Attachment F to the Comments of

AGA, APGA, NPGA, Spire, and ONE Gas

Docket Number EERE-2021-BT-STD-0027

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Attachment F

Commercial Water Heater LCC Model Technical Issues Walkthrough

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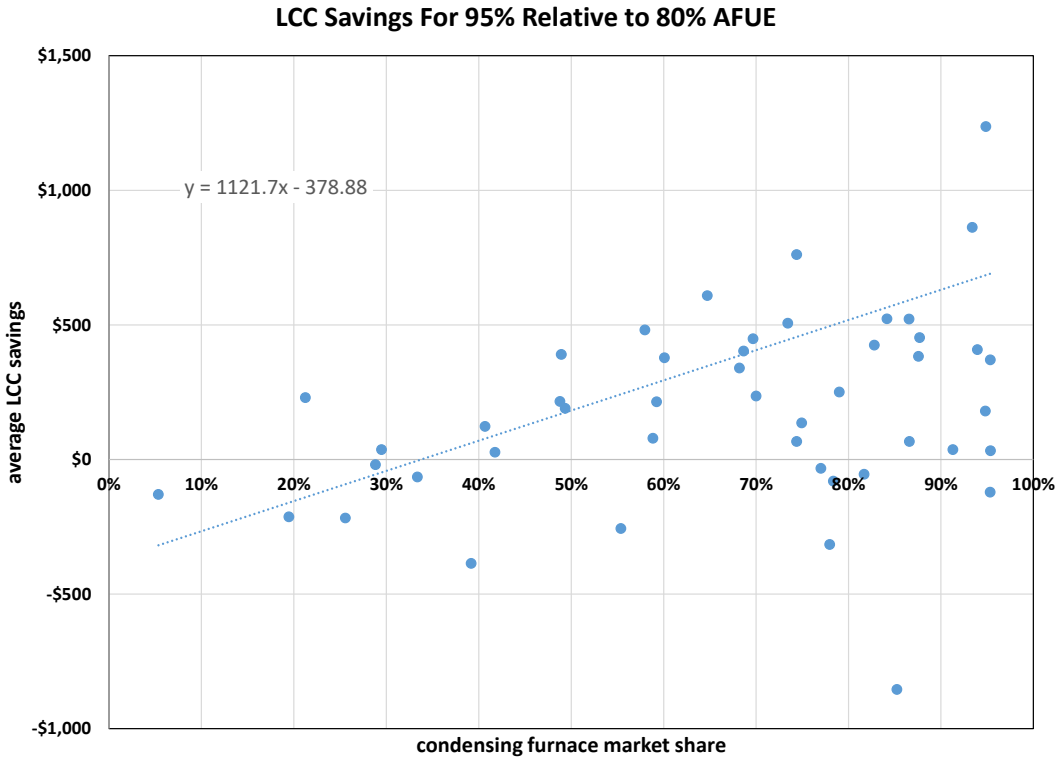
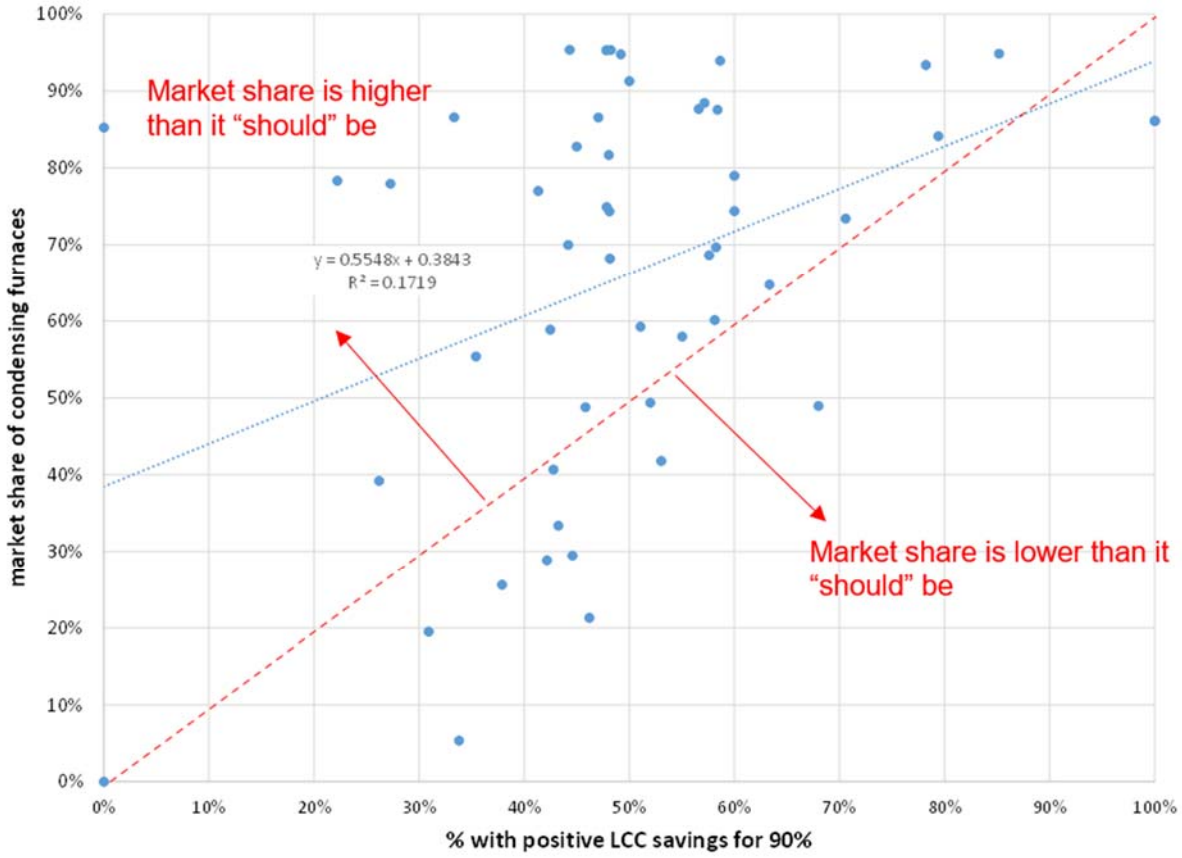
Random Assignment of Base Case Efficiency

