Attachment C to
Comments of APGA, et al.
Docket No. EERE–2018–BT–STD–0018
RIN 1904-AE39
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**Attachment C**

Comments of AHRI

(July 10, 2015)

AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE
we make life better™
2111 Wilson Boulevard Suite 500 Arlington VA 22201-3001 USA
Phone 703 524 8800 | Fax 703 562 1942
www.ahrinet.org

July 10, 2015

Ms. Brenda Edwards
U.S. Department of Energy
Building Technologies Program, Mailstop EE-5B
1000 Independence Avenue SW
Washington, DC 20585-0121

**Re**: Proposed Rule Energy Conservation Standards for Residential Furnaces;
Docket Number EERE-2014-BT-STD-0031

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Dear Ms. Edwards:

The Air-Conditioning, Heating, and Refrigeration Institute (AHRI) is the trade association representing manufacturers of air-conditioning, space heating, water heating and commercial refrigeration equipment. The AHRI member companies that manufacture residential gas furnaces account for practically all residential gas furnaces that are sold and installed in the U.S. We submit the following comments in response to the Department of Energy's (DOE) notice of proposed rulemaking (NOPR) regarding amended efficiency standards for residential non-weatherized and mobile home gas furnaces issued in the March 12, 2015 *Federal Register*. 80 Fed. Reg. 13,120.

AHRI recognizes the importance of using energy efficiently and the importance to our nation of product efficiency standards that save energy and money for American consumers. Since the passage of the National Appliance Energy Conservation Act of 1987, our furnace manufacturer members have worked continuously to include models at the highest levels of efficiency as part of expanded product lines that provide cost effective choices to meet the diverse heating needs of the U.S. Even though the federal minimum efficiency standard for residential furnaces has been essentially unchanged since 1992, today one out of every two residential furnaces shipped by our members is a condensing model utilizing the most efficient technology currently available.

As a general principle, AHRI supports the establishment of cost effective minimum efficiency standards for residential heating, cooling, and water heating equipment and we have been involved in a variety of ways to promote the establishment of such standards. Our involvement in those efforts will continue. However, in the present case, we cannot support the proposed revised minimum 92% AFUE standard for non-weatherized and mobile home residential gas furnaces. Our review of the NOPR and associated Technical Support Document (TSD) has identified significant errors and invalid assumptions that lead us to conclude that the proposed revised standard is not economically justified. Furthermore, the errors in the process for this rulemaking and the analytical tools used for the process are so significant that no revision to the existing minimum AFUE standard is justified.

## SUMMARY OF COMMENTS

Our comments on the NOPR and related TSD are presented in three general sections: Legal Issues and Concerns; Analytic Methods and Economic Analysis; and Technical Concerns. As part of our efforts to review and respond to the NOPR, we contracted with Shorey Consulting, Inc. to review particular aspects of the NOPR analysis and TSD. The information provided to us by Shorey Consulting, Inc. makes up the bulk of the comments provided in the Analytical Methods and Economic Analysis section of our comments. Also, in cooperation with the Air Conditioning Contractors of America (ACCA) and the Plumbing, Heating, and Cooling Contractors Association (PHCC), Shorey Consulting conducted a survey of contractors to gather information on actual installation costs for residential gas furnaces. (Appendix A is a report on the survey results.) On May 29, 2015, we also submitted shipment information for on the percentage of condensing gas furnaces shipped in the years 2010 through 2014, which is currently available in the rulemaking docket.

Specifically, AHRI's primary concerns with the NWGF and MHGF standards proposed in the NOPR include:

- The rulemaking violates statutory requirements that prohibit DOE from applying amended standards to a product with respect to which other new standards have been required during the prior 6-year period
- DOE has failed to provide the required Department of Justice competitive analysis determination in a timely manner and to adequately assess the impact on small businesses;
- The rulemaking violates statutory and DOE's own requirements by issuing substantive standards before first determining the final applicable test procedure that would measure compliance, and impermissibly alters the measured efficiency of NWGF and MHGFs;
- DOE has failed to accurately assess relevant market and consumer behavior, including modeling logic that makes such behavior random rather than reflecting any form of economic rationality;
- DOE has conducted the statutorily required cost-benefit analysis in a imbalanced and unfair manner that systematically overstates benefits and understates costs, and that is outside of its statutory authority in both the nature and extent of its application, leading to the erroneous conclusion the proposed standard is economically justified;
- The use of incremental markups for wholesalers and contractors despite clear evidence that the incremental markup concept has no foundation in either theory or fact;
- The use of an unrealistically low consumer discount rate when consumers are known to be unable to meet emergencies from cash or savings and the actual marginal source of funds is high interest debt;
- An incorrect analysis of the installation cost for furnaces when survey data of actual contractors shows results two or more times DOEs estimates;
- DOE's reliance upon manufacturing cost increases that are 35-45% too low for known, in production designs;
- The use of future manufacturing cost reductions based on projected savings from "learning" when actual cost data do not support such effects;

- Overestimations of the amount of time that consumers live in their homes and, therefore, the amount of energy savings they will receive from improved furnaces;
- Reliance on dubious results for a wide variety of variables throughout the individual and national life cycle cost analyses; and
- Incorrect separation of the assessment on manufacturers of the furnace and furnace fan analysis in direct contradiction of the assumptions and logic of the manufacturers impact model.

The end result of the above issues, as well as others identified elsewhere in the comment letter, is a proposed 92% AFUE standard for furnaces that:

- Will not result in savings of 2.78 quads but something less than 1.7 quads;
- Will not result in positive life cycle costs for either individuals or for the economy as a whole but rather will result in negative present value of approximately $300 per individual and $8 billion for the economy as a whole;
- Will result in 10-20% of homes being forced to switch from gas furnaces to electric heat pumps because venting of a condensing gas furnace is difficult to impossible; and
- Will result in significant harm to manufacturers as the combination of gas furnace and furnace fan standards stress the technical and financial capabilities of manufacturers.

The proposed standard does not meet DOE's statutory obligations as to economic justification of the standard and is outside of DOE's statutory authority. As a result, no change in the standard is justified.[1]

## LEGAL ISSUES AND CONCERNS

This rulemaking: (1) Violates section 6295 m(4)(B) of the Energy Policy and Conservation Act (EPCA), which prohibits application of amended standards to a product with respect to which other new standards have been required during the prior 6-year period; (2) Fails to provide the required Department of Justice competitive analysis determination in a timely manner and to adequately assess the impact on small businesses; (3) Violates EPCA by issuing substantive standards before first determining the final applicable test procedure that would measure compliance, and impermissibly alters the measured efficiency of NWGF and MHGFs; (3) Fails to accurately assess the relevant market and consumer behavior in the economic justification analysis (4) Conducts the required cost-benefit analysis in a imbalanced and unfair manner that systematically overstates benefits and understates costs, leading to the erroneous conclusion the proposed standard is economically justified; and (5) Performs a fundamentally flawed cost-benefit analysis outside of statutory authority both in the nature and extent of its application.

### DOE's Proposed Energy Efficiency Standards Violate EPCA's Statutory Requirements.

As DOE discusses extensively in the NOPR, the furnace fans rule that was published on July 3, 2014, and that requires compliance as of July 3, 2019, "directly impact(s) the design and manufacturing of the same product (i.e. residential furnaces)" and "these requirements are

[1] "No regulation is appropriate if it does significantly more harm than good." *Michigan v. EPA*, _ U.S. _ (June 29, 2015)(slip op., at 7).

impacting the same product in a very short period of time."[2] It was for this very reason that when Congress amended EPCA in 2007 through the Energy Independence and Security Act of 2007 (EISA 2007), mandating that DOE establish energy conservation standards or an energy conservation metric for electricity used for purposes of circulating air through duct work[3] (furnace fans), it at the same time it provided that:

> A manufacturer shall not be required to apply new standards to a product with respect to which other new standards have been required during the prior 6-year period.

42 U.S.C. 6295(m)(4)(B). These provisions were revised in EISA 2007 sections 304 and 305, which revised the furnace fan standards process under 6295(f)(4)(D) of EPCA to substitute "not later than December 31, 2013, the Secretary shall" for "the Secretary may," making the furnace fans standard mandatory by the end of 2013, and provided the prohibition on multiple new standards within a six year period for the same product.[4] It is very telling that DOE has discussed the overlapping nature of the furnace fans rule and the proposed furnace rule in this NOPR without ever mentioning the prohibition contained within 6295(m)(4)(B).

Given the extensive costs and concerns that DOE outlines throughout the NOPR, specifically at pages 13184-13185, it is unreasonable to conclude that somehow instead of the six year separation mandated in the statute Congress intended only a two year period between the compliance requirement date of the furnace fan rule and those of the amended furnace efficiency standards for the same product, as DOE is proposing here. The congressional intent behind the simultaneous adoption of the furnace fan standard mandate and 6295(m)(4)(B) is clear: to protect manufacturers from the cumulative costs DOE sets forth in the NOPR, by prohibiting DOE from applying new standards to that product until six years after the compliance date for a separate requirement for the same product (here the furnace fans rule). Additionally, because the entirety of section 6295(m) was added through EISA 2007, Congress was well aware of the potential conflict between the five year compliance timeframe for these products and 6295(m)(4)(B)'s requirements, as illustrated by the lead in language to the relevant compliance date provisions "Except as provided in subparagraph (B) . . . ."

The plain meaning of EPCA's statutory provisions thus establishes that the compliance date for amended residential furnace standards cannot be before July 3, 2025. Because DOE proposes a compliance date of January 2021 in the NOPR, and conducted the entirety of the NOPR analysis based upon that compliance date, both the proposed effective date and supporting analysis is improper and must be revised.

Because DOE has failed to address this issue in the NOPR, AHRI can only guess at DOE's reasoning behind the proposed compliance date. While AHRI is hesitant to make such

[2] 80 Fed. Reg. at 13,122; 13,184.
[3] 42 U.S.C. section 6295(f)(4)(D).
[4] DOE acknowledges throughout the NOPR that the furnace fans standard and furnace efficiency standards proposed in the NOPR will be applicable to the same product. *See, e.g.* 80 Fed. Reg. at 13,122 ("Today's proposed standard and the furnace fans standard impact the same product (i.e. residential furnaces), affect the same group of manufacturers, and go into effect in a similar timeframe" and 13,184 ("First, both this energy conservation standard NOPR and the energy conservation standards furnace fan final rule will directly impact the design and manufacturing of the same product (i.e., residential furnaces . . . Third, these requirements are impacting the same product in a very short period of time.")).

assumptions, it may be that DOE views the settlement agreement approved in April 24, 2014[5] as somehow compelling this result. This is not the case. While the settlement agreement and related Court Order required DOE to use its "best efforts" to *publish* a NOPR within one year of the agreement, it said nothing about the compliance date of the revised furnace standards. Thus, the settlement agreement is entirely in line with the provisions of 6295(m)(4)(B), which refer not to the publication of the rule, but the date that standards are required. An extension of the compliance date in this manner is well within DOE's legal authority, based upon the language of 6295(m)(4)(B) as well as its inherent authority. *See, e.g. CAB v. Delta Air Lines, Inc.,* 367 U.S. 316, 329 (1961) (agencies have power to postpone effective dates).

DOE's description within the NOPR of the furnace fans rule, the proposed furnace standards and other regulatory requirements supports the plain meaning of section 6295(m)(4)(B) that "required" as used in 6295(m)(4)(B) refers to the standards' compliance date. Throughout the NOPR, DOE uses the term "require" within the NOPR in the future tense, rather than present tense, referring to "requirement" as the point of the future compliance date of the rules, rather than a current requirement based upon the mere publication of a final rule.[6] For example (emphasis added):

- Page 13,130: "The standards established by the June 2011 direct final rule for the non-weatherized gas furnaces and mobile home gas furnaces *will not go into effect*, and thus, the standards established for these products in the November 2007 final rule *will require*" compliance beginning on November 19, 2015."
- Page 13,141 "The baseline AFUE levels analyzed represent the minimum AFUE standards that *will be required* starting on November 19, 2015, as a result of the November 2007 final rule."
- Page 13,142 "Because the furnace fans energy conservation standards *will likely require* that NWGF incorporate two stage performance, DOE has included two-stage as the design for NWGF in this analysis."
- Page 13,144 " . . . the 2014 furnace fans rule *will set* a level that effectively requires the use of this technology before the compliance date of this residential furnaces rulemaking."
- Page 13,147 "As noted in section IV.C, the furnace designs incorporate furnace fans that meet the standard that *will take effect* in 2019."

[5] *American Public Gas Association, et. al. v. Department of Energy, et. al.,* No. 11-1485 (D.C. Cir. Filed Dec. 23, 2011).

[6] This is entirely appropriate, even in light of the 2nd Circuit decision in *NRDC v. Abraham*, 355 F.3d 179 (2d Cir. 2004). First, *Abraham*'s analysis was limited to section 6295(o)(1), and did not address 6295(m)(4)(B), a different provision with clear congressional intent expressed in 6295(m) as a whole. Secondly, in *Abraham*, DOE itself supported the view that effective date meant the date after which a manufacturer must comply with an energy conservation standard, which is also the approach taken in the current NOPR, as described above. Third, *Abraham's* analysis is flawed, as it erroneously concludes that the terms (or their cognates) "publish," "establish," and "prescribe" are synonymous. *See Abraham*, 355 F.3d at 196. But where Congress uses distinct terms, those distinctions must be acknowledged. *Russello v. United States*, 464 U.S. 16, 23 (1983) ("Where Congress includes particular language in one section of a statute but omits it in another section of the same Act, it is generally presumed that Congress acts intentionally and purposely in the disparate inclusion or exclusion.") (internal quotation marks and citation omitted). In any case, as noted above, DOE is not bound by the analysis of an entirely different statutory provision with a different statutory purpose.

- Page 13,169 "When the standard *goes into effect*, an additional 21 percent of NWGF shipments and 29 percent of MHGF *will require* secondary heat exchanges . . ."
- Page 13,185 " . . . the furnace fan standard, for *which compliance will be required* in 2019."
- Page 13,173 "For the cumulative regulatory burden analysis, DOE looks at other regulations that could affect NWGF and MHGF manufacturers that *will take effect* approximately three years before or after the 2021 compliance date of amended energy conservation standards for NWGF and MHGF."

In particular, on page 13,173 of the NOPR, when noting the cumulative regulatory burden[7], DOE does not refer to the publication date, it utilizes only to the compliance date and provides the relevant regulations by compliance date in Table V.21. While the publication date of each rule is also provided, those dates are irrelevant, as they fall outside of the specific criteria DOE considers for taking regulations into account - those that "will take effect approximately three years before or after the 2021 compliance date of amended energy conservation standards for NWGF and MHGF."[8] It would make no sense for DOE to base the cumulative regulatory analysis in general on compliance dates, yet base the analysis of the most relevant and impactful regulation for the same product on publication dates instead. In fact DOE lists the furnace fans rule in Table V.21 based upon its compliance date. Furthermore, as DOE notes, the industry conversion costs for the furnace rule of $40.6 million are similar to those for the proposed furnace standards ($55 million), totaling $95.6 million. 80 Fed. Reg. 13,123. Just as for the cumulative regulatory burden analysis it is the compliance date that matters, for analysis of the furnace fans rule under section 6295(m)(4)(B) it is the compliance date as well.

Most importantly, DOE must read the term "required" consistently within section 6295(m)(4)(B) itself. That section of EPCA contains two uses of the word "required" within the same sentence, and if "required" within that sentence means the compliance date for any new standards (i.e. the furnace efficiency standards in this NOPR), then it must mean the compliance date for the "other new standards" (i.e. the furnace fan standards) as well. Since the proposed compliance date for the furnace efficiency standards is January 2021 (est.), and the established compliance date for the furnace fan standards is July 3, 2019, the proposed compliance date on the NOPR violates 6295(m)(4)(B).

Even assuming the relevant dates were the publication dates, the furnace fans rule was published on July 3, 2014, and DOE estimates that the furnace efficiency rule will be published in late 2016, which again violates 6295(m)(4)(B), as under that reading DOE could not publish the furnace efficiency standards until July 3, 2020. The only way that the dates set forth in the NOPR can be reconciled in a manner that does not violate EPCA would be to read "required" inconsistently within the same sentence – as meaning the publication date for the furnace fans

[7] DOE's "analysis" of cumulative regulatory burden consists of simply providing a list of the regulations that will be effective within three years of the proposed 2021 compliance date. The costs of only four of the twelve rules are listed, totaling $294 million, with the remaining costs of the eight other rules "TBD." There is no discussion of how DOE analyzed these costs or how they are factored into any of DOE's technical analysis. As described more fully below, DOE's failure to meaningfully consider these direct costs to manufacturers in its cost-benefit analysis stands in stark contrast to its consideration of global emissions outputs and other benefits in its analysis of the proposed standard's economic justification.

[8] 80 Fed. Reg. at 13,172.

rule and the compliance date for the furnace efficiency rule or vice versa. Any such reading would be completely arbitrary and without any legal or common sense basis. As a result, to reconcile EPCA's requirements, the compliance date of the furnace efficiency standards must be revised to be no earlier than July 3, 2025, and DOE's entire technical analysis must be revised to reflect that date as well.

In accordance with EPCA's plain meaning and how DOE has utilized the term "required" elsewhere in the NOPR as described above, manufacturers cannot be "required" to follow the furnace efficiency standards until six years after the furnace fan requirements are effective on July 3, 2019. *Air Line Pilots Ass'n v. FAA*, 3 F.3d 449, 453 (D.C. Cir. 1993) (internally inconsistent agency action is defective).

**DOJ Competitive Determination and Small Business Impact Analysis**

EPCA requires that DOE consider the impact of any lessening of competition, as determined in writing by the Attorney General, that is likely to result from the imposition of the standard (42 U.S.C. 6295(o)(2)(B)(i)(V)) and that the Attorney General shall make a determination of the impact, if any, of any lessening of competition not later than 60 days after publication of the NOPR. DOE is required to publish such determination in the *Federal Register*. 42 U.S.C. 6295(o)(2)(B)(ii). The importance of this factor is clear from EPCA's text, as it is the only one of the seven factors[9] that requires an outside agency determination.

The NOPR was published on March 12, 2015. However, as of July 10, 2015, which is 120 days after publication of the NOPR, the letter from the Attorney General has not been published. This is a clear violation of EPCA and denies stakeholders the opportunity to comment upon the analysis or DOJ's determination. This is particularly important, as four out of the 12 manufacturers identified in the market, or 30 percent of the market, were identified as meeting the Small Business Administration's definition of a "small business" (three domestic manufacturers).[10] DOE's conclusion on this point is somewhat uncertain, and the percentage may be even higher, as the NOPR also states at page 13,172 that there are *five* domestic manufacturers in the industry that qualify as small businesses.

DOE found that the domestic NWGF small manufacturer accounted for seven percent of the listings in DOE's CCMS database, but that 91 percent of its products would fail to meet the proposed standard. The two domestic MHGF small businesses accounted for 32 percent of the listings in the CCMS database, and they have zero product listings that would meet the proposed standard. Additionally, while not addressed in the NOPR, the TSD provides better information about the tremendous negative impact this rule will have on small business:

- Total Conversion Cost as a Percentage of EBIT is 244% greater small businesses than for other manufacturers.

[9] Evaluating whether a standard is economically justified requires that DOE consider six mandatory factors and one discretionary factor: (1) economic impact on manufacturers and consumers; (2) operating cost savings; (3) energy savings; (4) lessening of product utility or performance; (5) impact of any lessening of competition as determined in writing by the Attorney General (not DOE); (6) need for national energy conservation; and (7) other factors DOE considers relevant. 42 U.S.C. § 6295(o)(2)(B)(i).
[10] 80 Fed. Reg. at 13,192

- Capital Conversion Cost as a Percentage of Annual Capex are 506% greater for small businesses than for other manufacturers.

- Product Conversion Cost as a Percentage of Annual R&D are 98% greater for small businesses than for other manufacturers.

(TSD Table 12.6.1). DOE's very tepid small business impact analysis conclusion is that "two small manufacturers will need to develop a condensing product line from scratch" and they "may" face substantially higher costs and "may re-evaluate" the cost benefit of staying in the market.[11] The analysis of these costs is also evidence of DOE's imbalanced overall approach to costs and benefits. Pages and pages within the NOPR are devoted to Social Cost of Carbon (SCC) reductions that cumulatively total a reduction of 0.2 percent relative to the CO2 emissions in the base case without amended standards[12], while small business cost impacts that are 98%, 244% and 506% greater than other manufactures are not even mentioned in the NOPR. These small business impacts are clearly significant, and stakeholders must be allowed to review and comment on DOJ's written determination on this issue, something that because it has not yet been published as required now can only be done through a supplemental NOPR.[13]

In addition to EPCA's requirements, the Regulatory Flexibility Act ("RFA") was designed "to improve Federal rulemaking by creating procedures to analyze the availability of more flexible regulatory approaches for small entities." Pub. L. 96-354, 94 Stat. 1164 (Sept. 19, 1980). The RFA was later amended by the Small Business Regulatory Enforcement Fairness Act of 1996 ("SBREFA"). See Pub. L. 104-121, §§ 201-221, 110 Stat. 847 (Mar. 29, 1996). SBREFA's purposes include safeguarding a vibrant national economy driven by the small business sector by subjecting agency action to judicial review for compliance with the RFA. *Id.* at § 202(1) & (6). Congress also found that "the requirements of [the RFA], have too often been ignored by government agencies, resulting in greater regulatory burdens on small entities than necessitated by statute." *Id.* § 202(5).

The RFA/SBREFA enactments require the preparation of a regulatory flexibility analysis by an agency engaged in a rulemaking, such as the furnace standard NOPR. 5 U.S.C. § 603(a). Such analysis must meet numerous requirements including "a description of and, where feasible, an estimate of the number of small entities to which the proposed rule will apply;" "a description of the projected reporting, recordkeeping and other compliance requirements of the proposed rule;" and "any projected increase in the cost of credit for small entities." 5 U.S.C. § 603(b)(3)-(4) & 603(d)(1)(A). It must include an analysis of alternatives that would reduce the burden of regulation on small entities, including the exemption of small entities from the regulation. 5 U.S.C. § 603(c); see id. § 603(c)(4). *See also generally* 5 U.S.C. § 604 (final reg-flex analysis requirements). DOE's summary overview and brief dismissal of what are clearly devastating small business impacts does not meet these regulatory requirements.

[11] 80 Fed. Reg. at 13,193.
[12] 80 Fed. Reg. at 13,123
[13] This is well within DOE's ability under the April 2014 settlement agreement. "[I]f DOE determines that it requires additional time in order to conduct necessary technical analysis or to consider the comments of parties, then the period for completion of the final rule will be extended accordingly." Settlement Agreement at page 7.

**DOE Violated EPCA's Test Procedure Requirements and its Own Related Regulation on Test-Procedure Timing.**

EPCA requires that any new or amended energy efficiency standard include applicable test procedures. 42 U.S.C. § 6295(r). Energy efficiency standards are required to have applicable test procedures so that manufacturers are not left in the dark as to how compliance will be measured.[14] Additionally, the required economic and energy analyses under EPCA cannot be done properly without a firm grip on the applicable test procedure.

DOE acknowledges the importance of test procedures in the NOPR: "DOE is further required to develop test procedures to measure the energy efficiency, energy use, or estimated annual operating cost of each covered product prior to the adoption of a new or amended energy conservation standard." 80 Fed. Reg. at 13,128. Because understanding how proposed substantive standards will be measured in the real world is a necessary aspect of any EPCA efficiency standard, and because DOE must prove proposed efficiency standards are technologically feasible and economically justified as they will be enforced by DOE, both Congress in EPCA Section 6295(r) and DOE in its Process Rule, respectively, bound DOE to put test procedures in place before the finalization and issuance of proposed substantive rules. *See* 10 C.F.R., pt. 430, sub-pt. C, App. A, Process Rule 7(c) ("Final, modified test procedures will be issued prior to the NOPR on proposed standards.") (emphasis added); *see also Id.,* Process Rule 7(b) ("Any necessary modifications [of test procedures] will be proposed before issuance of an ANOPR [advance notice of proposed rulemaking] in the standards development process."). DOE is bound to follow its own regulations, and simply has not done so in this case. *FCC v. Fox Television Stations, Inc.*, 556 U.S. 502, 515 (2009) ("An agency may not … simply disregard rules that are still on the books. *See also United States v. Nixon*, 418 U.S. 683, 696 (1974)."); see also infra n.15 (collecting additional authorities binding an agency to its own law).[15]

Here, although in the NOPR DOE references a "February 2015" test procedure NOPR, the relevant test procedure was published in the *Federal Register* on March 11, 2015 (80 Fed. Reg. 12,876), only *one day* before the furnace efficiency standard NOPR. As DOE references actual publication dates for all other rulemakings in the NOPR, this hardly seems to be mere oversight. It is also a direct violation of DOE's regulatory requirements as set forth in DOE's own codified Process Rule, and significantly impedes the ability of stakeholders to effectively comment on the proposed efficiency standard.

First, there is no certainty as to how the changes to the test procedure will impact the efficiency standard, both because stakeholders are forced to simultaneously review the two proposed rules, and there is no certainty as to what DOE will adopt as the final test procedure. A single manufacturer may know the issues it identifies with the test procedure, but cannot know what

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[14] *See* 42 U.S.C. § 6291(6) (energy conservation standard is "determined in accordance with the test procedures prescribed under … section 6293"); 42 U.S.C. § 6295(o)(2)(B)(iii) (referencing efficiency standards "as calculated under the applicable test procedure"); 42 U.S.C. § 6295(o)(3)(A) (new or amended standards require the *prior* establishment of the test procedure).

[15] Constitutional notice requirements also stand behind the statutory and regulatory requirements that the "horse" of test procedure definition come before the "cart" of the establishment of energy-efficiency standards. Manufacturers must have adequate notice of the efficiency standards they face. Thus the requirements of EPCA and associated regulations should be read forcefully to avoid constitutional notice problems. *See, e.g., Vergara v. Hampton,* 581 F.2d 1281, 1285 (7th Cir. 1978) (citing *Ashwander v. TVA*, 297 U.S. 288, 341 (1936) (Brandeis, J., concurring)).

other issues will be raised by other stakeholders, let alone which comments DOE will accept or which changes to the test procedure, if any, DOE will make. DOE cannot know this either, until the comment period on the test procedure is closed and DOE has fully reviewed and addressed the comments made. Thus, neither stakeholders nor DOE know what the final test procedure will be that will be used to enforce the furnace efficiency standards. They all can only guess. DOE then is forced to use its best guess as to what the test procedure will be in analyzing the impacts of the proposed efficiency standards. This is precisely the reason behind DOE's requirement in the Process Rule that changes to the test procedure are identified early and is the basis for DOE's commitment to finalize test procedures prior to the NOPR on the related efficiency standards.

Furthermore, it is fundamentally unfair to propose a standard that will be enforced by DOE and FTC in terms of labeling requirements, but that will be measured by some undetermined test procedure. Violations of the efficiency standards, labeling requirements and manufacturer representations all are determined via the finalized test procedure. In this rule, DOE has identified at least five major changes to the test procedure that clearly will not be final until well after the comment period on the efficiency standard is closed. 80 Fed. Reg. at 13,133. The test procedure NOPR identifies several other changes as well. Yet DOE's statement as to which test procedure it is using is entirely unclear:

> DOE must base the analysis of amended energy conservation standards on the most recent version of its test procedures, and accordingly, DOE will use any amended test procedure when considering product efficiencies, energy use, and efficiency improvements in its analysis.

80 Fed. Reg. at 13,132-13,133. If DOE is basing its analysis on the most recent version of the test procedure, it is using the test procedure finalized in July 2013, which will not be the test procedure used to enforce the proposed standards. Thus DOE's conclusion as to the impacts of the rule are to at least some degree theoretical. It is also arbitrary and capricious for DOE to conduct the entire analysis of the efficiency rule using the old test procedure because the rule will be enforced using only the new test procedure. *Air Line Pilots Ass'n v. FAA*, 3 F.3d 449, 453 (D.C. Cir. 1993) (internally inconsistent agency action is defective). If DOE is using the test procedure proposed in the March 11, 2015 NOPR, then all the uncertainty concerns noted above are in play.

DOE, perhaps in an attempt to resolve the consequences of the approach it is has taken, claims any changes to the test procedure will have a "*de minimis*" impact and adoption of the proposed changes "have no statistically significant impact on the AFUE for condensing products." However, there is no such "*de minimis*" exception from EPCA's requirements. "If the Secretary determines that the amended test procedure will alter the measured efficiency or measured use, the Secretary shall amend the standard . . . ." 42 U.S.C. 6293(e)(2). First, DOE cannot read into the requirements a *de minimis* exception that Congress did not include. "[A]n agency literally has no power to act…unless and until Congress confers power upon it." *Louisiana Pub. Serv. Comm'n. v. FCC*, 476 U.S. 355, 374 (1986). If we give the force of law to agencies on matters as to which Congress did not express an intent, "we permit a body other than Congress to perform a function that requires an exercise of legislative power. *Michigan v. EPA*, _ U.S. _ (June 29, 2015)(slip op., at 3, THOMAS, J., Concurring). Second, for all of the uncertainty issues described above, the relevant analysis must be done not just for the proposed test procedure, but in the final analysis adopting the test procedure, because that is the test procedure that will be used to determine compliance with the efficiency standard. It is only after DOE has considered and resolved all comments on the test procedure that the required analysis of the impact on the related standard can be actually determined.

Furthermore, AHRI disagrees that the limited findings DOE has made thus far regarding the impact of the proposed changes to the related test procedure are sufficient. First, the NOPR sets forth five major changes to the test procedure, but does not address all the proposed changes in their entirety – there are more. DOE sets forth a few cautious statements on this issue, including that the changes "would not be expected" to change AFUE ratings, that provisions "were assessed" to have no impact, and that it has "tentatively determined that this amendment to the test procedure would not be substantial enough to merit a revision of the proposed AFUE efficiency levels for residential furnaces."[16] These qualified, tentative expectations and cursory conclusions, provided without any analysis, are not sufficient to meet the requirements of section 6293(e)(1).[17] When rulemaking is subject to public comment, the agency "must … reveal[] for public evaluation…the 'technical studies and data' [if any] upon which the agency relies." *Chamber of Commerce v. SEC*, 443 F.3d 890, 899 (D.C. Cir. 2006) (citation omitted); *see also American Radio Relay League, Inc. v. FCC*, 524 F.3d 227, 236 (D.C. Cir. 2008); *Indiana Sugars, Inc. v. FCC*, 694 F.2d 1098, 1100 (7th Cir. 1982) ("Conclusory formulations based upon ipse dixit are insufficient …. There must be an articulated rational connection between the facts found and the choices made.").

A review of the analysis that DOE provided at the March 26, 2015 public meeting on the test procedure illustrates, notwithstanding DOE's statements in the NOPR, that the proposed changes would alter the measured energy efficiency for both NWGF and MHGF products. DOE's own data showed a .28 to 1.19 percent point higher AFUE based upon the limited testing of 4 models of non-condensing two-stage/modulating furnaces. For condensing furnaces, DOE testing (again, of only 4 models) showed a decrease in AFUE of .08 to 1.5 percent. DOE provides no basis for concluding that these identified changes in AFUE do not "alter the measured efficiency" of these products.

Furthermore, DOE is making these statements about the impact on the proposed furnace standard, which is the one that will be enforced by DOE. This proposed standard also is uncertain, based upon all the stakeholder input to be received during the comment process. Simply put, there is a moving target in both directions when the test procedure is not finalized prior to a standards NOPR and when a final test procedure is not used in the standard's NOPR analysis. There is no ability for DOE in such a situation to meet its obligations under section 6295(e)(1), which requires DOE to determine the "extent" that any "proposed test procedure would alter the measured energy efficiency … of any covered product as determined under the existing test procedure."[18] DOE also did not include the proposed test procedure in the list of

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[16] 80 Fed. Reg. 13,142.
[17] "In the case of any amended test procedure which is prescribed pursuant to this section, the Secretary shall determine, in the rulemaking carried out with respect to prescribing such procedure, to what extent, if any, the proposed test procedure would alter the measured energy efficiency, measured energy use, or measured water use of any covered product as determined under the existing test procedure." 42 U.S.C. § 6293(e)(1)
[18] 42 U.S.C. § 6293(e)(1).

regulatory actions impacting manufacturers of these products. *See* 80 Fed.Reg. at 13,172, despite the fact that manufacturers must test these products to ensure they will continue to comply with either current or revised efficiency standards under the new test procedure, particularly since DOE itself has identified that the proposed changes could affect the compliance of different products with the current standard. This is cumulative testing that must be done at the same time testing must be done not only to comply with the listed regulations on page 13,172, but also with the furnace fans rule and the furnace standards proposed in the NOPR.

Finally, DOE makes an incorrect claim as to the date by which the test procedure must be amended. In the NOPR, DOE claims that the amended test procedure must be amended no later than December 19, 2014, because that is seven years after EISA 2007, which requires that DOE review test procedures at least once every seven years. 80 Fed. Reg. at 13,132. However, the date cited by DOE is December 19, 2014, a date over three months before the test procedure NOPR was proposed. Additionally, in the prior paragraph on page 13,132 DOE describes in detail the amendments to the test procedure that were finalized in July of 2013. DOE does not reconcile these conflicting statements. Based upon the July 2013 date, the next statutorily mandated review date for the test procedure is July 2020. AHRI certainly agrees that if DOE had amended the test procedure by December 2014, stakeholders could have avoided all of the above burdens and uncertainties the Process Rule and EPCA's requirements are designed eliminate. DOE may also determine that it is advisable to amend the test procedure before the next statutorily mandated date, but there certainly no mandate that it be done in any immediate timeframe simultaneous with the proposed furnace efficiency standard. Therefore there is no justification for DOE's simultaneous modifications of the furnace test procedure and standard in violation of DOE's statutory and regulatory requirements.

**The Cost-Benefit Analysis That DOE Performed To Support The Rule Is Contrary To Law.**

EPCA requires that DOE evaluate whether a standard is economically justified by considering six mandatory factors and one discretionary factor: (1) economic impact on manufacturers and consumers; (2) operating cost savings; (3) energy savings; (4) lessening of product utility or performance; (5) impact of any lessening of competition as determined in writing by the Attorney General (not DOE); (6) need for national energy conservation; and (7) other factors DOE considers relevant. 42 U.S.C. § 6295(o)(2)(B)(i). Thus, at EPCA's very core is the performance of a detailed, objective, multi-factor cost-benefit analysis. *See* 42 U.S.C. § 6295(o)(2)(B)(i) ("In determining whether a standard is economically justified, the Secretary shall, after receiving views and comments furnished with respect to the proposed standard, determine whether the benefits of the standard exceed its burdens … to the greatest extent practicable ….”). Yet here, the cost-benefit analysis DOE performed is woefully deficient for the reasons set forth in detail below, including a failure to accurately reflect the market for residential furnaces and consumer choices, and performance of a fundamentally flawed cost-benefit analysis outside of statutory authority plagued by exaggerations of the benefits claimed for the rule while minimizing or overlooking its costs.

***DOE Fails to Adequately Explain a Relevant Market Failure.*** As further explained below in the analysis provided by Shorey Consulting, DOE's cost-benefit analysis was not only lopsided but insufficiently grounded in economic theory. The whole point of imposing mandatory energy-efficiency standards on the marketplace is to try to solve for a market failure. *See, e.g.,* Noah M. Sachs, "Can We Regulate Our Way to Energy Efficiency? Product Standards as Climate Policy," 65 Vand. L. Rev. 1631, 1650-52 (2012); *see also Schurz Commc'ns, Inc. v. FCC*, 982 F.2d 1043, 1053 (7th Cir. 1992) (criticizing the agency (whose order was ultimately found arbitrary and capricious) for leaving "unremarked" an applicable standard requiring "evidence of a market failure"). The EPCA rulemaking factors make this clear by requiring a comparison of operating cost savings to energy savings, in a fashion that will not impose economically inefficient costs on manufacturers, lessen the utility of the underlying products, or reduce competition between manufacturers. 42 U.S.C. § 6295(o)(2)(B)(i)(I)-(V).

***DOE Fails to Account for Consumer Preferences in the Relevant Market.*** EPCA specifically commands that DOE consider "the economic impact of the standard on the . . . consumers of the products subject to such standard."[19] 42 U.S.C. § 6295(o)(2)(B)(i)(I). As explained in greater detail below, DOE's use of a randomized Monte Carlo analysis does not meet this requirement. By ignoring consumer preferences for a products such as non-condensing and condensing furnaces, for which consumers clearly have strong preferences based upon the climate in which they live, their income levels and the space/venting constraints of their homes and current furnaces, DOE is failing to analyze the real-world market for these products. "DOE's current analysis does not explicitly control for heterogeneity in consumer preferences, preferences across subcategories of products or specific features, or consumer price sensitivity variation according to household income." 80 Fed. Reg. at 13,182. Such an approach cannot be the basis for the required economic justification finding. "Not only must an agency's decreed result be within the scope of its lawful authority, but the process by which it reaches that result must be logical and rational." *Allentown Mac Sales & Service, Inc. v. NLRB,* 522 U.S. 359, 374 (1988).

The energy savings DOE claims therefore fail to meet the "substantial evidence" test. Substantial evidence requires DOE to "present on the record such relevant evidence as a reasonable mind might accept as adequate to support a conclusion, taking into account the record in its entirety … including the body of evidence opposed to … [its] view." *S&F Mkt. St. Healthcare LLC v. NLRB*, 570 F.3d 354, 361 n.* (D.C. Cir. 2009) (citations omitted). As to the necessary quantum of evidence an agency is required to deploy to support its factual conclusions, the substantial evidence test is more demanding than the arbitrary and capricious standard. *See American Paper Inst., Inc. v. American Elec. Power Serv.*, 461 U.S. 402, 412 n.7 (1983). DOE may be able to demonstrate a quantity of savings, but if the savings are not based upon any actual, rational choices consumers will make, it undermines every aspect of DOE's analysis, including: price elasticity, demand, fuel switching and shipment information at a bare minimum.

***DOE Fails to Adequately Analyze the Impact of the Proposed Standard on Consumer Subgroups.*** Looking at the impact of this rule in the real world market is also important because it clearly illustrates that the proposed standard will have a disproportionate negative impact on very vulnerable populations, such as seniors and low-income households. In Chapter 11 of the TSD DOE concludes that while senior-only households show similar or higher LCC savings and

[19] 42 U.S.C. § 6295(o)(2)(B)(i)(I). As explained in *Owner-Operator Independent Drivers Ass'n v. Federal Motor Carrier Safety Administration*, 656 F.3d 580, 587 (7th Cir. 2011): "Adherence to this [*State Farm*] rule is essential because it goes directly to the scope of the authority delegated to an agency by Congress; when an agency ignores a mandatory factor it defies a 'statutory limitation on [its] authority.' *United Mine Workers v. Dole*, 870 F.2d 662, 673 (D.C. Cir. 1989). Such an act is necessarily arbitrary and capricious."

shorter PBPs from purchasing more-efficient NWGFs for AFUE standards than the general population; they show reduced LCC savings and longer PBPs from purchasing more-efficient MHGFs than the general population. The impact is even worse for low-income households, which have reduced LCC savings from more-efficient NWGFs than the general population and longer PBPs than the general population at all efficiency levels (EL) in all regions except for northern households at the max tech EL. Low-income households also show reduced LCC savings and similar PBPs from more-efficient MHGFs for AFUE standards than the general population except households in the Rest of Country, which have somewhat higher LCC savings than the general population. DOE's analysis of the impact of the standards on this subgroup is also inadequate because it does not separately address the higher costs of capital for these subgroups relative to the average residential discount rate of 4.5 percent (80 Fed. Reg. at 13,151), nor does it evaluate the higher price elasticity low income or fixed income consumers would have relative to the average population. As with the cumulative regulatory burden and small business impact analysis, DOE also merely sets forth the results of this determination in the TSD, it does not sufficiently analyze or incorporate these findings into its overall cost benefit analysis.

**Negative Impacts on Consumer Utility from the Elimination of Non-Condensing Furnaces from the Market.** DOE also fails to consider the real world impact of the additional cost and installation requirements for households that will require additional venting or construction requirements to install condensing furnaces. The real world utility of non-condensing furnaces as replacements is important, as households that need to replace a furnace in the coldest months of the year, when furnaces are most in use, cannot afford to find alternative lodgings or wait it out several days to make the changes necessary to install a condensing furnace. "In addition, 'cost' includes more than the expense of complying with regulations; any disadvantage could be termed a cost." *Michigan v. EPA*, _ U.S. _ (June 29, 2015)(slip op., at 7). Agencies may not entirely fail to consider an important aspect of the problem when deciding whether regulation is appropriate. *Motor Vehicle Mfrs. Ass'n of U.S., Inc. v. State Farm Mut. Auto. Ins. Co., 463 U.S. 29, 43 (1983)*. DOE's "heat delivered is heat delivered" approach is entirely without basis, given the additional costs, construction and time that may be required and the additional electricity consumption that occurs through product switching. A clothes line will dry your clothes, but, that does not mean it has the same utility as a clothes dryer to consumers under an energy efficiency analysis.

