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Evaluation of DOE Supplemental Proposed Rulemaking on Residential Furnace Standards Life Cycle Cost Analysis: Inputs and Results with Emphasis on Southern California

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Acknowledgements

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1.0 Executive Summary

SoCalGas requested NegaWatt Consulting's assistance to further evaluate the potential impacts of the current U.S. Department of Energy (DOE) Supplemental Notice of Proposed Rulemaking (SNOPR) proceedings regarding Energy Conservation Standards for Residential Furnaces (Department of Energy, SNOPR, 2016). SoCalGas commissioned NegaWatt to review the rulemaking documents provided by DOE and assess the impacts, both positive and negative, of the newly added split standard and further evaluate the potential impact to SoCalGas' customer base in Southern California. The evaluation builds on the previous assessment conducted in June 2015 when the DOE issued the original notice of proposed rulemaking (NOPR).

The following general observations about the rule are as follows:

1. The market is already moving on its own towards higher efficiency furnaces, therefore this rulemaking may not be necessary.
2. The standard would be limiting free market forces and unduly push certain installers and manufacturers out of business.
3. Some switching to heat pumps and resulting energy use increase is likely.

Additional focus was placed on reviewing the DOE's updated life cycle cost (LCC) analysis. The LCC was checked for inputs, assumptions, and method. It was rerun using minor permutations and was filtered by region for California and Southern California.

The analysis showed that most of the initial concerns noted in the NOPR still exist in the LCC inputs, assumptions, and methods. The following are major concerns with the LCC analysis:

1. 100+ inputs are probability distributions, many of which have not or cannot be fully reviewed and vetted by key stakeholders.
2. First cost method draws on biased, proprietary, uncertain and aggregated inputs; asbestos abatement is not addressed for retrofit market.
3. The lifespan of a typical gas furnace appears overestimated at 21.5 years.
4. The DOE's marginal consumer electricity prices appear highly inaccurate.
5. The product price trend calculation comingles technologies and capacities.
6. DOE's new construction first cost contradicts SoCalGas territory figures.
7. AEO 2015 is outdated and predicts higher gas prices than AEO 2016.

Notwithstanding these (compounding) concerns, recalculating payback period and LCC savings for California and Southern California without any other changes to the DOE LCC (besides the use of AEO 2016) further illustrates the major detrimental impact this rule would have to SoCalGas customers:

- Payback periods in California for thresholds from 55 kBtu/hr to 75 kBtu/hr are approximately double those in the Rest of Country group.
- Average payback periods for California are near to and in some cases exceed the assumed furnace lifetime.

2.0 Introduction

NegaWatt Consulting has researched and evaluated some of the potential impacts to SoCalGas' customers of the current DOE SNOPR proceedings regarding Energy Conservation Standards for Residential Furnaces (Department of Energy, Rulemaking for Residential Furnaces Energy Conservation Standards, 2016).

This rule would impact minimum efficiency requirements for California and nationwide, and is the latest in a series that have circulated the DOE rulemaking process for several years. The current national minimum standard is 80% regardless of furnace capacity. The goal of this rulemaking is to set new nationwide minimum energy efficiency split standards based on capacity for these residential gas furnaces. The lower threshold capacity category would have an Annual Fuel Utilization Efficiency (AFUE) that will remain at 80%. The large capacity category would have an AFUE of 92%.

The DOE points to their analyses, spreadsheets and models stating that the national benefits of increasing the efficiency standard outweigh the costs overall, acknowledging a few will be hurt economically. Many in the gas and furnace industries say DOE has not been transparent during the process (although required per a recent settlement agreement), and have suggested that DOE is over-estimating the benefits of the proposed standard and underestimating the costs. The methodology and input data used to derive costs and benefits have been criticized for being overly complex, hard to validate, and in some parts proprietary.

Our research contends that the potential impact of the standard in Southern California is significant and that the rule is not cost-effective and would unduly disadvantage SoCalGas customers.