DOE has attempted to make the case that this is "ok" and that consumers actually do not consider economics when making these decisions. DOE's own residential furnace model actually demonstrates quite effectively that this is not the case. By looking at market share of condensing furnaces in each region vs. LCC savings of using a condensing vs. a non-condensing furnace a clear relationship emerges. [Note that this analysis was done by forcing all consumers everywhere to choose an 80% efficient furnace so that the savings associated with going from that to a higher efficiency product could be evaluated.]

The clear trend (which also exists if you compare 80% AFUE to 90, 92, or 98%) indicates that according to DOE's own model and the market share data consumers do in fact respond to good, or bad, economics. Note that adjusting what percentage of consumers are rule affected does not account for this. The market shares in certain regions are higher than others because individual consumers elected to adopt high efficiency products, or not, based at least in part on their individual economics. Simply adjusting what percentage of consumers are rule affected is the equivalent of saying that a consumer who has almost no incremental cost increase for going to high efficiency has the identical chance of adopting high efficiency products as a consumer that has a complicated venting and installation case where first costs are many thousands of dollars higher.



In addition to demonstrating that consumers do respond to economic incentives or disincentives for adoption of efficient technologies. The residential furnace model further shows that consumers overvalue efficiency improvements rather than undervaluing them. The figure below shows condensing furnace market share vs. the percentage of cases where LCC savings are positive. If consumers, on average, correctly considered economics the percentage of cases where LCC savings are positive should be equal to market share in that region. If market share is higher than this, consumers are biased toward adopting efficient products beyond what can be explained by economics and this is precisely what we observe. Consumers do not perfectly consider economics, but they do consider economics in these decisions and they systematically overvalue high efficiency options. At least that is the case in the DOE model.



Because residential consumers are likely to be the least sophisticated with respect to economic calculations, it is reasonable to assume that commercial customers are at least as likely to consider economics of their decisions. There are a couple of simple and obvious things that could/should be done to account for this. First, cases where there would be an extremely negative outcome of a standard cannot reasonably be expected to have adopted that much more expensive solution in the absence of a rule, these consumers should be considered to be affected by a rule. Similarly, consumers with an extremely short payback period and correspondingly good economics associated with adoption of higher efficiency products cannot reasonably be expected to be affected by a rule.

Without changing anything in the model, analysis of the output LCC savings and simple payback periods shows that excluding extremely good economic cases by eliminating cases with low payback periods results in substantially reduced LCC savings.