DOE fails to even consider these real-world market dynamics in its economic analysis, limiting such considerations to the simple additional cost of only installing the equipment. Real world utility is also important because DOE may not amend a standard if the new standard is "likely to result in the unavailability in the United States of any covered product type of performance characteristics or features that are substantially the same as those generally available in the United States." 42 U.S.C. 6295(o)(4). Without question, non-condensing furnaces, with their different venting and installation requirements, are generally available in the U.S. today and they will not be under the proposed furnace standard. While the percentage of shipments of such equipment is less than condensing furnaces with a declining trend, the proposed standard will eliminate this product entirely, with a loss of its utility to consumers as described above and in the Shorey Consulting analysis provided below. DOE's notes that "improvements in venting technology may soon allow a consumer to avoid some of these venting concerns,"[20] but DOE's hope for the future based upon technology that may or may not be realized cannot be the basis of the elimination of non-condensing furnaces through the proposed standard. As a result, a nationwide condensing requirement violates this statutory requirement.

***DOE Makes the Unrealistic and Unsupported Assumption Consumers do not Repair Furnaces.*** DOE also made the completely unrealistic assumption that consumers do not repair residential furnaces. 80 Fed. Reg. at 13,152. "DOE did not include a repair option in the consumer choice model and associate analysis. Current data collected by DOE suggests that repair in the case of major equipment failure, such as a furnace, would be minimal unless the furnace is relatively new." This analysis contradicts common sense and is entirely without support. DOE does not clarify the "current data" it refers to in more substantive TSD analysis, nor does DOE clarify what it means by "relatively new." DOE cannot support an exclusion of a repair option from its consumer choice model, particularly when certain consumers, such as seniors and low-income households, have a negative LCC and PBP[21], in addition to the households that would incur substantial additional installation costs with a condensing furnace. Given the assumed cost of an installed furnace under DOE's proposed standard of $2,730, which, as AHRI submitted data reveals is grossly underestimated, and the fact that consumers own their home for only approximately half of the time of the average life of a furnace, it is completely unrealistic to assume that consumers will never repair a furnace, but instead will almost always replace the furnace, either by installing a more expensive condensing furnace or switching to a product that consumes significantly more electricity.

***The NOPR Analysis Should Include a Realistic Timeframe of Furnace Ownership.*** Another non-market based assumption that overstates the benefits and understates the costs in DOE's analysis is the assumption that the relevant "lifetime" analysis should be the assumption of an average furnace lifetime of 22 years when average ownership of home is approximately 13 years.[22] 80 Fed. Reg. at 13,122. While EPCA refers to the average life of the covered product, given that most consumers purchase one or two furnaces in their entire lifetime, and certainly given that the average time of home ownership is half of the average life of the furnace, DOE should have considered this real world impact in its analysis. The fact that DOE will consider worldwide economic benefits and savings in emission reductions and monetize and claim emission reductions as relevant benefits (as opposed to energy and water savings as provided for in 6295(o)(2)(B)(i)(I) and (III), but does not consider the real world impact of the limited time consumers own a home, illustrates the one-sided nature of DOE's cost benefit analysis. If analysis expanding the plain language of the seven statutory factors is used to measure a proposed standards benefits as discussed in more detail below, then a consistent approach must be taken and a similar analysis must be used to analyze its costs as well.

***DOE provides no Basis for its use of Gross Markup Percentage Markup across All Efficiency Levels.*** In the NOPR, DOE assumed that the upper bound of the residential furnace industry's profitability was a "gross margin percentage" markup across all efficiency levels. DOE notes

[20] 80 Fed. Reg. 13,138.
[21] As noted below, DOE, taking a contradictory approach, did (appropriately) include repair costs in the LCC and PBP.
[22] http://eyeonhousing.org/2013/01/latest-study-shows-average-buyer-expected-to-stay-in-a-home-13-years/

that "Manufacturers do not believe they could maintain the same gross margin percentage markup as their production costs increase." 80 Fed. Reg. 13,158. DOE provides no basis as to why it continues to include this analysis despite contrary information from manufacturers, as it provides no actual or other information applicable to the market for these products justifying its continued use.

**The Cost-Benefit Analysis Set Forth in the NOPR is Systemically Biased and Unfair, Overstating Claimed Benefits and Understating the Manufacturer and Consumer Costs.**

***Mismatch in the Social Cost of Carbon (SCC) Analysis Looking to Global Benefits.*** In the NOPR, DOE analyzes global benefits but looks only at national costs. Despite this, throughout the NOPR DOE presents the *globally* derived benefits of emission reductions as part of the *national* savings, where they are compared to the statutorily limited national costs. *See, e.g.,* Table 1.5, 1.6, V.42, and V.45. While global benefits are useful general information, they should be excluded from the calculation of net benefits from the rule because these are not benefits to American taxpayers, whom the DOE is tasked to serve. It also is not in compliance with EPCA's mandate to consider economic impacts. Section 6295(o)(2)(B)(i)(I) of EPCA requires DOE to consider "the economic impact of the standard on *manufacturers and on the consumers of the products* subject to such standards" (emphasis added). Thus, DOE should be measuring the economic impact of SCC, if at all, on *the manufacturers and consumers of the product* at issue (*i.e*. the market), not on the entire U.S. population and certainly not on the worldwide population as a whole. Likewise, Section 6295(o)(2)(B)(i)(III) requires DOE to consider the total projected amount of energy (a clearly defined term that does not include environmental impacts such as carbon emissions), or as applicable, water savings likely to result *directly from the standard*. Worldwide emissions projected well in to the future simply do not meet this criteria.

Furthermore, this is both required and well within DOE's discretion regarding consideration of SCC, as under "current OMB guidance contained in Circular A-4, analysis of economically significant proposed and final regulations from the domestic perspective is required, while analysis from the international perspective is optional."[23] As discussed further below, EPCA is neither ambiguous nor does it provide DOE the discretion to select national or international costs and benefits. Specific statutory references to the economic impact on "manufacturers and consumers" and energy[24] as a defined term must also limit DOE's consideration of the SCC impacts in its analysis.

DOE's analysis is arbitrary because there is also no reason why America's contribution to climate change cannot be based on an analysis that compares costs to benefits on an apples-to-apples basis (*i.e.,* nationally). Additionally, EPCA is not an international statute, since, as its text and history in emerging from the OPEC Oil Embargo attest, the purpose of the statute is to guarantee this Nation's welfare and energy conservation, not the well-being of other countries. 42 U.S.C. § 6295(o)(2)(B)(i)(VI) (referring to "the need for national energy and water

[23] Technical Support Document: - Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866 (May 2013, Revised July 2015).
[24] EPCA defines "energy" as meaning "electricity, or fossil fuels"—not the environmental dimensions of improving energy efficiency). 42 U.S.C. § 6291(3).

conservation") (emphasis added). EPCA authorizes DOE to conduct only a national analysis.[25] There are no references to global impacts in the statute. *Kiobel v. Royal Dutch Petroleum Co.*, 133 S. Ct. 1659, 1669 (2013) (applying the well-known presumption against the extraterritorial application of U.S. law).

***Social Cost of Carbon Estimates Are Unfairly Measured and Weighted in DOE's Cost Benefit Analysis.*** Executive Order 12866 requires agencies, to the extent permitted by law, to assess the costs and benefits of an intended regulation, and recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation only upon a reasoned determination that the benefits justify the costs. As discussed above, EPCA sets forth six specific factors to be considered in the relevant cost benefit analysis, with economic impacts limited to manufacturers and consumers and national and economic impacts limited to energy as a defined term. Inclusion of SCC on a global scale while at the same time being statutorily limited to asses only national costs and costs on manufacturers or consumers of the product will render EPCA's statutory factors meaningless, which neither an Executive Order or guidance under an Executive Order has the authority to do. The IWG SCC guidance notes an agency's ability to limit consideration to domestic impacts, and provides the tools to do so, calculating the domestic benefit at about 7-10 percent of the global benefit and determining that values from 7 to 23 percent should be used to adjust the global SCC to calculate domestic values. Only by conducting a balanced and equitable cost benefit analysis can DOE determine the regulatory approach that makes the most sense, and "know which come at too great a cost and which are a good deal for society."[26]

***Mismatch in the Time Spans Used for Regulatory Analysis.*** DOE's cost benefit analysis is also arbitrary and unfair as it measures the direct costs to consumers and manufacturers over only a 30-year period but looks at the indirect benefits of carbon-reduction over three centuries (the U.S. is not even that old).

The core failure is not that DOE is applying its 30-year "analytic time frame" inconsistently—for instance, by counting up avoided carbon emissions in year 31 and beyond. Instead, the problem is that the costs imposed on manufacturers are highly discrete direct costs, whereas the SCC analysis the agency has undertaken is inherently speculative, embracing all manner of highly indirect, ripple-effect costs as they trace out over an enormous span of time.

While DOE does note that the proposed standard actually increases emissions of sulfur dioxide, nitrous oxide and mercury as a result of product substitution, DOE has failed to otherwise calculate increased carbon emissions flowing from new regulatory standards, such as emissions from the mining and production of [an] increased volume of raw materials, OEM [original equipment manufacturer] factory retooling, additional trucks needed to ship larger units, and additional warehouse space needed for larger units among others. Agencies cannot selectively calculate effects tending to support only increased regulation, but must instead equally analyze impacts both tending to support and to undermine regulation. *See, e.g., American Trucking Ass'ns v. EPA,* 175 F.3d 1027, 1051-53 (D.C. Cir.) (requiring EPA to analyze not just the health

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[25] DOE appears to concede as much by labeling Table I.5 a "Summary of *National* Economic Benefits and Costs …." 80 Fed. Feg. at 12,123 (emphasis added). In reality, though, the table does not comport to its label for it includes *global* carbon benefits and excludes costs imposed on manufacturers, listing only the incremental installation costs only of those of consumers who purchase the product.

[26] https://www.whitehouse.gov/blog/2015/07/02/estimating-benefits-carbon-dioxide-emissions

detriments of ground-level ozone, but ground-level ozone's health benefits as well), modified on reh'g in irrelevant respect, 195 F.3d 4 (D.C. Cir. 1999), rev'd in irrelevant respect, *Whitman v. American Trucking Ass'ns*, 531 U.S. 457 (2001). Furthermore, a key problem in premising regulatory action on purported carbon benefits over such long timespans is that the approach cannot take account of the other policy responses to the issue of climate change that will inevitably arise. The result may be to promote excessive and economically unjustified regulations because the actual benefits have been overestimated by duplicative emissions reduction claims.

***Application of Unfair and Inconsistent Criteria for the Inclusion of Benefits and Costs.*** A key example of DOE's arbitrary and unfair treatment is its analysis of indirect impacts on employment as a result of the proposed standard. *See* 80 Fed. Reg. at 13,176. In its analysis, DOE states:

> DOE understands that there are uncertainties involved in projecting employment impacts, especially changes in later years of the analysis. Therefore, DOE generated results for near-term time frames (2021-2026), where these uncertainties are reduced.

80 Fed. Reg. at 13,176. The NOPR language appears to address general uncertainties, but review of the relevant discussion in the TSD analysis reveals that the uncertainties are merely a function of the particular model DOE has selected:

> DOE notes that ImSET is not a general equilibrium forecasting model, and understands the uncertainties involved in projecting employment impacts, especially changes in the later years of the analysis. Because ImSET does not incorporate price changes, the employment effects predicted by ImSET would over-estimate the magnitude of actual job impacts over the long run for this rule. Because input/output models do not allow prices to bring markets into equilibrium, they are best used for short-run analysis. DOE therefore include a qualitative discussion of how labor markets are likely to respond in the longer term. *In future rulemakings, DOE may consider the use of other modeling approaches for examining long run employment impacts.*

NOPR TSD 16-1 (emphasis added). In other words, because DOE is utilizing a model appropriate for short-run analysis to analyze employment impacts, therefore it must limit its analysis to the short run. Instead of contorting the real world impacts on employment resulting from the proposed standard to fit the model, DOE should instead select a model that is appropriate for the rigorous cost benefit analysis it is obligated to conduct. "Not only must an agency's decreed result be within the scope of its lawful authority, but the process by which it reaches that result must be logical and rational." *Allentown Mac Sales & Service, Inc. v. NLRB,* 522 U.S. 359, 374 (1988). DOE provides no reason for its arbitrary selection of a short-run model to evaluate long term costs, and thus must take the step it notes and select an appropriate model to examine long run employment impacts. DOE's determination to instead "qualitatively discuss" the long run impacts means that the cost will not be adequately considered in the quantitative analysis and are costs are underestimated. The use of the ImSTET model for this particular purpose also fails Executive Order 13,563's commitment that regulatory decision making will be "based upon the best available science."[27]

Unsurprisingly, after limiting its analysis to the short-run, DOE concludes that the results of this five year analysis[28] are likely to have a negligible impact on labor in the economy. "The net change in jobs is so small that it would be imperceptible in national labor statistics and might be offset by other, unanticipated effects on employment." 80 Fed. Reg. at 13,176. DOE at no point clarifies why such a restrictive view of costs and loss of jobs, which have immediate and real negative impacts on individuals and communities (DOE estimates that in 2026 TSL 3 will lead to a loss of 1,800 jobs)[29] must be limited to five years due to "uncertainties," while the SCC monetization can be analyzed well over a 30 year period despite separate governmental findings that the estimates are imperfect, incomplete, approximate, provisional and highly speculative (see further discussion below). Furthermore, while DOE evaluates these employment impacts only as a net change in national labor statistics, there is no such restriction placed on the SCC analysis. Fair is fair, and if costs are to be evaluated in such a manner, then benefits must be too, and DOE should analyze SCC impacts only as a net change in total global emission levels over a similar five year period. Alternatively, DOE must select analytical tools that match the timeframes and scope of its SCC analysis to the greatest degree possible, in order to present an accurate evaluation of the market impacts of the proposed standard, and to ensure the integrity and fairness of the regulatory process.

Given the current selection of methodologies and timeframes utilized in the cost-benefit analysis, it is unsurprising DOE concludes the proposed standard is justified. But the process used to reach that conclusion matters, and DOE should be measuring costs and benefits objectively, in the same general timeframes, with similar methodologies and underlying criteria on what to exclude or include based upon uncertainties. DOE's rational alternatives are either: (a) to devote the same resources and energy to analyzing indirect regulatory costs over the same time horizon as it does to analyzing indirect regulatory benefits; or (b) at the very least, to scale back the horizon over which carbon emissions benefits are reckoned so as to harmonize that time scale with that used to assess the cost impacts that its EPCA rules create. Where, as here, DOE selects neither of these two choices in an EPCA rule, it is impermissibly stacking the cost-benefit deck in violation of its statutory requirements. *Business Roundtable v. SEC*, 647 F.3d 1144, 1148-49 (D.C. Cir. 2011) (agencies cannot "inconsistently and opportunistically frame[] the costs and benefits of [a] rule").

Even beyond the fact that modeling becomes more unreliable the further in time it attempts to offer predictions,[30] such a brand of analysis is fundamentally irrational. On its own terms, it is

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[27] http://www.whitehouse.gov/sites/default/files/omb/inforeg/eo12866/eo13563_01182011.pdf
[28] The NOPR at page 13,162 refers to an even shorter limitation of through the year 2023
[29] NOPR TSD Table 16.4.1.
[30] *See, e.g., Center for Sustainable Economy v. Jewell*, 779 F.3d 588, 608 (D.C. Cir. 2015) (noting "the difficulty of predicting the behavior of energy markets over decades-long time horizons"); S.P. Kothari & Jerold B. Warner, *Measuring Long-Horizon Security Price Performance*, 43 J. OF FIN. ECON. 301, 301 (1997) ("Conclusions from long-horizon studies require extreme caution."); S.P. Kothari & Jerold B. Warner, *Econometrics of Event Studies*, *in* HANDBOOK OF CORPORATE FINANCE: EMPIRICAL CORPORATE FINANCE 3, 8 (B. Espen Eckbo, ed., vol. 1, 2007) ("While long-horizon methods have improved, serious limitations of long-horizon methods have been brought to light and still remain. We now know that inferences from long-horizon tests 'require extreme caution' (Kothari and Warner, 1997, p. 301) and even using the best methods 'the analysis of long-run abnormal returns is treacherous'

not valid—the negative impacts of economic losses imposed today on an industry and its participants echo down through time every bit as much as avoided carbon-related benefits. For instance, a policy that causes a family's breadwinner to lose a job today may continue for generations to injure that family's descendants and the community in which that family resides. In its analysis of direct impacts on employment, DOE noted that some large manufacturers have "already begun moving production to lower-cost countries," including an estimation of 2,692 lost jobs in its analysis. 80 Fed. Reg. at 13,171. Yet no comparable, apples-to-apples, future based analysis of indirect cost effects based upon these immediate and direct costs was undertaken here. Additionally, because industry faces budget constraints, increasing manufacturer costs robs the national economy of the benefits of new R&D efforts that could both improve product utility and increase consumer welfare as well as lead to new breakthroughs in energy-efficiency technology.

Presumably, DOE did not perform such an analysis concerning the adverse economic impacts of the proposed standard levels because of the inherently speculative nature of doing so. Yet any SCC analysis that purports to make carbon-related predictions concerning the positive economic ripple effects of reduced emissions stretching down three centuries hence is no less speculative. The fact that the United Nations' Intergovernmental Panel on Climate Change, certain academic economists, DOE, and others have devoted significant resources to analyzing the ultra-long-term effects of carbon emissions, making such work available "off the shelf"—while there is no similarly voluminous body of literature addressing the economically contractionary effects of regulations over the same extended time frame is not a proper basis for allowing the analysis here to be performed in such a lopsided fashion.

***Inconsistency in applying price elasticity, repair assumptions, and rebound effects.*** The NOPR analysis also does not proceed on a reasoned basis, as it considers key factors in the cost-benefit analysis inconsistently, and at a minimum assumptions are not adequately explained in terms of the different manner in which key factors such as price elasticity, repair assumptions and the rebound effect are included in the overall cost benefit analysis. As a result DOE's results are based on inconsistent and insufficiently explained analysis, impermissibly creating an arbitrary result upon which stakeholders cannot sufficiently comment. *Air Line Pilots Ass'n v. FAA*, 3 F.3d 449, 453 (D.C. Cir. 1993) (internally inconsistent agency action is defective).

For example, DOE makes the following inconsistent statements:

- **Rebound Effect**

  In the TSD at 10-15, DOE noted that in its annual energy use analysis, it included a rebound effect to estimate that 15 percent of the estimated energy savings do not materialize. "For the NOPR, DOE applied a rebound effect of 15 percent." NOPR TSD at 10-16. However, in other parts of its analysis it did not:

(Lyon, Barber, and Tsai, 1999, p. 165). These developments underscore and dramatically strengthen earlier warnings (e.g., Brown and Warner, 1980, p. 225) about the reliability — or lack of reliability — of long-horizon methods. This contrasts with short-horizon methods, which are relatively straightforward and trouble-free.")

> "The results in Table 10.5.1 are not adjusted for the impact of the rebound effect discussed in chapter 8. For the NIA, DOE applied a rebound effect parameter that reduces the estimated national energy savings." 10-15.
>
> "DOE considered the possibility that some consumers may use a higher-efficiency furnace more than a baseline one, thereby negating some or all of the energy savings from the more-efficient product. Such change in behavior when operating costs decline is known as a (direct) rebound effect. However, the increased furnace usage associated with the rebound effect provides consumers with increased value (*e.g.*, more comfortable indoor temperature). *DOE believes that, if it were able to monetize the increased value to consumers of the rebound effect, this value would be similar in monetary value to the foregone energy savings.* Therefore, the economic impacts on consumers, with or without including the rebound effect in the analysis, are the same. NOPR TSD at 8-16, 17 (emphasis added).

This approach is arbitrary for several reasons: First, DOE provides no reasoned basis for treating the rebound effect inconsistently within the NOPR analysis. It was appropriately applied (although AHRI does not necessarily agree to the determined amount) in the annual energy use, and it should be applied consistently to all analysis. Second, DOE's justification for exclusion makes no sense. If furnace usage is a proxy for consumer value, then the logical conclusion is that consumers get more value out of a less efficient furnace which requires more usage for the same amount of heating. Finally, DOE cannot exclude the impact of events it has determined are actually occurring in the market based solely upon its completely unsupported *belief* that *if* it only had the ability to monetize it, the impact would be similar. That may be permissible for Lady Catherene de Bourgh's evaluation of her pianoforte skills ("If I had ever learnt, I should have been a great proficient.")[31], but it cannot be the basis for excluding a factor that impacts the calculated energy savings of the proposed standard.

- **Price Elasticity**

In the NOPR analysis, DOE concludes that the relevant prices are both inelastic and elastic:

> "[C]onsumer demand for heating and air conditioning is inelastic, *i.e.*, the demand is not expected to decrease significantly with an increase in the price of the equipment. TSD 6-5 (analyzing markups).
>
> "DOE's use of a simple least squares fit is equivalent to an assumption of *no significant first price elasticity effects* in the cumulative shipments variable." TSD 8C-5. (analyzing shipments)
>
> "This reflects that in general, *consumers place a relatively high importance on the first cost differences*." TSD 8J-2. (fuel switching analysis)

[31] Austen, Jane. *Pride and Prejudice* page 212.

> "Because consumers are sensitive to the cost of heating products, a standard level that significantly increases the purchase price may induce some consumers to switch to a different heating system rather than purchase a NWGF. The decision to switch is affected by the total installed cost and operating costs, including the energy use and energy prices for alternative products" 8J-1. (fuel switching analysis)
>
> "DOE did not analyze the potential option of switching from a condensing to a non-condensing "NWGF because the significant installation cost to install a new Category I vent system for the non-condensing NWGF makes such switching unlikely to occur." 8D-17.
>
> "DOE determined that consumers would expect a PBP of 3.5 years or less to justify the purchase of a more-expensive but more efficient NWGF. If the PBP of installing a more efficient NWGF exceeded 3.5 years, DOE forecasted that the consumer would switch to either a heat pump or electric furnace.

DOE's conflicting determination regarding price elasticity enables it to conclude that higher prices for more efficient condensing furnaces will not significantly affect shipments or industry markups, leading to lower consumer and manufacturer costs and higher energy savings (because prices are inelastic) while at the same time concluding that higher prices that lead consumers to switch products will avoid the LCC and PBP cost impacts from the higher cost efficiency products, including the higher cost of installation of a condensing furnace (because prices are elastic). This inconsistency is without basis, overstates the claimed benefits of the proposed standard, and fails to meet the requirements of a reasoned and rational cost benefit analysis.

- **Repair Costs**

  Repair costs are not excluded from the LCC and PMP, nor should they be. Yet they *are* excluded from the consumer choice model, based upon DOE's conclusory statement that consumers will not repair major appliances.

> "DOE estimated repair costs at each considered efficiency level using a variety of sources, including "2013 RS Means Facility Repair and Maintenance Data, manufacturer literature, and information from expert consultants. DOE accounted for regional differences in labor costs, as discussed in appendix 8D." TSD 8J-18.
>
> "The results show that the households that switched had lower total installed, maintenance, and repair costs as a result of switching." 8J-21.
>
> Net Present Value of Consumer Benefits – "The annual operating cost includes energy, repair, and maintenance costs." 10-19.
>
> "Savings represent decreases in operating cost (including energy, repair, and maintenance) associated with the more energy efficient product purchased in the standards case compared to the base case." 10-24.

> LCC Output "Contains energy use, electricity use, total installed price, annual repair, maintenance costs . . . " 10A-1.

As noted earlier in this comment letter, the exclusion of repair costs from the consumer choice model is entirely without reasoned basis or factual support, and is supported merely by DOE's conclusory statements. The NOPR analysis should be revised to include them in the choice model, with stakeholders given a meaningful opportunity to comment on the revised analysis.

**DOE's Claim to Environmental Regulatory Power, and Thus to Include Environmental Benefits in EPCA's Cost-Benefit Analysis, Is Unlawful**

Congress enacted EPCA in reaction to the Organization of Oil Producing and Exporting Countries ("OPEC") Oil Embargo in the 1970s. *Center for Biological Diversity v. NHTSA*, 538 F.3d 1172 (9th Cir. 2008). It is without question a statute developed to address energy[32] conservation (hence the title). Yet DOE specifically asserted that it had environmental power here ("DOE routinely conducts a full economic analysis that considers the full range of impacts to the customer, manufacturer, Nation and environment, as required under 42 U.S.C. § 6295(o)(2)(B)(i) and 6316(e)(1).") (emphasis added). 80 Fed. Reg. 13,135. However, there is no such requirement, as neither of those provisions in EPCA references environmental impact, as even a quick scan of them reveals. "[A]n agency literally has no power to act…unless and until Congress confers power upon it." *Louisiana Pub. Serv. Comm'n. v. FCC*, 476 U.S. 355, 374 (1986). By relying on this factor in the cost-benefit analysis, which Congress did not intend DOE to consider, DOE thus acted arbitrarily and capriciously under the APA. Given the limited scope and specific factors to be evaluated in the cost benefit analysis that Congress specifically set forth in EPCA, DOE's cost benefit analysis must be limited to the factors set forth in EPCA.

DOE might argue that environmental factors can be considered in light of Section 6295(o)(2)(B)(i)(VII) ("other factors the Secretary considers relevant"), but here DOE specifically disclaimed any such argument by stating that it "has not considered other factors in development of the standards in this final rule." 80 Fed. Reg. at 13,180. Finally, as discussed above, DOE's actual application of its consideration of environmental factors goes well beyond any "additional consideration," and its imbalanced weighting and measurement of environmental factors relative to the other required factors under EPCA is such that the standards proposed are no longer based solely on the energy consumed at the point of use, as is statutorily required. 42 U.S.C. 6291(4) – (6). *See also* 76 Fed. Reg. 51281, 51282 (August 18, 2011) and 51284 ("In practice, the consideration of FFC energy and emission impacts is likely to have comparatively small effects on DOE's analysis of the economic justification of specific alternative appliance efficiency standards")[33]. The analysis in the NOPR goes well beyond this scope of use, and these environmental impacts, rather than energy savings at point of use, are the fundamental justification of the proposed standards.

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[32] EPCA defines "energy" as meaning "electricity, or fossil fuels"—not the environmental dimensions of improving energy efficiency). 42 U.S.C. § 6291(3).

[33] Technical Support Document: - Social Cost of Carbon for Regulatory Impact Analysis – Under Executive Order 12866 (February 2010).

**The Department of Energy's Social Cost of Carbon Analysis Fails to Meet the IQA's Decision-making Standards.**

The Information Quality Act ("IQA") is contained in the Treasury and General Government Appropriations Act for FY 2001, Pub. L. 106-554, § 515, 114 Stat. 2763 (Dec. 21, 2000). The IQA is also set out in a note to 44 U.S.C. § 3516 in the annotated code. The IQA provides that the Office of Management and Budget ("OMB") and the federal agencies must establish guidelines "for ensuring and maximizing the quality, objectivity, utility, and integrity of information (including statistical information) disseminated by Federal agencies." IQA Section (a) & (b)(2)(A). DOE's use of Social Cost of Carbon (SCC) estimates in the NOPR fail to meet these requirements and its utilization of these values in its economic justification of the proposed standards was impermissible.

First, the interagency process used to develop the SCC estimates was opaque. The agencies involved were disclosed but not which personnel participated, or whether outside consultants were used. This violates OMB guidelines.[34] Second, the SCC estimates were not peer reviewed. DOE was forced to concede that the National Resource Council (part of the National Academies of Science) criticized the models the interagency process used as "suffer[ing] from uncertainty, speculation, and lack of information about (1) future emissions of GHGs; (2) the effects of past and future emissions on the climate system, (3) the impact of changes in climate on the physical and biological environment, and (4) the translation of these environmental impacts into economic damages." 80 Fed. Reg. at 13,160. Even if those models have been peer reviewed, peer review of the models alone is not sufficient because the problem is how the models are being applied to justify the efficiency rule in particular. The SCC estimates are as much a product of the inputs to the models as they are the product of the models themselves. The inputs that drive both the 2010 and 2013 SCC Estimates were never peer reviewed—nor are the majority of them even known. *See Nat'l Black Media Coal. v. FCC*, 791 F.2d 1016, 1023 (2d Cir. 1986) ("it is the methodology used in creating the maps and studies, and the meaning to be inferred from them" that must be open to public comment) (citation and internal quotation marks omitted).

Third, in order to translate certain predicted climate-change effects into economic damages, the interagency SCC analysis relies on arbitrary damages functions. These damage functions translate variables, such as projected sea level rise, to estimated economic damages. By their nature, we know very little about the correct functional form of damage functions. According to a well-known economist, "[the model] developers ... can do little more than make up functional forms and corresponding parameter values. And that is pretty much what they have done." (R.S. Pindyck, Climate Change Policy: What Do the Models Tell Us?, NBER Working Paper Series, WP 19244, at 11 (July 2013). If anything, DOE's own statements further support AHRI's objections. See 80 Fed. Reg. at 13,161 (conceding that the damage models are imperfect, incomplete, approximate, provisional and highly speculative).

[34] Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by Federal Agencies; Republication, 67 Fed. Reg. 8,452 (Feb. 22, 2002); OMB Circular A-4 (2003), *available at* https://www.whitehouse.gov/omb/circulars_a004_a-4/.

## ANALYTIC METHODS AND ECONOMIC ANALYSIS

The proposed new minimum efficiency standards for non-weatherized residential gas furnaces and for mobile home furnaces are based on analytical models that are designed to measure the economic results of proposed standard levels on consumers, manufacturers and the economy as a whole. The core conclusion reached by DOE is that both individual consumers and the U.S. will benefit from a 92 AFUE minimum standard for non-weatherized and mobile home gas furnaces.[35]

However, DOE has made conceptual mistakes in its modeling process and errors in its assumptions that make these core conclusions incorrect. The modeling processes used by DOE, in particular its Life Cycle Costing (LCC) model, do not accurately measure either the economic effects on consumers or the amount of energy saved. DOE and its contractors also make mistakes in core assumptions used in the LCC model such that the model, even as structured by DOE, does not support DOE's conclusions. Some of the same logic issues also infect the National Impact Analysis (NIA) model, causing it to completely incorrectly assess the effect of the proposed regulations. There is also an unrelated conceptual error in the Government Regulatory Impact Model (GRIM) that causes DOE to underestimate the combined effect of this gas furnace and the furnace fan standards on manufacturers.

When correctly analyzed, the information collected for this rulemaking does not support any change in the current minimum AFUE standards. Any revised standard must be analyzed relative to the market that exists in the absence of that revised standard. The vast majority of the homeowners who would benefit from higher efficiency furnaces are already purchasing them. Virtually all of the purchasers whose behavior will be changed by the proposed standard will see negative life cycle cost savings. In fact, when correctly analyzed, the energy saving from the proposed standard is no more than 63% percent of DOE's estimate and the present value to the economy as a whole is negative by as much as $8.5 billion.

In addition, DOE's proposal to set a standard requiring condensing gas furnaces nationally will create a significant number of situations, 15-20% of all housing units, where it is not practical to install such a furnace. This is not merely a question of economic return; rather it is one of the ability to vent a condensing furnace in a safe reasonable manner. Some of these situations will include multi-family units with individual furnaces that have no connection to outside walls other than through living spaces, row houses with limited outside wall area and houses with finished basements where installing a venting system would entail significant reconstruction of the house. It would also effectively force many homeowners to convert from gas furnaces to electric heat pumps or electric furnaces for a net increase in energy consumption. In each of these instances, requiring a condensing gas furnace would result in the loss of features and utility associated with the regulated product in a manner that is not permissible under EPCA.

[35] The proposed standards deal with both non-weatherized gas furnaces and mobile home furnaces. This discussion will focus on the non-weatherized gas furnaces although the comments on the modeling processes apply to both product categories.

*Comparing a Revised Standard to the Market Without That Revised Standard*

In a rulemaking such as this DOE determines what level of standard provides the best balance of benefits and costs and provides energy savings beyond that occurring in the market under the existing minimum standard. Essentially, DOE is assessing the effectiveness of the current market to promote energy savings without new regulations. The analysis needs to determine who is benefiting, who is adversely affected and how much is the effect to either group. It turns out that DOE's current models are inadequate to do these tasks.

In a market economy the basic equilibrium concept is that prices paid and quantities purchased will reflect the intersection of consumer utility and producer cost. Market failure exists when actual prices or quantities are not at that equilibrium point, either for individual consumers or for the society as a whole. The underlying justification for minimum efficiency standards on products is that there are such a market failures – that consumers purchase low efficiency products when reasonable assessment of the economic returns to those consumers show that they would be economically better off purchasing more efficient ones.[36]

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*What is a Working Market?*

The test for whether a market is working is to determine whether consumers are acting rationally; are their purchases in line with their actual economic value? In specific for products where DOE sets energy efficiency standards this becomes a question of whether the actual percent of consumers purchasing high efficiency products corresponds to the percent that have positive economic value from such a purchase.

It is important to distinguish, however, between market failure and economic rationality. Economic rationality assumes that consumers are making choices based on their economic interest. Someone who has better economic returns from owning a more efficient product is more likely to buy that product than someone who does not. Economic rationality for consumers is an analog to a demand curve. Each individual consumer has an economic return from choosing a

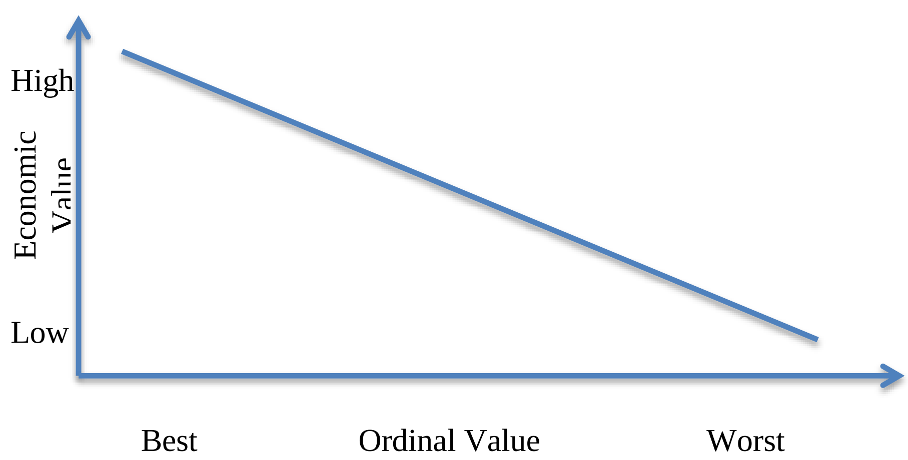
[36] There may be many reasons why such a market failure exists but understanding why the failure exists is not critical at this point. Regulation makes economic sense simply if there is such a market failure.

more efficient product. A more efficient furnace has much greater value to a consumer in Fairbanks AK than it does to a consumer in Miami FL. Market failure occurs not because people are irrational but because they do not compute their economic return properly.

To determine whether there is a match between consumers with positive economic value and the market share for more efficient products, DOE needs a way to compute economic value to the consumer. Quite reasonably, DOE chooses to use change in Life Cycle Cost (LCC) as the metric of economic value. [37] However, DOE uses an incorrect process for calculating that LCC. This error affects both DOE's determination of whether there is a problem and also how DOE analyzes the benefits of its possible solutions.

In the case of heating and cooling equipment, the LCC for any house is almost exclusively a function of the house, not of the occupants.[38] Therefore, it is possible, in principle, to make an ordinal ranking of economic value for all consumers of warm air gas furnace (Figure 1):

Figure 1: Ordinal Ranking

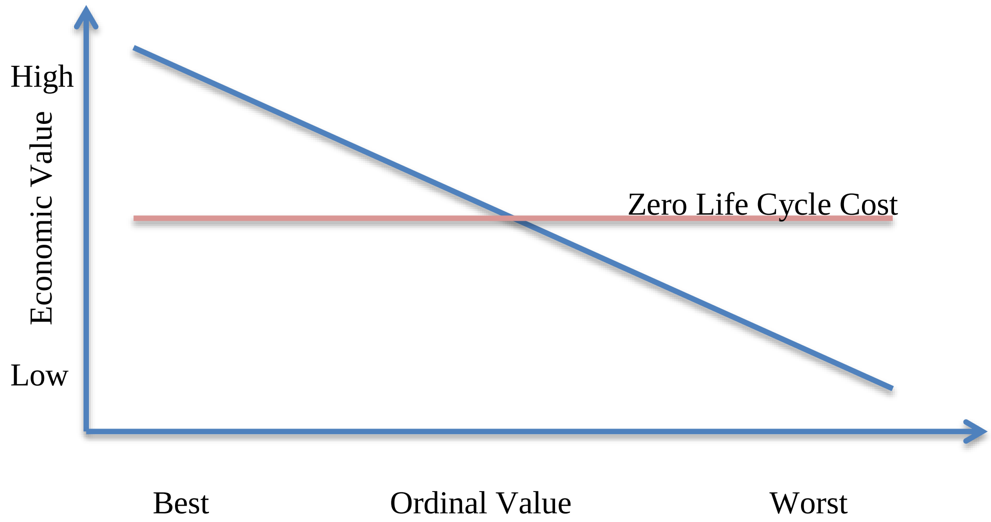



The market clearing point (Figure 2) in a functioning market would be at the nth customer, where the nth customer is the one where the life cycle cost is equal to zero. All customers with positive life cycle costs would have higher ordinal rankings and all customers with lower rankings would have negative life cycle costs.

[37] For the purposes of this discussion, we will define economic value as the life cycle cost (present value of energy savings minus increased purchase price) for the product to the consumers being ranked, just as DOE uses this metric.

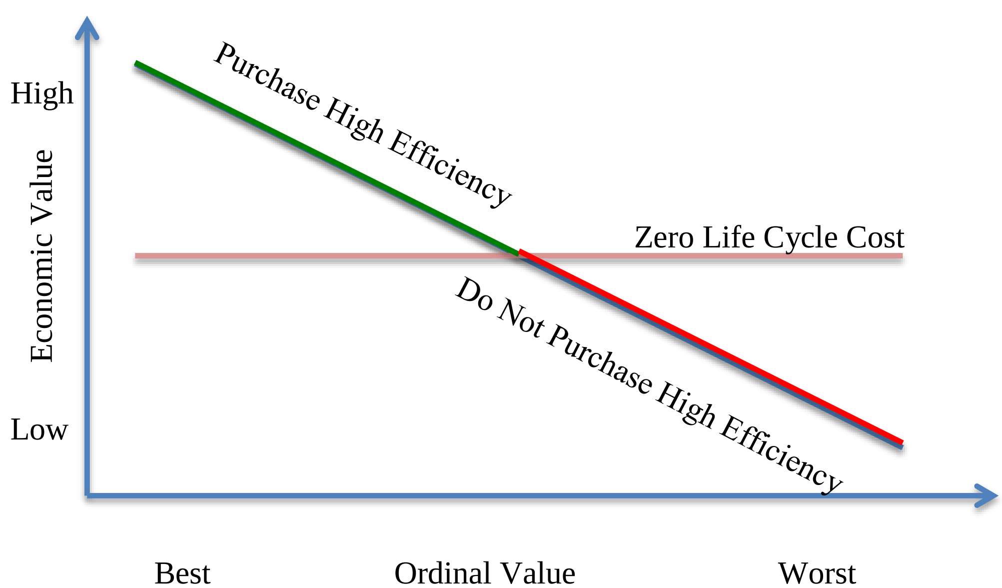
[38] DOE recognizes the dependence on the structure, not the occupants in its Life Cycle Cost model DOE: EERE-2014-BT-STD-0031, 2014-02-06 NOPR Spreadsheets: Residential Furnace Life-Cycle Cost and Payback Period Analysis (LCC Model), where the energy use calculations have no occupant-related variables (See sheet 'Energy Use (Calcs)"). The only occupant-related variable is the consumer discount rate.

Figure 2: Break Even Point



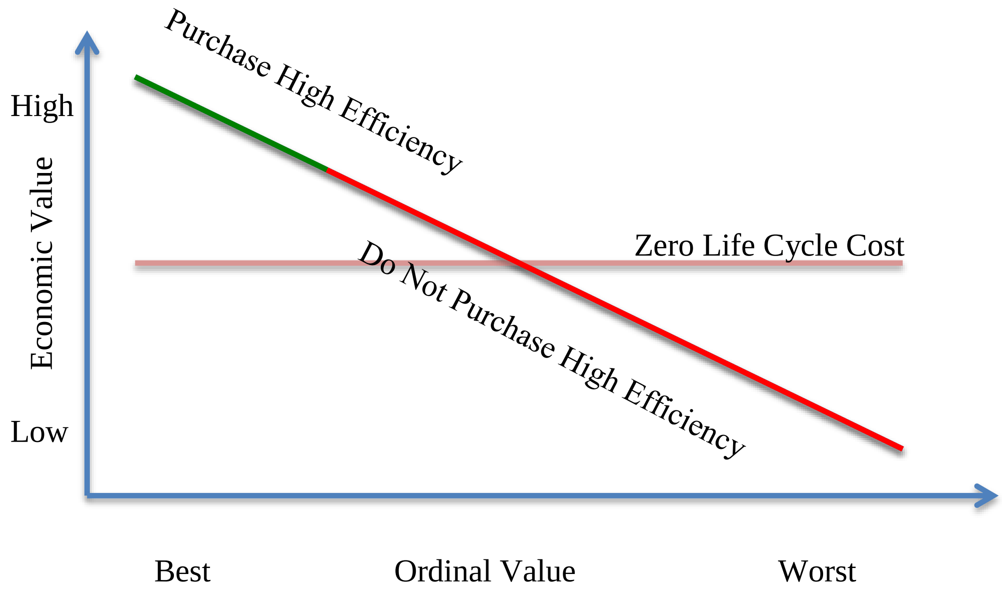

In a functioning market, the market share of higher efficiency products would be the percentage of customers whose ordinal numbers are greater than that of the nth, breakeven customer (Figure 3).

