 1. Given that TDV does not adequately capture this tradeoff, we recommend that the ACM Reference Manual specify that the same fuel source be used in the reference and proposed design for water and space heating. For electric water heating, we recommend that the reference design use a large electric water heater (above 55 gallons).

NRDC has also commented previously on the discrepancy in the hot water heating load calculated in the software for heat pump water heaters and gas water heaters. We understand that the CEC is investigating this issue and expects to update the software in the spring of 2016; we appreciate this upcoming modification.

We also appreciate the efforts of the CEC to reduce the barriers in Title 24 to the installation of heat pump water heaters in existing homes.

Thank you for the opportunity to comment.

Sincerely,

Meg Waltner
Manager, Building Energy Policy
Natural Resources Defense Council

Appendix 1 – NRDC Comments 2016 Title 24 45-Day Language re: Residential Water Heaters

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.

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 1-A.

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 1-B. 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)[23]
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 1-C. 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>

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 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

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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.

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

Appendix 1-A: 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

Water Heater Data

Currently Active Water Heater: Heat Pump 2.6

Name: Heat Pump 2.6

Heater Element Type: Heat Pump

Tank Type: Small Storage

Energy Factor: 2.6

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	1,473		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 1-B: 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.[5]

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,[6] 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)[7]*.66 = .254 MTCO2/kWh

Taking into account distribution and transmission system losses of 11% [8], the recommended blended marginal emissions rate is:

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

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

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

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

[8] 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.

<u>Appendix 1-C: Failure of TDV to account for societal value in greenhouse gas reduction.</u>

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.

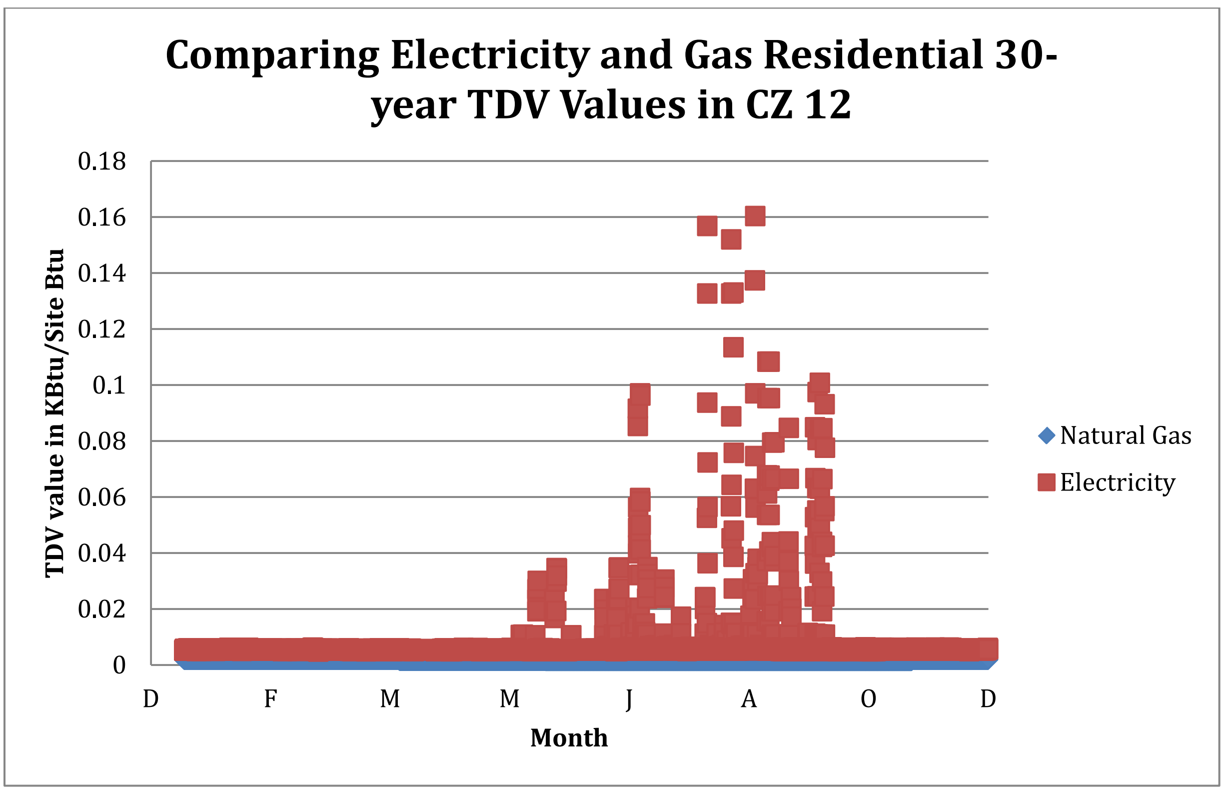

Figure 3: Comparison of Gas and Electric TDV values in Climate Zone 12[9]

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.

[9] 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.

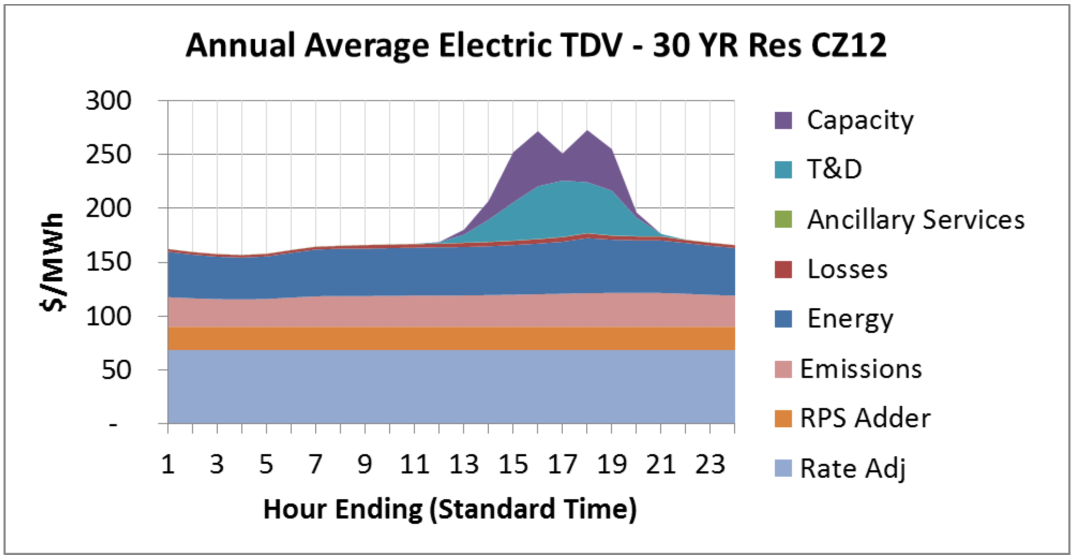

Figure 4: Average Annual Electric TDV Values for CZ12 show the constant RPS adder.[10]

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