3.0 Objectives

The focus of our research was the evaluation of the DOE's LCC analysis (Department of Energy, RF_SNOPR_LCC_2016-08-30.xlsm, 2016), and to evaluate its inputs and results with emphasis on California and Southern California. This included developing the capability to re-run the DOE's LCC spreadsheet, with and without certain modifications. To the extent possible given available time and resources, we also reviewed the proposed rule in more general terms, beyond the life cycle cost component, and are sharing our observations in this report.

4.0 Approach

This analysis is based on the latest LCC version available in the rulemaking docket (Department of Energy, RF_SNOPR_LCC_2016-08-30.xlsm, 2016). We have also considered several other DOE documents from the docket in our review, notably: the SNOPR (Department of Energy, SNOPR, 2016), the presentation provided by DOE on

October 17, 2016 in Washington, DC (Department of Energy, Furnaces SNOPR deck, 2016), various comment letters by others, and last but not least, the Technical Support Document (Department of Energy, TSD, 2016).

We reviewed a list of the major assumptions and inputs into the LCC, and individually researched those that appeared to have the most impact or to be the most questionable from a Southern California perspective. The number of inputs and assumptions into this calculation being very large, there was not sufficient time to review *all* assumptions and inputs.

Finally, the building sample database contained in the LCC was filtered in two steps, first for California only, and second for Southern California. This was done so that a consistent regional centric analysis calculation could be rerun. The region selection was made by filtering for weather station in the building sample. The California calculations only consider buildings that use the following weather stations: BFL, BLH, EKA, FAT, LAX, MHS, PRB, RBL, RDD, SAC, SAN, SCK, SFO[1]. The Southern California calculations only consider buildings that use the following weather stations: LAX (Los Angeles), SAN (San Diego), BLH (Blythe), BFL (Bakersfield), and FAT (Fresno).

No other changes were made to the DOE spreadsheet, other than to narrow it down by region, run it for various capacity thresholds, and use AEO 2016 (instead of AEO 2015) for energy prices. The results reported are for residential non-weatherized gas furnaces (NWGF). NWGFs are *by far* the largest market segment impacted by this rulemaking, with a share of 95%, per the DOE's own figures. This analysis does not show combined market figures as is done in one section of the original LCC analysis, and instead, focuses to show the significant issues surrounding NWGFs alone.

5.0 General Observations

One. The national market appears to have moved substantially toward the proposed 92% AFUE level without it being mandated by a standard. The chart below shows that more than 50% of gas furnaces on the national market are already above 90% AFUE, 42% of which are above 92% AFUE (U.S. Energy Information Administration, Proposed efficiency standards may eliminate noncondensing gas furnaces, 2015).

(Over, please)

[1] Weather stations are designated according to the 3-letter IATA code for the nearest airport.