Figure 3: Purchase Share




Market failure occurs when the number of consumers purchasing high efficiency products is up and to the left of the intersection between the ordinal ranking line and the actual breakeven life cycle cost (n actual is less than n predicted, when the ordinal ranking value starts from the highest economic value) (Figure 4).

Figure 4: Market Failure




The challenge for DOE in setting standards is, first, to determine whether such market failure exists. Second, DOE must evaluate what standard level makes sense. Third, since DOE is required to consider alternatives to standards, DOE must determine whether standards are the most effective means of rectifying any market failure.

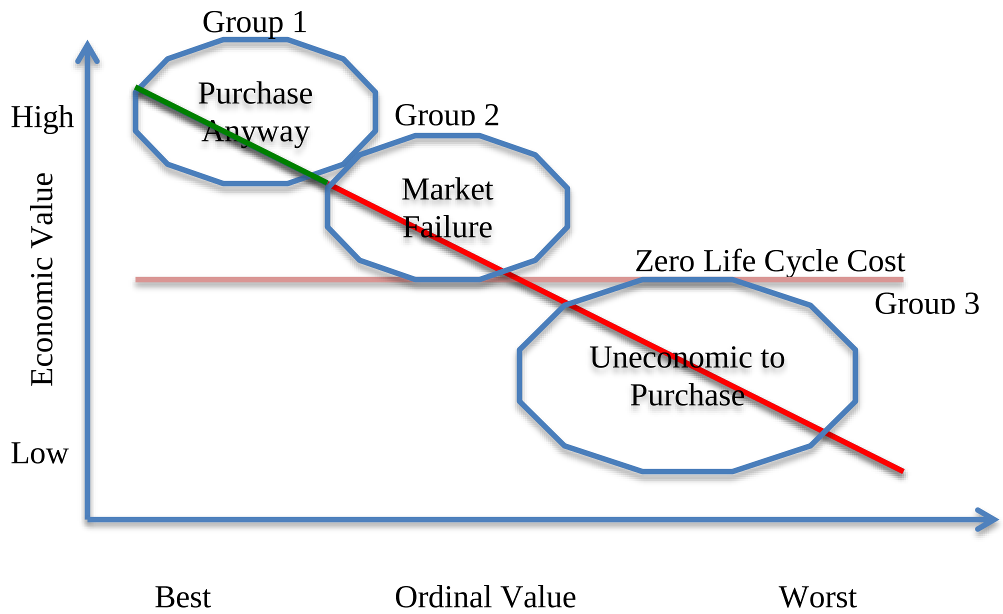
*Understanding Who is Affected*

In order to understand the degree of market failure, DOE must consider three groups of consumers (Figure 5):[39]

- Group 1: Purchase Anyway – these are consumers for whom more efficient equipment has positive life cycle cost savings and who will purchase more efficient equipment with or without standards
- Group 2: Market Failure – these are consumers who would have positive life cycle cost savings but who chose not to purchase more efficient equipment absent standards
- Group 3: Uneconomic to Purchase – these are consumers for whom more efficient equipment does not have positive life cycle cost savings and who make the economically rational choice not to purchase more efficient equipment

[39] There is, logically, a fourth group – consumers who chose to buy more efficient equipment even though the life cycle cost savings are negative. This group is very small, in the single digit percentages, and can be safely ignored for the purposes of standard setting.

Figure 5: Market Failure Purchase Groups




For the purposes of standard setting, Group 1 is irrelevant. These consumers are unaffected by any standard and their economic performance (the savings in life cycle cost and in energy are) do not count in any standard assessment. Group 2 are the net "winners", these are consumers whose individual economics and whose benefits to society are improved by being forced to purchase more efficient equipment. Group 3 includes "losers", those who are coerced into purchasing more efficient equipment at the expense of their own personal financial advantage.

A well-crafted set of standards would have a large portion of consumers in Group 2, a very small number in Group 3 and relative indifference to the number in Group 1. The goal of regulatory analysis is to determine the size and composition of the three groups.

*Determining Whether There is a Problem*

Unfortunately, DOE's analytical tools are incapable of determining which consumers are in which group. In theory:[40]

1. DOE would rank all 60 million or so structures with gas furnaces by life cycle cost savings for the base case without standards (for this rulemaking, 80 AFUE furnaces).
2. It would then discard the 50% of structures with the highest life cycle cost savings representing the current market share of furnaces meeting the potential standard
3. DOE would then determine how many remaining structures have positive life cycle cost savings (Group 2: Market Failure) and how many have negative life cycle cost savings (Group 3: Uneconomic to Purchase)
4. The sum of the positive and negative life cycle cost savings from Groups 2&3 represent the net benefit and cost of the regulation.

[40] This discussion covers replacement applications for simplicity and clarity. Segmenting for regions, new construction or other sub-groups would follow an analogous procedure.

However, the DOE life cycle cost modeling procedure does not do this. Instead, it:

1. Selects structures randomly from the pool of 60 million eligible units
2. Assigns a base case efficiency and a standards case efficiency to each selected structure on a weighted random basis without regard to economic results to the consumer
3. Calculates the life cycle cost savings for that combination of base case and standard case costs and savings
4. Sums the various costs and savings to get a mean and median distribution of life cycle costs

These may appear to be the same processes, but they are not. The DOE random assignment approach does not produce an ordinal ranking of the life cycle costs. Instead, it produces some sort of random distribution of consumer economics. The DOE methodology cannot discriminate between consumers who fall into the three decision groups.

The problems with the DOE methodology are:[41]

1. Random selection of structures and fuel costs does not give an ordered ranking
2. Weighted random assignment of base case and standards case costs and savings can defy economic rationality: a consumer can be assigned an illogical base and standards case situation such as 95% furnace as the base case purchase and a 92% furnace as the post standard case
3. Consumers can be assigned illogical combinations, such as computing the costs and benefits of 98% furnaces in Miami or the costs and benefits of low efficiency furnaces in Alaska

DOE is acting as if the market were non-rational, that is that it has no rationality whatsoever. Basically, DOE assumes that all consumer decisions are random so it produced and uses a random number generator. What is needed is a methodology that assumes the marketplace is rational but calculating incorrectly (that the market functions but incorrectly) and measures the degree of market failure. The LCC does not do that.[42]

This weakness of the DOE modeling approach is not a new insight. GAMA, a predecessor to AHRI, recognized that there were flaws in the way that DOE used its Crystal Ball and Monte Carlo simulation approach in 2004.[43] The flaws in the DOE use of Monte Carlo simulations to determine "winners" and "losers" from proposed standards are, in fact, deeper and more significant than even GAMA recognized at the time. DOE is using a tool designed to measure uncertainty in a randomly distributed population to measure an ordered, determined structure. It is trying to use a hammer to put in screws. This may sort of work sometimes. If the median life

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[41] The Gas Technology Institute has reviewed the cases produced by DOE's random assignment process and has identified outlier economic results caused by the random assignment process. http://www.gastechnology.org/reports_software/Documents/21693-Furnace-NOPR-Analysis-FinalReport_2015-07-07.pdf

[42] DOE could use much of its existing data to create a proper ordinal model. This would entail using the Residential Energy Consumption Survey (RECS) to create an ordinal ranking of installation costs and energy savings in a deterministic fashion as a separate analysis and without the Crystal Ball randomizer. DOE could possibly use distributions and Monte Carlo simulations for the variables associated with households, not structures. However, this approach would need considerably more thought and work before DOE could adopt it.

[43] GAMA Bulletin to Furnace and Hydronics Divisions, September 15, 2004, see Appendix B

cycle cost savings computed by the DOE methodology are highly positive and the actual market share of high efficiency products is low, then the likelihood is high that there is a market failure going on. In this case, pounding a screw into drywall with a hammer actually works. However, this is not the situation facing the furnace rulemaking, where the current share of condensing furnaces is on the order of 50% of the market. DOE needs a modeling process that actually measures the ordered nature of economics, considers consumer choice rationally and correctly assigns purchasers into the Group 1: Purchase Anyway, Group 2: Market Failure and Group 3: Uneconomic to Purchase categories. DOE's random assignment methodology does nothing of the kind. It is using its hammer to pounds screws into oak. The results are not pretty.

*Implications for Furnace Analysis*

Reviewing the DOE results from the LCC model and, for the moment accepting all of the DOE assumptions and recognizing the limitations of the modeling process, indicates that approximately 20-30 percent of the residential furnace market could possibly be considered as in Group 2: Market Failure. The remainder is either already purchasing condensing furnaces or would have negative economic results from purchasing one. This represents the absolute maximum degree of market failure; the actual degree is much smaller because of the limitations in DOE's LCC analysis and because of errors in DOEs assumptions. Since DOE's analytical method is not designed to provide an answer to the question of market failure, insights into that question must be teased out of the analysis done by DOE so far.

One measure is the percent of purchasers who have "Net Benefit" in LCC, meaning that the discounted operating cost savings are greater than the increased installed cost. The Net Benefit characterization is derived from the LCC output entitled "LCC Saving" – the net savings (or net cost) calculated in each of the 10,000 Crystal Ball runs in the LCC (Figure **6** and Figure 7). In addition, DOE's model generates LCC savings at each 10 percentiles, and the difference can be calculated by subtracting the two (Figure 8). This is the method used by DOE in establishing the "Simple Payback" in its LCC model results.[44]

[44] Results report generated from running Crystal Ball analysis of LCC model provided by DOE: EERE-2014-BT-STD-0031, 2014-02-06 NOPR Spreadsheets: Residential Furnace Life-Cycle Cost and Payback Period Analysis. Displayed results exclude the 0 and 100 percentiles, where the values represent oddities caused by the peculiarities of the random assignment of Base and Standards cases. The calculations also use the 90 AFUE level to avoid confusion again caused by base case choices for the higher AFUEs. Note, the "LCC Savings" are calculated for each individual building in the model run, the differences between percentiles is for the aggregate of all runs.

Figure 6: "Winners" and "Losers" Predicted by DOE

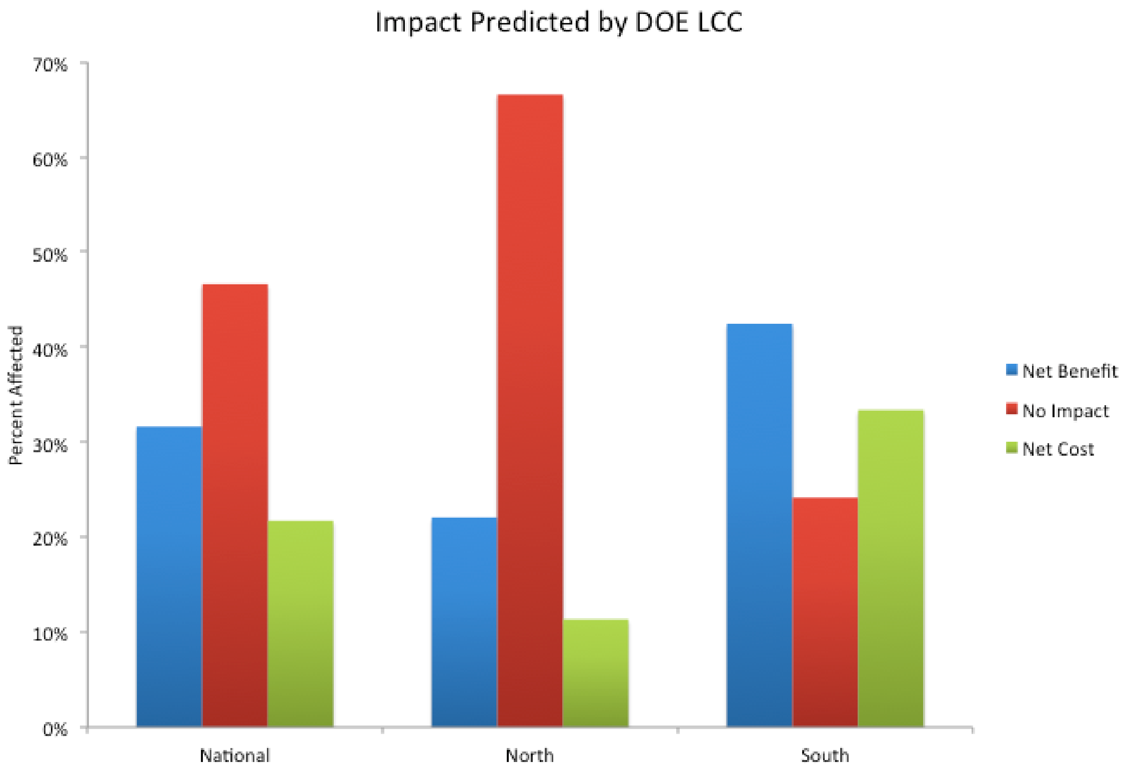



Figure 7: Differences in LCCs for Each Crystal Ball Random Number

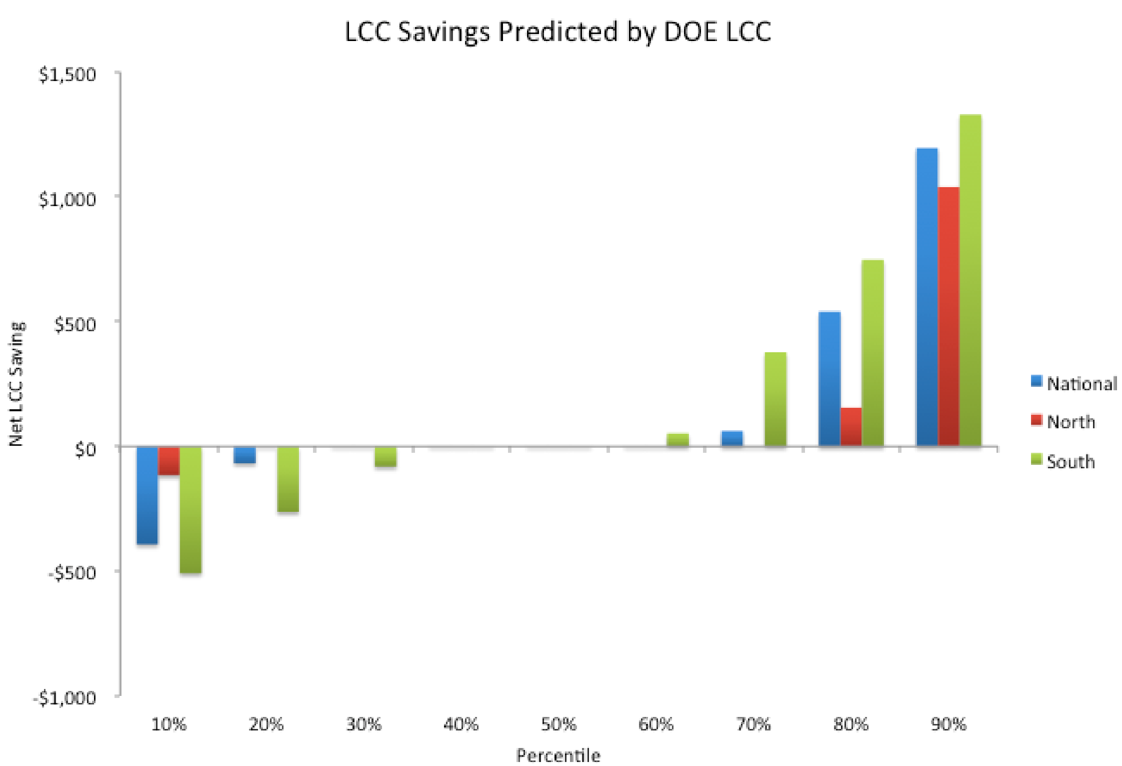
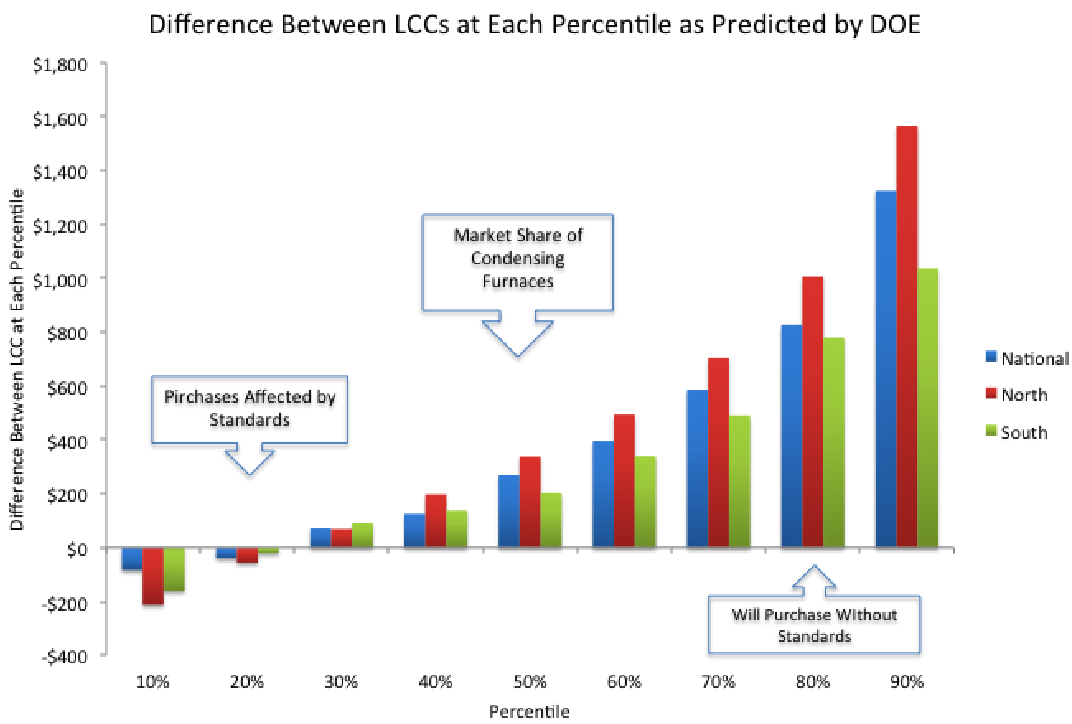


Figure 8: Difference Between Crystal Ball Percentiles




These analyses appear to show that the proposed standards are benign since most households in the North are unaffected and a plurality in the South benefit (Figure 6). In actuality, these results essentially reflect the assumed share of condensing furnaces in the Base Case. The "No Impact" result is obtained when the Base Case and the Standards Case are the same, i.e. when the Base Case already assumes that the homeowner is planning to purchase a condensing furnace. DOE assumes that condensing furnace share in the Base Case is National: 47%, North: 66% and South: 25%.[45] These are the values that appear in the "No Impact" charts.

These results do not mean there is a benign "No Impact", it means that these purchasers are being arbitrarily assigned to Group 1: Purchase Anyway without any regard to the actual economic returns to them or to any of the other purchasers who are excluded from this group. In reality, any reasonable characterization of marketplace behavior would expect that the high positive life cycle cost savings shown in the 70th to the 90th percentiles would be in the "No Impact" category. Because of random assignment, DOE is arbitrarily assuming that consumers are acting counter to their economic interests. It is assuming the conclusion it is trying to prove. While this may be comforting to an analyst or an advocate, it is not a piece of serious thought. Rather it is being arbitrary and capricious in its use of analytical tools and data. In any serious analysis, the "No Impact" portion of would shift to the far right of the graph so that the large positive life cycle cost savings now shown in that chart would be replaced by smaller or negative savings.

[45] US Department of Energy, Technical Support Document: Energy Efficiency Program For Consumer Products And Commercial And Industrial Equipment: Residential Furnaces, February 10, 2015 (Furnace TSD) p. 8I-11

What the LCC Savings analysis also appears to show is that about 20-30 percent of furnaces are sold in situations where the LCC savings are positive, meaning that this is the degree of market failure. These 20-30 percent are situations where the economics are positive while the purchase choice was not already going to be a condensing furnace. As discussed above, while this is really an artifact of the incorrect modeling process, it provides an upper bound of the possible degree of market failure. Similarly, the differences in LCCs at various percentiles show that LCC savings occur for 70% of all cases (Figure 8). Again, this represents a twenty-percentage point market failure since 50% of the market already purchases condensing furnaces. In addition, approximately 10 percentage points more of situations have Net Benefits than Net Costs (Figure 6). In other words, using standards to address market failure results in 10% more of the situations adopting positive behavior than would have occurred without standards. Since the LCC analysis is replete with other errors, this is the maximum degree of market failure and the maximum amount of net amelioration of that failure.

Counter intuitively, the LCC Savings data seems to show that the greatest market failure is in the South where there is a higher percentage of Net Benefit households and the degree of benefit is larger. It is fiendishly hard to tease out the actual LCC performance of an individual data point among the 10,000 in the Crystal Ball analysis. The calculated results in the South are probably a reflection of the lower initial market share for condensing furnaces and also errors in the assumptions and calculations.

*Implications for Selection of Standard Levels*

DOE also uses its LCC process as part of the analytical support for its considerations of three of the seven factors it is required to evaluate in order to select a standard level:

- Factor (1) The economic impact of the standard on manufacturers and consumers of the products subject to the standard;
- Factor (2) The savings in operating costs throughout the estimated average life of the covered products in the type (or class) compared to any increase in the price, initial charges, or maintenance expenses for the covered products that are likely to result from the standard;
- Factor (3) The total projected amount of energy (or as applicable, water) savings likely to result directly from the standard

Because the DOE modeling process does not lead to a correct assessment of the effects of any standard level on consumers because it does not correctly calculate life cycle costs, DOE cannot use the current model to evaluate Factor (2). DOE uses the results of the LCC analysis to determine the economic gains and losses at the level of the individual house as well as the energy savings and then accumulates those results in the NIA model. The errors in the LCC are, thus, carried over into the NIA so that it does not provide reliable results for DOE to assess Factors (1) and (3). Even before correcting for errors in the application of DOE's models, the process for setting standards is not accurate. Relying on the current LCC model in any form amounts to arbitrary and capricious analysis, particularly since the random (*i.e.* arbitrary) assignment of furnace choices in a non-random environment is at the heart of the DOE process.

## DOE LCC Model Errors

In addition to the errors in modeling logic, the LCC model also contains errors in its data and assumptions. The four principal ones are:

- Continued reliance on the discredited concept of "incremental" markups through the distribution channel
- Incorrect use of average versus marginal consumer discount rates
- Incorrect costs of installation
- Incorrect ex-plant manufacturer costs for energy improvements
- Overestimate of the time that a homeowner stays in a home

There are also numerous areas where the LCC model produces results that do not appear to be reasonable or realistic, indicating that there are flaws either in the input data or in the logic of the model itself. In aggregate, these errors reduce the portion of the market in Group 3: Market Failure from possibly 20% to none of the residential furnace market.

*Markups*

DOE calculates the cost to end customers of improved energy efficiency by taking the projected manufacturing cost of more efficient products and multiplying that cost by a markup to get from ex-plant cost to selling price by the manufacturer ("Manufacturer Markup") and by a series of markups through the distribution channel.[46] The number and amount of channel markups depends on the number of steps in the distribution channel. In all cases other than at the manufacturer, DOE uses an "incremental" markup for the additional cost of more efficient equipment. DOE justifies its use of incremental markups in a paper written by Larry Dale, *et. al*.[47]

Shorey Consulting has demonstrated in a series of comments that there is no empirical support for the basic concepts in the Dale paper, that there are alternative theoretical explanations for margin structure that do not correspond to those predicted by the Dale paper in the distribution channel for heating and air conditioning equipment and that interviews with heating and air conditioning wholesalers, distributors and contractors directly contradict the conclusions of the Dale paper.[48] DOE has not responded to or refuted these comments and criticisms. For this furnace rulemaking, LBNL has admitted that it has "not contacted directly individual contractors or distributors."[49] In addition, DOE has not responded to AHRI's question whether it has "ever conducted interviews with HVAC contractors, wholesalers or distributors on their actual markup

[46] As a matter of policy and to prevent anti-competitive activities, AHRI does not comment upon markups or other pricing related matters at the manufacturer level

[47] Dale, Larry; Millstein, Dev; Coughlin, Katie; Van Buskirk, Robert; Rosenquist, Gregory; Lekov, Alex and Bhuyan, Sanjib: *An Analysis of Price Determination and Markups in the Air Conditioning and Heating Equipment Industry,* Lawrence Berkeley National Laboratory LBNL-52791, January 2004, Abstract

[48] Shorey, Everett: Incremental Markups – A Critical Review of Theory and Practice Comments on *An Analysis of Price Determination and Markups in the Air Conditioning and Heating Equipment Industry* - LBNL-52791, submitted on behalf of AHRI

[49] EERE-2014-BT-STD-0031, 2015-04-13 Transcript: U.S. Department of Energy Public Meeting: The Energy Conservation Standards For Residential Furnaces Page 123, Lines 10-11.

practices."[50] The sum total of DOE's support for its theory is: "Following standard economic theory, competitive firms facing inelastic demand either set prices in line with costs or quickly go out of business."[51] As Shorey Consulting has shown in its previous comments, this "standard economic theory" has never been validated empirically and efforts to do so generally show that industry structure only weakly correlates with profitability. THE DOE argument is a castle built not on sand, but quicksand.

AHRI, ACCA (the trade association of heating and air conditioning contractors), PHCC (the trade association of plumbing, heating and cooling contractors) and Shorey Consulting conducted a survey of contractors on installation costs and on markup practices for residential gas furnaces.[52] The survey addressed this question in two waves, the first wave (604 responses) asked:

> Q1: Does your company use different markups for the price of 80% AFUE Efficiency and for High Efficiency residential gas furnaces?
>
> Q2: In the past, when new efficiency standards for air conditioners, heat pumps or other products occurred, did your typical markup change?

The second wave (170 responses) asked (italics in original):

> Q1: Does your company use different *percentage* markups for the price of 80% AFUE Efficiency and for High Efficiency residential gas furnaces?
>
> Q2: In the past, when new efficiency standards for air conditioners, heat pumps or other products occurred, did your typical *percentage* markup change?

The results from the survey are shown in Figure 9 and Figure 10.

[50] EERE-2014-BT-STD-0031, Stakeholder questions regarding the Furnace Rulemaking, Questions on Furnace Rulemaking and Related Models, Question 2
[51] Furnace TSD p. 6-6
[52] AHRI, ACCA, PHCC and Shorey Consulting, Inc, Survey of Furnace Installation Contractors, June 2015 attached as Appendix B

Figure 9: Contractor Survey Markup Question 1

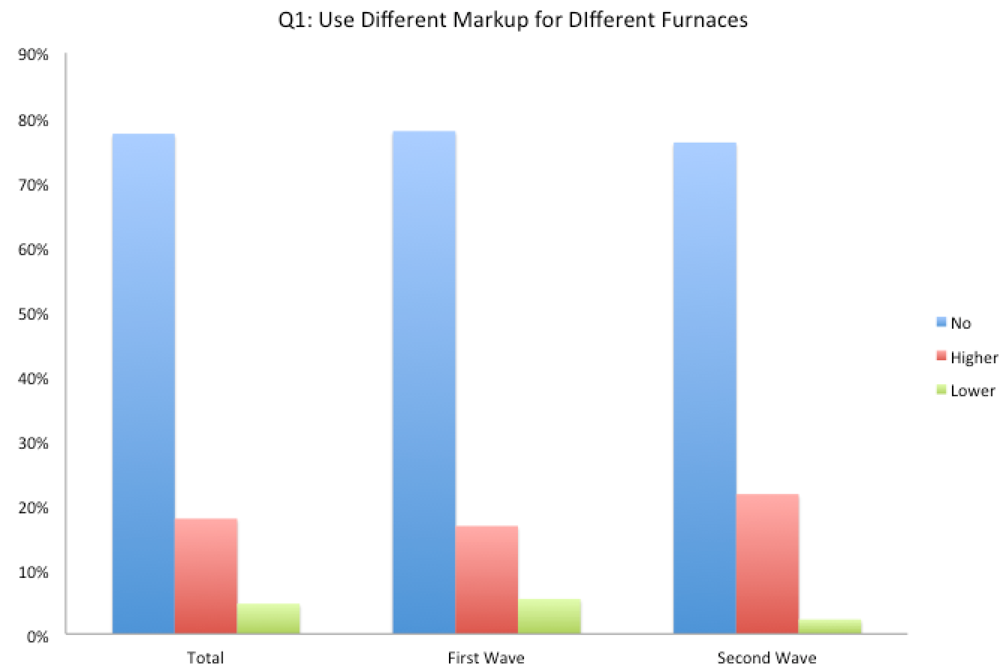
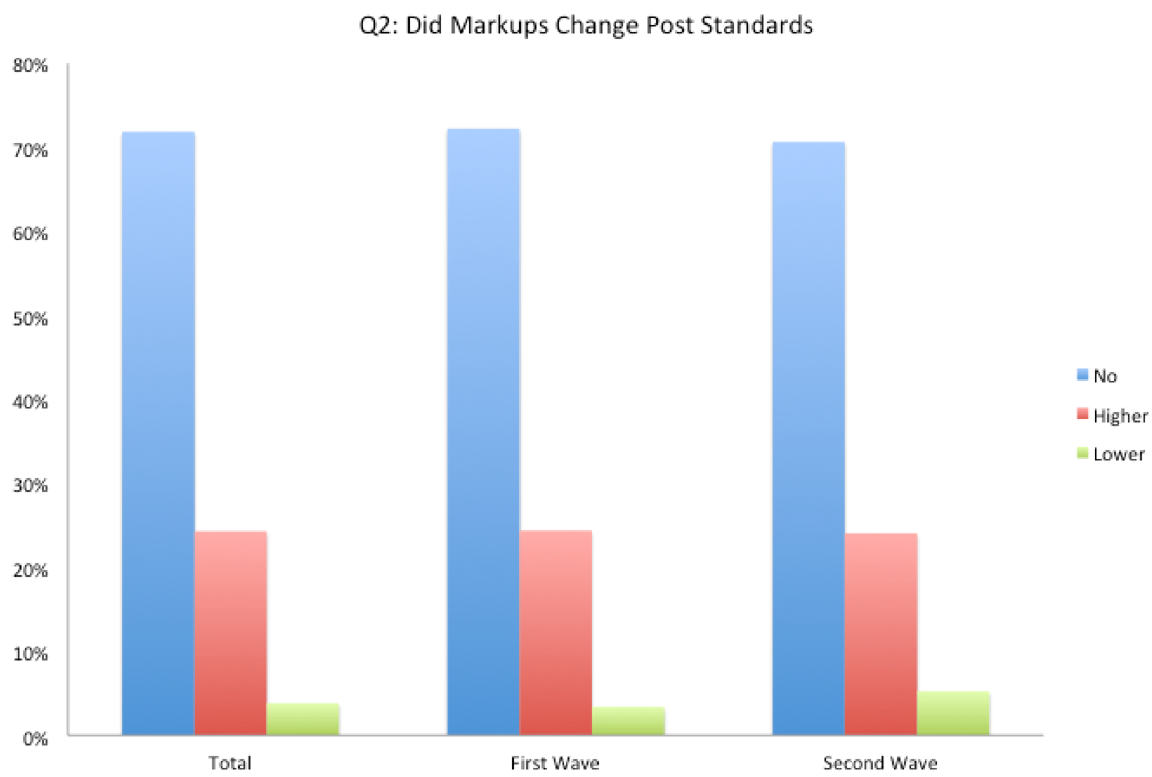



Figure 10: Contractor Survey Markup Question 2




This survey established that contractors do not use different markups pre and post standards, directly refuting the conclusions of the Dale paper. If anything, the markups increased, not decreased as predicted by Dale *et. al*. The nearly identical results in the two waves of the survey demonstrate that the contractors understood the question to refer to percentage markup in both waves.

DOE's continued reliance on the incremental markup concept amounts to arbitrary and capricious behavior. First, there is no empirical support for the general contention in the Dale paper that profits/margins will converge on the long term cost of capital, there is an alternative theoretical explanation why they might not in the heating and air conditioning industry. Second, the minimal empirical data cited by Dale either is irrelevant or tends to support the presence of consistent gross margins. Third, AHRI has now supplied interview data with distributors and wholesalers, interview data with contractors and survey data of contractors, all of which directly contradict the Dale paper. DOE has not supplied any references to *any* empirical data that it has relied on that shows a difference in markups on pre and post standard products. The incremental markup theory has no theoretical and no empirical foundation and cannot be relied on in the face of actual data. In the most simple and direct terms, the Dale theory is just plain wrong as a description or a prediction of margin behavior in the distribution channels for HVAC equipment.

*Discount Rates*

DOE shows a curious pattern of using marginal costs whenever it chooses to do so and average costs when it wishes. It chooses to try and use marginal markups instead of average ones even when the data show that the marginal and the average are the same. It uses incremental costs for higher efficiency equipment. It uses learning curves to estimate the future cost of equipment. It uses marginal gas and electricity prices. Yet it chooses to use average consumer discount rates.

In the case of consumer discount rates, DOE has relied on average, not marginal sources of funds:

> "DOE's approach involved identifying all relevant household debt or asset classes in order to approximate a consumer's opportunity cost of funds related to appliance energy cost savings and maintenance costs. The approach assumes that in the long term, consumers are likely to draw from or add to their collection of debt and asset holdings *approximately in proportion to their current holdings* when future expenditures are required or future savings accumulate."[53] (Emphasis added)

This statement represents a complete misunderstanding or mischaracterization of the nature of consumer balance sheets and of the flow of funds for consumers. There is no evidence that consumers can and do "draw from or add to their collection of debt and asset holdings approximately in proportion to their current holdings". DOE has certainly never provided any such evidence. Rather, consumers have very limited options to raise funds, particularly in the magnitude of $3000-$5000 for a new furnace.

As Shorey Consulting pointed out in its comments on the recent dishwasher rulemaking:[54]

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[53] Furnace TSD p. 8-24

[54] EERE-2014-BT-STD-0021, AHAM Comments, DOE Dishwasher Standards NOPR_FINAL (00036272), March 25, 2015, Appendix A, p. 12 (Table added)

> "In its analysis, DOE looks at the percentage share of consumer balance sheets made up of different types of assets.[55] It does not consider whether consumers could add to any of these asset or liability classes and/or what it would mean in the savings/consumption trade-off to do so. In reality, the actual amount of low cost funds (such as checking accounts) is, effectively, finite or can be replenished only by the consumer adjusting the savings/investment decision. For example (Table 1) consumers in Income Group 3 have 37.3% of their financial debt and equity in home mortgages, another 14.1% in other forms of debt, 3.4% in relatively liquid account (Savings and Money Market Accounts) and the remainder in longer-term assets and stocks and other investments.[56]
>
> What these percentages obscure is the absolute magnitude of the amounts available to consumers and the relative ability to generate additional funds from the various sources. In reality, except for minor purchases, most households' access to additional funds comes from credit card debt.
>
> - The average household in Income Group 3 has $2916 in cash and other immediately liquid assets. This is the entire cushion available to a household for any emergencies and can be replenished only by extra savings. The small amount of cash and immediately liquid assets in household accounts is testament to the difficulty in generating additional savings.
> - Mortgages comprise the bulk of consumer debt, however, refinancing a mortgage to purchase a new dishwasher is impractical. The transaction costs for a refinancing are greater than the cost of a new dishwasher.
> - Other Equity covers the totality of a household's non-liquid financial assets including retirement savings. Assuming that a household can tap its retirement funds to pay for a new dishwasher seems to be an extremely aggressive and unwarranted assumption.
>
> This leaves other forms of consumer debt as the only marginal source of funds."

Table 1: Household Financial Data

| | Income Percentile | | | | | |
|---|---|---|---|---|---|---|
| | <20 | 20.0-39.9 | 40.0-59.9 | 60-79.9 | 80-89.9 | 90-100 |
| Liquid | $475 | $1,270 | $2,916 | $6,739 | $13,473 | $51,000 |
| Mortgage | $5,760 | $18,216 | $32,121 | $69,654 | $120,234 | $179,200 |
| Other Debt | $3,979 | $6,744 | $12,108 | $16,786 | $27,270 | $50,924 |
| Other Equity | $3,347 | $14,415 | $38,977 | $99,311 | $249,456 | $997,340 |
| Total | $13,561 | $40,645 | $86,122 | $192,489 | $410,433 | $1,278,465 |
| | | | | | | |
| Liquid | 3.5% | 3.1% | 3.4% | 3.5% | 3.3% | 4.0% |
| Mortgage | 42.5% | 44.8% | 37.3% | 36.2% | 29.3% | 14.0% |
| Other Debt | 29.3% | 16.6% | 14.1% | 8.7% | 6.6% | 4.0% |
| Other Equity | 24.7% | 35.5% | 45.3% | 51.6% | 60.8% | 78.0% |
| Total | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% | 100.0% |

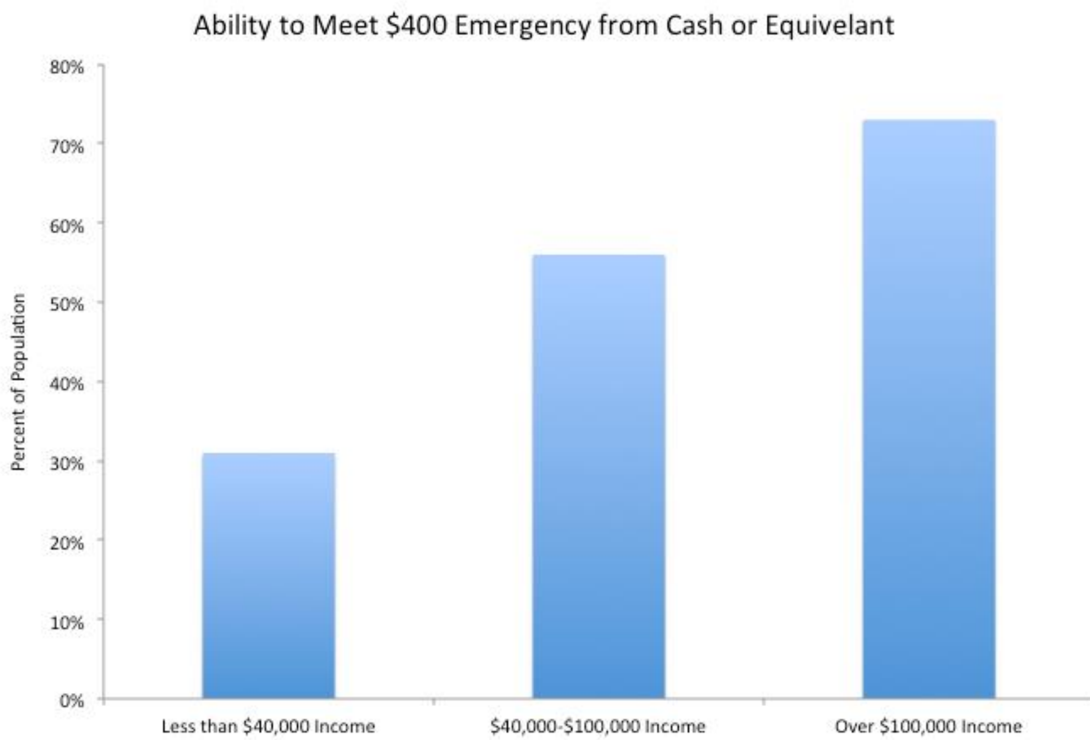
These comment remain true for DOE's analysis of furnaces.

[55] Dishwasher TSD Table 8.2.1.6, page 8-25
[56] Federal Reserve Board, 2013 Survey of Consumer Finances, Tables 6-13 and 13-13

In addition, there have been three new surveys, two public and one private, that demonstrate the fragility of consumer savings levels, the difficulty consumers have in meeting emergencies from cash or other liquid assets and the reliance on debt for major purchases.

First, the US Federal Reserve Board conducted a survey of household economic well being that asked whether respondents could meet a financial emergency from cash or a credit card paid off at the end of the month (Figure 11).[57] This survey found that 56% of middle-income households could do so, or, conversely that 44% could not. Of course, the replacement of a furnace is nearly 10 times the amount studied in this survey, so the percentage able to use cash or the equivalent would almost certainly be very substantially lower.