Product	Average LCC savings (baseline DOE model)	Average LCC savings (payback times <3 years excluded)
CGIHWSB (TSL 3)	$1047	$883
CGITWH (TSL 3)	$63	**-$55**
CGSWH (TSL 3)	$301	**-$48**
RDGSWH (TSL 3)	$90	**-$19**

Given that consumers actually do consider economics, however imperfectly. It is not reasonable to assume that even those with extremely short payback periods would be affected by a rule and it is even more unlikely that those with extremely long payback periods would be unaffected by it. Even applying the most simple-minded approach to reflect consumer's consideration of economics in decision making, where 100% of consumers voluntarily adopt equipment with negative payback period, 90% of consumers voluntarily adopt when payback time is less than 1 year, 80% at 2 years, etc. until all consumers are affected by the rule for 10+ year payback times yields dramatically different results.[1]

Product	Average LCC savings (baseline DOE model)	Average LCC savings (allowing for minimal economics based decisions)
CGIHWSB (TSL 3)	$1047	$892
CGITWH (TSL 3)	$63	**-$181**
CGSWH (TSL 3)	$301	**-$106**
RDGSWH (TSL 3)	$90	**-$121**

Failure to consider uncertainty or considering it arbitrarily

The Commercial Water Heater LCC model is built to be a Monte Carlo simulation. The purpose of a Monte Carlo analysis is specifically to deal with cases where multiple inputs in a complicated situation are uncertain. But, the quality and accuracy of a Monte Carlo analysis is inherently dependent on the input assumptions and probability distributions used as inputs. DOE fails to include uncertainty in some cases where uncertainty is known to exist and uses arbitrary assumptions to account for it in other cases. This is particularly problematic in the current case because DOE is proposing standards with LCC savings that are a very small percentage of the total life-cycle costs. Any error or omission could be

[1] Note that this was done by: 1) forcing all consumers to be affected by the rule, 2) determining whether or not a consumer is affected by the rule using the linear function described above where the probability of voluntary adoption is 100% for cases with negative payback period with probability decreasing by 10% for every additional year of payback period, and then 3) adjusting the resulting LCC savings to match the % not affected given by DOE.

reasonably expected to completely eliminate the theoretical savings under the rule.[2] Further, the use of averages that do not consider extremes serve to eliminate cases where economic outcomes would be extremely negative.

The list of issues here is not exhaustive but serves to illustrate a subset of the most obvious problems.

1) Venting – DOE has included a variety of inputs in the cost of venting. One of these is a probability of "Extraordinary Venting Costs". The probability used is 2% and the result of a determination (randomly) exists is that an extra venting cost multiple of between 2 and 3 is used. The TSD does not discuss the origin of either the probability of extraordinary venting costs or their magnitude. The inclusion of this factor is likely completely justifiable, but its application here is arbitrary.
   There are other assumptions applied during the calculation of venting costs that, again, are meant to deal with things that are certainly present and should be accounted for, but the values themselves appear to be arbitrarily assigned by DOE. For example: 25 percent of commercial buildings built prior to 1980 were assumed to have a masonry chimney and 25 percent of these are required to be relined. There is no associated reference for either value. Similarly, the number of elbow bends are numbers assigned by DOE with no referenceable source or field observation.
2) The costs associated with labor, for venting or any other part of installation, have inherent uncertainty, particularly over time, and this uncertainty is not dealt with at all.
3) Energy costs – These obviously have a material impact on the economic outcomes of efficiency standards. Future energy costs are known to be uncertain, the uncertainty has been quantified (AEO retrospectives for example), and the uncertainty is ignored. Note also that the AEO forecast has historically projected systematically high prices for future energy costs which, if accounted for reasonably, would likely completely eliminate LCC savings.
4) Equipment Lifetime – "DOE assumes that the lifetime distribution for a class of CWH unit is the same within an equipment category, across all efficiency and standby loss levels." Given that different efficiency requirements drive different materials choices, thickness, manufacturing processes, etc. and cause different levels of condensation and acid exposures this arbitrary assumption does not seem reasonable. It is worth mentioning that in section 83.3.1 DOE apparently does consider the lower reliability of heat exchangers in condensing vs. non-condensing units. However, they also assume, without reference or logic, that the cost of heat exchanger replacement is one third of the total water heater replacement cost. It seems just as likely that this type of failure will cause a need for complete replacement and, the added negative economic impact of more frequent equipment outages on the business operation is not considered.
5) Equipment Costs – No uncertainty or variable is considered in equipment costs either now or in future years. Uncertainty in underlying assumptions is also not considered. For example, markups on equipment are considered and are considered to be different for new vs. replacement, or commercial rather than residential installations, but within any of these categories there is no variability.
6) Other arbitrary assumptions

[2] The range of LCC savings is between 0.58% and 1.35% of LCC costs for the various product types at the proposed TSL.

a. DOE assumed the material cost of repairs was 50 percent of the sum of the identified component costs for each system.
b. Vent sleeving was included in 50% of instances where the system had no elbows and length of less than 30 feet.
c. Triangular distributions with arbitrary parameters were used for vent length.

Note that these and myriad other arbitrary assumptions may not have large effects on LCC savings, but given the extremely small savings upon which DOE is trying to justify a rule, the bar for getting the input distributions right is high.