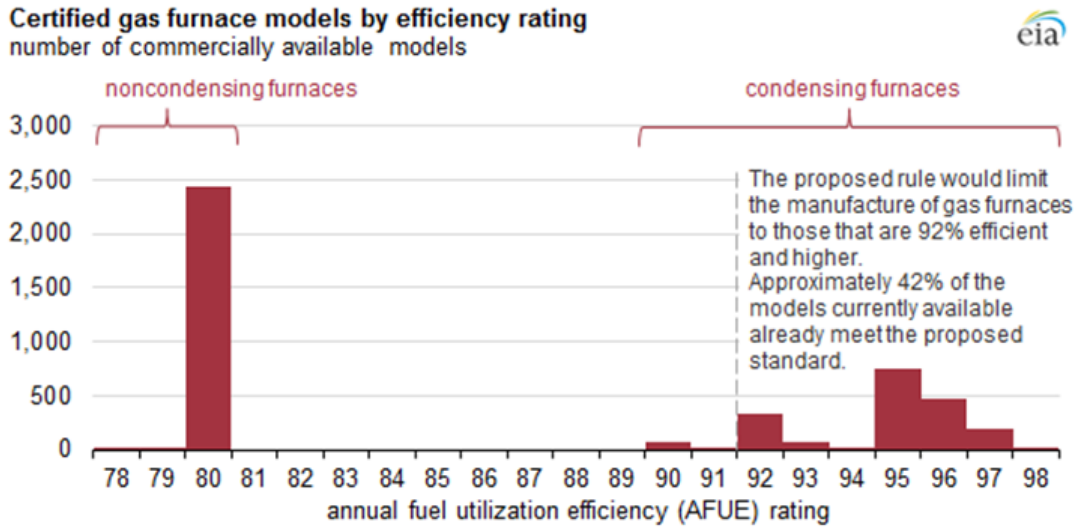

Figure 1: Commented distribution of residential gas furnaces by efficiency

These data can support the position that the standard is not needed, because where the higher efficiencies make economic sense, they are already being adopted by consumers. Government intervention would therefore appear unnecessary.

Two. A lack of product differentiation and consumer choice occurs as the range of efficiency improvements narrow above 90% AFUE. A case can be made that the proposed standard is limiting the furnace products offered to U.S. consumers and in fact, while well-intentioned, the DOE may be inadvertently picking winners and losers. This issue was a major concern to industry when Canada raised their minimum standard from 78% AFUE to 90% AFUE, effective in 2012. Canadian industry was worried then that the product itself would start to become a commodity to the consumer and thus, many small- and medium-sized furnace manufacturers would go out of business. Also, this ruling could negatively impact small businesses owners and installers that deal exclusively in non-condensing furnaces.

Three. Increased costs of minimum efficiency gas furnaces, particularly in the retrofit market where the switch from non-condensing to condensing furnaces require changing the flue and providing a condensate drain, make fuel-switching (using split-system or mini-split heat pumps) an attractive alternative to consumers on a cost, rather than performance basis. A switch from gas to electricity may however *increase* source emissions and source energy consumption due to the losses in generation, transmission and distribution of electricity. This is particularly true if resistance-only furnaces are chosen, or, in the case of heat pumps, in regions with very cold weather where heat pumps don't function well and built-in backup resistance heaters are triggered often. The resulting increased emissions and source energy use are contrary to the stated goals of the legislation that provides the basis for efficiency standards.

DOE contends in its analysis that some fuel switching will occur, but that the rule overall will remain beneficial. It is our opinion that the DOE analysis is optimistic in this respect.

6.0 Findings regarding LCC assumptions, inputs, & method

One. Over one hundred input parameters to the spreadsheet are modified or adjusted using probability distributions. The researchers who built the spreadsheet often used their professional judgement in determining the distribution's shape and values, and did not justify it with a source. The DOE allows this based on their (subjective) right to "deliberative process." While we did not have the resources to attempt to refute each assumption, we identified several that were particularly questionable, and are addressing them below. We are not addressing distributions that do not influence the result significantly. The latter applies for example to the new construction vs. retrofit percentage: DOE uses 25/75, whereas California has a ratio closer to 15/85.

Two. The DOE's method to determine furnace and installation first cost is very complex and draws on a very large number of input parameters, including a teardown analysis, manufacturer input, and economic literature. There are any number of general issues with this approach – teardown analysis may not account for innovation, advances in manufacturing, and changes driven by yet-unknown future value- or performance-engineering; manufacturer input may be biased; economics not being a "hard" science, literature and methods will vary depending on the source. In addition, there are regional differences that were not properly accounted for, and have significant impact on the alleged savings figures.

Furthermore, it appears that the cost of asbestos removal in retrofitted homes is largely ignored in the DOE analysis. We conducted an informal survey of asbestos abatement contractors, and learned that the added cost can range approximately from $250-$1,000 depending on site conditions. In addition, asbestos abatement causes delays, inconvenience, and safety concerns, which likely results in additional fuel switching.