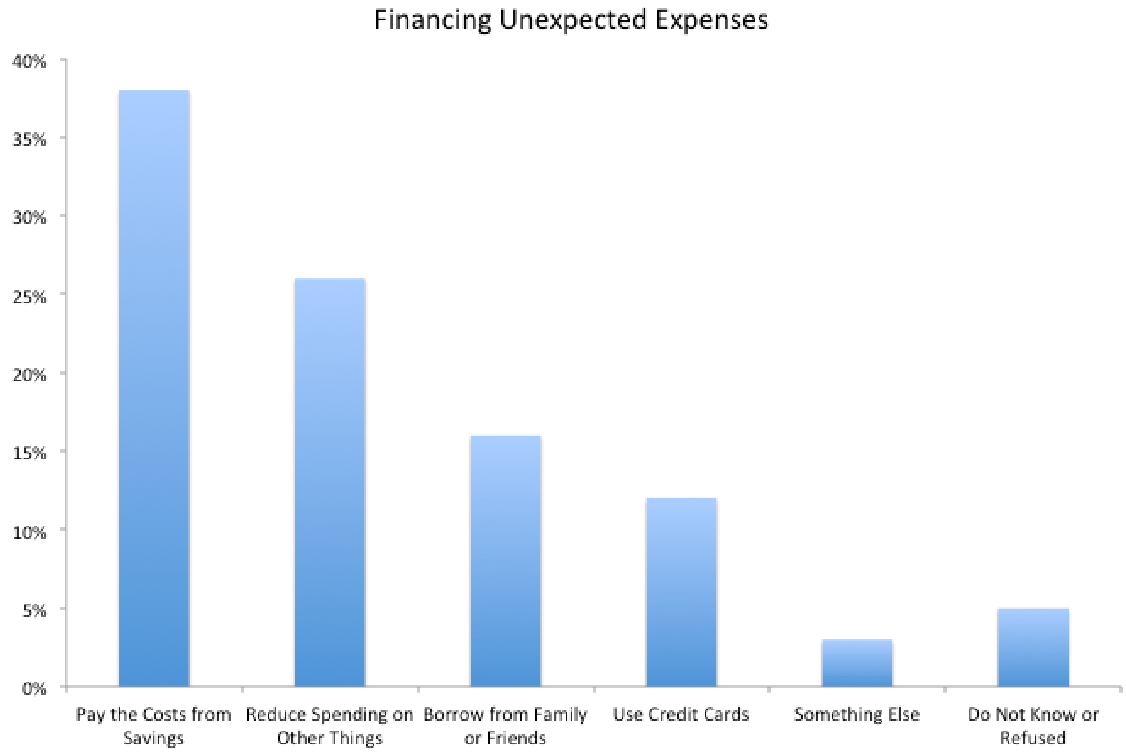
Figure 11: FRB Emergency Survey




Second, Bankrate conducted a Money Pulse poll and found that 36% of consumers could meet a $500 emergency car repair or a $1000 medical expense from savings (Figure 12).[58] The remainder would use a variety of means, including deferring consumption, borrowing from friends and credit cards to meet the expense. Again, this is an amount well below the cost of a furnace replacement and might well limit the availability of funds from, say, family and friends.

[57] Board of Governors of the Federal Reserve System, Report on the Economic Well-Being of U.S. Households in 2014, May 2015, p. 18
[58] http://www.bankrate.com/finance/smart-spending/money-pulse-0115.aspx

Figure 12: Bankrate Survey



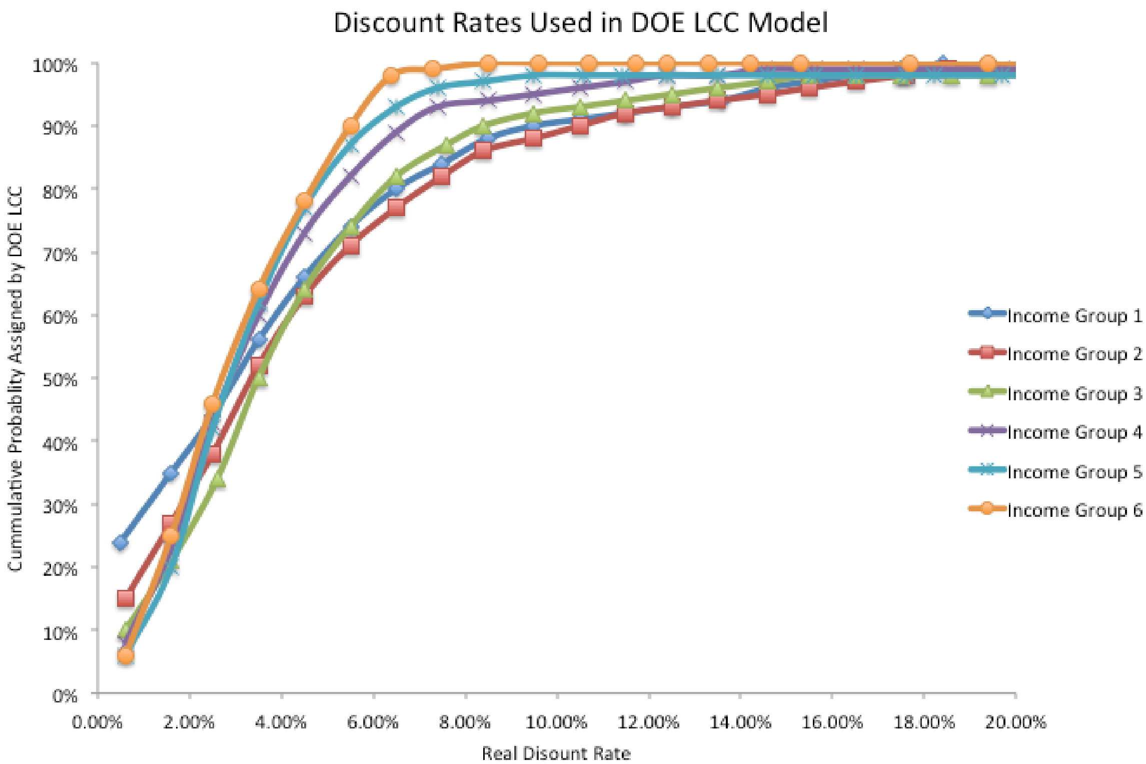

Third, a furnace manufacturer participates in a consumer survey with over 10,000 respondents. This survey found that 55% of consumers used some sort of financing for the purchase of HVAC equipment. This survey is unpublished.

In this context, the DOE assumed real discount rates appear to be improbable representations of the actual financial situations faced by consumers. In its LCC, DOE has average discount rates of (Figure 13):[59]

- Income Group 1 (0-20$^{th}$ Percentile) – 4.9%
- Income Group 2 (20-40$^{th}$ Percentile) – 5.1%
- Income Group 3 (40-60$^{th}$ Percentile) – 4.8%
- Income Group 4 (60-80$^{th}$ Percentile) – 4.0%
- Income Group 5 (80-90$^{th}$ Percentile) – 3.8%
- Income Group 6 (90-100$^{th}$ Percentile) – 3.6%

[59] Assumptions report generated from running Crystal Ball analysis of LCC model provided by DOE: EERE-2014-BT-STD-0031, 2014-02-06 NOPR Spreadsheets: Residential Furnace Life-Cycle Cost and Payback Period Analysis

Figure 13: DOE Assumed Consumer Discount Rates




The true marginal discount rates for consumers are much more likely to cluster around 8-9% than around 3-5%. First, as demonstrated by both reasonable analysis of consumer balance sheets and the survey data, only a minority of consumers will be able to use cash or other savings in order to pay for a furnace replacement. Even then, cash is not a low/no cost source of funds since it must be replaced with high cost funds or deferred consumption in order to rebuild the liquidity cushion. The marginal source of funds for most consumers is credit card debt (estimated by DOE at 14.2-15.0% interest rate)[60]. According to the American Housing Survey, only 7% of respondents had home equity loans or lines of credit (the lowest cost of borrowing for most consumers).[61] (While home mortgages are also a low cost source of funds, the transaction costs and time for refinancing a mortgage make first mortgages an unlikely source of funds for a furnace replacement.) A small portion of households in Income Groups 5 and 6 may be able to finance a furnace replacement by drawing on non-retirement savings. However, these will also have a cost of funds estimated by DOE at 4.2% for debt to 9.2% for equities.[62] While this may yield an average cost of consumer capital below 8-9%, it is unlikely that DOE wishes to justify standards on the ability of the upper 10% of consumers to finance them at relatively lower costs of capital.

[60] Furnace TSD, p. 8-26
[61] US Department of Census, American Housing Survey, 2013 National Public Use File, proportion of respondents in mortg.csv file with home equity loan interest
[62] Furnace TSD, p. 8-27

*Installation*

There is something systemically wrong with DOE's installation data. Where comparable, the DOE installation costs are approximately half of the costs estimated by contractors. The contractors however have only experience with the cost of condensing furnace installations that are acceptable to consumers while the DOE data covers economically attractive as well as regulatory forced, uneconomic installations. Thus the actual difference in installation costs is likely to be $1000 or more above that represented by a simple comparison between contractor and DOE data.

It is not possible, given the nature of the LCC model, to estimate how incorrect the DOE analysis is. The total cost of installation is clearly incorrect. The differences in installation costs between efficiency levels on the surface appear to track with empirical data. However, the empirical data is only for those installations that currently make economic sense to the purchaser (that is, by definition, the only data that exists in the field). Therefore, the DOE data is incorrect both in absolute magnitude and by the costs of the currently non-economic installations. The incremental costs for the non-economic installations (especially in the North where the savings from a condensing furnace can be significant) are virtually certainly higher than the amounts currently estimated by DOE.

AHRI, ACCA and PHCC conducted a survey of furnace contractors to determine typical installation costs for non-condensing and condensing furnaces. The survey received[63]:

- 774 total responses
- 580 with some usable data on installation costs
- 580 with some usable data on markups
- 399 usable installation cost responses from DOE's "North" region, 181 from DOE's "National" region (South) and 4 from region unknown[64]

This is approximately a 7% response rate of usable data from the total membership of ACCA and PHCC and nearly a 10% total response rate. Usable responses represent just less than 1% of the total universe of plumbing, heating and air conditioning contractors.

The mean cost of installation for replacement applications from the survey was[65]:

| Type | North | South |
|---|---|---|
| Non-Condensing | $2167 | $1962 |
| Condensing | $2736 | $2531 |
| Difference | $569 | $569 |

63 AHRI *et. al.* Installation Survey

64 Regions defined in Technical Support Document: Energy Efficiency Program For Consumer Products And Commercial And Industrial Equipment: Residential Furnaces, February 10, 2015. p.2-

65 See AHRI, *et. al.* Survey for methods to compute values

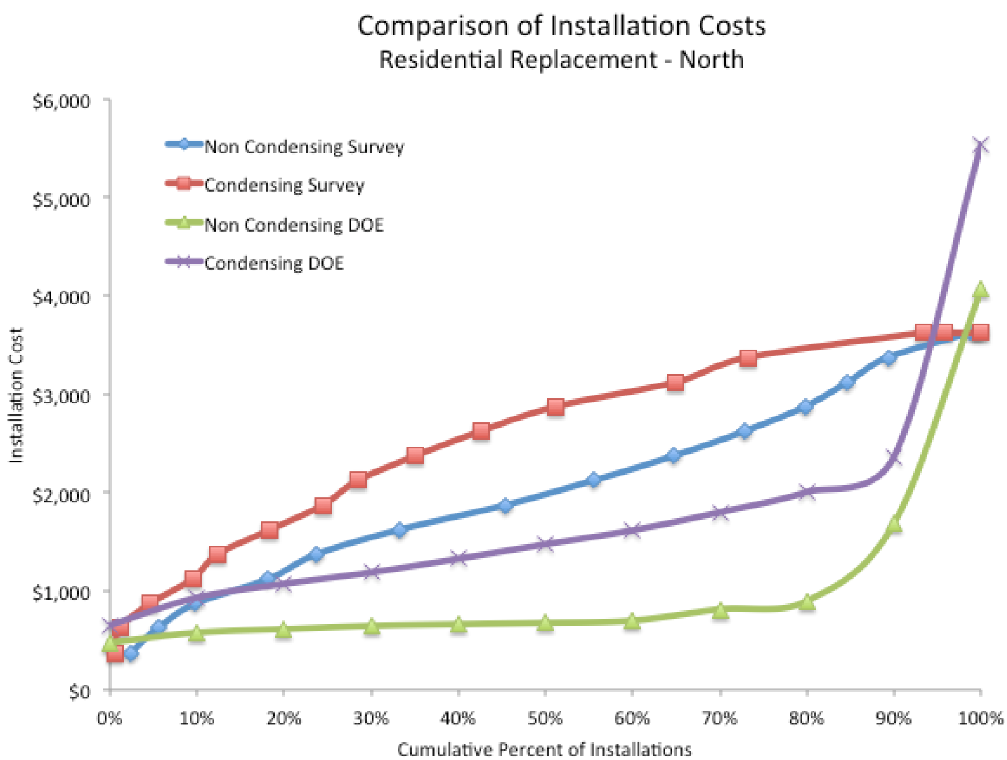
By contrast, the median cost in the DOE analysis is[66]:

| Type | North | South |
|---|---|---|
| Non-Condensing | $680 | $508 |
| Condensing | $1477 | $952 |
| Difference | $797 | $444 |

The mean costs for the DOE data are distorted by high outlying values.

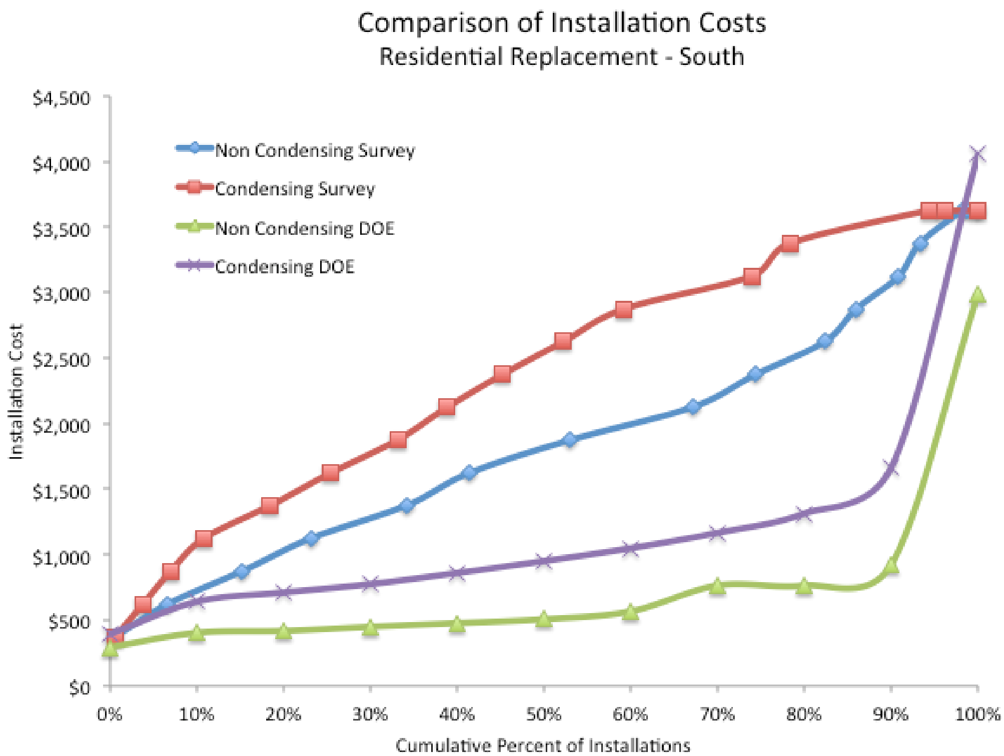
The total distribution of costs shows a consistent pattern of DOE underestimating the cost of installation (Figure 14 & Figure 15).

Figure 14: DOE vs. Contractor Survey Furnace Installation Costs – North




[66] Forecasts report generated from running Crystal Ball analysis of LCC model provided by DOE: EERE-2014-BT-STD-0031, 2014-02-06 NOPR Spreadsheets: Residential Furnace Life-Cycle Cost and Payback Period Analysis

Figure 15: DOE vs. Contractor Survey Furnace Installation Costs - South




DOE developed its installation costs using RS Means data for various cost components and then tried to determine which components were required for each building in the RECS database. The use of RS Means data is a well-established practice and this data is the most comprehensive available on the cost components of construction. The problem is unlikely to be the RS Means data itself. Rather, building up costs from components is an inherently tricky exercise because it is easy to make systemic mistakes. There is no evidence that DOE calibrated its installation cost estimates with market data, leading to some sort of systemic error.[67]

Again it is important to recognize that contractors in the AHRI, ACCA and PHCC survey only have experience with, and thus responded to the survey, with estimates of installation costs for economically attractive projects. Expensive difficult installations are, by definition, excluded from the survey results. Thus the comparison between percentiles is misleading. Because the market share for condensing furnaces is approximately 50%, the survey data on the cost of installing a condensing furnace only goes up to the 50$^{th}$ percentile of costs. The 100$^{th}$ percentile of installation costs for condensing furnaces corresponds to the 50$^{th}$ percentile of non-condensing furnace installation costs (Figure 16 and Figure 17).

[67] Navigant, on behalf of DOE, uses a component cost methodology to estimate manufacturing costs. While industry may disagree with Navigant's analyses, Navigant does make concerted efforts to calibrate its models with actual manufacturing cost data. LBNL, in its analysis of installation costs for DOE seems not to have made such an effort or has done so massively incorrectly.

Figure 16: Adjusted Installation Comparison - North

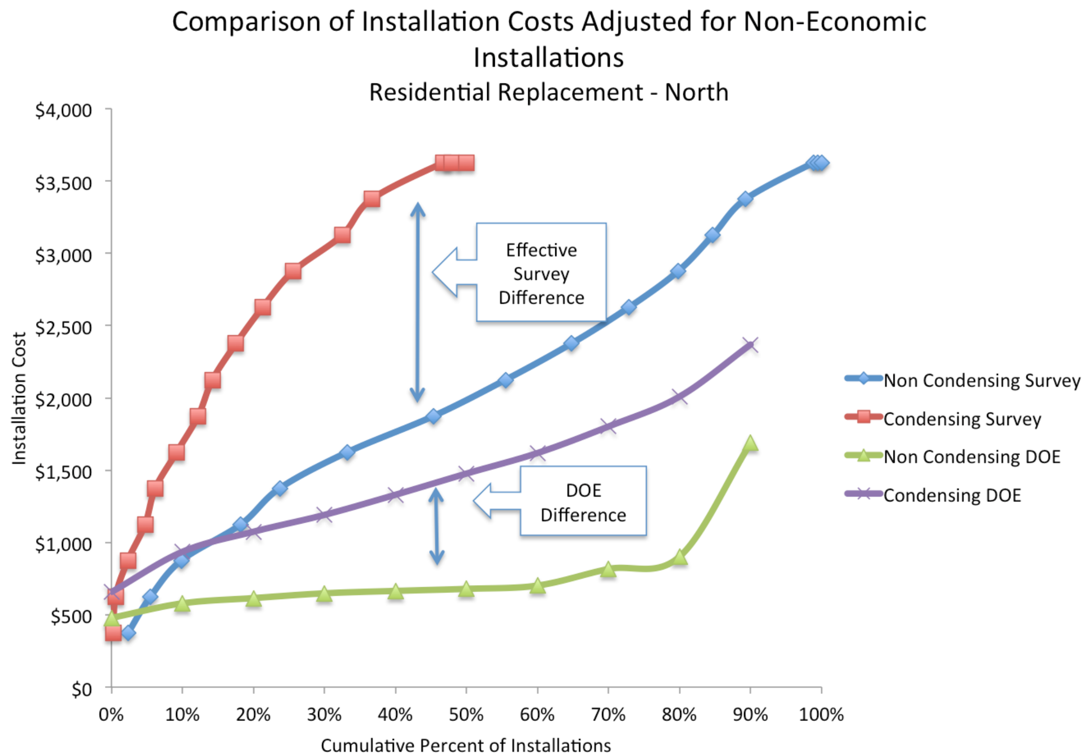
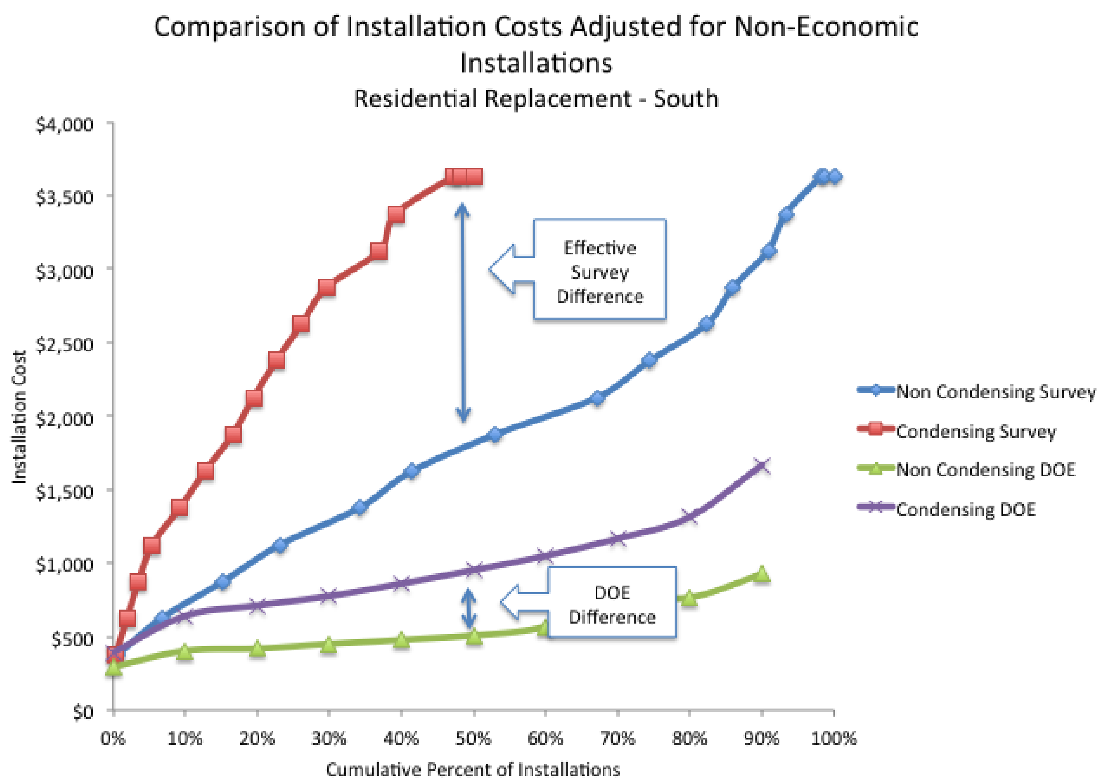



Figure 17: Adjusted Installation Comparison - South



Using the comparison corrected for difficulty of installations, the installation cost for condensing and non-condensing furnaces becomes approximately $1700 for both the North and the South, or $1000 to $1300 more than the DOE estimate.

The burden of proof in all these analyses rests with DOE to demonstrate that its approach and results correct. DOE is clearly not correct around installation costs. It is not in the scope of commenters or outsiders to debug the DOE models and correct them. DOE must reconsider its total approach to installation costs and reissue its analysis. Unfortunately, the component cost methodology is so integrated into the LCC that rationing the costs in the model by a factor as a proxy to correct for the error is not possible.

This error pollutes the DOE analysis in three ways. First, the differences in cost between non-condensing and condensing furnaces are unreliable at best and almost certainly inaccurate and understated. This will distort both the LCC and the National Impact Analysis (NIA) models since they estimate differentials in life cycle costs. Second, the significant increase in costs also increases the amount that consumers must pay for a furnace replacement, further highlighting the need to use marginal consumer interest rates and the probability that consumers will need to use debt to finance a furnace replacement. Thirdly, the shipments analysis in the NIA is built around consumer price elasticity. Increasing the cost of installation will have a ripple effect on the shipments module of the NIA and from there into the manufacturer impact analysis.

Again, it is incumbent on DOE to correct its installation cost methodology and reissue its analysis for further review.

*Ex-Plant Manufacturer Costs*

DOE predicts that the ex-plant cost of condensing furnaces will increase over the base case 80 AFUE due to increased labor and materials in order to achieve higher efficiencies. AHRI has asked manufacturers to determine the actual costs of achieving these efficiency levels based on *actual* production costs coupled with adjustments for enhanced fan motors required under the furnace fan rule. DOE's costs are approximately 10% lower than the AHRI member costs. While this is a reasonable variation, *in total*, given the inherent uncertainty of the DOE teardown cost method, DOE is underestimating the cost increase for efficiency by 35-40%. DOE then applies a learning curve factor to project its cost estimates out until 2021, the expected effective date of the proposed standards. Neither DOE's cost estimate nor its use of the learning curve factors is correct and DOE should adopt the AHRI cost estimates in its economic analysis for LCC and the NIA analyses of the effects of these proposed standards.

The comparative costs for an 80,000 Btu/h furnace are (Table 2):[68]

[68] DOE estimates from LCC model, sheet "Prod Price", cells F23-27. These are essentially the same as values as shown in Table 5.11.1 (Page 5-26) of the TSD plus the standby/off mode power supply and the increased ECM multi-stage motor for the 98 AFUE unit. The manufacturer estimates come from manufacturers on either their actual costs or their cost estimates including upgraded motors and power supplies. For purposes of comparability, AHRI accepts the DOE base case cost for the purposes of this comparison.

Table 2: Comparative ex-Plant Manufacturing Costs

| | DOE | AHRI Manufacturers | AHRI's Incremental Cost versus DOE 's from 80 AFUE |
|---|---|---|---|
| 80 AFUE | $359.98 | $359.98 | |
| 90 AFUE | $444.29 | $480.42 | 143% |
| 92 AFUE | $459.91 | $495.63 | 136% |
| 95 AFUE | $514.65 | $570.51 | 136% |
| 98 AFUE | $677.04 | $708.19 | 110% |

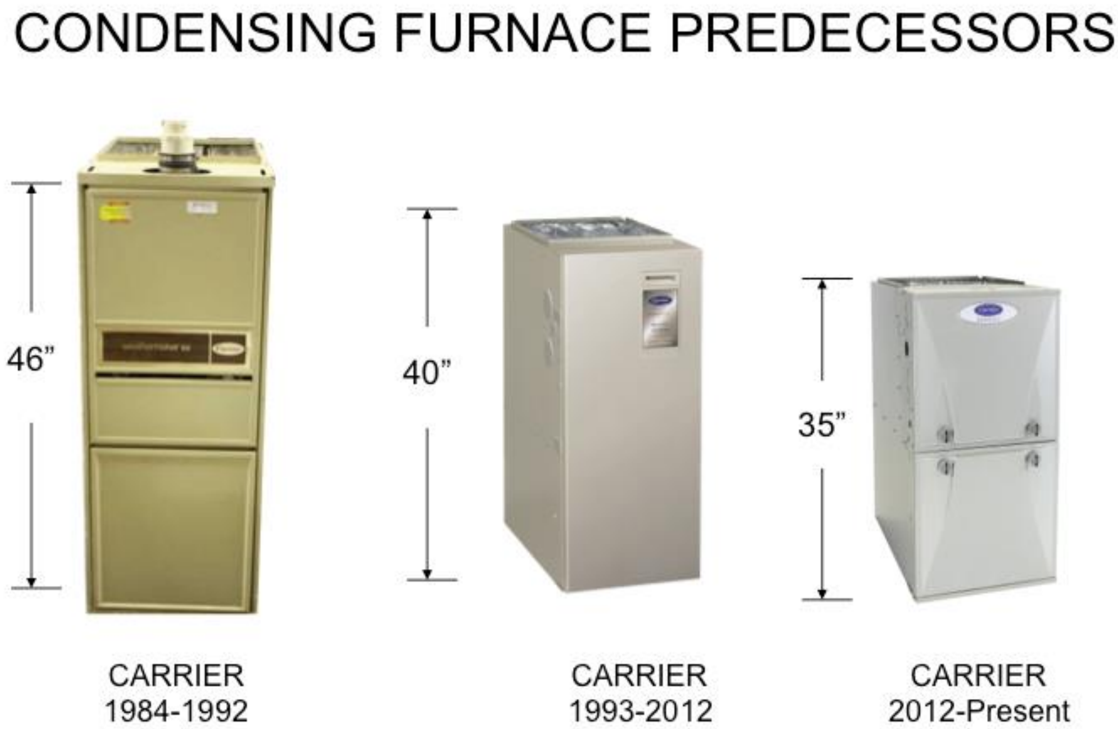
These products are now in full production by AHRI members since condensing furnaces now represent nearly 50% of total furnace shipments. Thus, the cost estimates reflect actual experience in a competitive market, not engineering forecasts.

DOE seeks to discount the ex-plant costs through application of a learning curve cumulative future cost reduction. There are two problems with this. First, the data produced by DOE to calculate the future learning reductions seems to show that the learning effect has ended. Second, most of the "learning" value for these products has already been captured in designs in current production. DOE should not use the learning curve factor in this rulemaking either for the LCC nor the NIA analyses.

Manufacturers began production of condensing furnaces since at least 1984. These have evolved over time to smaller and better thought through designs (as an example, see Figure 18).[69] This evolution shows that much of the available cost reductions from evolving designs and scale economies have already been captured in current costs. It is not likely that there are major future reductions to come from "learning" related to cumulative volume.

[69] Carrier Corporation, Condensing Furnace Predecessors

Figure 18: Evolution of Condensing Furnace Designs




The learning curve concept is purely an empirical one with no real theoretical support and is dependent on the actual trends in the underlying data.[70] As such, the selection of the data series is critical to the application of the concept. Either the actual data supports a learning effect or they do not. However, it is not appropriate to pick and choose data for this analysis. If DOE, or anyone else, starts to select to include some data and not others, then the relationship and the forecast becomes the definition of arbitrary – it is whatever the data selector wants it to be.

The importance of data and taking it as it comes can be seen through Figure 8C.3.3 in the Furnace TSD (Figure 19). It appears that there has been a structural change in the price/shipment relationship for the final seven data points. DOE chose to fit a single curve through all its data points rather than the more obvious solution of starting a separate curve for the final seven. Victor Franco, for DOE, stated: “we fit basically, we do the best fit to that curve.” By inspection (Figure 20), there would be a better fit by drawing two curves. One would go through the last seven data points and one would go through the others. However, this can only be inferred by inspection since DOE has not responded to AHRI’s request to release the actual numerical data behind the graphs.[71]

[70] Shorey, Everett; Comments on Use of Experience Curves in Appliance Efficiency Standard Setting (DOE Docket No. EE-2008-BT-STD-0012) March 23, 2011, contained as Attachment B in AHAM Comments on the Department of Energy Notice of Data Availability and Request for Comment on Equipment Price Forecasting in Energy Conservation Standards Analysis; Docket No. EE-2008-BT-STD-0012

[71] EERE-2014-BT-STD-0031, Stakeholder questions regarding the Furnace Rulemaking, Questions on Furnace Rulemaking and Related Models, Question 4

Figure 19: DOE Furnace TSD Figure 8C3.3

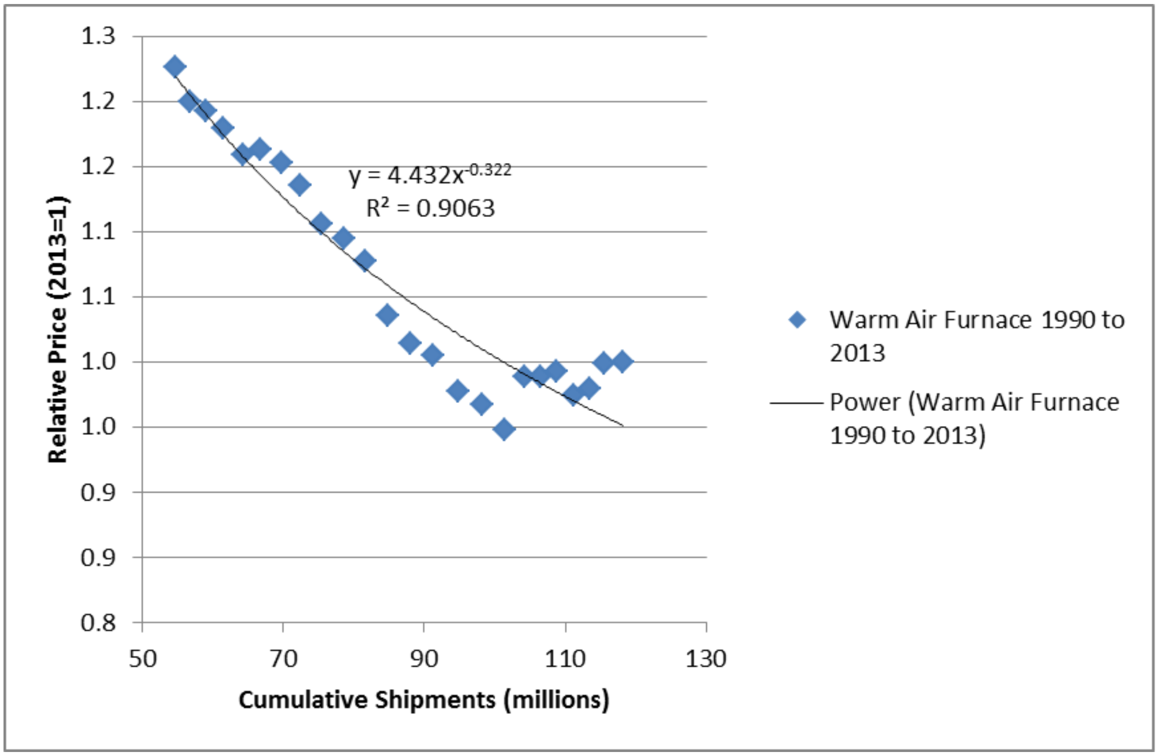
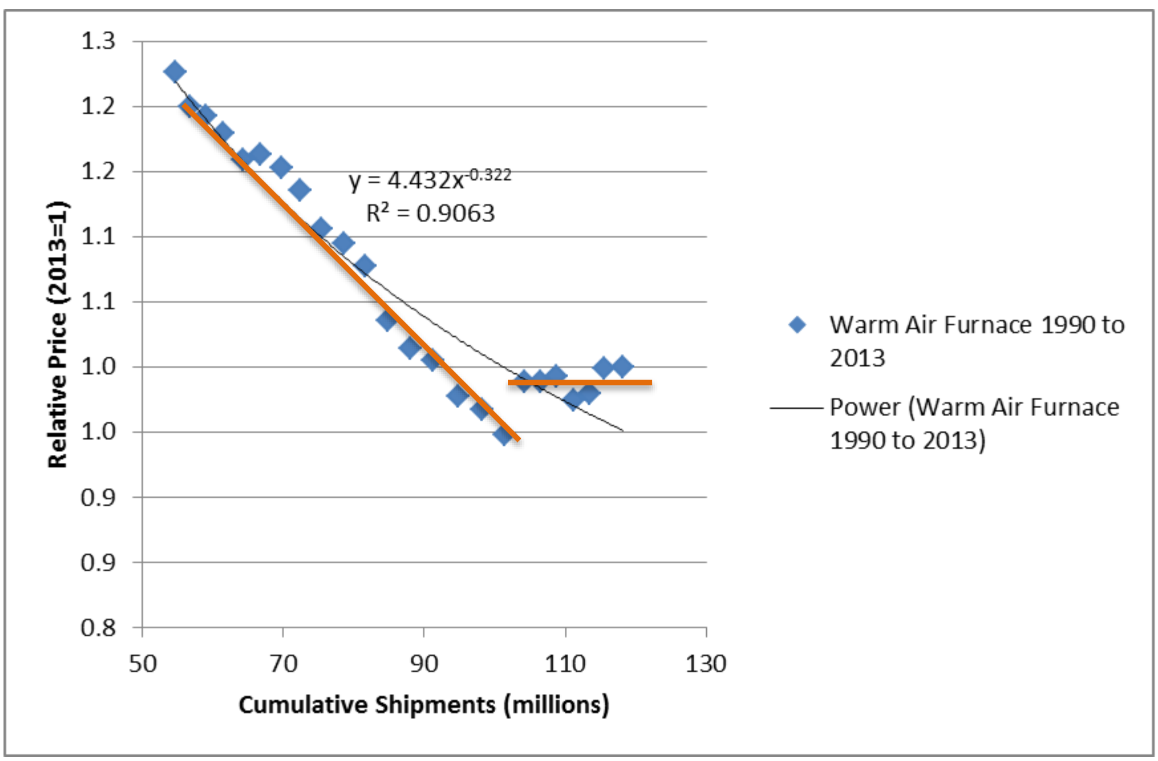



Figure 20: More Likely Statistical Relationships



Based on the empirical evidence, there appears to be a new relationship building. DOE attempts to discount this data by saying "part of those values are distorted by the market"[72] referring to earlier comments in the public meeting referencing the presence of tax credits. Andrew Delaski made the same point also during the public meeting:

> "One thing that's happening with that data is that the tail end coincides with some pretty rich tax credits that were applied. And those tax credits were intended to distort the market; they were intended to try to change consumer behavior market distortion. And the tax credits, I would submit, likely had an effect on prices. Tax credits -- the benefits for tax credits -- are shared among consumers and manufacturers. Some of those costs are passed on to consumers in lower prices, but some of those costs, some of those credits end up in enabling prices to stay higher than they otherwise would." [73]

First, neither DOE nor Mr. DeLaski (who does not speak for DOE other than the reference to his comments by Mr. Franco) provides any evidence that the tax credits "distorted" the market or that they were "shared among consumers and manufacturers". Those statements are pure conjecture. Second, tax credits in various forms have been in place since 2005, but excluded 2008, so that their effects should have shown up in other years and disappeared in 2008.[74]

More importantly, this is exactly the kind of cherry picking of data that cannot be done with an empirical relationship. The DOE analysis runs for 24 years. All sorts of things have happened in that period of time. There have been recessions, major swings in shipment volumes, changes in production costs, changes in labor contracts, changes in production locations. Any one of these could be plucked out and used as an excuse to exclude or modify that data point. In establishing an empirical relationship, you either use the data or you have no foundation for your analysis. Otherwise the analysis and the forecasts are purely arbitrary.

*Length of Time in the Home*

DOE has done its LCC analysis based on the length of time that a furnace lasts. However, the appropriate measure is the lesser of the length of time that the furnace lasts and the length of time that a purchaser remains in the home. The purpose of the LCC is to determine the economic effects on the person who purchases a new furnace by looking at the future cost savings in energy to that purchaser. The underlying assumption is that those savings actually accrue to the purchaser. If not, then the LCC model is not providing an accurate assessment of the purchaser's economic situation. If the purchaser lives in a home for the life of the furnace, he or she receives the benefits of the energy savings for the amount of time assumed in the LCC. However, if the purchaser moves before that time, then the he or she either does not receive the projected benefits or the sale price of the house must reflect the present value of those future benefits.

The core assumption behind the appliance standards program, as discussed earlier, is that there is a market failure – the market for appliances is not operating appropriately because homeowners are not purchasing more efficient appliances when it is in their interest to do so. DOE is positing market inefficiency for furnaces. It would be a very odd assumption to assume that the resale

[72] 2015-03-27 Transcript, p.113, line 14
[73] 2015-03-27 Transcript, p.111, line 22 top. 112, line 12
[74] IRS, Notice 2009-53, http://www.irs.gov/pub/irs-drop/n-09-53.pdf

market for *houses* is efficient with respect to furnace savings (when those savings and the cost of the furnace are a small portion of the total sales price of the home) when the market for the *furnaces* themselves is not efficient. DOE has not responded to AHRI's request for clarification of its assumptions and rationale on this topic.[75]

This would not be a problem if the length of ownership of a house were equal to or longer than the expected lifetime of a gas furnace. However, analyses by the National Association of Home Builders show that "the typical buyer of a single-family home can be expected to stay in the home approximately 13 years before moving out."[76] This average is considerably lower in the South and West than it is in the Northeast and Midwest.

As such, the DOE LCC model has incorrect values in its distribution of lifetimes. It needs to readjust its model to incorporate a lifetime distribution based on the length of time in the home, not on the lifetime of the furnace. Alternatively DOE needs to provide a rationale about why the market for homes is efficient for furnace savings when the market for furnaces is not.

*Other LCC Issues*

There are other issues with the LCC model that raise serious questions about how well it is calibrated and how accurate its forecasts are. In total, these are significant enough so that DOE should withdraw its current analysis, develop a simpler model to analyze LCCs and reanalyze the consumer economics. The current model is complicated without being sophisticated, is riddled with obviously incorrect results and is un-calibrated and, thus, unreliable in its estimates.
First, there is something wrong with the way that the LCC calculates electricity use. The mean values for electricity use per building are clearly incorrect. They are reported as:[77]

| AFUE | DOE kWh/ Year |
|---|---|
| 80 AFUE | 333.2 |
| 90 AFUE | 720.0 |
| 92 AFUE | 705.7 |
| 95 AFUE | 777.9 |
| 98 AFUE | 950.0 |

The electricity consumption for the condensing furnaces is clearly an error. Not only is the absolute magnitude of the electricity consumption incorrect for condensing furnaces, the relationship between the various condensing furnaces is improbable. The incorrect relationships exist for all regions and sub-groups in the DOE analysis. Something is wrong with the analysis

[75] EERE-2014-BT-STD-0031, Stakeholder questions regarding the Furnace Rulemaking, Questions on Furnace Rulemaking and Related Models, Question 6
[76] National Association of Home Builders, http://eyeonhousing.org/2013/01/latest-study-shows-average-buyer-expected-to-stay-in-a-home-13-years/, full earlier study can be found at http://www.nahbclassic.org/generic.aspx?genericContentID=110770&channelID=311
[77] Cells E43-47, Sheet "Statistics", EERE-2014-BT-STD-0031, 2014-02-06 NOPR Spreadsheets: Residential Furnace Life-Cycle Cost and Payback Period Analysis

and it is too complicated for commentators to debug the DOE model. The burden of proof is on DOE to produce a correct and reliable model.[78]

This discrepancy in electricity use may be related to problems with fan energy consumption, where the results do not correspond with basic spot tests for reasonableness. According to one industry official:

> "Here again something seems to be wrong with the fan energy and electricity calculations. The table on the left below shows the differences between the TSD table and the LCC file. I think that they are both flawed. In the TSD table, the low electricity usage in the South does not pass the sniff test. In the LCC file the jump between 80% and 92% in all regions doesn't pass the sniff test and neither does the South being lower than the North for 80% but higher for all others.
>
> The "sniff test" approach is shown at the right below. I assumed that the FER run hours are blower operating hours for the "Ave" case and then modified those hours by the heating and cooling load hours for other cities, the ratio of 1 to 2nd stage, and the capacity ratio (AFUE ratio). Assuming that the same input furnace would be used regardless of AFUE (This seems OK as most furnaces increment inputs at about 20 MBH which would be too much of a derate.) For blower watts I chose levels that align with known furnaces and the TSD. For the North I used Minneapolis and Dallas for the South.
>
> The sniff test analysis shows that the kWh/yr. should go down when moving from an 80 to a 92 in the North *and* Region IV. This is due to less run-time in heating since capacity is higher with the same input on a 92. For the South, the move to 92 increases kWh/yr despite fewer heating run hours as cooling watts dominate.
>
> For the Average values, both the LCC and TSD values are very close to the mean of Navigant's North and South values. It does not match my approximation for Region IV in either TSD or LCC.
>
> So, what values did DOE use to determine energy savings and payback use? If they used either set it appears that there are errors."[79]

---

[78] DOE has not responded to questions from AHRI on why these errors exist. EERE-2014-BT-STD-0031, Stakeholder questions regarding the Furnace Rulemaking, Questions on Furnace Rulemaking and Related Models, Question 1

[79] Communication from AHRI member

**Annual Electricity Consumption kWh/yr**

| Energy Eff Level | | TSD | LCC | LCC-TSD | Estimated |
|---|---|---|---|---|---|
| **Ave** | | | | | |
| 0 | NWGF 80% | 312 | 349 | 37 | 436 |
| 1 | NWGF 90% | 289 | 727 | 438 | |
| 2 | NWGF 92% | 283 | 718 | 435 | 431 |
| 3 | NWGF 95% | 275 | 786 | 511 | |
| 4 | NWGF 98% | 363 | 957 | 594 | |
| **North** | | | | | |
| **Energy Eff Level** | | **TSD** | **LCC** | **Diff** | **Estimated** |
| 0 | NWGF 80% | 369 | 397 | 28 | 376 |
| 1 | NWGF 90% | 342 | 674 | 332 | |
| 2 | NWGF 92% | 335 | 662 | 327 | 352 |
| 3 | NWGF 95% | 325 | 704 | 379 | |
| 4 | NWGF 98% | 438 | 819 | 381 | |
| **South** | | | | | |
| **Energy Eff Level** | | **TSD** | **LCC** | **LCC-TSD** | **Estimated** |
| 0 | NWGF 80% | 228 | 295 | 67 | 589 |
| 1 | NWGF 90% | 211 | 787 | 576 | |
| 2 | NWGF 92% | 206 | 782 | 576 | 616 |
| 3 | NWGF 95% | 200 | 878 | 678 | |
| 4 | NWGF 98% | 251 | 1113 | 862 | |

**HLH / CLH Analysis**

| | | | | | | 80 | | | 92 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **City** | **HLH** | **CLH** | **Htg Run Hrs** | **Clg Run Hrs** | **Total Run Hrs** | Clg kWh | Htg kWh | **total** | Clg kWh | Htg kWh | **total** | |
| **Base (Reg IV)** | **2250** | **800** | **830** | **640** | **1470** | 224 | 212 | **436** | 246 | 184 | **431** | Ave |
| **Minneapolis MN** | **2800** | **400** | **1033** | **320** | **1353** | 112 | 264 | **376** | 123 | 229 | **352** | North |
| Los Angeles CA | 2000 | 600 | 738 | 480 | 1218 | 168 | 188 | 356 | 185 | 164 | 349 | |
| Phoenix AZ | 1500 | 1700 | 553 | 1360 | 1913 | 476 | 141 | 617 | 524 | 123 | 646 | |
| San Francisco CA | 3000 | 600 | 1107 | 480 | 1587 | 168 | 283 | 451 | 185 | 246 | 430 | |
| Houston TX | 1000 | 2200 | 369 | 1760 | 2129 | 616 | 94 | 710 | 678 | 82 | 759 | |
| **Dallas TX** | **1500** | **1600** | **553** | **1280** | **1833** | 448 | 141 | **589** | 493 | 123 | **616** | South |
| Atlanta GA | 1500 | 1400 | 553 | 1120 | 1673 | 392 | 141 | 533 | 431 | 123 | 554 | |
| Seattle WA | 3500 | 300 | 1291 | 240 | 1531 | 84 | 330 | 414 | 92 | 287 | 379 | |
| Washington DC | 2000 | 900 | 738 | 720 | 1458 | 252 | 188 | 440 | 277 | 164 | 441 | |
| New York NY | 2500 | 700 | 922 | 560 | 1482 | 196 | 235 | 431 | 216 | 205 | 420 | |
| Boston MA | 2500 | 500 | 922 | 400 | 1322 | 140 | 235 | 375 | 154 | 205 | 359 | |

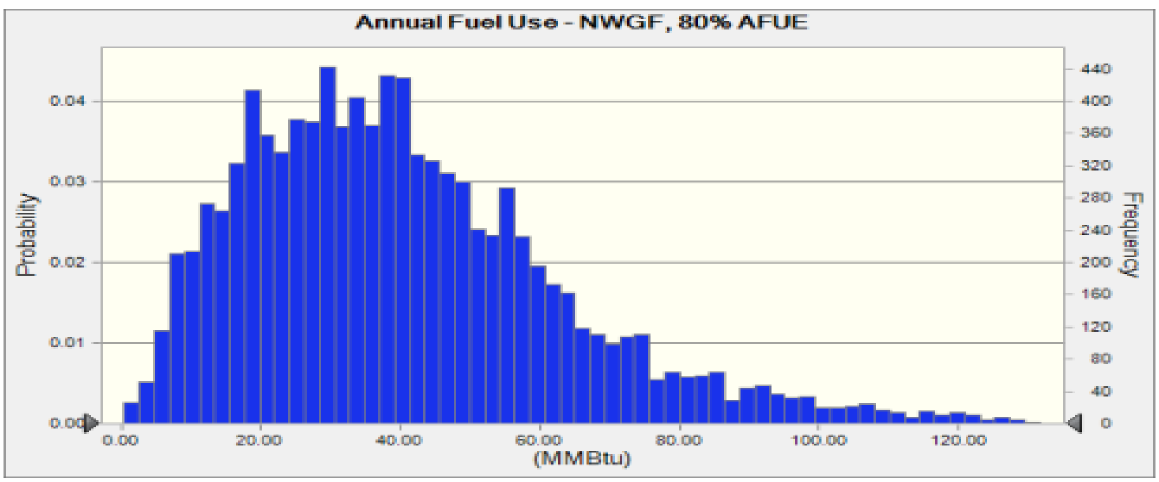
| | **kW** | **AFUE** | |
|---|---|---|---|
| heating kW (low) | 0.17 | 80% | Assumed to be 2-stage at 65% |
| cooling kW (high) | 0.35 | | |
| heating kW (low) | 0.18 | 92% | 2-stage with 10% more watts |
| cooling kW (high) | 0.39 | | |

Htg kWh = Htg Run Hrs /0.65 x heating kW (low)

Htg kWh = Htg Run Hrs /0.65 x heating kW (low) x 80/92

There is also something quite odd in the calculation of Annual Fuel Use. As can be seen from the graphs, the fuel use for 80 AFUE furnaces has a plausible distribution (Figure 21):[80]

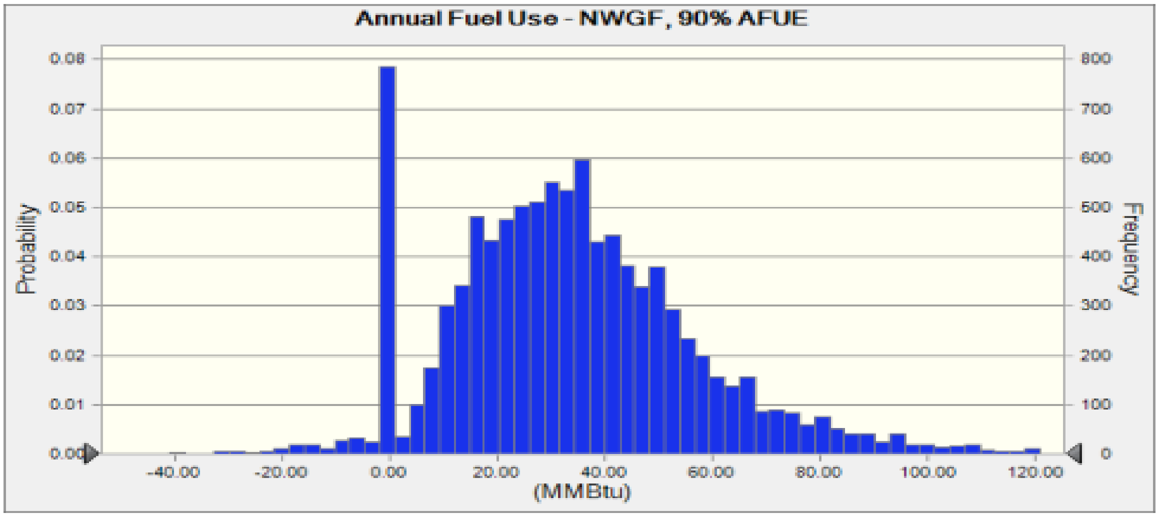
Figure 21: LCC Projected Fuel Use for 80 AFUE Furnaces




80 Graphs from Forecasts report generated from running Crystal Ball analysis of LCC model provided by DOE: EERE-2014-BT-STD-0031, 2014-02-06 NOPR Spreadsheets: Residential Furnace Life-Cycle Cost and Payback Period Analysis

However, the fuel use for 90 AFUE furnaces has a very odd distribution (Figure 22):

Figure 22: LCC Projected Fuel Use for 90 AFUE Furnaces




Again, while it is not practical to debug the LCC model, the large value at zero fuel use and the negative values are highly unlikely to be real reflections of actual conditions. The negative fuel uses are unlikely to represent gas wells on peoples' properties. Something is significantly wrong with the DOE LCC model if it is projecting zero and/or negative fuel use.

Finally, the Crystal Ball process is, in itself, flawed in its usage. The simulations, including the number of variables and the number of forecasts, are out of control. If there were only two values for each of the 109 assumptions in the LCC model, the total number of combinations would be $8.5 \times 10^{37}$. For comparison, the total number of seconds since the beginning of the universe is on the order of $4.4 \times 10^{17}$. No amount of Monte Carlo simulation runs can be accommodated to test the various permutations of the LCC model. Further, there are 4550 structures in the RECs database with gas furnaces. This means that, on average, each structure is tested twice for other variables. Because of this limited sampling, the actual variance and the significance of these non-structure related variables are illusory when DOE attempts to forge fine distinctions in the analysis.[81] The LCC is complicated in its calculations but it is of very limited explanatory value in its application.

*Options for the LCC Analysis*

As discussed here, the LCC is a theoretical and practical mess. It has evolved over the decades from a model with some conceptual plausibility to one that is complex without being insightful. It models randomness where there is none, such as the energy and cost savings for any particular house, and ignores randomness where it is likely to exist, such as in the projection of future energy prices. It is time for DOE to take a deep breath and re-examine critically this model. This is not some out of the blue request. DOE has been warned for at least a decade that there is a

[81] GAMA pointed out this flaw in its 2004 critique of the LCC model and proposed one form of solution. (Appendix A) DOE has not chosen to correct these errors in the intervening decade.

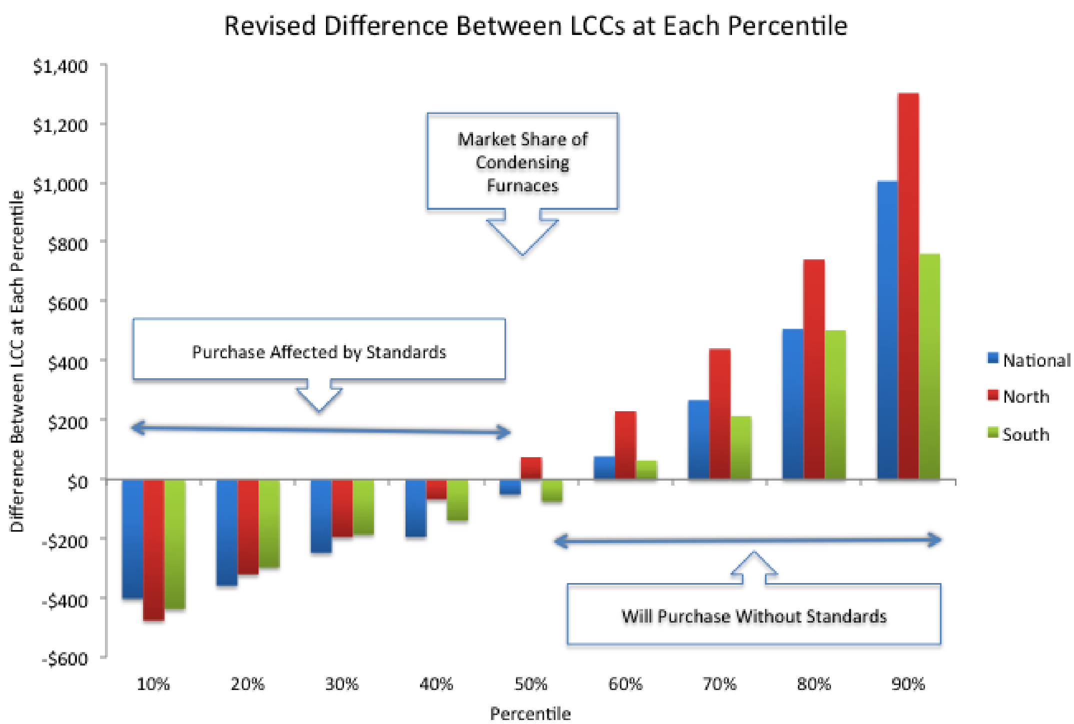
problem here. It has chosen to ignore or belittle those warnings. Now the flaws in the model have become glaring and it has produced a set of conclusions that provide incorrect policy direction to DOE. There may be aspects of the current LCC that can be salvaged, but it needs a clear rethink.

If DOE wishes to model uncertainty, a useful but not necessarily overriding goal, then DOE should convene a group of analysts to review both the LCC and the NIA models to discuss how to make them work properly and transparently. Bad models serve neither side well in any review. Models that are driven by manipulatable assumptions can cut one way or another depending on who is doing the analysis. It behooves everyone to get the modeling process done correctly.

## Results with Corrected Data

When all of the corrections to DOEs assumptions and calculations are taken into account, market failure vanishes. Again, this is an approximation of the degree of market failure since the DOE LCC model does not calculate in an ordinal fashion. The likelihood is that these estimates, in fact, overstate any degree of benefit from the proposed standards (
Figure 23). [82]

Figure 23: More Likely Savings in LCC

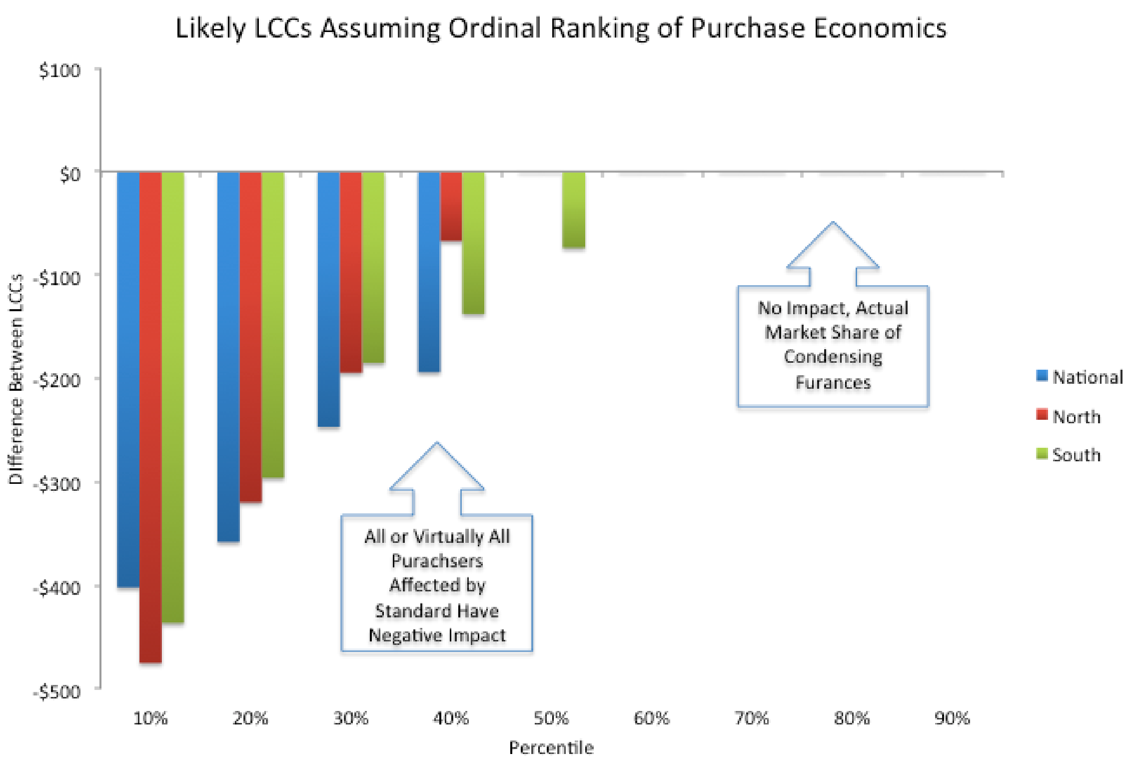



[82] Calculated as described in footnote 44 with adjustments for average, not incremental markups, increased ex-plant costs, increased incremental installation costs of $200 (note: actual difference is more likely over $1000) and revised discount rate. The estimated correction in installation costs is a conservative estimate relative to the $1000+ difference implied from the contractor survey. Differences between time of home ownership and lifetime of furnace have not been included.

What this means is that there is no justification for a minimum efficiency standard from the standpoint of consumer welfare or consumer economics. The consumers to the right of the graph with positive LCCs are already purchasing condensing furnaces and the people on the left are not. The market is functioning and the market share of condensing furnaces can be expected to continue to increase as the economic return to consumers continues to improve.

If a minimum efficiency standard is imposed, what will happen is that the "winners", the consumers who have positive life cycle cost changes, will be unaffected. They are already going to purchase a condensing furnace. The only people who will be affected are the "losers", those who have negative life cycle cost changes and who will be forced to purchase a condensing furnace even though it is not in their financial interest to do so (Figure 24). Their negative life cycle cost is a direct tax on them to promote energy efficiency. The average negative life cycle cost will be at the 25$^{th}$ percentile and will be approximately $300.

Figure 24: LCCs of Purchasers Whose Actual Behavior is Affected by Standard




## Imposition on Difficult to Impractical Installations

One consequence of a minimum efficiency standard requiring condensing gas furnaces is that it will cause major disruption to a significant portion of buildings where venting a condensing furnace will be difficult to impractical. In principle, all installation problems could be solved with money. At the extreme, one could tear down a house, redesign it, move the furnace to an easily accessible outside wall and rebuild the house. Since this would be a ridiculous requirement, there will be some set of buildings where installation of venting systems for a condensing furnace is impractical. Approximately 15-20% of buildings currently with gas furnaces fall into this impractical installation situation. DOE attempts to understand and/or mitigate this situation by proposing fuel switching, *i.e.* assuming that these applications will switch from gas furnaces to electric furnaces or electric heat pumps. Leaving aside the legal question about whether this is removing a set of features currently available to consumers, there are practical reasons why this may be unreasonable. In most instances, such conversions will also lead to a net increase in total source energy consumption.

*Installation Issues*

Installing a condensing furnace requires either access to an eligible outside wall or the ability to run new venting systems up an existing chimney. It also requires a functioning, all-weather condensate drain. In some applications, this is either relatively simple or actually saves money. In existing houses, 24% of the houses in the South have their furnaces in the garage. It is highly likely that these will have easy access to an eligible outside wall. In many new homes it will be possible to install a condensing gas furnace and a power vented gas water heater and avoid the cost on installing a chimney.

While these simple installations exist, there are a substantially larger set of buildings where installations will be much more complex and would require extensive reconstruction. Virtually all of these will be in existing buildings. It is important to keep in mind that furnace installations in existing buildings are mostly emergency replacements when a furnace has failed in the heating season. Therefore, there is a high premium on the ability to install a furnace quickly (hours or small number of days) in order to prevent a house from freezing. There is rarely time for major reconstruction.

In roughly declining order of installation complexity these difficult applications include:

- Multi-family housing where the furnace is located in the middle of the dwelling
- Row houses where there are only exterior walls at the front and back of the house
- Houses with finished basements where reaching an eligible outside wall would require tearing down and replacing ceilings and walls
- Houses with furnaces in unheated spaces, especially attics, where there is danger of condensate freezing in the drain line

The difficulties with these applications are well recognized in the industry and do not currently have technically acceptable solutions. In the survey of furnace installing contractors, over 200 provide written comments, the bulk of which were:[83]

1. There are installations, especially multi-family buildings and completely finished basements, were venting a condensing furnace is impractical to impossible and would require moving walls, ceilings or other construction not ordinarily done by HVAC contractors.
2. There are installations where it is not possible to vent a condensing furnace because of code limitations on vent location (away from windows, etc.).
3. Some applications have furnaces in unconditioned spaces where freezing of the condensate line is considered an unacceptable issue.

[83] AHRI, ACCA, PHCC and Shorey Consulting, Inc, Survey of Furnace Installation Contractors, p. 11-2 and Appendix C

4. In some southern areas, the payback from a condensing furnace is unacceptable to the consumer
5. A condensing furnace standard makes the most sense for new construction, where there are not installation issues.

Examples of the comments include:

> "It would be next to impossible to get entire apartment complexes with existing 80% furnaces to convert to new due to the cost of running pvc, drywall, etc. Same applies for low-income families and those with difficult installs (completely finished basement). This would lead to these customers trying to fix a very old, unsafe and inefficient furnace (perhaps only 40% efficient) instead of upgrading to at least a new safe 80% efficient model."

> "Some installations, because we are a "basement" area of the country will be VERY difficult/costly because of finished basements. This can make accessing an exterior wall next to impossible without tearing out drywall and creating a new chase way for PVC."

> "Finished basements with centralized equipment mechanical rooms, basements with low ceiling height and homes with no previsions for condensate removal cause a significant amount of additional work and cost to the homeowner when installing high efficiency furnaces"

> "There are multiple situations, especially in larger urban cities, where a condensing furnace installation is literally impossible. These include historic buildings, concrete buildings, and other buildings where distance to acceptable vent location violates manufacturer's install guidelines, or where the only way to vent a condensing furnace would be through other homeowner's condos. There needs to be some sort of exception process to handle these situations."

> "In townhomes and condo's 80% models are installed because of venting issues. If 92% models were required additional costs would include construction of chase ways and could add $3,000 to $5,000 to the price of the installation. There are also cases where a 92% model could not be installed no matter what."

> "Not all homes are able to use sidewall vented units. Here in the northeast we have houses with finished basements with the units in the middle of the house. To replace the unit you have to rip apart the basement for the venting and intake. Also many houses do not have the window clearance and/or ground clearance for direct vent. And the chimney can't be lined for it because it is being used for multiple appliances. I understand the desire to increase efficiency but when you are adding all these other required costs it drives the price up unreasonably in many cases. Why not mandate all 80% units to be two stage and ecm motor? It would work better for most homeowners."

> "We have had several installations where upgrading to a condensing furnace was not possible, not because of costs, but simply not being able to conform to Code with the venting requirements."

It is useful to go back to what it takes to vent properly a condensing furnace. First there needs to be the ability to run a vent pipe to the outside within the pressure drop limitations of the combustion fan. Second, that outside wall must be away from operable windows and doors. Thirdly, and not covered by codes, there must be a place to vent the condensate that will not generate substantial consumer backlash. (This may turn out to be a much bigger issue than currently recognized.) Finally, there must be a way to drain condensate.

The standard practice is to vent to an outside wall for cost and practical reasons. While it may be theoretically possible to run supply and vent piping up an existing chimney, the distances often exceed the pressure drop limitations and may not be possible depending on chimney construction and the use of the same or parallel chimney for other applications. Also, doing so requires feeding the piping down the chimney from the roof, making a connection to an elbow inserted in the wall opening of the existing flue pipe and then connecting to the furnace. From Shorey Consulting's own experience with the installation of a condensing boiler, this may not be practical even in a non-emergency replacement. The thought of standing on a roof trying to feed over thirty feet of PVC tubing into a chimney to make a connection with a 4" elbow in the middle of the winter is not an encouraging one. Therefore access to an outside wall with sufficient clearance from operable windows and doors will, in most cases, be a practical necessity.

Multi-family buildings, row houses and houses with finished basements all have or may have challenges in finding a practical route to an eligible outside wall. Many multi-family buildings with gas furnaces have the furnace in the middle of the living unit with no access to an outside wall without tearing down a ceiling and running venting through the space between floors of the building, even assuming that such an open space exists (*e.g.* buildings made with precast concrete floors may have the ceiling of one floor directly attached to the structure of the floor above it, there is no open plenum and no place to run venting). Row houses have only front and back walls and may have finished spaces separating the furnace from either of those walls. Reaching an outside wall may be impractical and that wall may be too close to an operable window or door, may vent under a porch or have other limitations. This same situation will apply to many finished basements. The route to an eligible outside wall may pass through a finished space where it would be necessary to rip down ceilings, walls or other structures and replace them. Even leaving aside the cost and the certain substantial negative consumer reaction to such construction, there remains the issue of doing so under the time pressure of an emergency replacement.

An under-recognized aspect of siting the venting for a condensing furnace is the visual and other effects of the condensate. While this may not be precluded by code, there will almost certainly be negative consumer backlash to visual problems from poorly located venting. One example of the unsightliness of condensate venting can be seen (Figure 25):[84]

[84] Venting from condensing boiler operating in water heating mode in April. Condensate plume and levels are significantly greater during heating season.

Figure 25: Condensate from a Condensing Boiler

Condensate drainage, like the aesthetics of condensate plumes, is an issue of practice but of considerable concern. When furnaces are located in unconditioned spaces, such as unheated attics, there is the danger of the condensate line freezing resulting in back flooding of condensate into the furnace, and thus triggering a shut off of the furnace. The DOE LCC model assumes that this problem can be solved with heat tape on the condensate drain line. In principle this may be true. However, a significant number of contractors do not consider heat tape to be an adequate solution. The contractors believe that a heat tape system is not sufficiently reliable to serve as part of a heating system that needs high reliability, particularly in extremely cold weather. Until this issue is resolved, some significant portion of contractors are going to resist installing condensing furnaces.

*Number of Difficult Installations*

The ease, or difficulty, of venting a condensing furnace is reasonably related to building type and furnace location. The distribution of furnace locations is highly regional (Table 3):[85]

[85] RECS database sorted by building type and furnace location

Table 3: Distribution of Furnace Locations within Buildings

| North | Basement Conditioned | Basement Unconditioned | Crawl Space | Garage | Indoor | Attic Conditioned | Attic Unconditioned | Total |
|---|---|---|---|---|---|---|---|---|
| Single Family Detached | 45.7% | 14.8% | 11.2% | 3.9% | 3.4% | 0.1% | 2.9% | 81.9% |
| Single Family Attached | 3.2% | 1.6% | 0.7% | 1.0% | 0.4% | 0.0% | 0.5% | 7.4% |
| Apartments 2-4 | 0.8% | 2.0% | 0.3% | 0.0% | 2.0% | 0.0% | 0.0% | 5.1% |
| Apartments 5+ | 0.0% | 0.0% | 0.0% | 0.0% | 5.6% | 0.0% | 0.0% | 5.6% |
| Total | 49.7% | 18.4% | 12.2% | 4.8% | 11.4% | 0.1% | 3.4% | 100.0% |
| | | | | | | | | |
| South | | | | | | | | |
| Single Family Detached | 7.0% | 4.5% | 16.7% | 21.6% | 8.5% | 1.1% | 22.7% | 82.1% |
| Single Family Attached | 1.1% | 0.4% | 0.7% | 2.0% | 1.4% | 0.2% | 1.0% | 6.7% |
| Apartments 2-4 | 0.1% | 0.1% | 0.4% | 0.0% | 2.6% | 0.0% | 0.2% | 3.4% |
| Apartments 5+ | 0.0% | 0.0% | 0.0% | 0.0% | 7.8% | 0.0% | 0.0% | 7.8% |
| Total | 8.3% | 5.1% | 17.8% | 23.6% | 20.3% | 1.3% | 23.8% | 100.0% |

In the North, most furnaces are located in basements, either conditioned or unconditioned. In the South, furnaces are spread across a variety of locations.

In general, garages, crawl spaces and unconditioned basements are likely to be the easiest locations to vent a condensing furnace. At the other extreme, indoor locations and unconditioned attics in the North are likely to be the most challenging locations. Indoor locations have the highest percentage of multi-family units and unconditioned attics are most likely to have condensate freezing issues (Table 4).

Table 4: Difficulty of Installation by Furnace Location

| | | Basement - Conditioned Finished | Basement - Conditioned Uninished | Basement - Unconditioned | Crawl Space | Garage | Indoor | Attic - Conditioned | Attic - Unconditioned | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| North | | | | | | | | | | |
| | Easy | | 12.70% | 18.39% | 12.19% | 4.82% | | | | 48.09% |
| | Questionable | 37.02% | | | | | | 0.11% | | 37.14% |
| | Impractical | | | | | | 11.36% | | 3.41% | 14.77% |
| | | 37.02% | 12.70% | 18.39% | 12.19% | 4.82% | 11.36% | 0.11% | 3.41% | 100.00% |
| South | | | | | | | | | | |
| | Easy | | | 5.05% | 17.78% | 23.55% | | 1.28% | 23.78% | 71.45% |
| | Questionable | 8.26% | | | | | | | | 8.26% |
| | Impractical | | | | | | 20.29% | | | 20.29% |
| | | 8.26% | 0.00% | 5.05% | 17.78% | 23.55% | 20.29% | 1.28% | 23.78% | 100.00% |

Single-family houses with conditioned finished basements will often have installation issues. It is unclear what percentage of these homes will require significant construction in order to find a venting solution.

The Impractical category of installations, not all of which are truly impractical, represents 15-20% of all homes with gas furnaces. The "Questionable" category in the North is 35-40% of homes with gas furnaces. A reasonable estimate is that 15-20% of homes will have installation issues that make installing a condensing furnace impractical. Again, these are almost always going to be homes where the LCC of installing a condensing furnace is negative, so that the consumers will be forced to go through a system conversion that is both economically unattractive and cumbersome to implement. The solution would be for purchasers to switch to electric furnaces or heat pumps but this raises significant question about the net energy savings from an electric installation versus a gas one.

National Impact

The national impact of a condensing furnace standard is likely to be a negative national net present value and to yield energy savings at most roughly 60% of those predicted by DOE, or a reduction in projected energy savings from 2.5 quads to approximately 1.6 quads. These differences are largely as a result of the ordering problem identified in the discussion of the LCC and, secondarily, as a result of changes that would take place in the National Impact Analysis (NIA) from corrections to the assumptions in the LCC. There is also a carry-over effect on the energy savings estimates made in the furnace fan analysis that need to be adjusted to take into account changes in total installed furnace costs from this rulemaking.

The basic structure of the NIA is that it takes the LCC results and accumulates, or layers, them over time. It adjusts the characteristics of the furnace inventory using a combination of a retirement factor and a shipment forecast as the basis for determining how many furnaces are added/changed in any year of the layering process. As such, and if all the assumptions were the same, the basic LCC results for individual furnaces would be reflected in the aggregate national analysis. However, there are several modifications to the LCC assumptions that tend to make the national analysis show more positive results than just an accumulation of the individual impacts:

- The discount rates used in the NIA are 3% and 7%, as dictated by OMB standards. The 3% rate is lower than the consumer rate actually used by DOE in the LCC and the 7% rate is lower than the rate that DOE should use. Lower discount rates will tend to improve the LCC results.
- DOE continues to use learning curve cost reductions in the NIA analysis. While these do not have a huge effect, over time they tend to improve the LCC results.
- DOE adjusts the fuel consumption by a Full Fuel Cycle Energy Use Factor that tends to increase energy use for both the base and the standards case and, therefore, the total fuel savings.
- The price elasticity elements in the shipments forecast (within the NIA) tend to depress shipments of more expensive higher efficiency equipment that tend to depress the LCC results but usually less than the improvements from other factors.

By far the biggest factor affecting the NIA relative to a simple accumulation of LCC results is the inclusion of the social cost of carbon. A discussion about the appropriateness of including the social cost of carbon, how it is monetized and whether it is statutorily permissible to consider effects outside the US is beyond the scope of these comments.

*Energy Savings*

The computation process for the NIA implicitly ignores the ordering issues raised in the discussion of the LCC model. The NIA assumes a base case market share for regular and high efficiency products. The calculation process essentially reduces the size of the affected market by the share of the higher efficiency products (a 40% share of high efficiency products means a reduction in the affected market by 40%).[86] The NIA then takes the average energy consumption for the base and the high efficiency products and computes from there.

The flaw in this process with respect to this furnace rulemaking is that the distributions of building energy use by the high efficiency products and by the low efficiency ones whose consumption is changed by the standard are not the same. So the averaging calculation is incorrect. The average energy demand in buildings where condensing furnaces are purchased in the absence of standards is almost certainly higher than the average energy use of the buildings where condensing furnaces were not purchased absent standards.

This effect results in an over estimate of the energy savings by the difference between the average for the total distribution of energy consumption and the average for the lower 50% of consumption (since the current market share of condensing furnaces is approximately 50%)(Figure **26**).[87]

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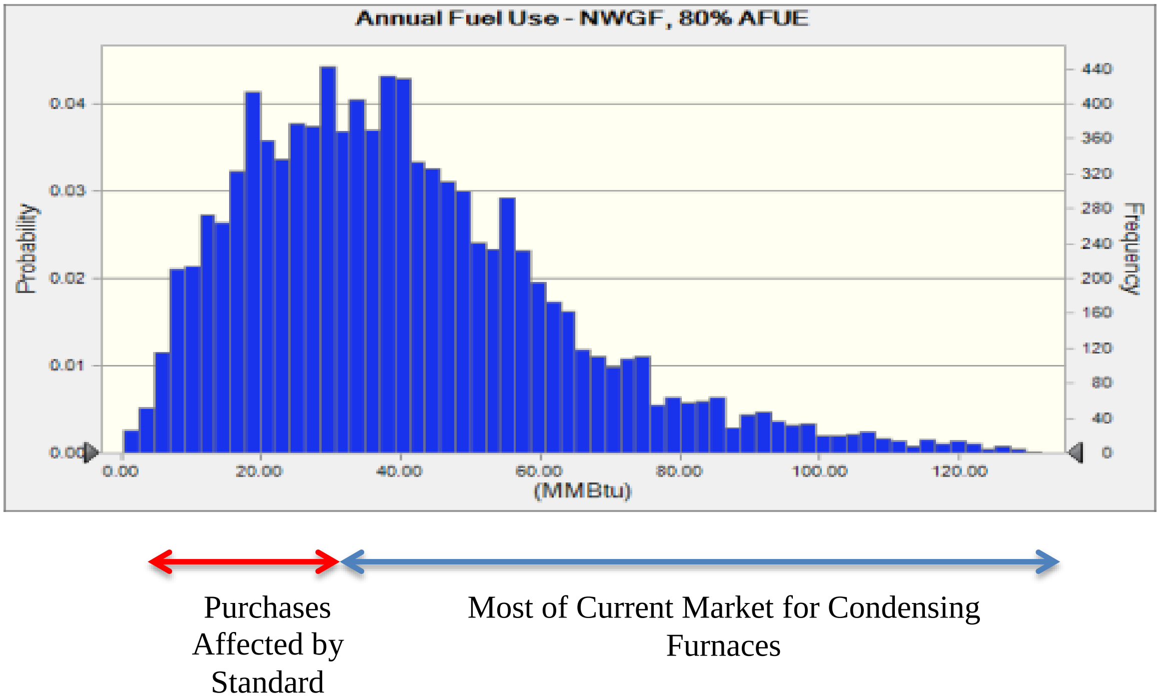
[86] The NIA actually does this for a range of efficiencies, but the effect is the same as if there were only one.
[87] The true effect is actually somewhat more pronounced as the market share of condensing furnaces is likely to increase between now and the time standards go into effect, but this factor is probably small relative to the uncertainties in most of the total analysis.

Figure 26: Implicit Example of Ordering Issue for NIA Analysis




It is difficult to determine exactly how significant this mistake is since the random selection process compromises distributions of energy use and the savings estimated in the LCC. A reasonable first approximation is to take the energy use for the 25th percentile of the 80 AFUE furnaces as the average for the consumption affected by the standard and compare it to the energy use by the median 80 AFUE furnaces that underlies the actual NIA calculations:

| Percentile | Base 80AFUE | Calculated 92 AFUE | Difference |
|---|---|---|---|
| 25th | 23.49 MMBtu/Year | 20.43 MMBtu/Year | 3.06 MMBtu/Year |
| 50th | 37.44 MMBtu/Year | 32.56 MMBtu/Year | 4.88 MMBtu/Year |

The saving of 3.06 MMBtu/Year is 63% of the original 4.88 MMBtu/Year so the likely actual savings in energy are on the order of 63% of those projected by DOE.

In reality, the expected savings should even be somewhat less than this because of the effects of the price elasticity function in the shipments model. This shows up in two ways. First, DOE underestimates the incremental total installed cost of a high efficiency furnace, as reviewed in the discussion of the LCC. Second, the increased cost of a furnace, even as projected by DOE, will increase the cost of a furnace for the purposes of the furnace fan rulemaking. The actual replacement of furnaces with PSC motors by those with higher efficiency motors as forecast in the furnace fan analysis will be lower than projected in that analysis. DOE needs to go back and recalculate the projected savings from the furnace fan rule that are now being eliminated and subtract those from the savings projected in this rulemaking. A simpler approach would have been to combine the two analyses; an ex-post correction in this rulemaking is as close a substitute as possible.

DOE estimated that the total energy savings from the combined furnace and standby/off mode improvements for the proposed standard at 2.515 quads of energy. The actual savings are much more likely to be in the range of 1.58 quads or lower. The projected reductions in various pollutants will also be reduced proportionately.

*National Net Present Value*

The national net present value of the proposed rule is almost certainly negative before consideration of the social cost of carbon. On a first principles basis, the negative national life cycle cost would be the average life cycle cost for affected furnaces times 20 years times average affected furnace shipments. A reasonable first set of assumptions is:

- Projected average life cycle cost to consumers of a loss of $300 per furnace (p. 35)
- Average annual shipments of 3.5 units million (TSD p. 9-15, Figure 9.5.4)
- 45% of shipments affected by standard (market-based condensing furnace share at 55%)
- Analysis life of 40 years

This yields a national life cycle cost of a negative $8.5 billion dollars. Reducing the discount rates to 3 and 7% will tend to make the loss somewhat smaller since the lower discount rates will increase the effects of the savings over the years as will including the full fuel cycle effects. These changes will certainly not change the negative effect into a positive one. This is in contrast to DOE's estimate of a positive national value of $3.1-16.1 billion before including the social cost of carbon.