Three. The DOE likely overestimates the lifespan on the typical gas furnace at 21.5 years in their current LCC analysis. In Canada, when the Energy Efficiency Branch of the British Columbia Ministry of Energy and Mines proposed an Annual Fuel Utilization Efficiency (AFUE) ≥ 92% in January 2014, their modeling assumption included a product lifetime of 15 years, six-and-half years less than the DOE uses in its NOPR analysis. Life Cycle Cost significantly increases with shorter product lifetimes.

Four. The DOE uses questionable values for marginal electricity prices in California in their LCC analysis. In 2015-$, prices in the LCC range from $0.17/kWh to $0.19/kWh. Actual tier 2 residential prices for example for the San Diego region are $0.39/kWh, or about *double* the DOE's value (SDG&E, 2016). We were unable to obtain clarification if the DOE values are supposed to constitute *average* marginal electricity costs (which would be lower than actual marginal cost), or how the DOE figures were devised. Incorrect energy cost assumptions of the magnitude shown above would essentially invalidate the DOE's LCC results; clarification is therefore strongly advised.

Five. DOE's product price trend assumptions and calculations are questionable. The product price trend as calculated by the DOE uses experience rates derived from

producer price indices (PPI) for warm air furnaces, with data from the BLS, that was then extrapolated (TSD Appendix 8C). The rates are a regression on actual furnace data. The method appears to be applied correctly. However, there are some issues, notably:

1) It appears that the DOE has not disaggregated the PPI data by condensing and non-condensing furnaces. Non-condensing furnaces are mature and the learning rate should be near 0; the rate should be different for condensing furnaces. Also, the majority of the historical data from 10 years or longer ago is likely made up of non-condensing furnaces. It is not appropriate to extrapolate that into the future, where condensing furnaces would be used exclusively if the DOE rule is enacted.
2) DOE appears not to have normalized the data by furnace capacity (in Btu/hr), nor researched the respective sensitivity. It is probable that normalization would change learning rates, because cost per Btu/hr goes down as furnaces get larger, and innovation may progress differently with size. How that impacts result depends on the home mix and is not known.

Six. For new construction, the DOE contends that payback is immediate, due to the first cost for the higher efficiency option being lower. This contradicts SoCalGas figures for production housing, where the installed cost for a 92% furnace over an 82% furnace is higher by $385, $495 and $551 for 40, 60 and 80 kBtu/h respectively in California:

40,000 btu/hr	0.82 AFUE	$2,303
	0.92 AFUE	$2,688
	0.95 AFUE	$2,834
60,000 btu/hr	0.82 AFUE	$2,362
	0.92 AFUE	$2,857
	0.95 AFUE	$3,501
80,000 btu/hr	0.82 AFUE	$2,426
	0.92 AFUE	$2,977
	0.95 AFUE	$3,907

Figure 2: Production housing first cost for installed furnaces, SoCalGas territory, per our internal sources

The DOE results appear to draw from the fact that high efficiency furnaces can be vented horizontally, and therefore a vertical buildout with roof penetration is not required. This is not correct for California, where flues are almost always built vertically, no matter the technology, and regardless of whether the furnace is installed in the attic or in an attached space such as a mechanical closet or the garage.

Seven. DOE uses outdated price forecasts for energy prices. DOE uses the AEO 2015 (U.S. Energy Information Administration, American Energy Outlook, 2015). In comparison, AEO 2016 (U.S. Energy Information Administration, American Energy Outlook, 2016) anticipates lower natural gas prices. The LCC savings that DOE estimated using AEO 2015 would be reduced and payback times would increase accordingly.

7.0 Findings regarding regional impact

Notwithstanding other concerns, the DOE spreadsheet was used "as is", and the results were narrowed down to California, and then Southern California, to assess the potential regional impact. We began with "calibration" (i.e. rerun the spreadsheet "as is" to confirm DOE results) and it was successful.

The results of the regional impact study are shown in the table on the following page. Numerical results are limited to residential NWGF, which represent 95% of the market that this rulemaking applies to.