Even including the social cost of carbon (estimated by DOE at $0.7-11.7 billion) will probably not swing the national net present value into a positive number. The DOE estimate of the value of the social cost of carbon needs to be reduced to 63% of the projected value to account for the reduced fuel savings (p. 43). This would lead to a social cost of carbon value of from $0.4 to 7.4 billion, not nearly enough to change the calculus.

Even if the social cost of carbon turned a negative national net present value into a positive one, there are serious questions whether imposing a standard on that basis would be within DOE's authorization. DOE would be saying that the only market failure was a result of mispricing natural gas. Correcting that analytically would require imposing a "carbon tax" (in this case the social cost of carbon) into the calculations. This would represent a dramatic shift in policy priorities for DOE away from a consideration consumer economics to a major recrafting of national energy policy under cover of a minimum efficiency standard.

Given the clear errors in the way that the LCC and the NIA assess the cost to consumers of a standard and the wide discrepancy between the DOE estimate and the likely actual one, DOE needs to rebuild its analytical tools and reconsider its projections.

Manufacturer Impact

The DOE process for assessing manufacturer impact is based, in large measure, on an analysis of future cash flows as analyzed through the Government Regulatory Impact Model (GRIM). By establishing minimum standards on two different aspects of the same product in two distinct rulemakings, DOE has violated one of the core assumptions in the logic of the GRIM. As such, DOE is substantially underestimating the adverse impact on manufacturers in both this furnace and in the recent furnace fan rulemakings. Even without reviewing and revising any of the assumptions in the respective GRIM analyses, the change in industry value under the "Preservation of Operating Profit Markup Scenario" for the combined rulemakings is a loss of $56 million versus the loss of $17 million projected for the furnace rulemaking.[88]

[88] Furnace TSD Table 12.5.2, p. 12-21 and 2014-07-03 Energy Conservation Program for Consumer Products: Energy Conservation Standards for Residential Furnace Fans; Final Rule, Table V-14

The core logic of the GRIM is that it uses the standard analytic financial valuation approach of discounted future cash flows to assess change in industry value. It is a forward-looking model. Among other assumptions, there is one crucial simplifying assumption buried in the GRIM. It assumes that any future regulatory-related product redesigns would be co-terminal with the normal industry product redesign cycle. Basically, the statutory six-year lockout provision for future rulemakings would allow manufacturers to bring their product development cycles into sync with the regulatory cycle. Therefore, future product redesign costs were excluded from the GRIM analysis.[89]

This seemed to be a reasonable assumption at the time the GRIM was developed since DOE had not proposed regulating separately two aspects of the same product. In addition, limitations in spreadsheet software at the time the GRIM was developed made calculating multiple regulations on the same product quite complex. As a result, the GRIM has not included a procedure for analyzing situations like the effects of the furnace fan and the furnace rulemakings. Assuming that the costs for complying with the first rule are “stranded assets” for the purpose of the second one is not a solution (as is currently the only option in the GRIM methodology). Using this approach has the perverse effect of *raising* industry value because stranded assets increase non-cash deductible expenses and, thus, reduce taxes. Clearly, this does not reflect the reality of true impacts on manufacturers.

The results of two successive sets of standards requiring redesign of the same product twice in close succession are more than just the effects on industry value. The industry cash flow analysis shows major decline in free cash flow in 2019 for furnace fans and in 2019 and 2020 for furnaces.[90] This will put stress on smaller manufacturers and on those manufactures without independent access to outside sources of funds. The sequential redesigns will also stress product design capabilities for most firms.

Again, DOE is putting unwarranted stress on the capabilities of manufacturers for no discernible benefit in terms of ameliorating market failure or creating economic benefit to consumers or the economy as a whole.

## TECHNICAL ISSUES

The Monte Carlo methodology used to analyze consumer Life Cycle Costs (LLC) and payback periods is fundamentally flawed and does not properly assesses the effect of the proposed revised standard on American consumers. The information provided by Shorey Consulting Inc. clearly explains the flaws in the Monte Carlo methodology to assess the LCC and pay back for consumers. The decision to use randomly assigned variable completely disconnects the results of the Monte Carlo simulations from any semblance of realistic market conditions. Without addressing the estimated energy savings of any one of the 10,000 Monte Carlo simulations, the total effect is to overestimate the energy savings that can be expected. The projected 2.7% quads of energy savings assumed by the analysis overestimates the national energy savings by more than 1 quad. Our estimate is a potential total energy savings of 1.7 quads which is about 40% lower than the NOPR estimate.

The rulemaking has mischaracterized the status of the market in the absence of any revised standard. One significant factor is DOE’s overestimation is its mischaracterization of the percentage of furnaces currently being shipped that are higher efficiency condensing units and the projection of the increase in that percentage in the future. On May 29, 2015, AHRI provided shipment data to DOE on the percentage of condensing gas furnaces shipped in the years 2010 through 2014. That data showed that the values that were used for those years in the NOPR analysis were low by about 10 percentage points. Consequently,

[89] Everett Shorey, of Shorey Consulting, Inc., supervised the development of the initial version of the GRIM and set its core logic structure when he was at Arthur D. Little, Inc. The Association of Home Appliance Manufacturers, AHRI and it predecessors sponsored the development of the GRIM.
[90] Furnace TSD, Figure 12.5.2, EERE-2010-BT-STD-0011-0068, Furnace Fan TSD, Figure 12.5.2

the projected shipments of condensing furnaces in the absence of any revised standard is significantly underestimated and the percentage of the population that would be potentially affected by a revised standard significantly overestimated. This corrected information of itself should require a revised analysis for this rulemaking.

DOE has overestimated the energy savings to be achieved by the proposed standard and underestimated the installed cost of these higher efficiency models. LCC estimates for individual consumers have significantly underestimated the cost of higher efficiency furnaces in 3 different aspects. The results of our contractor survey indicate that for the North, the mean cost of installation in DOE's LCC analysis is 2 to 3 times less than the mean actual cost of installation that consumers are paying for a replacement furnace, depending on the type of furnace. For the South, the survey results indicate that the mean cost of installation in DOE's LCC analysis is 2.5 to almost 4 times less than the mean actual cost of installation that consumers are paying for a replacement furnace, depending on the type of furnace. Our survey is data from the field on the cost of a typical furnace replacement installation. The survey responses do not include costs for replacement installations that are difficult and require added system or site work.

The NOPR analysis' estimate of the increase in the manufacturers' production cost for models at various levels of increased efficiency is about 35% too low. This information is based on a survey of our members in which we asked them to characterize their production costs as a percent relative to DOE's estimated values.

The NOPR analysis assumes that a distinct lower incremental markup is applied to products with efficiencies above the baseline model. The results of our contractor survey showed that the large majority of contractors use the same markup for all furnace models, regardless of efficiency. Furthermore, almost 15% of the responding contractors use a higher markup for condensing furnaces. The comments provided in the Shorey Analysis address additional concerns with the fundamental approach taken in the analysis to estimate total markup on products.

Considering these factors together, the analysis underestimates the cost of installing a higher efficiency furnace by a factor of 2 to 4 and underestimates the increased cost of that higher efficiency furnace by about 35%. To put this in a simple dollars and cents perspective, the average total installed cost of a replacement 92% non-weatherized gas furnace is about $4100 based on our information. This is about 50% greater than the total installed cost estimate found in Table 8.2.11.

As mentioned above, another factor which further distorts DOE's LCC analysis is the arbitrary decision to ignore the rebound effect in estimating the cost of operating higher efficiency furnaces. Although DOE estimates that the rebound effect at 15%, the cost associated with the increased energy consumption caused by this effect is not factored into the LCC for these models. DOE justifies this omission with the rationale that the value of the improved level of comfort resulting from a higher thermostat setting (i.e. more use of the furnace) offsets the increased energy cost resulting from this increased use. Thus the rebound effect does not increase the LCC nor extend the payback period even though the household with the new higher efficiency furnace will use more energy, on a relative basis, than it did with the old furnace and the actual savings in the monthly energy bill will not be as great as estimated based on the incremental efficiency increase of the new furnace. We agree comfort is real but, it has no real monetary value. Operating the furnace more to increase the comfort level in their home will increase consumers' monthly heating bill by X dollars. That is real. If the potential monthly reduction in a consumer's monthly heating bill could have been 15% but actually was only 13 % because of the rebound effect those added dollars paid by the consumer cannot be considered savings. The cost of the new higher efficiency furnace must be compared against the real benefit of the actual monthly energy bill paid to operate the furnace, not a mythical benefit that pretends the consumer's bill is less than it really is.

The estimate of the baseline furnace heating annual burner operating hours (Table 7.3.3) appears to have anomalous results relative to the information provided in Tables 7B.2.1 and .2. Specifically, considering missing only the average values provided. Table 7.3.1 shows an average heating use for non-weatherized furnaces of 64.3 million Btu in the North and 35.0 million Btu for the rest of the country and for mobile home furnaces an average heating use of 47.8 million Btu in the North and 26.6 million in the rest of the country. The average heating use in the North for a non-weatherized furnace is about 84% higher than the rest of the country; for a mobile home furnace, it is about 80% higher than the rest of the country. The average adjusted heating loads in Table 7.3.2 for these respective furnace types and regions of the country exhibit similar ratios, which is as expected. However, the annual burner operating hours for a non-weatherized furnace in the North is only 57% higher than the rest of the country. The TSD indicates that the burner operating hours is derived from the heating load. That being the case, we question the validity of the estimated annual burner operating hours. The error seems to be in the average BOH for the rest of the country which is disproportionately high. Based on the ratios of the energy use and adjusted heating load, the average BOH for a non-weatherized furnace in the rest of the country should be about 476.5 hours. This estimate is 15% less than the average BOH of 557 hours shown for the rest of the country in Table 7.33. A simple calculation starkly discloses the significance of this anomalous value. A baseline furnace with an input of 80,000 Btu/h operated for 557 hours will consume 44.5 million Btus in a year. This is more than 25% higher than the average heating energy use of 35.0 million Btus shown for the rest of the country shown in Table 7.31. This overestimation of average annual energy use in the rest of the country is compounded by the fact that the BOH values are used in Section 7.3.2 to estimate furnace electricity use during the heating season. Thus the average electricity use for the rest of the country is similarly overestimated.

One other issue on which we have comments is the consideration of alternatives to standards. Purchases of condensing gas furnaces have been occurring at high numbers regardless of the current minimum efficiency standards. Purchasers who do not currently buy condensing furnaces predominately have poor economic returns or face difficult installations. Therefore, the real effect of the proposed revised minimum standard will be to leave the "winners" alone and punish the "losers". Given this situation DOE should consider other ways to encourage energy conservation and the use of efficient products.

There are three principle barriers to further market share gains for condensing furnaces:

- Actual or perceived installation issues
- Total furnace and installation cost premiums over 80 AFUE furnaces that are not economically justifiable from energy savings
- Marketplace inertia

In addition, reducing the use of heating fuel can be accomplished through changes in consumer behavior and other factors not immediately associated with the furnace itself. A combination of measures designed to address these factors is much more likely to reduce heating fuel consumption at lower cost and with fewer negative impacts than would a minimum efficiency standard.

It seems clear from the comments by contractors, and from past experience with other products, that markets reach a tipping point where a new technology becomes standard, accepted practice. There is a significant undercurrent, especially in the North, in the comments from installers in the AHRI, ACCA, and PHCC survey that condensing furnaces have become the standard product provided by a contractor unless installation issues preclude its use. Most homeowners purchase 2-3 furnaces in their lives and rely heavily on the contractor for advice on what to install. One key to increasing the share of condensing furnaces is to accelerate the trend for condensing furnaces to be a contractor's common practice and DOE should consider programs that help do that. The goal is to get contractors to think first about proposing and using a condensing furnace and to reduce consumer hesitancy about accepting one when proposed. Given market demand, manufacturers will adapt their product lines just as they have been doing for gas furnaces for the past 30+ years. Approaches like this have been successful in achieving continued market share gains for more efficient product. For example, early efforts to promote front-load washing machines

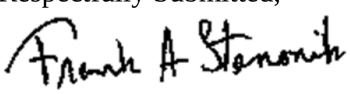
in New England and the Pacific Northwest yielded continuing market share gains through training and incentives to appliance sales representatives after the expiration of direct consumer incentives.[91]
At the same time it must be recognized that an approach such as this would not eliminate the need for 80 AFUE furnaces. There will be climate areas where the extra cost of a condensing furnace will never be economically attractive in replacement situations. There will always been extremely problematic installations where venting a condensing furnace is not practical. Approaches based on training, education and other sponsored R&D could easily accelerate the rate of market share gain for condensing furnaces without penalizing those localities and installations where they are not appropriate.

CONCLUSION

The significant legal issues we have identified, the critical flaw in the use of the Monte Carlo analysis, the many errors in assessing current energy use; estimating energy savings; the cost and benefit of higher efficiency furnaces; and failure to properly characterize the market in the absence of any revised standard lead us to conclude that no increase in the current residential furnace minimum efficiency standard is justified by the analysis provided for this rulemaking.  AHRI reaffirms our commitment to support the establishment of cost effective minimum efficiency standards for residential heating, cooling, and water heating equipment and our willingness to consider various ways to promote the establishment of such standards.

AHRI appreciates the opportunity to provide these comments. If you have any questions regarding this submission, please do not hesitate to contact me.

Respectfully Submitted,



Frank A. Stanonik
Chief Technical Advisor

Attachments: Appendices A and B

[91] See, for example, the discussion on trade incentives in: Shorey, Everett and Eckman, Tom, Appliances & Global Climate Change; Increasing Consumer Participation In Reducing Greenhouse Gases, Pew Center on Global Climate Change (now Center for Climate and Energy Solutions), October 2000

# Survey of Furnace Installation Contractors

June 2015

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PHCC PLUMBING-HEATING-COOLING CONTRACTORS ASSOCIATION
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# Furnace Installation Survey of Residential Contractors

## Overview of Survey

The Air-Conditioning, Heating and Refrigeration Institute (AHRI), in conjunction with ACCA Association and the Plumbing-Heating-Cooling Contractors Association (PHCC) conducted a survey of residential heating contractors during March and April 2015 to understand the differences in installation costs between condensing and non-condensing gas furnaces. In addition, the survey collected data on past experiences with equipment markups following the implementation of DOE energy efficiency standards. The survey was conducted to provide empirical data to inform the standard setting process undertaken by DOE for residential non-weatherized gas furnaces.

The survey received:

- 774 total responses
- 580 with some usable data on installation costs
- 580 with some usable data on markups
- 399 usable installation cost responses from DOE's "North" region, 181 from DOE's "National" region (South) and 4 from region unknown[1]

This is approximately a 7% response rate of usable data from the total membership of ACCA and PHCC and nearly a 10% total response rate. Usable responses represent just less than 1% of the total universe of plumbing, heating and air conditioning contractors.

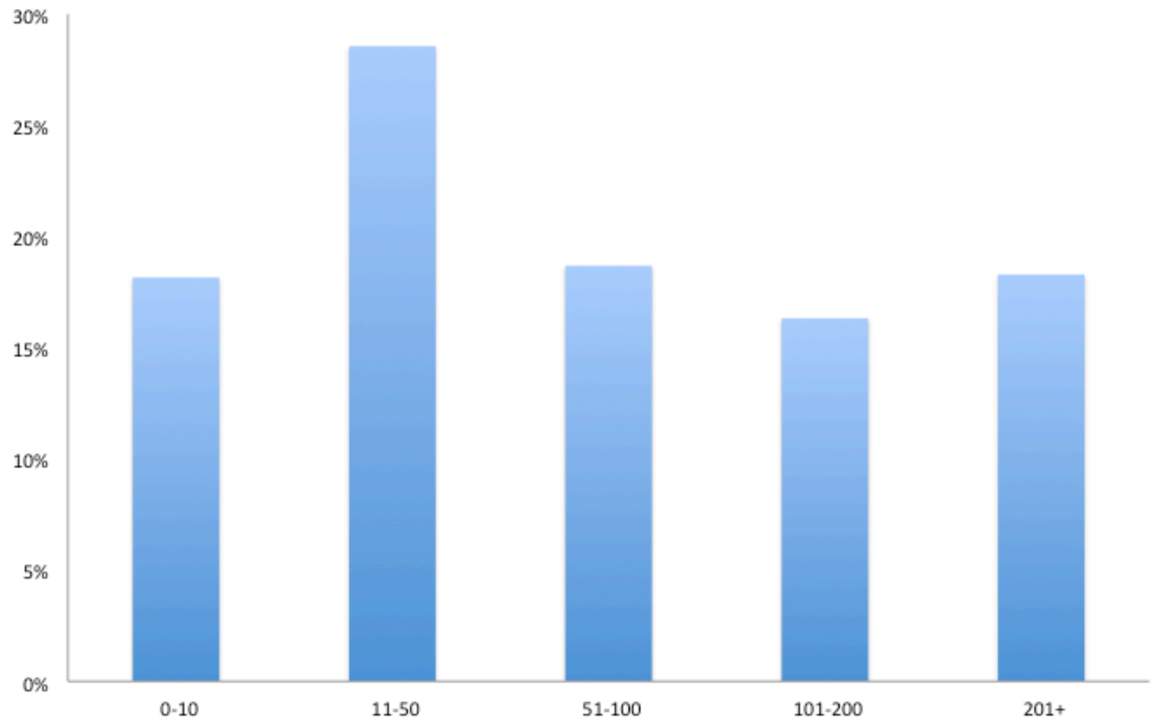
The survey was distributed in two versions, one in the initial release (First Wave) and a second release (Second Wave) with a slightly re-worded markup question. There were 604 total responses to the initial release and 170 for the second release. There were no significant differences between the two releases on installation costs. The text of the surveys is contained in Appendices A&B.

## Characterization of Respondents and Installations

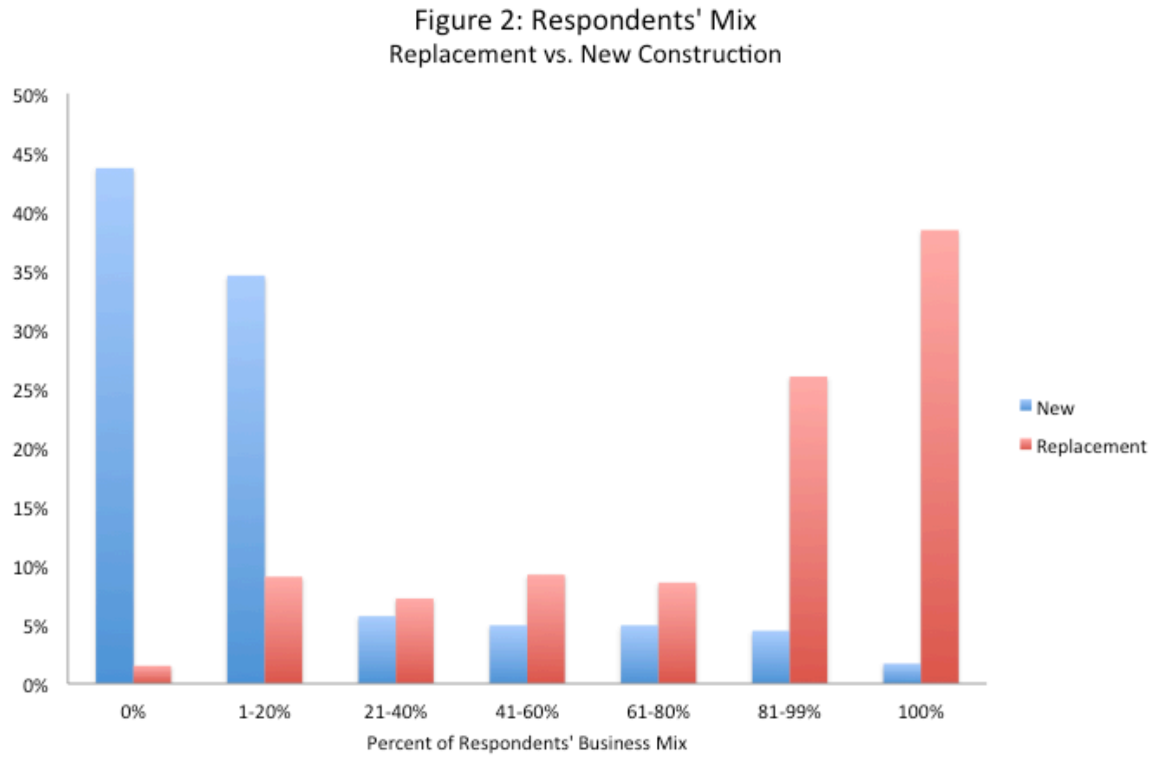
Of the total respondents, they averaged just fewer than 100 furnace installations per year and with a range across the number of installations (Figure 1). This corresponds to approximately 70,000 annual non-weatherized gas furnace installations per year, or 2-3% of total annual gas furnace shipments.

[1] Regions defined in Technical Support Document: Energy Efficiency Program For Consumer Products And Commercial And Industrial Equipment: Residential Furnaces, February 10, 2015. p.2-5

Figure 1: Number of Furnace Installations per Year




Most respondents focus on replacement units, with 64% of the respondents having 80% or more of their furnace installations as replacement units (Figure 2). This reasonably corresponds with the estimates that approximately 75% of the shipments of gas furnaces are for replacements.




On average, just fewer than 50% of the furnaces in new homes were condensing and just over 50% in existing homes (Figures 3&4). In the North, condensing furnaces were used in 55-60% of the installations while non-condensing furnaces were used in 65-70% of the installations in the South.

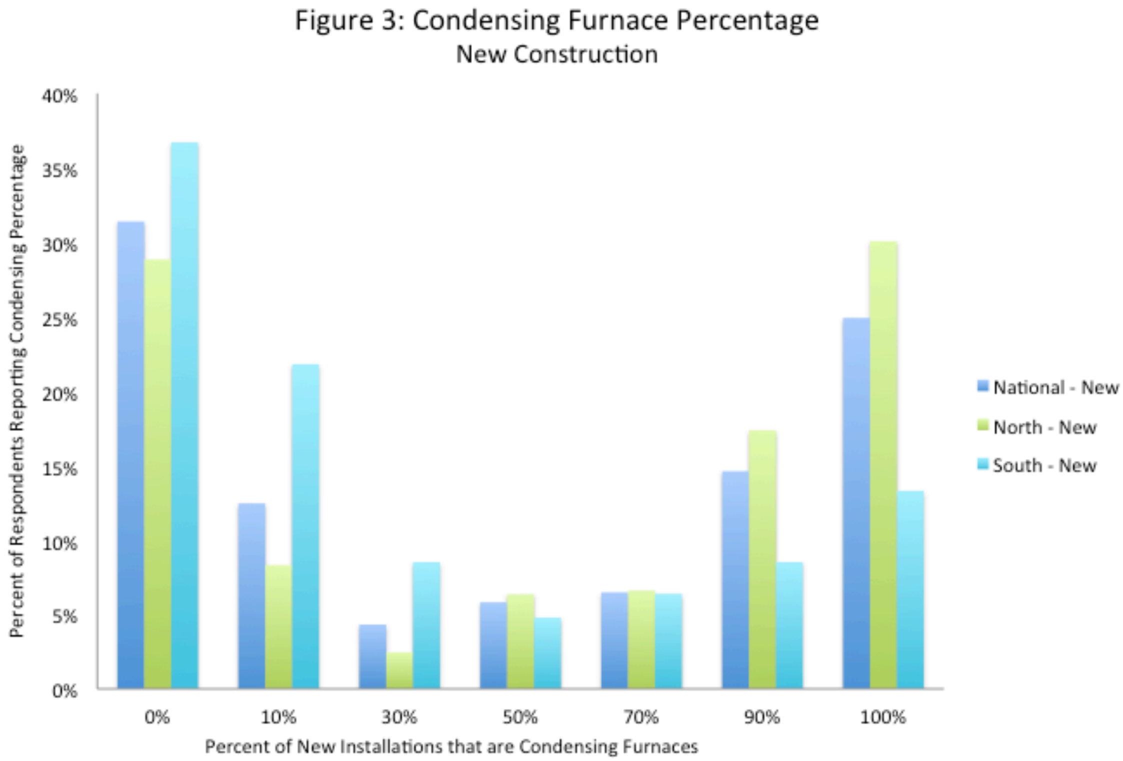


Figure 3: Condensing Furnace Percentage
New Construction
40%
35%
30%
25%
20%
15%
10%
5%
0%
Percent of Respondents Reporting Condensing Percentage
0%
10%
30%
50%
70%
90%
100%
Percent of New Installations that are Condensing Furnaces
National - New
North - New
South - New

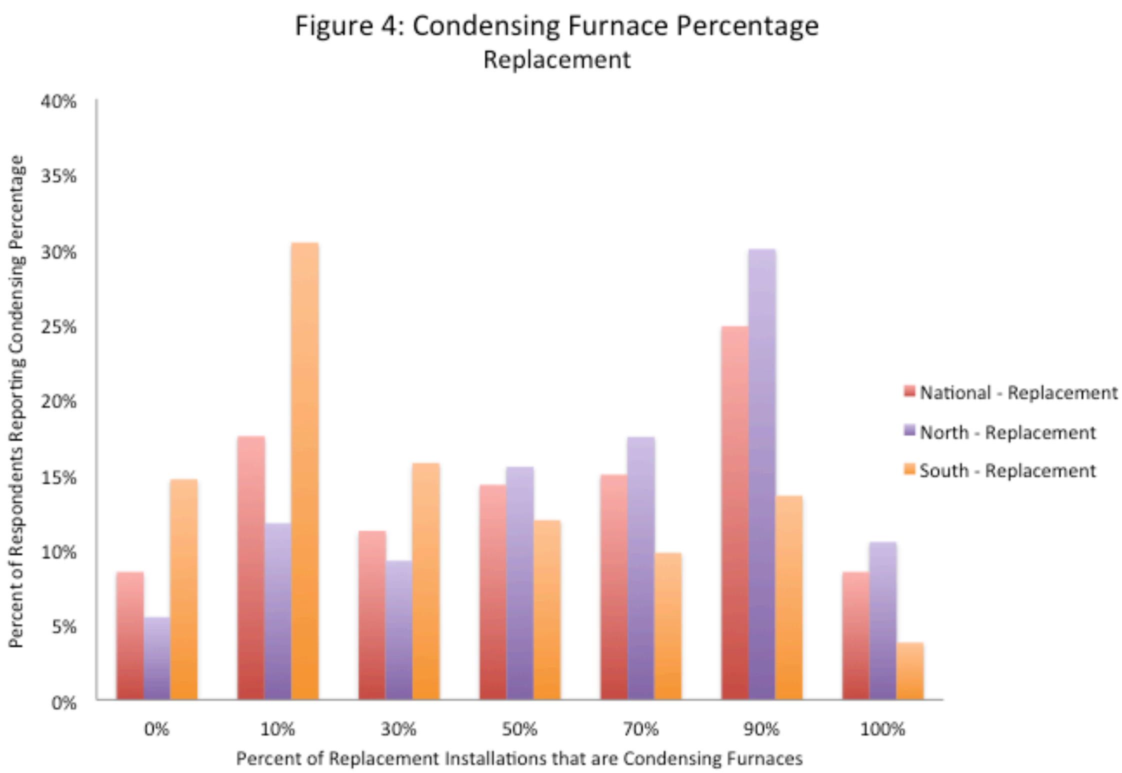


Figure 4: Condensing Furnace Percentage
Replacement
40%
35%
30%
25%
20%
15%
10%
5%
0%
Percent of Respondents Reporting Condensing Percentage
0%
10%
30%
50%
70%
90%
100%
Percent of Replacement Installations that are Condensing Furnaces
National - Replacement
North - Replacement
South - Replacement

## Installation Costs

The survey asked respondents to estimate the cost for installing a gas furnace in a "typical" installation, both for new construction and replacement:

> "For installations in *new* homes in 2014, what was the total cost of installation (labor, materials, venting, overhead and profit) but excluding the furnace and ductwork for an "average" project? We realize there is no "average" project but we would like your best estimate of what the typical cost might be for a unit with input and blower capacity similar to DOE's baseline model."[2]
>
> The question was repeated for *existing* homes.

Respondents were offered cost options in bands of $250 from "Less than $500" to "Over $3500".

The average installation cost[3] varied from $2730 for replacement installations in the North to $1908 for new installations in the South. The differences in average installation costs are significant at the 95% confidence level for the South (Figure 5). There is considerable variation in installation costs between respondents (Figure 6) and the survey seems to have underestimated the maximum cost so that there is a clustering in the highest band.

The difference between average installation costs for non-condensing and condensing furnaces is between $500 and $600, with condensing furnaces having higher installation costs for both new construction and replacements and in all locations (Figure 7).[4] There is a wide variation in the difference in installation costs for those respondents reporting on the cost for both non-condensing and condensing furnaces. A very small group reports that non-condensing furnaces have higher installation costs and 15-30% report essential the same cost. Otherwise, the variation is large with a substantial portion reporting increased costs up to $1000 and a long tail of differences out to over $2000 (Figure 8).

---

[2] The DOE "baseline model" was defined as: Input: 80,000 Btu/h, AFUE: 80%, Blower: 1200 cfm.

[3] Installation costs are computed by taking the midpoint of the cost bands and $375 for the lowest band and $3750 for the highest.

[4] The difference in installation cost for "All Reponses" is the difference between the sums of the installation costs divided by the total number of responses. The difference in installation cost for "Report Both" is the sum of the differences between the two responses divided by the number of respondents providing both answers.

Figure 5: Average Installation Costs

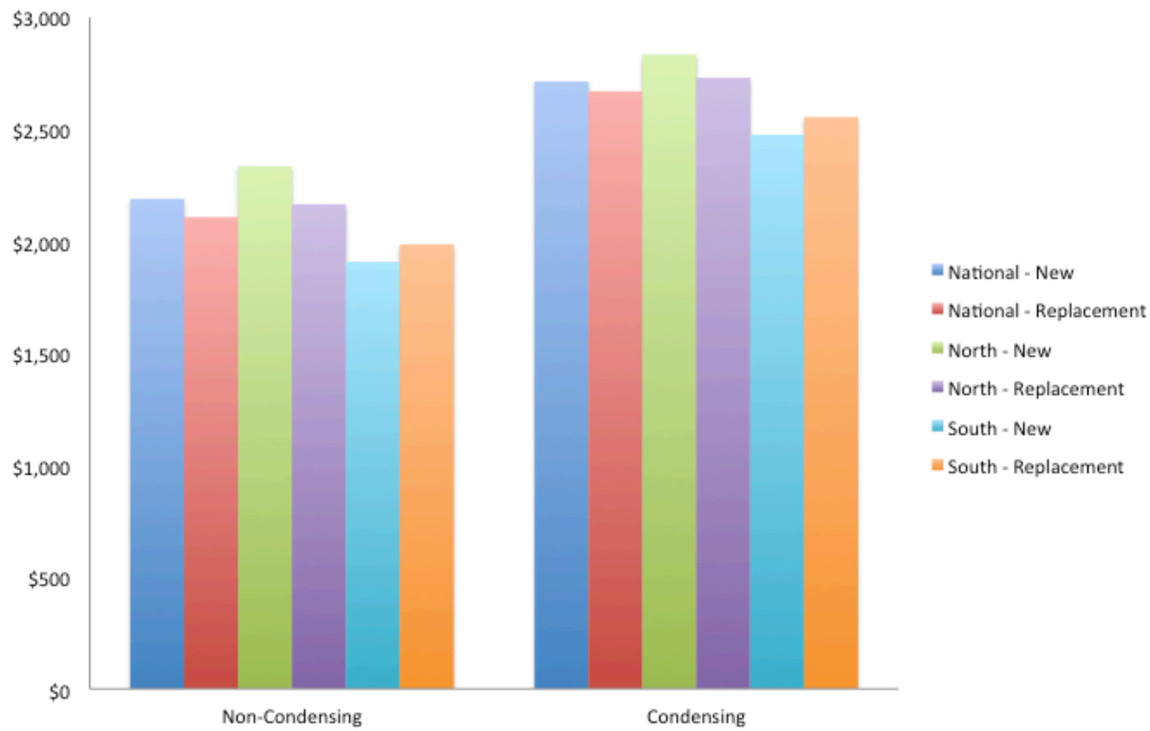
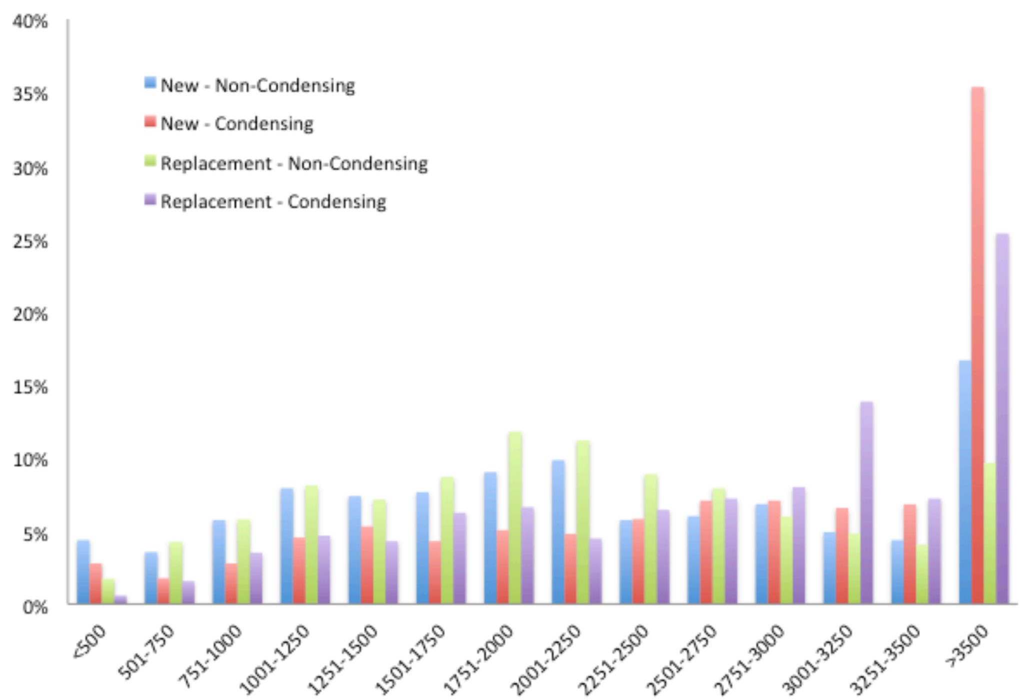



Figure 6: Distribution of Installation Costs
National



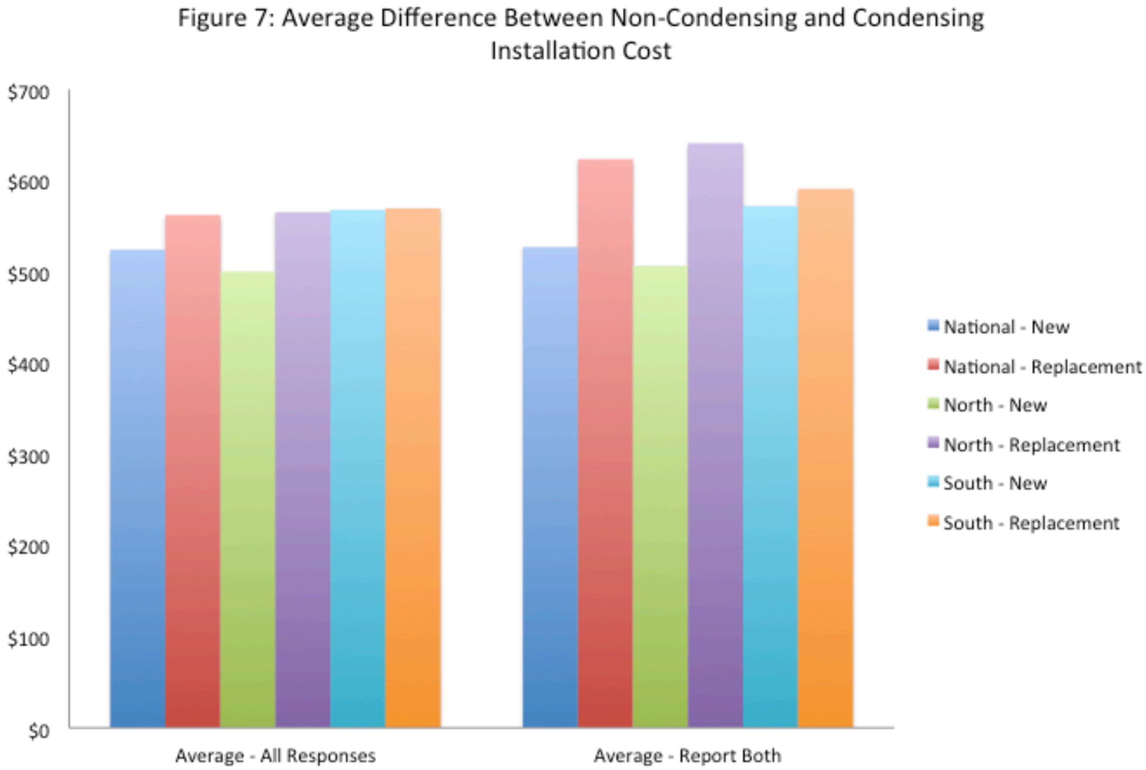


Figure 7: Average Difference Between Non-Condensing and Condensing Installation Cost
$700
$600
$500
$400
$300
$200
$100
$0
Average - All Responses
Average - Report Both
National - New
National - Replacement
North - New
North - Replacement
South - New
South - Replacement

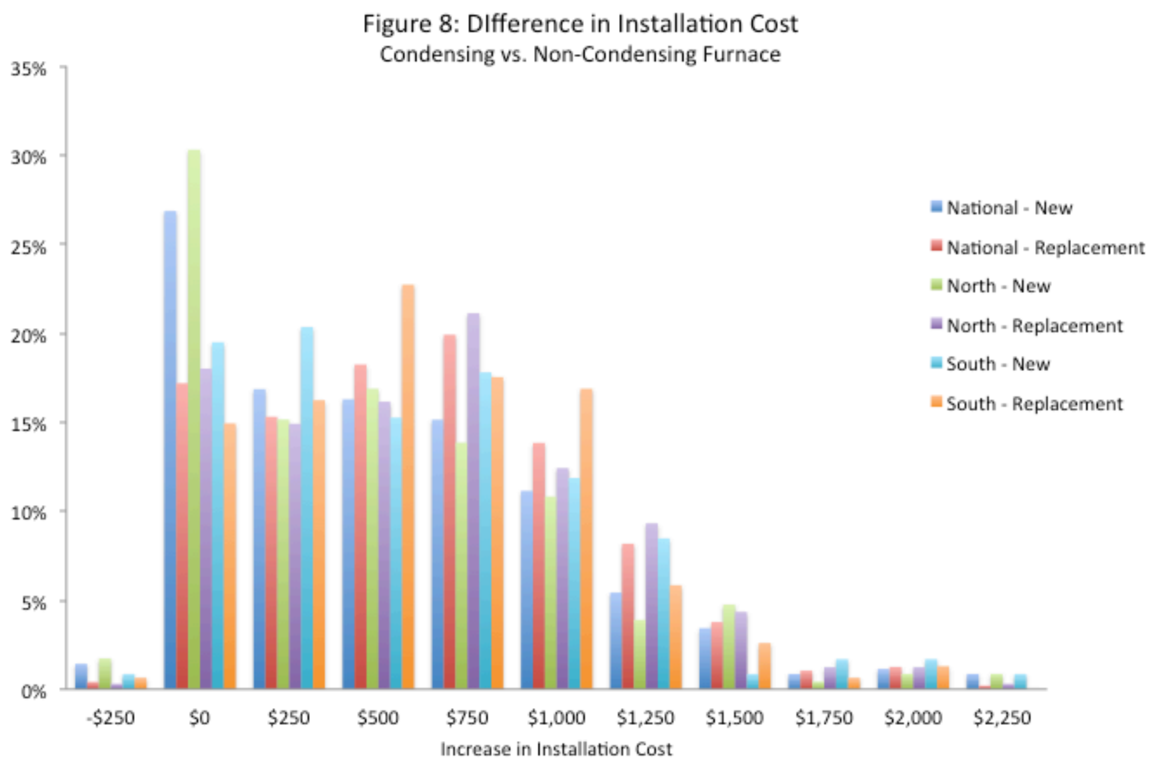



Figure 8: DIfference in Installation Cost
Condensing vs. Non-Condensing Furnace
35%
30%
25%
20%
15%
10%
5%
0%
-$250
$0
$250
$500
$750
$1,000
$1,250
$1,500
$1,750
$2,000
$2,250
Increase in Installation Cost
National - New
National - Replacement
North - New
North - Replacement
South - New
South - Replacement

## Post-Standards Markups/Margins

One of the assumptions in DOE's analytic process for setting efficiency standards is the markup/margin[5] applied by contractors on both pre and post-standard products. DOE has posited that the markup/margin will be lower for the post-standard product.

The survey tested this concept with two questions, which were modified slightly for clarity between the first and second waves of the survey:

First Wave (604 responses)

Q1: Does your company use different markups for the price of 80% AFUE Efficiency and for High Efficiency residential gas furnaces?

Q2: In the past, when new efficiency standards for air conditioners, heat pumps or other products occurred, did your typical markup change?

On review, it was possible that these formulations could be misinterpreted to refer to absolute dollar markup/margin rather than percentage. So in the second wave, they were changed to:

Second Wave (170 responses)

Q1: Does your company use different *percentage* markups for the price of 80% AFUE Efficiency and for High Efficiency residential gas furnaces?

Q2: In the past, when new efficiency standards for air conditioners, heat pumps or other products occurred, did your typical *percentage* markup change?

The responses to the two formulations were, essentially, identical. Contractors do not have lower markups on the more expensive condensing furnaces and markups do not decline following new efficiency standards (Figures 9&10). If anything, contractors report that markups increased. The similarity between the results in the First Wave and the Second Wave indicates that contractors originally understood the question to refer to percentage markups.

[5] As used here and by DOE, a "markup" is the factor used to multiply costs to reach selling price. A "margin" is the difference between costs and selling price divided by selling price. Revenues – Costs = Gross Profit, Gross Profit/Costs = Markup, Gross Profit/Revenues = Margin.

Figure 9: Use Different Markup for Condensing Furnace

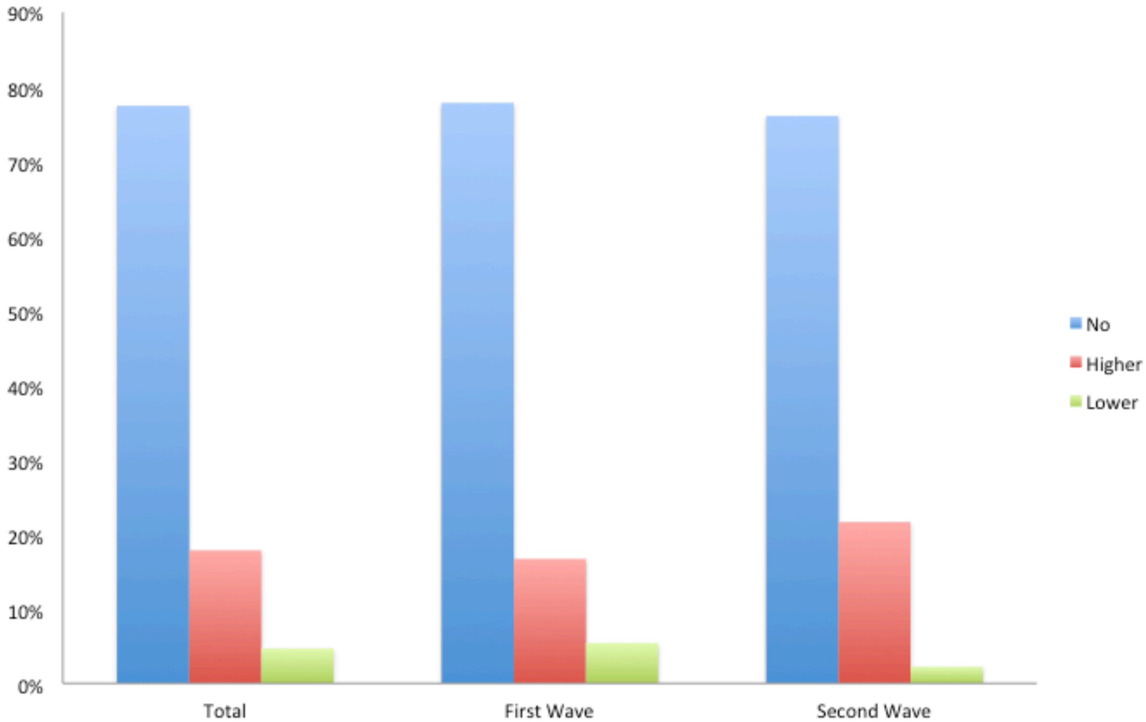
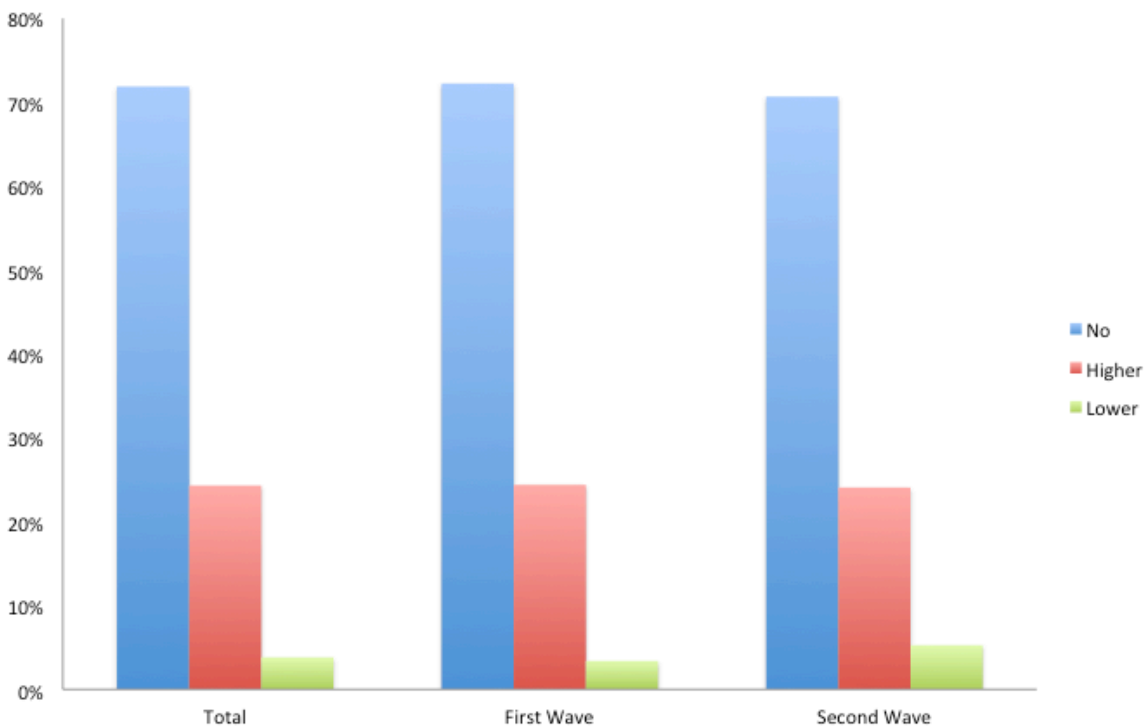



Figure 10: Did Markups Change Post Standards



## Limitations of the Data and Analysis

As with all analyses, there are limitations on the scope and accuracy of the data and conclusions. All surveys have sample error based on the size of the sample, where this form of error is generally well understood. In addition, all surveys have data accuracy and coverage errors that are generally hard to define statistically. Based on the coverage of approximately 70,000 furnace installations, the sample error (at the 95% confidence level) is 0.4%. Based on the sample of 580 contractors, the sample error is 4.1%. The variations found in the survey are large enough that they are greater than either sample error.

All cost values are computed based on mid-point ranges of the data bands. This brings in some level of estimation error. Given the number of usable data points, these errors have the tendency to cancel each other out. While this is a source of potential error, this is a standard approach for dealing with data bands.

Contractors were surveyed on their perception of installation costs for an "average" project. This could have widely different meanings for the responding contractors and there are almost certainly wide variations in the costs for individual projects. With that caveat, this data provides a "top-down" marketplace anchor for any other form of estimation.

Contractors' perceptions are based on projects they actually install. Therefore, their estimates of installation costs are limited to those applications where their customers accept condensing furnaces. This will almost always be in applications where the economic returns are attractive. The written comments from the contractors indicate that there is a range of other applications where the problem of venting a condensing furnace would be substantial. Therefore, the contractors' perceptions of installation costs represent a *lower-bound* on the costs that might be incurred if there were a national standard requiring condensing furnaces.

## Written Comments

Contractors were given the opportunity to provide additional comments and approximately 200 did so. Those comments fall into five major categories:

1. There are installations, especially multi-family buildings and completely finished basements, were venting a condensing furnace is impractical to impossible and would require moving walls, ceilings or other construction not ordinarily done by HVAC contractors.
2. There are installations where it is not possible to vent a condensing furnace because of code limitations on vent location (away from windows, etc.).
3. Some applications have furnaces in unconditioned spaces where freezing of the condensate line is considered an unacceptable issue.

4. In some southern areas, the payback from a condensing furnace is unacceptable to the consumer
5. A condensing furnace standard makes the most sense for new construction, where there are not installation issues.

The full set of written comments (edited for spelling and some grammar) is contained in Appendix C.

# Appendix A

# Furnace Installation - ACCA

## Furnace Installation Cost Survey

**The US Department of Energy sets minimum efficiency standards for residential heating and cooling equipment, including natural gas furnaces. In order to set efficiency levels that most accurately capture the effects on consumers and contractors, ACCA and the heating manufacturers' association, AHRI, is conducting a survey of installation costs. In addition we are seeking some information on markup practices. This survey should take less than 15 minutes to complete. Please complete based on the business your company did in 2014. Of course, all responses will be kept anonymous unless you want a call back. Thank you for your cooperation.**

**Note: For the current DOE activity to revise the minimum efficiency standard for residential gas furnaces, DOE is using a baseline furnace model with the following characteristics:**

**Input: 80,000 Btu/h**
**AFUE: 80%**
**Blower: 1200 cfm**

**Please base your answers on providing a model of similar input and blower capacity.**

# Furnace Installation - ACCA

## Business Location and Volume

1. What state are you in?

2. Do you serve multiple states?

- Yes
- No

Which ones?

3. How many residential gas furnace installations did your company perform in 2014?

- Fewer than 10
- 11-50
- 51-100
- 101-200
- More than 200

## Furnace Installation - ACCA

### New Construction

4. What percentage of those total gas furnace installations was in *new* homes?

- 0%
- 1-20%
- 21-40%
- 41-60%
- 61-80%
- 81-99%
- 100%

5. What percentage of your *new* home gas furnace installations was a high efficiency (condensing) furnace instead of an 80% AFUE efficiency (non-condensing) furnace?

- 0%
- 1-20%
- 21-40%
- 41-60%
- 61-80%
- 81-99%
- 100%

6. For installations in *new* homes in 2014, what was the total cost of installation (labor, materials, venting, overhead and profit) but excluding the furnace and ductwork for an “average” project? We realize there is no “average” project but we would like your best estimate of what the typical cost might be for a unit with input and blower capacity similar to DOE’s baseline model.

| | 80% AFUE Efficiency (Non-Condensing) | High Efficiency (Condensing) |
|---|---|---|
| Installation Cost | | |

## Furnace Installation - ACCA

### Existing Homes

7. What percentage of those total gas furnace installations was in*existing* homes?

- 0%
- 1-20%
- 21-40%
- 41-60%
- 61-80%
- 81-99%
- 100%

8. What percentage of your *existing* home gas furnace installations was a high efficiency (condensing) furnace instead of an 80% AFUE efficiency (non-condensing) furnace?

- 0%
- 1-20%
- 21-40%
- 41-60%
- 61-80%
- 81-99%
- 100%

9. For installations in *existing* homes in 2014, what was the total cost of installation (labor, materials, venting, overhead and profit) but excluding the furnace and ductwork for an "average" project? We realize there is no "average" project but we would like your best estimate of what the typical cost might be for a unit with input and blower capacity similar to DOE's baseline model.

| | 80% AFUE Efficiency (Non-Condensing) | High Efficiency (Condensing) |
|---|---|---|
| Installation Cost | | |

## Additional Question

**Thank you for your responses on installations. We have one other set of questions. The US Department of Energy uses two different contractor markups in its analysis: a Base Case markup for Minimum Efficiency products and a lower Incremental Markup for more expensive, High Efficiency equipment.**

10. Does your company use different markups for the price of 80% AFUE Efficiency and for High Efficiency residential gas furnaces?

- ○ No
- ○ Yes – Higher
- ○ Yes – Lower

11. In the past, when new efficiency standards for air conditioners, heat pumps or other products occurred, did your typical markup change?

- ○ No
- ○ Yes – Higher
- ○ Yes – Lower

12. Are there any other comments you would like to make about installation, markups or furnaces in general?

Thank you for your participation.

# Appendix B

AHRI

we make life better®

PHCC PLUMBING-HEATING-COOLING CONTRACTORS ASSOCIATION®
*Best People. Best Practices.®*

## Furnace Installation - PHCC2

### Furnace Installation Cost Survey

**The US Department of Energy sets minimum efficiency standards for residential heating and cooling equipment, including natural gas furnaces. In order to set efficiency levels that most accurately capture the effects on consumers and contractors, PHCC and the heating manufacturers' association, AHRI, is conducting a survey of installation costs. In addition we are seeking some information on markup practices. This survey should take less than 15 minutes to complete. Please complete based on the business your company did in 2014. Of course, all responses will be kept anonymous unless you want a call back. Thank you for your cooperation.**

**Note: For the current DOE activity to revise the minimum efficiency standard for residential gas furnaces, DOE is using a baseline furnace model with the following characteristics:**

**Input: 80,000 Btu/h**
**AFUE: 80%**
**Blower: 1200 cfm**

**Please base your answers on providing a model of similar input and blower capacity.**

## Furnace Installation - PHCC2

### Business Location and Volume

1. What state are you in?

2. Do you serve multiple states?

- ○ Yes
- ○ No

Which ones?

3. How many residential gas furnace installations did your company perform in 2014?

- Fewer than 10
- 11-50
- 51-100
- 101-200
- 201-250
- More than 250

## Furnace Installation - PHCC2

### New Construction

4. What percentage of those total gas furnace installations was in*new* homes?

- 0%
- 1-20%
- 21-40%
- 41-60%
- 61-80%
- 81-99%
- 100%

5. What percentage of your *new* home gas furnace installations was a high efficiency (condensing) furnace instead of an 80% AFUE efficiency (non-condensing) furnace?

- 0%
- 1-20%
- 21-40%
- 41-60%
- 61-80%
- 81-99%
- 100%

6. For installations in *new* homes in 2014, what was the total cost of installation (labor, materials, venting, overhead and profit) but excluding the furnace and ductwork for an “average” project? We realize there is no “average” project but we would like your best estimate of what the typical cost might be for a unit with input and blower capacity similar to DOE’s baseline model.

| | 80% AFUE Efficiency (Non-Condensing) | High Efficiency (Condensing) |
|---|---|---|
| Installation Cost | | |

## Furnace Installation - PHCC2

### Existing Homes

7. What percentage of those total gas furnace installations was in *existing* homes?

- 0%
- 1-20%
- 21-40%
- 41-60%
- 61-80%
- 81-99%
- 100%

8. What percentage of your *existing* home gas furnace installations was a high efficiency (condensing) furnace instead of an 80% AFUE efficiency (non-condensing) furnace?

- 0%
- 1-20%
- 21-40%
- 41-60%
- 61-80%
- 81-99%
- 100%

9. For installations in *existing* homes in 2014, what was the total cost of installation (labor, materials, venting, overhead and profit) but excluding the furnace and ductwork for an “average” project? We realize there is no “average” project but we would like your best estimate of what the typical cost might be for a unit with input and blower capacity similar to DOE’s baseline model.

| | 80% AFUE Efficiency (Non-Condensing) | High Efficiency (Condensing) |
|---|---|---|
| Installation Cost | | |

## Furnace Installation - PHCC2

### Additional Question

**Thank you for your responses on installations. We have one other set of questions. The US Department of Energy uses two different contractor percentage markups in its analysis: a Base Case markup for Minimum Efficiency products and a lower Incremental markup for more expensive, High Efficiency equipment.**

10. Does your company use different *percentage* markups for the price of 80% AFUE Efficiency and for High Efficiency residential gas furnaces?

- ○ No
- ○ Yes – Higher
- ○ Yes – Lower

11. In the past, when new efficiency standards for air conditioners, heat pumps or other products occurred, did your typical *percentage* markup change?

- ○ No
- ○ Yes – Higher
- ○ Yes – Lower

12. Are there any other comments you would like to make about installation, markups or furnaces in general?

Thank you for your participation.

# Appendix C: Comments from Contractors

| General/Installation Comments |
| --- |
| Northern Contractors |
| I don't have a problem with the increase of eff. because that is all I install |
| Furnaces in general in my region of the country 80% efficiency furnaces are very wide spread and changing to condensing furnaces in many applications is not feasible due to freezing conditions that may exist |
| 80% NON-CONDENSING FURNACES ARE NEEDED! SEVERAL FURNACES ARE IN UNCONDITIONED SPACES AND ALLOWED TO FREEZE AND CONDENSING FURNACES MUST BE ON A CONDITIONED SPACE. |
| Some homes do not have a smart or easy path to the outdoors without changing hot water heaters also. |
| Some multifamily housing will be almost impossible to install high efficiency without redoing water heater flues and opening up drywall chases etc. |
| Our preference is to sell high efficiency but some installations are more difficult posing high costs to the consumer. Low income and fixed income clients struggle with the associated costs. |
| In freezing locations, such as ventilated attics, 90+% condensing furnaces may not always fit the applications because of condensing lines freezing and furnaces failing to fire, therefore the ongoing need for 80% furnaces in those applications. |
| In our market we have a very high percentage of homes with finished basements and low ceiling height basements that makes installing a high efficiency furnace very costly and in some cases almost impossible without extensive remodeling. |
| There are existing residential and commercial structures where a condensing furnace will be a headache for the owner including structures that are empty and not heated or heated to only a very low temperature for long periods of the winter. Heating these to warmer temperatures and electric heat tracing of areas of installations in unconditioned spaces will have a net increase in energy usage, operating costs and initial investment. It will be a lose, lose and lose rule without intelligent exceptions. |
| We only use the 80% where we can not use the condensing furnaces, mainly on homes with finished basements |
| This was a hard survey to fill out because every house is different. |
| 80% furnaces are still needed for certain applications and budgets. |
| Condensing furnaces are impossible to install in some older homes to satisfy the venting requirements. |
| Many homes in our area have no direct means to vent a high efficiency furnace so costs are completely unreasonable to even consider the upgrade (houses with |

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| finished or no basements, condos, middle of the row townhouses, etc.). Any requirement to force these homeowners to upgrade to high efficiency is completely irresponsible. |
| Some homes due not lend themselves to having a high efficiency furnace installed without major construction issues. This situation hits lower income households harder. It seems this was never considered when the previous mandate was issued or it was underestimated with how it would impact some houses. |
| There are some jobs where you simply cannot install a condensing furnace, such as one in an unconditioned space. We should enforce quality installations rather than higher AFUE's. |
| There are situations where it is not feasible, practical or possible to install high efficiency furnaces located in cold attics or furnaces located in closets of multi level apartment complexes. |
| I feel that the biggest problem with a 90% furnace mandate is that it is just not possible in some applications. In St Louis a lot of furnaces are in basements that are below grade with no way to vent a 90%. They are also some in attics where the condensate will freeze. 90% furnaces are great and we recommend them, but sometimes they just can't be installed. Then what? |
| There are going to be some serious hardships for people that live in condominium and row homes in our neck of the woods. The increased cost to the homeowner would far outweigh the energy efficiency benefits they would receive from a higher efficiency furnace. |
| Typically the cost to vent an 80% furnace is higher because we usually install a chimney liner. |
| These prices are based on installations where a 90% furnace is able to be installed. In instances where a 90% is not practical but will be enforced the cost to install could easily be double the cost of installation of a practical installation. |
| Not sure the survey took into account the additional cost when a high efficiency unit can't easily be installed |
| I do believe we still need an exception for 80% furnaces where venting issues arise. Multiple story buildings, finished basement where getting a PVC flue out will cause hardship etc. |
| The homeowners are finding it difficult justify the cost as they have other areas to spend their money i.e. [insulation, windows etc.] |
| Not all homes are able to use sidewall vented units. Here in the northeast we have houses with finished basements with the units in the middle of the house. To replace the unit you have to rip apart the basement for the venting and intake. Also many houses do not have the window clearance and/or ground clearance for direct vent. And the chimney can't be lined for it because it is being used for multiple appliances. I understand the desire to increase efficiency but when you are adding all these other required costs it drives the price up unreasonably in many cases. Why not mandate all 80% units to be two stage and ecm motor? It |

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| would work better for most homeowners. |
| Make a provision and exception for townhouses and condominiums where it is impossible to get vents out |
| In townhomes and condo's 80% models are installed because of venting issues. If 92% models were required additional costs would include construction of chase ways and could add $3,000 to $5,000 to the price of the installation. There are also cases where a 92% model could not be installed no matter what. |
| It would be simple process to impose the 95% furnace only be installed on all new construction moving forward. This would be a giant step towards the end goal. As long as 80% furnaces are allowed to be installed on New Build the builder will take the cheap way out. As the new construction changes to 95% the industry itself will migrate that way. There are some applications that 95% are just not reasonable due to conditions of existing install and nature of that house. Making then change to 95% will become cost prohibitive and likely cost an additional 4 to 5 thousand more to make the application feasible. Most consumers are not prepared to make that adjustment. Even if you made it mandatory that if a remodel was happening and the furnace were being replaced that a 95% be installed. At least the consumer would know they have to budget it in. Policing this is impossible I would think. Again new construction is the key to getting the ball rolling in the right direction. |
| We do not install condensing furnaces in non-conditioned spaces (attics) no matter what. I'd rather lose the job than to go against principles. |
| Some applications it would be nearly impossible to install high efficiency equipment. Such as; replacements in apartment buildings, Homes where it is not practice to run the pvc vents |
| The real issue is that many homes are not designed for a condensing furnace such as location in a unconditioned space where freezing condensate will occur or where venting and condensate removal will involve extreme measures that would require thousands of dollars more to install. Generally our customers want upgrade to high efficiency if it makes sense. Does it make sense to build a condition room in an attic? Do we jack hammer a slab floor to install a condensate drain or use a pump and risk the probability of flood damage? It seems that the American public is the party not being represented in this big government power grab. |
| Many old homes have no viable space for installing PVC venting and many customers can still barely afford 80% furnaces let alone the additional cost of 92% plus and since these furnaces have a shorter lifespan, that is a real issue for customers. |
| Making 90+% furnaces the minimum efficiency is the equivalent of telling gasoline manufacturers that 95 octane is the minimum they can produce. While it produces better results, it is more expensive. Consumers should have the right to decide the efficiency of their equipment; not contractors and definitely not the federal government. |

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| Of particular concern is for furnaces installed outside of the building envelope (attic or garage) where in colder climates condensing equipment can fail to work or cause damage due to freezing condensate. |
| It does not cost much more to put in a 92% furnace compared to an 80% on new construction if you don't install a B-vent flue for the water heater. Replacements obviously vary depending on the venting situation but we always try to get the customer into the higher efficiency units if possible. |
| Sometimes we will still need an 80 percent furnace |
| You do not specify so we've assumed that we are replacing 80% with 80% and 90% with 90%--no change in venting. Changing the venting when upgrading from 80% to condensing will be the largest cost besides the heater and labor and may actually add more cost to the job than the heater itself depending on the application. In our scenarios, venting could add $3000 + to the cost of a job depending on access (high rises) and carpentry, painting, wall paper for soffits, removal of condensate for heaters in unconditioned space, duct modifications for heater relocation etc. The proposed change cannot be looked at on a single level, It is a multifaceted issue and if exemptions will be given, who, where and how quickly? Where will equipment come from if manufacturers are producing to the minimum 92% standard, will it be available for a home in the north with sub zero temperatures? ETC. Please consider the alternative of mandating a minimum 80% 2-stage heater with a high performance motor. The total year around energy savings are probably greater than those gained by a higher AFUE requirement. |
| The main issue with the installation of a 90% furnace isn't always the cost but the installation. Not all replacement jobs can have a 90% furnace installed due to location of the existing system. New construction would be the only time that a 90% furnace could be installed on every job. |
| We almost always use high-efficiency equipment unless the installation does not allow it. We have multiple locations usually multi family weather is no possibility of installing condensate disposal system |
| I feel the government is trying to control too much they need to quit and get back to what they were design for. |
| As a company, almost always we use 92%+ gas furnaces. The exception are in attics because of the condensate freezing, in apartments and condos where heat loads are very low and retrofitting the flues are impossible or very costly, and real estate and foreclosure jobs where value is the deciding factor. When this was proposed before we had estimated some jobs could be $7000.00 or more due to modification required for the venting and condensate |
| You must remember in some replacements it is impossible to get a high efficiency installed. Due to not being able to get the vents out side. Also it is the same in some apartments |
| 80% gas work better on dual fuel system they use less electricity, last longer, they do not freeze in none heated space. They are less likely to have heat exchanger |

| |
|---|
| failure |
| There are many situations that do not allow for the PVC flues required for 90% furnaces. An example would be a finished basement with drywall ceilings. You cannot expect a homeowner to take down drywall for a furnace installation. |
| There are certain installations that only an 80% gas furnace can be installed due to venting issues. |
| I am against raising the national minimum above 80% AFUE for existing homes due to the venting and condensate problems of installing 90% + furnaces. If they want to raise it for new construction that would be fine. |
| Use a 2-stage heat 80% furnace as a base. There are MANY installations in the replacement areas that there is NO practical way to vent a 90% to the exterior of the home without EXTENSIVE cost and remodeling involvement. |
| Due to construction details of existing residences, not all homes are High Efficiency Eligible. Mandatory High Efficiency should be reserved for new construction only. |
| Mandating condensing furnaces will be a problem in certain situations where a drain is not available or venting is an issue such as multi story apartment buildings |
| Changing the minimum efficiency to 92+% AFUE on RNC jobs makes complete sense; there are too many applications where venting in existing homes is too costly and/or unsafe. |
| In our are retro-fitting from 80% to condensing furnaces will be near impossible in some homes due to venting issues. In homes where it possible increases in installation costs will prevent some homeowners from replacing equipment. They will elect to keep their old furnace thus negating any efficiency increase that they would receive from a new 80% furnace. |
| Some existing homes cannot upgrade from 80% to 92% systems without significant rework of the original system |
| I inspected furnaces; these numbers reflect permitted furnace installs. |
| Efficiency standard on an ac is totally different than on a furnace, since a furnace requires pvc flues. As well as most the time in replacement work with out doing construction to the house there is no way to get pvc flues ran outside |
| You cannot install 80% furnaces in multiple level condos or apartments. |
| There are replacement applications that dictate an 80% furnace. There will physically no way to get a 90+ flues out of the premises. |
| If this changes takes effect it would be a disaster for certain multi family homes and condominiums that we currently service. Average additional cost to install a 92% vs. 80% would be around $3,000 just for the venting changes alone |
| 80 per centers are usually lower margin budget shoppers. |
| It costs more to install furnaces so they are easier and less expensive to maintain. |

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| If we did sloppy work and without taking maintenance and service into account our labor cost might be as much as 30% less. Mechanical equipment should not be permitted to be located in unconditioned spaces, i.e. never in attics or crawl spaces or zero clearance locations anywhere. |
| In some homes, due to decks, patios, garages and other obstructions, it is very costly to vent a condensing furnace. Other homes have attic-based equipment. Freezing of condensate in northern attics is a concern. |
| YES-VERY IMPORTANT If a customer that has an 80% furnace HAS to replace it with a condensing furnace, some installs could cost thousands of dollars more because of where the 80% furnace is currently installed (i.e. attic or other similar installs where the furnace is located in a non conditioned space. The issue is preventing equipment & drain from freezing.) These I feel should be hardship exceptions. I am all in for condensing equipment for new construction, and replacements where equipment is in a conditioned space. |
| Condensing furnaces cannot be installed in the attics of northern states without added costs. Other sites will not accept the required venting for high efficiency. |
| Increased cost and job problems will be a big issue for those that live in a town house, condo or any other type of home that will not adequately accommodate a 92% efficient furnace system. |
| Personally I don't like installing condensing furnaces above the attic insulation line. There is a reason in the north they don't put water heaters and water lines outside the insulation line. So now we are forced to put a condensing furnace outside envelope of the house? |
| Some applications in our area there will be a significant expense on the homeowner to install a 90% also resulting in a major remodel of the home. Some installations are in an attic or in the middle of the home where venting is not possible. |
| Not always able to change because of flue options |
| In total agreement for higher efficiency standards. For those installs that there is a cant do, create an exclusion waiver verified by town inspector |
| I believe in high efficiency equipment, from environmental and economic perspectives; presently to meet energy star requirements it is very difficult to install a furnace out side the building envelope (attic, etc.) in Utah we don't install high efficiency furnaces in attic's due to freezing potential. The most logical way (from my perspective) to upgrade the regional standards would be to simply require high efficiency on new construction (or remodels that require permit application to prove sizing and design (manual's J, D, and S). For existing homes there are simply too many conditions that either completely prohibit upgrading from a standard (80%) furnace to high efficient; if the government is truly interested in the environmental benefit of high efficiency than pay incentives on existing homes for upgrades; that way they are not imposing an unfair cost on existing homes that were built in compliance with the codes at the time they were |

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| built. |
| Sometimes it is impossible to find a safe location to vent a condensing furnace. |
| In some homes due to obstructions such as decks the cost to install condensing furnaces is considerably higher than non-condensing. For northern installations, condensing furnaces in attics may lead to frozen condensate systems. |
| I agree with the new law, all furnaces should be a minimum of 92% efficient |
| There are many cases where you cannot install condensing furnaces do to existing conditions. Attics susceptible to freezing, condos with limited exterior walls, act. |
| The AFUE of the furnace reflects only combustion...not system design. Proper system design is where we as a trade should spend our efforts |
| It's important to understand the regional complexities with regard to any HVAC installation. There should always be flexibility in design and how varying efficiencies can be incorporated as such. |
| The average person can't afford another increase. Please leave well enough alone |
| There are many applications in the Boston area where a high efficiency condensing furnace is not possible without huge amounts of modifications to the building in order to vent outside. In some cases there is no possible way. |
| Too many components can fail in hi eff furnaces! |
| In my area most of the homes do not have masonry chimneys that will pass any inspection for having a clay flue liner. So, might as well install a condensing furnace because of the better efficiency and eliminating heat loss up the chimney. On another note, I've argued the point about the stretch code and it pertaining to duct work. This state is so concerned about sealing up every little crack in the duct section connections, yet here we are arguing about a more efficient heating appliance compared to a less efficient one. Now, if you look at heating equipment in general, in Western Mass we have a ratio of about 10 to 1 of boilers compared to furnaces. In Berkshire County there is a 4 to 1 ration of hydronic to steam boilers. There has been a huge advancement in technology towards efficiency in hydronic heating, for example; Installing circulators on the supply after the air separator as opposed to on the returns. Another example is installing a variable speed circulator and zone valves as opposed to a circulator on each zone, which according to Taco Industries will save the customer up to 30% in energy savings. Considering that the electrical companies were given approval to hike up what they are charging for electricity to an extreme amount because they didn't upgrade their power plants and the gas supply network back 15 or so years ago. Another point I want to make with efficiency and boilers is that 90% of steam boiler installations are not done according to manufacturers' specs. Their specs are of minimums and most manufacturers state that the installer has to evaluate the existing system before they decide on boiler size and on pipe diameters for risers and headers. At a seminar recently, I asked the guest speaker, Dan Hollihan what would be the worst that could happen if steam boilers weren't installed according to manufacturers' specs, or hydronic boilers piped the "Old Ways", and |

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| he stated that the installer was causing the home owner to pay $50 to over $250 more in heating bills alone a month. So, my point is why are we getting so picky about furnace efficiencies and the tightness of ducts, and not giving a crap about boilers and installing them to efficient standards? The less energy we use the more worthwhile and more money goes back into the consumers' pocket in the long run. Did you know that in Germany, a heating appliance inspector goes in each building in his jurisdiction and if the heating appliance is 10 years old or older, he gives the owner a 30 day time period to replace it with the newest advanced appliance on the market, or he will go back after 30 days and rip out the old appliance and force the owner to install a new one. Now I don't agree with that extreme, but we should be going into the future with efficiency on our minds and mandatory training for inspectors to be well educated as well as the installers on proper ways to install heating equipment. Just when I thought I've seen it all, I find another installation where some idiot had a brainstorm of an idea. I'm to the point where I tell the potential customer that if they want me to work on their equipment they are going to have to pay me to re-install it. In the long run, it's the homeowner that gets it in the end, might as well make it hurt less in their benefit. |
| Using a tax deduction and utility rebate programs work very well in convincing people to move toward more efficient heating and air conditioning appliances. There are situations that would cause a lot of problems if 80% furnaces were not available, such as a customer I had this winter that needed a new furnace. This customer had a condominium with a 80% furnace in a second floor closet in the center of the unit that vented through the roof. We had 3 to 6 feet of snow on the roof with giant ice dams, 3 to 6 feet of snow on the ground on top of bushes next to the buildings. If an 80 % furnace was not available the cost to revent the new furnace would be astronomical in these circumstances. |
| In the northeast a great number of 80% furnaces are located in attics this would require added work, expense to provide freeze protection as per installation instructions |
| Here in Ma. snow levels are a problem. Cannot get enough height many times outside |
| It's a percentage increase over the cost of the furnace. Higher cost for higher efficiency makes the price higher. 20% of $500 is less than 20% of $900 |
| Natural draft with a chimney has fewer repairs and there for overall cost to run is less |
| I support the higher efficiency standards |
| Have the doe caused enough problems with new water heater standards now furnaces what next |
| Go with 92% eff min |
| A lot of existing houses in Massachusetts are not built in accommodation to direct vent appliances. I.e. window and door clearance along with basement height. |
| What about reliability, getting parts for condensing furnaces. |

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| I believe that if you take away 80 afue furnaces than the us department of energy should be responsible to educate (home owners) the average homeowner about the differences in the units. Like service (which is way more Money than servicing an 80 unit) life expectancy (again less than an 80). |
| 80% furnaces are a must in un-heated locations where condensate can freeze! |
| Forcing people to upgrade venting and adding additional cost to the homeowner isn't fair |
| High efficiency allows relocation to reduce total duct length thereby improving airflow. Usable space and efficiency. Unit to more centralized. When replacing both heat and hot water with condensing possible to reduce costs by sharing condensate pump, and re-using existing b-vent or chimney as pipe chase. When heat by Hit water, Combi-boiler even more savings. |
| Again, Government is trying to dictate to the common folk!!! |
| Trying to meet all new energy standards are only driving up all cost. The duck blower test ratings are a little extreme these systems are made in the field not a controlled environment. I think the extra cost and time it takes to do all the new standards does not weigh itself out. There are also a lot of situations that you will need a 80 % furnace on swap outs. |
| Due to rebates it has been easy to sell the high efficiency products. Most consumers are also pleased with the savings of energy when presented with the quote |
| In some older homes, high efficiency units cannot be installed. |
| Non condensing furnaces and boilers would eliminate all chimneys that are unlined and over 50 years old, a good idea in my opinion |
| Has anyone considered installations in condos where a condensing unit is not in option? |
| High efficiency boilers are subject to many callbacks due to the complexity of the product. |
| When selling a system most customers are looking at the bottom line. It is more inexpensive to replace an 80% with an 80%, but to install a 92% the cost doubles. Most customers do not want to pay more for the upgrade. |
| It is not fair to tell someone they have to spend there money ONLY the way you wan, lower efficiency equals less problems and longer life amounting to much more money savings, not to mention the other problems that occur when a stupid vent sensor fails in the middle of winter. How do you save money when you have to rebuild your house because the furnace safety shut it down and froze and split all the plumbing but then the sensor came back on and thawed out the frozen pipes and flooded everything!? HOW I ASK? |
| I believe in trying to reduce energy usage whenever possible or practical. For many homeowners the 92% furnace installation will be relatively easy. For many condo owners, it could be cost prohibitive. If the cost issue delays someone from |

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| replacing their furnace, it could have lethal consequences. I believe a blanket rule is impractical for existing homes. All new homes should be able to reach the 92% requirement with little effort. |
| In the northeast there are still many jobs that require 80% furnaces and sometimes can't vent 90% pluses |
| Why have 92% furnaces in 60% energy efficient houses?? |
| 80% eff. furnaces are still in need for condos and apartments where venting can be a challenge |
| Installations of 80% units are almost always in rental housing. In these cases, the landlord is usually responsible for the cost of the installation and the tenant for the fuel bill. The landlords do not want to pay extra for the higher efficiency unit and ask for the 80% unit. This seems unfair to the tenant who has no voice in the replacement planning process, even though the tenant is responsible for the higher operating cost going forward. It is important for all Americans to understand the need for conservation and for reducing our "carbon footprint". PHCC should be a leading voice in improving the efficiency of our heating systems. Instead of arguing to save an obsolete equipment category in order to save landlords money, PHCC should be advocating for programs that will help landlords to make the upgrades that will save energy and money in the long run. |
| Generally I would always recommend a move to 90% condensing furnaces or above if venting is possible there are some cases condominiums for example where there is no way to get external venting into the home there should be 80% solution for these small amount of application |
| There are some installations where it is impossible to install a 90% furnace, so I think there will always be a market for the 80% furnace |
| Converting 80% to 92% in an existing structure could require an unimaginable amount of added cost to a homeowner, if the new venting system doesn't have easy egress. Many of the existing vent systems are enclosed and aren't accessible for replacing the components. |
| This proposed regulation will have a particularly huge negative impact on multifamily high-rise buildings that do not currently have high efficiency furnaces. |
| Leave it alone. If mobile home furnaces are changed to condensing, it will cause problems we don't need and the return on investment will not be there. |
| 90% are more involved but worth the upgrade |
| We don't get enough money for the work we do! |
| Be smart about the realities of the retrofit business. Mandate ECM or variable speed motors in the 80% furnaces if you are really concerned about efficiency. Mandate condensing furnaces on new construction. |
| A 80% replacement furnace has no venting costs when replacing same for same. To replace a 80% with a 90+% the venting and condensate drain can run as much as $1000. |

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| Sometimes an 80% furnace replacement is the only option due to building restraints |
| I think that if they want to regulate for 90%+ furnaces they should only mandate for new construction.  The issues we run into is when we cannot find a place to vent a 90% furnace to mfg. specs do to the way the homes were designed and or finished. |
| Of the standard (80%) efficient furnaces we installed, at least half of them were in homes where there was 0% chance of installing a high efficient furnace according to manufacture's specifications and local codes. |
| 90+ gets higher mark up for water risk (attics) & roofer for new flue pipe and new insulated drain line (attics) |
| What about installations subject to freezing i.e. attic outdoor equipment closets |
| I believe 92% should be the minimum in new construction only. There are some existing homes that would be very expensive to run an additional vent system. |
| The price options in this survey were not wide enough to accurately demonstrate the price difference.  I see the major issue being that it's NOT possible to install 90+ in some homes. |
| High efficiency furnaces are not the answer for every situation we come across. The option for 80% should still be there. |
| Cost vs. benefit in existing homes sometimes is not worth the cost due to issues with venting and drains. |
| There are multiple situations, especially in larger urban cities, where a condensing furnace installation is literally impossible.  These include historic buildings, concrete buildings, and other buildings where distance to acceptable vent location violates manufacturer's install guidelines, or where the only way to vent a condensing furnace would be through other homeowner's condos.  There needs to be some sort of exception process to handle these situations. |
| There are a lot of homeowners out there with 80% furnaces that cannot afford to replace them let along afford to replace them with a 90+ unit and all the necessary venting associated with that.  Heating needs to be provided at a cost effective price for all homeowners in each tier of equipment. |
| Do not recall the last time we sold an 80% furnace |
| Finished basements with centralized equipment mechanical rooms, basements with low ceiling height and homes with no previsions for condensate removal cause a significant amount of additional work and cost to the homeowner when installing high efficiency furnaces |
| Along with the direct costs associated with upgrading from an 80% to a 90+% the potential additional costs (remodeling, relocating, etc.) should be factored in where a direct upgrade is not possible due to space or venting limitations. |
| Some installations, because we are a "basement" area of the country will be VERY difficult/costly because of finished basements. This can make accessing an |

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| exterior wall next to impossible without tearing out drywall and creating a new chase way for PVC. |
| It would be next to impossible to get entire apartment complexes with existing 80% furnaces to convert to new due to the cost of running pvc, drywall, etc. Same applies for low-income families and those with difficult installs (completely finished basement). This would lead to these customers trying to fix a very old, unsafe and inefficient furnace (perhaps only 40% efficient) instead of upgrading to at least a new safe 80% efficient model. |
| We don't want 80% furnaces to go away. There is a place for them in the HVAC trade. Let the market determine their continued availability. |