The region selection was made by filtering for weather station in the Building Sample (RECS database) tab. The California calculations consider buildings that use the following weather stations (by IATA 3-letter airport code): BFL, BLH, EKA, FAT, LAX, MHS, PRB, RBL, RDD, SAC, SAN, SCK, and SFO. The Southern California calculations consider buildings that use the following weather stations: LAX, SAN, BLH, BFL, and FAT. The DOE LCC also contains edge case results for commercial buildings that use residential furnaces. However, this does not apply to California, as the regional filtering eliminates all these cases. The results shown here are therefore exclusively residential situations.

The table on the next page shows average LCC savings, simple payback period, and average payback period for the split standard thresholds from 55 kBtu/hr to 75 kBtu/hr. Higher threshold results are omitted due to low building sample size (< 10 samples) for the large furnace category. AEO 2016 was selected in the energy price forecast dropdown provided by DOE in the LCC spreadsheet. An AFUE of 92% was assumed for the large furnace categories.

All regions specified by DOE are included as well as our Californian cases:

1) "National", "North", and "Rest of Country" NWGF results are from the default LCC spreadsheet but with one modification: the selection of AEO 2016.
2) "California" and "Southern California" results are similar to those above but with the buildings samples filtered to those locations.

Colors range from red to green, from least to most desirable values, respectively.

As shown in the table below, average and simple payback period are consistently worse in California than in the Rest of Country group. California has payback periods that are approximately double those for the Rest of Country group.

We consider an average payback period of 10 years or less fair for consumers but that is not achieved for California for any of the thresholds shown. In our opinion an average payback period of 10 years is a reasonable goal considering the assumed (optimistic) average furnace lifetime is 21.5 years, and that the average single family home ownership period in the Western United States is 13 years[2].

[2] http://www.nahb.org/en/research/housing-economics/special-studies/archives/how-long-buyers-remain-in-their-homes-2009.aspx

Metric	Location	Split Standard Threshold [kBtu/hr]				
		55	60	65	70	75
Average Savings [$]	National	$629	$662	$621	$637	$637
	North	$607	$669	$607	$621	$610
	Rest of Country	$644	$654	$638	$656	$677
	California	$383	$715	$260	$281	-$37
	Southern California	$3	$229	$169	$187	-$5
Simple Payback Period [yrs]	National	6.7	6.6	6.8	6.7	6.6
	North	7.3	7.2	7.3	7.2	7.0
	Rest of Country	5.3	4.9	5.0	4.8	5.0
	California	10.4	7.7	11.6	11.0	11.8
	Southern California	19.0	11.0	13.8	11.4	12.5
Average Payback Period [yrs]	National	11.7	10.7	10.0	10.1	10.0
	North	10.6	10.1	10.4	10.5	10.6
	Rest of Country	12.5	11.3	9.6	9.7	9.2
	California	21.3	17.2	19.4	20.5	24.4
	Southern California	26.1	21.7	16.3	17.3	21.0

Assumptions: AEO 2016; 92% AFUE for large furnace category; residential buildings only for California due to sample size; results omitted when there are < 10 samples above the threshold

Figure 3: Regional LCC NWGF results

8.0 Conclusions

Given the limited time, resources and impending comment deadline, NegaWatt could only address a few of the many aspects of this complex and long-running rulemaking. Nevertheless, many serious concerns about the rulemaking in general and about the LCC analysis in particular continue to be issues that are unaddressed in the rulemaking documents provided by the DOE. The recurring concerns that continue to go unaddressed in the NOPR, NODA, and now SNOPR, does not yield a high confidence in the accuracy of the presented results.

If the rule is imposed with the newly proposed split standard, the rule would appear to result in major undue negative impact on customers in Southern California, and many other customers in mild climates across the nation. Using DOE's own data and methodology, the economics for this significant group of customers are highly unfavorable, while also inadvertently increasing the net source energy and emissions from increased potential fuel switching.

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