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| Southern Contractors |
| We work in San Diego CA with old wall heater and floor furnace style systems |
| Some existing homes, townhouse and condos may be very expensive to retrofit for a condensing furnace. There should be some exemption. |
| When an existing furnace of less than 90% is installed it is often impossible or at best extremely difficult to find a way to vent 90% furnaces without either going through finished space or adding substantial existing cost for finding a suitable venting location. |
| Venting and condensate drainage will be a huge issue with existing homes in my market. |
| In our area, the cost of condensing furnaces is extremely high and not worth the extra cost given the low heating hours and low cost of natural gas. It is a hardship on many families to pay the extra approx. $1,000 for the condensing furnace. |
| We will not install a condensing furnace in an unconditioned attic. |
| We just added the additional cost of the equipment and material |
| The codes need to continue to improve, I am probably an outlier here in that I think it is a positive for the entire industry to see the standards continue to improve over time |
| Venting will be an issue in existing homes. Condensate issues as well |
| Higher efficiency furnaces (90+) add to hers scores, if a Builder needs to meet a code minimum hers score in the Dallas market I have price advantage on some brands that makes it economical for the Builder to do better efficiency. |
| The SEER and EER ratings for 95% furnaces need to have a credit for efficiency. We are penalized for the EER rating due to the secondary heat exchanger. Need to have credit on the rating or some method to make the 95% furnace compatible with the 80% when installing high SEER AC's |
| Keep the 80% furnace. There are times when it just makes sense to install the 80% furnace. |
| 90% or more in efficiencies will cause more horrible issues. Most homeowners do |

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| not have the money to make the change to 90%. You have to think about the retro fit market. Getting a PVC flue from a basement or another central part of the home to the outside. From an attic stand point you have to look at making 2- new penetrations and having them leak proof. Tile, Metal? EXPENSE. Homeowners will try to fix a bad furnace rather than replace it due to the cost. |
| 90% AFUE furnaces in Texas do not have a reasonable pay back. The 90% furnaces we sold were due to the type of sealed attic construction requiring a sealed combustion furnace |
| The proposed standard will increase the end user's price on a typical furnace by 175%. In our area we do not use heat enough to warrant such an increase/no payback. |
| High AFUE furnace change outs require more cost since accessories and upgrades are required. Change vents, install to meet updated codes, etc. |
| We only use 80% efficient furnaces when there is no good way to vent a 90% furnace without having to open walls and ceilings. We do usually provide the homeowner the option, but seldom will the customer want to have his walls or ceiling cut into. |
| I strongly support the new efficiency standard of 92%, however we must solve the problems that occur when the condensing furnace is installed in an unconditioned, below freezing space |
| The cost difference in our market is that most of the time you must totally rework the vent in the existing homes to use a 92% furnace. |
| Even though I am in a climate where most contractors are installing 80% across the board, we have been installing 90%+ units in the higher end new constr. homes that we do because of the Icynene insulation. They are better. This is progress. I can see them allowing 80% on replacements, but the move to 90% on new construction should be across the board. I don't know what ACCA's position is on this, but please DO NOT IMPEDE PROGRESS! |
| I cannot see installing above 80% furnaces in my area of the country do to the fact that our heating days are so minimal. The cost of maintenance and repair would out pace the gas savings of the equipment. |
| High cost of installing condensing furnaces will cause homeowners to use unsafe old furnaces and could result in loss of life for some. |
| Make homes more efficient by improving the envelope |
| If the home is a 2 story or greater and it currently has a 80% furnace and we have to install a high efficient furnace it is very difficult to replace the venting. |
| Set the standard and hold it, need financial aid for senior and only approved company. To many company ask what they have to spend be for troubleshooting. |
| Forcing High Efficiency Gas Furnace Installation's In Phoenix AZ is not always in the clients best interest |
| We have had several installations where upgrading to a condensing furnace was |

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| not possible, not because of costs, but simply not being able to conform to Code with the venting requirements. |
| Many of our customers are lower income and cannot afford the additional price of a 92% furnace. Also, the venting of these furnaces is difficult due to the age of the homes and codes for the venting of these units. |
| A 92% AFUE is fine for new construction, but can be extremely difficult in retrofit due to venting regulations and clearances. |
| In retrofit installations there are different cost associated with replacing an existing mid efficiency furnace. We are not able to use the existing venting system. When discussing the cost to our clients of upgrading to a 92% AFUE furnace in our climate it is not a good fiscal decision. Our heating season is only two to three months. |
| I feel that the customer should be the one to decide what seer rating they want after all they are paying the bill. |
| Canadian standard, ULC S636 should be adopted in USA at least in part perhaps in northern climate zone |
| My comment is the same for minimum standards as they relate to furnaces and air conditioners or any other mechanical device… I would rather see an approach to multi-staging for energy efficiency as opposed to raising the SEER/AFUE/HSPF/COP! My opinion, this approach would accomplish the goals of comfort, efficiency, and cost. |
| I would not oppose the new standard for new construction project, but for replacement and existing, could run into a large cost that would have to be passed on to the customer. |
| People only have so much available cash before regulation put them into debt, to modify an existing home to fit with the current insulation requirements is tough enough as the space available just isn't there and now we have to modify the entire structure to fit condensing piping, how are they going to afford that, I can see new construction but this should be waved for existing buildings |
| 90% furnace are a lot harder to install, And could add a lot of other cost to the homeowners. Furnaces located in the middle of the house will cause drywall work and possible major construction. You will also run into draining issues |
| Condensing furnaces present a dilemma in cold climates; how do you prevent the condensate from freezing? They present a different one in replacement projects; how to drain the condensate? How to run the vents? While condensing furnaces are excellent products, they are not always the best choice. Better to offer incentives/tax credits rather than make the 80% units illegal. |
| We do not have natural gas available in our service area, so there would be no advantage to offering lower cost lower efficiency furnaces. Frankly, I would always try to move my customer to the higher efficiency furnace. I don't see any advantage to using 80% units, because in the mountains of north Georgia/western North Carolina, the area is heat dominant and the simple truth is that the |

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| difference in installation costs of higher efficiency is negligible once you learn the proper way to do the install. |
| Higher cost for condensate drain with neutralizers, pumps, heat tape, etc. Because existing mechanical rooms have no floor drains and our local codes require these systems to drain in to the sanitary waste not landscape areas. |
| In our area a high percentage of furnace are located in the attic I don't recommend a 90 % furnace Drain freezing can be a bad event and heat taped drains seem counterproductive |
| For licensed plumbers, it is a death sentence, for bootleggers, it's a dream come true. |
| Concentrate on ducts, infiltration, & attic insulation in existing homes. ACCA Standard 5 |
| Most of my clients with gravity flue units will have to incur the extra expenses involved with higher eff. units. Replacement costs in existing houses with finished basements will be very costly. |
| In Louisiana we only have a couple of weeks that heat is used, it is obscured cost wise to install anything but an 80% furnace except in a foam house |
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| We use the same percentage mark up for all residential furnace or air conditioning replacement jobs. IMHO under no scenario should a lower incremental margin be used for High Efficient furnaces or air conditioners. Nor should condensing furnaces be mandatory. I think the better benefit is to consider requiring a variable speed blower, which would increase efficiency of the furnace, and air conditioner if a condensing furnace is not a viable option. |
| I think that all new homes should be required to install furnace with 95% AFUE. I think in the replacement market we should have the option for the 80%, In some home especially multi-family residential, it would be very costly to install drains and different vents. |
| Some states prohibit tie-in of condensate to existing drain systems in homes and require the condensate from the furnaces to be externally discharged. This is a serious issue in winter months. If further push is made to convert to all condensing furnaces a review panel needs to help set standards for the handling of the condensate - either manufacturers need to provide some type of heat tape with the units for heating the drain lines or codes need to be addressed to allow draining into existing internal structure drains. |
| Really not a lot of need for 92% in San Antonio. Yes we have a few cold days but not many. It would be terrible to force this on consumers when they don't need it. |
| I love high efficiency furnaces |
| I'm a Fuel Oil Dist. mainly do oil equipment, the few gas furnaces installed usually go high efficiency, I can only remember 1 commercial boiler we did not, but that would allow a Oil Burner to be installed if there is interruption to gas service, or fuel pricing becomes favorable. |

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| No one in their right mind would pay the premium for a condensing furnace in South Texas. |
| Before they start forcing us to sell water leaks to customer maybe they can discuss drainage and decide on a imc code for draining the pieces of crap. We go round and round with local municipalities and homeowners. I hate installing high efficiency furnace. Even when installed to manufactures and imc specs, still have issues with backed up frozen drains. Not worth the money to install when my insurance has to eat 3-4 claims a year. If they continue, think I'm gonna drop heating off my business name and just do ac. Think ill save up to take winters off. |
| There will be homes, apartments and condos where installing new 90% venting will be all but impossible or cost thousands of dollars more for demo and repair of the building structure to install proper venting. |
| They need to look at the real cost of upgrading the vent systems in all types of homes not just single story single-family homes. |
| The increased efficiency for my area, Austin, Tx, will not pay for itself in the furnaces lifetime in natural gas savings. Also many installs will not be possible for AOR due to the mandatory change from typeB flue to pvc flue without remodel for multiple story homes. |
| 92 % are a waist of money in Texas |
| There would be a lot of other costs involved with a furnace installation should the minimum change to 92%. These costs would involve patching drywall, and painting |
| Our installs have a ACCA Manual J performed....for our area of Southern California the heating loss average is 30,000 BTU. We install 80% eff. 60,000 BTU... 2-stage furnace and only use 1st. stage for heating. We never have had a compliant as to comfort issues during winter months. 92% eff. furnace will be grossly over size to our customers due to our mild winter climate. Also the SEER and EER rating get worse since air has to pass thru two-heat exchangers vs. just one.....Even variable speed blower motors are effected by two heat exchangers. |
| We promote High AFUE & SEER numbers for all our clients and always provide a good-better-best solution. I do sympathize with my colleagues whom are working in below freezing conditions where condensing appliances require more challenges, but that also provides more potential sales opportunities. Evolve or die!! |
| 80% furnaces are best! |
| There are applications where it is impossible to replace an 80% furnace with a high efficiency type, especially in apartments and condo's. The added cost to the owner could be crazy if the application is not practical. I like the idea but it doesn't seem fair in all circumstances to the homeowner. |
| High efficiency is great too bad not everyone especially those on social security can afford it. Find bigger fish to fry thank hvac- |
| Not sure what you are wanting, but the $550 ONG (Oklahoma Natural Gas) Rebate |

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| offsets the additional labor and parts to install a 96.1% AFUE-97% AFUE Furnace over an 80% furnace. We had 1 or 2 scenarios where we weren't able to give the homeowner that deal because the water heater and furnace were tied into the same flue pipe going through 2 stories in a home. I rarely offer 80% furnaces. Sometimes a furnace closet will only accommodate a 14" wide furnace and we have to go back with an 80% furnace. |

| Comments on Markups/Margins |
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| Our markups are the same on all equipment. Our upfront cost on 90 % equipment is higher but the installs take about the same amount of work to install |
| We have to gradually phase in more margin, as the sticker shock is enough to make them ask can we just repair it? |
| I don't think this survey on 80% afue furnaces and DOE issues is the place to ask about mark ups or anything to do with money issues. That should be reserved for mix group participation. |
| We try and maintain a 45% to 50% margin on all jobs |
| We do a 2 step pricing on most jobs. We price based on margin and markup and then we do a cost-plus $2600/crew/day comparison. With cheaper equipment if you work on margin, you will never make enough and with ultra high-end equipment the margin % will price you ridiculously out of the market. |
| Markups are generally increased when there are many rebates offered by manufacturers, utilities, and the federal government |
| We rarely sell an 80% furnace, we use lower margins because this is our 'cost cutter' approach for people who just want the cheapest thing, we sell very few and its mostly due to application issues when we cannot reasonably install direct vent piping. Our mark-ups are percentages we put on top of equipment, parts, labor and overhead. Our overhead figures are factored into the job costs to be recovered. Because of this approach, we do not need to mark-up lower dollar equipment sales to try and recover the correct amount of overhead because it had already been factored into our costs per man day of labor. |
| We don't MARK UP, we use margins to calculate price. |
| While our mark-up remained the same, the total job selling price to the consumer has risen significantly with every new energy mandate in order to cover the rising cost of meeting these changes. |
| I have worked in the Phoenix market that achieved a 52%GM California 52% Florida 30 to 40% Iowa30 to 40% |

Note: Comments edited for spelling and some grammar.

GAMA-*An Association of Appliance & Equipment Manufacturers*
2107 Wilson Boulevard • Suite 600 • Arlington, VA 22201 • Phone: (703) 525-7060 • Fax: (703) 525-6790 • www.gamanet.org



September 15, 2004

**TO: FURNACE DIVISION**
**HYDRONICS INSTITUTE DIVISION**
(Delegates, Government Affairs, Technical Representatives)

GAMA Analysis of Lifecycle Costs in
DOE's Residential Furnace/Boiler Rulemaking

GAMA sent a letter to DOE in August 2002 claiming that LBNL's analytical method for determining the impacts of new standards on consumer lifecycle cost is flawed, and that their use of the Monte Carlo results to sort U.S. households into "winners" (net financial benefit) and "losers" (net financial costs) is misleading. DOE replied in the Advance Notice of Proposed Rule issued July 29, 2004 that "GAMA's comment seems to directly criticize the use of the Monte Carlo methodology in general, rather than the correctness of DOE's particular application of it." Of course, that is not correct. Use of the Monte Carlo method may be perfectly appropriate, but we disagreed with LBNL's use of the method and interpretation of the results. DOE also challenged us to produce our own contradictory analysis. We have done so below.

**LBNL's LCC "Uncertainty Analysis"**

There are 1,986 households in DOE's Residential Energy Consumption Survey (RECS) that have a non-weatherized gas furnace. The remainder of our discussion applies to that product although our methods and conclusions apply to the other products as well. In calculating lifecycle costs, DOE's team defined a score of variables to which they assigned probability distributions rather than single values. Ostensibly, selecting values from these distributions enhances the analysis by accounting for "uncertainty." According to DOE's Process Rule, DOE is committed to considering uncertainty in rulemaking analysis.

We contended in our 2002 letter that LBNL's method of selecting only 10,000 random sets of values from the 1,986 households had no analytical significance. In addition the method is:

- expensive
- time consuming, and
- difficult and expensive to examine and reproduce.

To test our contentions, we modified LBNL's lifecycle cost spreadsheet for non-weatherized furnaces. The modifications:

- Removed all probability distributions and replaced them with single values.

- Calculated a single LCC for each household in the RECS database.
- Weighted the results according to the RECS weighting.

In effect, we completely eliminated the "uncertainty" from the uncertainty analysis and calculated the LCC for each RECS household based on single-point "most-likely" input values as defined by DOE.

The results of our method and LBNL's method are nearly identical.

**Figure 1: LBNL LCC Results for Standard Level 33 (92% Condensing Furnace with Enhanced PSC Motor)**

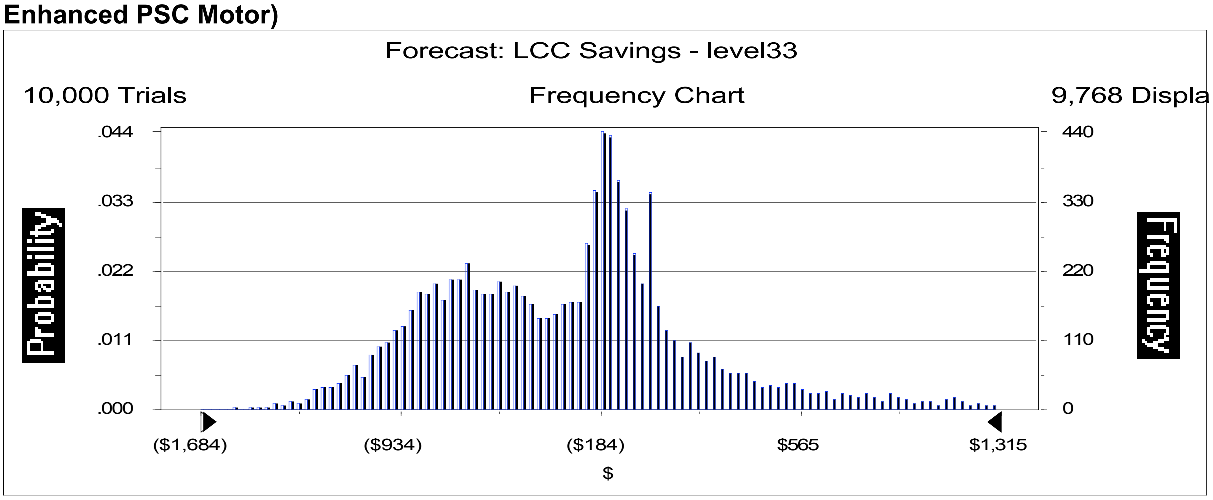
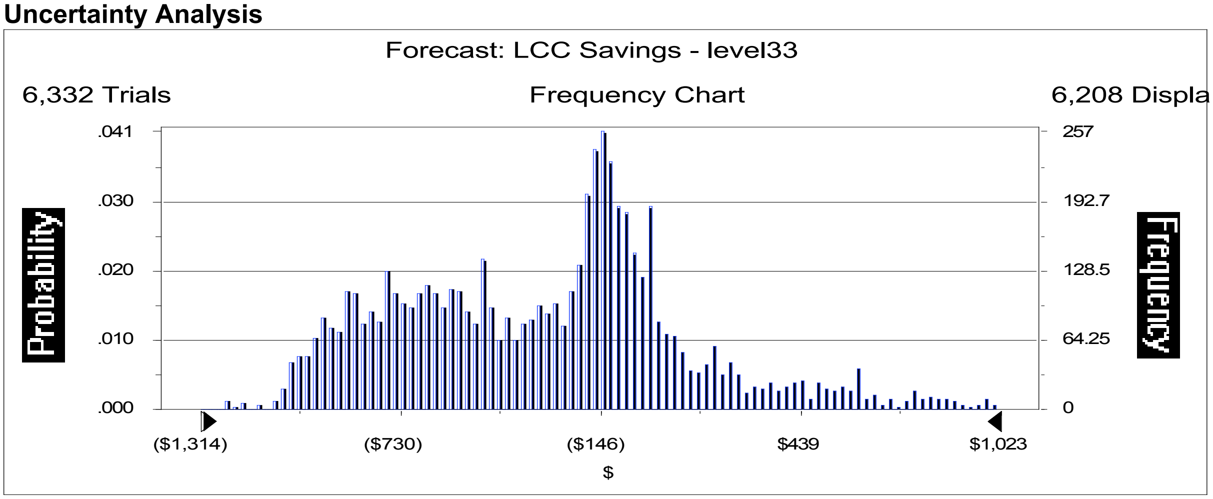



**Figure 2: GAMA LCC Results for Standard Level 33, Using Single Point Values with No Uncertainty Analysis**




This similarity demonstrates that the LNBL analysis is simply an imperfect estimate of the range of impacts across the U.S. and that their accounting of "winners and losers" is nothing more than an accounting of the number of RECS households whose mean LCC outcomes lie above and below the "$0" line.[1] They could have done this simply using the RECS database, without resorting to Monte Carlo analysis.

**Uncertainty at the Household Level**

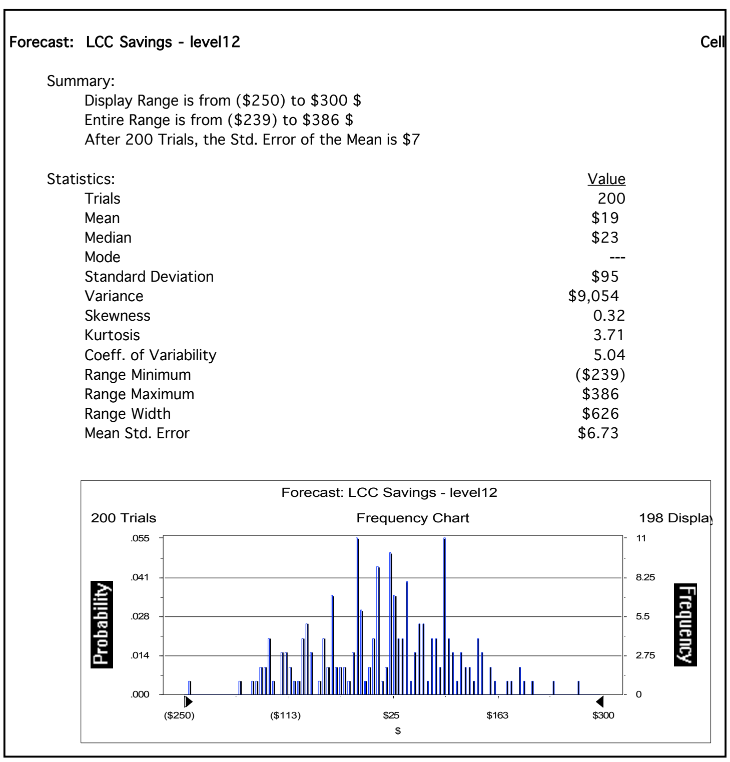
While we have shown that the Monte Carlo method adds no value when assessing national impacts, we also argued in our 2002 letter that Monte Carlo can be very useful in assessing the range of possible impacts at the household level.

To demonstrate this, we again modified the LBNL spreadsheet. This time we programmed the spreadsheet to:

- Step through each RECS household once.
- For each household, using the Monte Carlo method, select 200 random sets of values using the probability distributions used by DOE in the national analysis.
- Aggregate the results, using the weighting of each household as defined by RECS.

Figure 3 shows the results for a typical RECS household for a particular standard level.

**Figure 3: GAMA LCC Results for Standard Level 12 using Monte Carlo Sampling**




[1] The Monte Carlo method, with more iterations, applied in LBNL's manner does result in a more precise answer to the question "if I select a household at random from the U.S. population, what are the chances that household will achieve net LCC savings?" than could the discrete analysis we conducted can provide. However, the answer to that question is irrelevant to the rulemaking.

The roughness of the graph is due to the relatively small number of random samples (200). The number of samples is limited by computing power: running 200 simulations for each of the 1,986 RECS households took 15 hours—but is sufficient to illustrate our argument from our 2002 letter to DOE that there is wide variation in the possible results for single households that has gone unexplored in the DOE analysis.

Is the household above a "winner" or a "loser"? Although the mean outcome for this household is a $23 savings (and, thus, it is counted as a winner in Figure 2), the distribution of possible results ranges from a $239 loss to a $363 savings. With the median of $19, this household has nearly an equal chance of being either a winner *or* a loser.

Does DOE's method count this household as a winner or a loser? They count it as 1/2 a winner and 1/2 a loser. Two such households in the DOE analysis sum to be 1 winner and 1 loser. Their conclusion: 50% of households are winners and 50% are losers. The correct interpretation is:

> All households (both of them, in this case) have at least a 50% chance of being a winner.

We revealed in Figures 1 and 2 that DOE's method is equivalent to a simple accounting of mean outcomes of each RECS household. When outcomes are normally distributed with little skew, such as in this analysis, there is a 50% probability that the actual outcome will lie above the mean and a 50% probability that the outcome will lie below it. So, when DOE says "40% of households are winners, 20% of households are losers, and 40% have no impact" (a certain policy success), the underlying truth is that, contrary to what LBNL leads DOE and the public to believe, very few of those 40% winners are *clear* winners. Similarly, few of those 20% losers are clear losers.

Since LBNL does not calculate the range of possible results for each household, they cannot determine the certainty with which each household achieves net LCC savings and costs. But with our modified version of DOE's LCC spreadsheet, we can.

Consider the results for standard Level 12—an 81% 2-stage furnace with no Category III venting, which in LBNL's analysis looks like an attractive contender for the new standard level. Table 1 provides DOE's results.

**Table 1: LBNL LCC Results for 81% AFUE 2-stage Modulating Non-weatherized Furnace**

| Average Savings | Net Cost | No Impact* | Net Benefit |
|---|---|---|---|
| $88 | 19% | 26% | 55% |

This understandably leaves policymakers with the (false) impression that 55% of U.S. households will certainly benefit from a standard set at Level 12. In fact, those winners and losers are not so clear-cut. As revealed by our analysis in Table 2, each has only a certain probability of being a winner or a loser.

**Table 2: GAMA LCC Results for 81% AFUE 2-stage Modulating Non-weatherized Furnace Considering Uncertainty**

| Probability of Achieving LCC Savings | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **100%** | **90%** | **80%** | **70%** | **60%** | **50%** | **40%** | **30%** | **20%** | **10%** | **0%** |
| 1% | 12% | 21% | 29% | 38% | 46% | 55% | 64% | 71% | 74% | 74% |

In other words, the fraction of households that have a 100% chance of saving money as a result of a minimum standard of 81% AFUE is only 1%.

Given this revelation, policymakers may choose to accept a less than certain, but still moderately certain outcome. In that case, demanding an 80% likelihood of achieving net savings yields only 21% of all households.[2] That is a far cry from the 55% percent that the LBNL analysis would imply. In fact, looking at our table, you can achieve 55% winners only if you drop your expectations all the way down to odds of 40% or better of saving money. Interestingly, 17% of households fall between 60% and 40% probability of winner—scarcely different from a coin toss—and 26% of households have 0% chance of achieving any savings at all.

Similarly, the number of households incurring net LCC losses depends on the probability with which they incur those losses.

**Table 3: GAMA LCC Results for 81% AFUE 2-stage Modulating Non-weatherized Furnace Considering Uncertainty**

| Probability of Incurring LCC Costs | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **100%** | **90%** | **80%** | **70%** | **60%** | **50%** | **40%** | **30%** | **20%** | **10%** | **0%** |
| 0% | 0% | 3% | 10% | 19% | 28% | 36% | 45% | 54% | 63% | 73% |

In this case, there are no households that will, with 100% certainty, incur net LCC losses. If policymakers want to avoid losers and prefer winners, they should require a high degree of probability of winning (e.g. 80%) and a low probability of losing (e.g. 20%). Fifty-four percent (54%) of households have at least a 20% chance of losing money at this standard level.

This is the type of uncertainty analysis that the Process Rule requires but which has been beyond LBNL's and DOE's inclination and ability to conduct. Keep in mind that we urged DOE in our 2002 letter to evaluate results in this manner, claiming that DOE's method of analysis, interpretation, and presentation gave a misleading and inflated impression of the benefits of the standards. DOE and LBNL, to our knowledge, have

[2] The other 79% are not necessarily "losers"—the analysis contains a number of households that achieve net savings of $0 because they voluntarily purchased a product of similar or higher efficiency.

refused to explore this, even though it took us less than three days to do so once we had the LCC spreadsheet available to us.

The full accounting of LCC winners based on their probability of winning is attached as Annex A. Other results can be generated in just a few minutes:

- The accounting of households with payback periods less than, say 7 years, based on the probability of achieving that payback.
- The average amount of net LCC savings or costs for households in each percentile of winners and losers.

All provide a rich insight into the true impacts of more stringent standards on U.S. households, and the uncertainty of those impacts.

The results can be generated for product classes other than non-weatherized furnaces, albeit after several hours of computing time, very likely with similar results.

Mark Kendall
Vice President, Technical Affairs

# ANNEX A

*Fractions of U.S. Households Achieving Net LCC Savings*

| | Probability of Achieving Net LCC Savings | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Standard Level** | **100%** | **>=90%** | **>=80%** | **>=70%** | **>=60%** | **>=50%** | **>=40%** | **>=30%** | **>=20%** | **>=10%** | **>=0%** |
| 78% AFUE - NAECA Min. | 100% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| 80% AFUE - Incr. HX Area | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| 80% AFUE - PSC+ | 19% | 39% | 46% | 51% | 55% | 58% | 60% | 62% | 64% | 66% | 70% |
| 80% AFUE - ECM | 0% | 1% | 1% | 3% | 5% | 9% | 15% | 22% | 29% | 38% | 57% |
| 80% AFUE - BC/ECM+ | 1% | 4% | 7% | 11% | 15% | 21% | 26% | 33% | 39% | 45% | 60% |
| 80% 2-stage Mod | 4% | 16% | 23% | 29% | 35% | 40% | 46% | 51% | 56% | 62% | 69% |
| 80% 2-stage Mod ECM | 1% | 3% | 7% | 11% | 18% | 24% | 31% | 37% | 45% | 52% | 65% |
| 80% 2-stage Mod BC/ECM+ | 1% | 5% | 9% | 15% | 21% | 27% | 34% | 40% | 46% | 52% | 64% |
| 81% AFUE - Incr. HX Area | 0% | 1% | 6% | 16% | 29% | 44% | 60% | 72% | 74% | 74% | 74% |
| 81% AFUE - PSC+ | 0% | 1% | 9% | 21% | 35% | 50% | 65% | 73% | 74% | 74% | 74% |
| 81% AFUE - ECM | 0% | 1% | 2% | 6% | 11% | 17% | 25% | 35% | 47% | 57% | 74% |
| 81% AFUE - BC/ECM+ | 0% | 2% | 7% | 12% | 19% | 27% | 34% | 43% | 51% | 59% | 74% |
| 81% 2-stage Mod | 1% | 12% | 21% | 29% | 38% | 46% | 55% | 64% | 71% | 74% | 74% |
| 81% 2-stage Mod ECM | 0% | 3% | 8% | 13% | 20% | 28% | 36% | 45% | 52% | 60% | 73% |
| 81% 2-stage Mod BC/ECM+ | 0% | 3% | 9% | 15% | 23% | 30% | 38% | 46% | 53% | 60% | 72% |
| 82% AFUE - Incr. HX Area | 0% | 0% | 0% | 0% | 0% | 2% | 3% | 5% | 8% | 13% | 54% |
| 82% AFUE - PSC+ | 0% | 0% | 0% | 0% | 1% | 2% | 4% | 6% | 9% | 15% | 55% |
| 82% AFUE - ECM | 0% | 0% | 0% | 0% | 1% | 2% | 3% | 5% | 8% | 12% | 33% |
| 82% AFUE - BC/ECM+ | 0% | 0% | 0% | 1% | 2% | 4% | 7% | 10% | 14% | 20% | 41% |
| 82% 2-stage Mod | 0% | 0% | 1% | 2% | 4% | 7% | 10% | 13% | 17% | 24% | 50% |
| 82% 2-stage Mod ECM | 0% | 0% | 1% | 2% | 3% | 5% | 8% | 11% | 15% | 22% | 42% |
| 82% 2-stage Mod BC/ECM+ | 0% | 0% | 1% | 2% | 4% | 6% | 10% | 14% | 18% | 25% | 45% |
| 83% AFUE - Incr. HX Area | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 1% | 1% | 3% | 12% |
| 90% AFUE | 1% | 5% | 8% | 11% | 15% | 18% | 22% | 25% | 30% | 35% | 49% |
| 90% AFUE - PSC+ | 3% | 11% | 16% | 20% | 25% | 29% | 33% | 37% | 41% | 47% | 60% |
| 90% AFUE - ECM | 1% | 3% | 7% | 10% | 13% | 17% | 21% | 26% | 33% | 40% | 58% |
| 90% AFUE - BC/ECM+ | 1% | 4% | 8% | 11% | 16% | 21% | 27% | 31% | 37% | 44% | 61% |
| 91% 2-stage Mod ECM | 2% | 6% | 11% | 16% | 22% | 27% | 32% | 37% | 42% | 48% | 63% |
| 91% 2-stage BC/ECM+ | 1% | 6% | 12% | 16% | 22% | 28% | 33% | 38% | 43% | 50% | 65% |
| 91% Step Mod ECM | 0% | 2% | 5% | 8% | 12% | 16% | 20% | 26% | 32% | 38% | 57% |
| 91% Step Mod BC/ECM+ | 0% | 2% | 5% | 8% | 12% | 16% | 21% | 26% | 32% | 40% | 58% |
| 92%AFUE - Incr. HX Area | 1% | 6% | 11% | 15% | 20% | 25% | 31% | 35% | 41% | 46% | 61% |
| 92% AFUE - PSC+ | 3% | 10% | 17% | 24% | 30% | 37% | 42% | 47% | 53% | 58% | 74% |
| 92% AFUE - ECM | 1% | 3% | 7% | 11% | 15% | 20% | 26% | 32% | 39% | 48% | 70% |
| 92% AFUE - BC/ECM+ | 1% | 4% | 9% | 13% | 18% | 24% | 31% | 38% | 45% | 53% | 73% |
| 93% 2-stage Mod ECM | 2% | 7% | 13% | 19% | 26% | 33% | 40% | 47% | 53% | 59% | 76% |
| 93% 2-stage Mod BC/ECM+ | 2% | 7% | 13% | 19% | 26% | 34% | 41% | 48% | 54% | 61% | 77% |
| 93% Step Mod ECM | 1% | 3% | 6% | 10% | 14% | 18% | 25% | 31% | 38% | 48% | 69% |
| 93% Step Mod BC/ECM+ | 0% | 3% | 6% | 10% | 14% | 18% | 25% | 31% | 38% | 48% | 70% |
| 96% AFUE Step Mod ECM | 0% | 1% | 2% | 4% | 7% | 8% | 11% | 13% | 16% | 22% | 44% |
| 96% AFUE Step Mod BC/ECM+ | 0% | 1% | 2% | 3% | 6% | 9% | 11% | 13% | 17% | 22% | 45% |

*Fractions of U.S. Households Incurring Net LCC Cost*

| | Probability of Incurring Net LCC Cost | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **100%** | **>=90%** | **>=80%** | **>=70%** | **>=60%** | **>=50%** | **>=40%** | **>=30%** | **>=20%** | **>=10%** | **>=0%** |
| 80% AFUE - Incr. HX Area | 0% | 0% | 0% | 0% | 0% | 1% | 1% | 1% | 1% | 1% | 1% |
| 80% AFUE - PSC+ | 4% | 7% | 9% | 12% | 13% | 16% | 18% | 23% | 28% | 35% | 54% |
| 80% AFUE - ECM | 16% | 36% | 45% | 52% | 59% | 65% | 69% | 71% | 72% | 73% | 74% |
| 80% AFUE - BC/ECM+ | 14% | 28% | 35% | 41% | 47% | 52% | 59% | 63% | 67% | 70% | 73% |
| 80% 2-stage Mod | 4% | 12% | 17% | 23% | 28% | 34% | 39% | 45% | 51% | 58% | 70% |
| 80% 2-stage Mod ECM | 9% | 22% | 28% | 36% | 42% | 50% | 56% | 63% | 67% | 71% | 73% |
| 80% 2-stage Mod BC/ECM+ | 9% | 22% | 28% | 34% | 40% | 46% | 53% | 59% | 64% | 69% | 73% |
| 81% AFUE - Incr. HX Area | 0% | 0% | 0% | 1% | 14% | 30% | 45% | 58% | 67% | 73% | 74% |
| 81% AFUE - PSC+ | 0% | 0% | 0% | 1% | 10% | 24% | 40% | 54% | 66% | 73% | 74% |
| 81% AFUE - ECM | 0% | 18% | 28% | 40% | 49% | 58% | 64% | 69% | 72% | 74% | 74% |
| 81% AFUE - BC/ECM+ | 1% | 15% | 24% | 32% | 40% | 48% | 56% | 62% | 68% | 72% | 74% |
| 81% 2-stage Mod | 0% | 0% | 3% | 10% | 19% | 28% | 36% | 45% | 54% | 63% | 73% |
| 81% 2-stage Mod ECM | 1% | 14% | 22% | 30% | 39% | 47% | 55% | 61% | 67% | 72% | 74% |
| 81% 2-stage Mod BC/ECM+ | 2% | 15% | 22% | 28% | 36% | 45% | 52% | 59% | 65% | 71% | 74% |
| 82% AFUE - Incr. HX Area | 20% | 61% | 67% | 69% | 71% | 73% | 74% | 74% | 74% | 74% | 74% |
| 82% AFUE - PSC+ | 19% | 60% | 65% | 68% | 71% | 72% | 74% | 74% | 74% | 74% | 74% |
| 82% AFUE - ECM | 41% | 62% | 66% | 69% | 71% | 73% | 74% | 74% | 74% | 74% | 74% |
| 82% AFUE - BC/ECM+ | 34% | 54% | 60% | 64% | 68% | 70% | 72% | 73% | 74% | 74% | 74% |
| 82% 2-stage Mod | 25% | 51% | 57% | 61% | 64% | 68% | 71% | 73% | 74% | 74% | 74% |
| 82% 2-stage Mod ECM | 33% | 52% | 59% | 63% | 66% | 69% | 71% | 73% | 74% | 74% | 74% |
| 82% 2-stage Mod BC/ECM+ | 30% | 49% | 56% | 61% | 65% | 68% | 71% | 72% | 74% | 74% | 74% |
| 83% AFUE - Incr. HX Area | 63% | 72% | 73% | 74% | 74% | 74% | 74% | 74% | 74% | 74% | 74% |
| 90% AFUE | 26% | 40% | 45% | 49% | 53% | 56% | 59% | 63% | 66% | 70% | 73% |
| 90% AFUE - PSC+ | 25% | 39% | 45% | 49% | 53% | 57% | 61% | 66% | 70% | 75% | 83% |
| 90% AFUE - ECM | 28% | 46% | 53% | 60% | 65% | 69% | 73% | 76% | 79% | 83% | 85% |
| 90% AFUE - BC/ECM+ | 25% | 42% | 49% | 55% | 59% | 65% | 70% | 75% | 78% | 82% | 85% |
| 91% 2-stage Mod ECM | 22% | 38% | 43% | 49% | 54% | 59% | 64% | 70% | 74% | 79% | 84% |
| 91% 2-stage BC/ECM+ | 21% | 36% | 42% | 47% | 53% | 58% | 64% | 70% | 74% | 80% | 85% |
| 91% Step Mod ECM | 29% | 47% | 54% | 60% | 66% | 70% | 74% | 77% | 81% | 83% | 85% |
| 91% Step Mod BC/ECM+ | 28% | 46% | 54% | 60% | 65% | 70% | 74% | 78% | 81% | 84% | 85% |
| 92%AFUE - Incr. HX Area | 25% | 40% | 45% | 51% | 55% | 60% | 65% | 71% | 75% | 80% | 85% |
| 92% AFUE - PSC+ | 25% | 40% | 46% | 51% | 57% | 62% | 68% | 75% | 81% | 88% | 96% |
| 92% AFUE - ECM | 29% | 51% | 59% | 66% | 73% | 79% | 83% | 88% | 92% | 96% | 98% |
| 92% AFUE - BC/ECM+ | 26% | 46% | 54% | 61% | 68% | 74% | 81% | 86% | 90% | 94% | 98% |
| 93% 2-stage Mod ECM | 23% | 39% | 46% | 52% | 58% | 65% | 72% | 80% | 86% | 92% | 97% |
| 93% 2-stage Mod BC/ECM+ | 21% | 38% | 45% | 51% | 58% | 65% | 73% | 80% | 86% | 92% | 97% |
| 93% Step Mod ECM | 29% | 51% | 60% | 68% | 74% | 80% | 85% | 89% | 93% | 96% | 98% |
| 93% Step Mod BC/ECM+ | 28% | 51% | 60% | 67% | 74% | 80% | 85% | 89% | 93% | 96% | 98% |
| 96% AFUE Step Mod ECM | 55% | 77% | 82% | 85% | 88% | 90% | 92% | 95% | 97% | 98% | 98% |
| 96% AFUE Step Mod BC/ECM+ | 55% | 78% | 83% | 87% | 89% | 91% | 94% | 97% | 98% | 99% | 100% |

# ANNEX A

*Fractions of U.S. Households with no LCC Impact*

| | Probability of Achieving No Impact | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Standard Level** | **100%** | **>=90%** | **>=80%** | **>=70%** | **>=60%** | **>=50%** | **>=40%** | **>=30%** | **>=20%** | **>=10%** | **>=0%** |
| 80% AFUE - Incr. HX Area | 99% | 99% | 99% | 99% | 99% | 99% | 99% | 99% | 99% | 99% | 99% |
| 80% AFUE - PSC+ | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 80% AFUE - ECM | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 80% AFUE - BC/ECM+ | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 80% 2-stage Mod | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 80% 2-stage Mod ECM | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 80% 2-stage Mod BC/ECM+ | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 81% AFUE - Incr. HX Area | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 81% AFUE - PSC+ | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 81% AFUE - ECM | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 81% AFUE - BC/ECM+ | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 81% 2-stage Mod | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 81% 2-stage Mod ECM | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 81% 2-stage Mod BC/ECM+ | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 82% AFUE - Incr. HX Area | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 82% AFUE - PSC+ | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 82% AFUE - ECM | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 82% AFUE - BC/ECM+ | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 82% 2-stage Mod | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 82% 2-stage Mod ECM | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 82% 2-stage Mod BC/ECM+ | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 83% AFUE - Incr. HX Area | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 90% AFUE | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% | 26% |
| 90% AFUE - PSC+ | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% |
| 90% AFUE - ECM | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% |
| 90% AFUE - BC/ECM+ | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% |
| 91% 2-stage Mod ECM | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% |
| 91% 2-stage BC/ECM+ | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% |
| 91% Step Mod ECM | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% |
| 91% Step Mod BC/ECM+ | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% |
| 92%AFUE - Incr. HX Area | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% | 14% |
| 92% AFUE - PSC+ | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| 92% AFUE - ECM | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| 92% AFUE - BC/ECM+ | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| 93% 2-stage Mod ECM | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| 93% 2-stage Mod BC/ECM+ | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| 93% Step Mod ECM | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| 93% Step Mod BC/ECM+ | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| 96% AFUE Step Mod ECM | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% | 1% |
| 96% AFUE Step Mod BC/ECM+ | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |