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Cost-Effectiveness Analysis of Alternative Hydronic Heater New Source Performance Standards

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This report was prepared by NERA Economic Consulting ("NERA") on behalf of the Hearth, Patio and Barbecue Association ("HPBA"). The analyses described in this report use information collected and developed by HPBA experts as well as information from public sources. The NERA project team worked with the HPBA experts to review the information, but NERA makes no representation as to its accuracy.

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Executive Summary

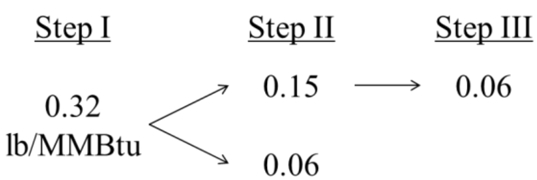
This study evaluates the cost-effectiveness of increasingly stringent particulate matter emissions standards for hydronic heaters. Using detailed information on compliance costs and economic assessments consistent with EPA guidelines for economic analysis, we have developed estimates of the incremental cost per ton for three “steps” of alternative new source performance standards (NSPS).[1]

1. Step I standard of 0.32 lb/MMBtu (the current Voluntary Program standard);

2. Step II standards of 0.15 lb/MMBtu and 0.06 lb/MMBtu; and

3. Step III standard of 0.06 lb/MMBtu (from a Step II standard of 0.15 lb/MMBtu).

Figure E-1. Standards Evaluated in NERA Analysis

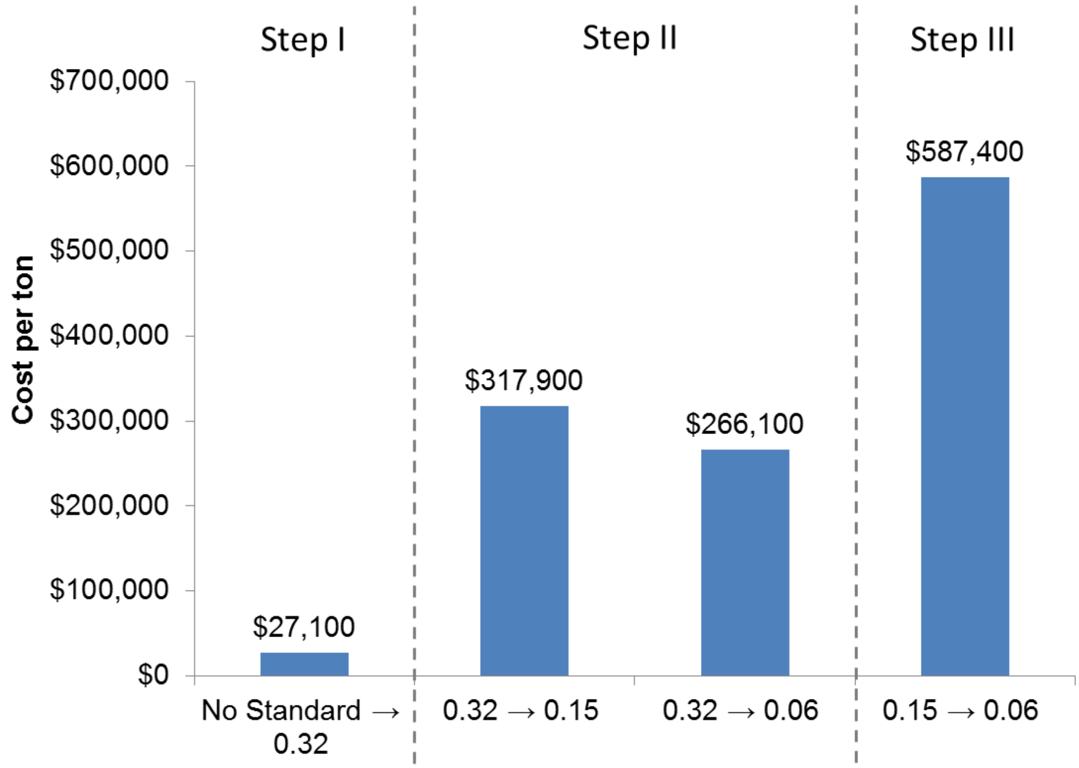


We have developed estimates of the annual costs and annual emission reduction benefits of these three alternative standards for an illustrative production year using detailed engineering cost and other information for the three standards developed by an industry expert, as explained in appendices to this report, as well as recent information provided by the U.S. Environmental Protection Agency (EPA) in its recent proposed rulemaking.

Figure E-2 summarizes the results of our analysis in terms of cost per ton of annual emission reductions. The Step II standards (reflecting a tightening from 0.32 lb/MMBtu to 0.15 or 0.06 lb/MMBtu) would cost about ten times as much per ton of annual emission reductions as the Step I standard (reflecting a transition from no standard currently to 0.32 lb/MMBtu), and the Step III standard (reflecting a tightening from 0.15 lb/MMBtu to 0.06 lb/MMBtu) would cost nearly twice as much per ton as the Step II standard. The large costs for the Step II and Step III standards would cause large price increases for hydronic heaters and severe contractions in hydronic heater sales quantities.

[1] EPA also has proposed to lower the “cap” (highest permitted emission rate for any test run) from 18 g/h to 7.5 g/h, thereby increasing the stringency of the standard. This component of EPA’s Step I proposal was not considered in the cost estimates relied upon here, which were prepared before the proposal was published in the Federal Register. We would not expect this component to have a significant effect on our results. Note that there are no caps in EPA’s Step II or Step III proposals.

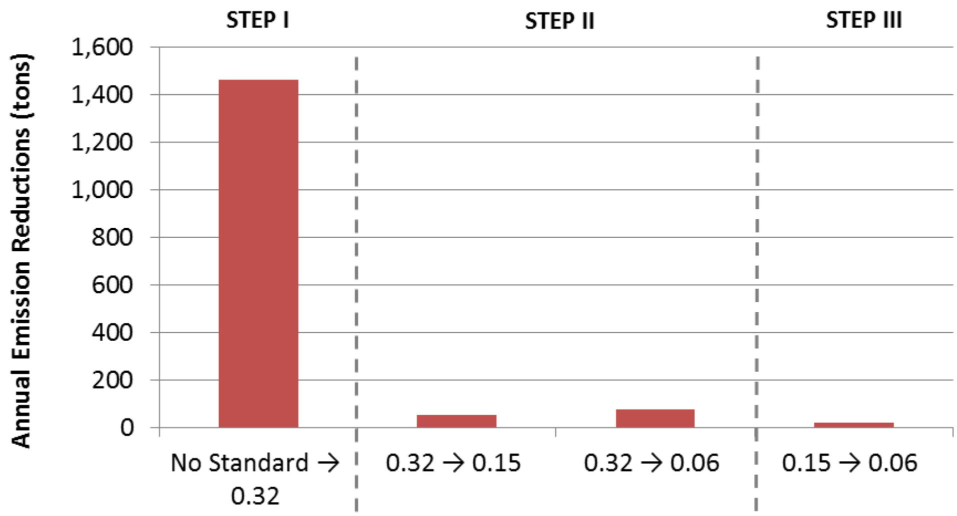
Figure E-2. Cost-Effectiveness of Alternative Hydronic Heater NSPS



Source: NERA calculations as explained in text

Figure E-3 illustrates the potential annual emission reductions from hydronic heaters. We estimate that the Step I standard would reduce annual emissions from new hydronic heaters by about 1,500 tons. Tightening the standard to 0.15 lb/MMBtu in Step II would reduce annual heater emissions by only 55 more tons, and (as shown in Figure E-2) it would cost over ten times as much per ton as the Step I standard. Tightening the standard further to 0.06 lb/MMBtu in Step II or Step III would reduce annual emissions by only about 20 more tons (beyond a 0.15 lb/MMBtu standard). Both Step II and Step III standards would lead to large price increases that would cause severe contractions in hydronic heater sales and would delay scrappage of older hydronic heaters with high emissions.

Figure E-3. Annual Emission Reductions from Alternative NSPS



Source: NERA calculations as explained in text
Note: Emission reductions are from new heaters only in a single calendar year.

As noted, these results are based on cost and related information developed by an industry expert and peer reviewed by a panel of industry experts. We use sensitivity analysis to assess the implications of changing uncertain estimates used to calculate costs and annual emission reductions, including the underlying compliance cost information and the price elasticity of demand. Although the specific estimates of dollars per ton change under the sensitivity cases, none of the sensitivity cases modifies our basic conclusions, i.e., that the Step II and Step III standards would be much less cost-effective than the Step I standard and lead to large reductions in hydronic heater sales and reductions in the scrappage of older heaters with high emissions.

I. Introduction

This report evaluates the cost-effectiveness of alternative particulate matter (PM) emissions standards for new hydronic heaters. Consistent with economic principles and guidance provided by the U.S. Environmental Protection Agency (EPA) and the Office of Management and Budget (OMB), we focus on the incremental cost-effectiveness of increasingly stringent emission standards. That is, we compare the added annual costs and annual emission reduction gains of three sequential steps of increasingly stringent standards.

A. Background on Hydronic Heater Emission Standards and Study Objectives

EPA introduced a voluntary emissions program for hydronic heaters in 2007. In the current phase of the Voluntary Program, hydronic heater models are "qualified" if their PM emissions are 0.32 pounds per million Btu (lb/MMBtu) of wood fuel input or lower. This represents an average emissions improvement of 90 percent over "conventional" hydronic heaters (EPA 2014a). Several states have adopted a standard of 0.32 lb/MMBtu for hydronic heaters sold in the state. In February 2014, EPA proposed alternatives for national new source performance standards (NSPS) for several types of wood heaters, including hydronic heaters (EPA 2014b).

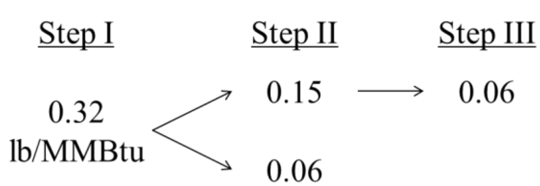
We consider three potential "steps" of increasingly stringent NSPS for hydronic heaters:[2]

1. Step I standard of 0.32 lb/MMBtu;

2. Step II standards of 0.15 lb/MMBtu and 0.06 lb/MMBtu; and

3. Step III standard of 0.06 lb/MMBtu (from a Step II standard of 0.15 lb/MMBtu).

Figure 1. Standards Evaluated in NERA Analysis



Note that Step I reflects a transition from the current status of no emission standard for hydronic heaters to the introduction of a 0.32 lb/MMBtu standard. Thus, analysis for Step I is based on comparisons between conventional hydronic heaters (which are not required to comply with an

[2] EPA also has proposed to lower the "cap" (highest permitted PM emission rate for any test run) from 18 grams per hour (g/h) to 7.5 g/h, thereby increasing the stringency of the standard. This component of EPA's Step I proposal was not considered in the cost estimates relied upon here, which were prepared before the proposal was published in the Federal Register. We would not expect this component to have a significant effect on our results. Note that there are no caps in EPA's Step II or Step III proposals.

emission standard) and “qualified” hydronic heaters under the current Voluntary Program with emissions of 0.32 lb/MMBtu or less.

The objective of this report is to evaluate these potential hydronic heater standards in terms of their incremental cost-effectiveness as measured by dollars per ton of particulate matter emissions reduced.

Note that the alternative standards would directly affect only new hydronic heaters. But the NSPS would have an indirect effect on emissions from existing hydronic heaters because of market effects. In particular, as discussed below, price increases for new hydronic heaters due to compliance with more stringent NSPS affect the scrappage rates of existing hydronic heaters and thus the overall annual emissions of new and existing hydronic heaters.

B. Overview of Methodology

There are four major elements in our cost-effectiveness methodology.

1. Estimate the annualized compliance costs per hydronic heater (unit cost) under different NSPS;

2. Determine the effects on new hydronic heater prices and sales of different NSPS;

3. Determine the effects on annual emissions (emission reductions) of different NSPS; and

4. Determine the incremental cost-effectiveness of different NSPS.

The following are brief summaries of these elements of our calculations.

1. Unit Compliance Costs

We first estimate the annualized compliance costs per hydronic heater (unit cost) associated with each alternative NSPS. Compliance costs represent the cost of modifying existing hydronic heater models and individual units to meet a specific emissions standard. We use detailed estimates of compliance cost components – including capital costs per model, other fixed costs per model, and variable costs per unit – developed by an industry expert and peer reviewed by a group of expert reviewers. Appendix A provides the detailed compliance cost estimates and summarizes the methodology used to develop and validate the estimates. This information represents the best source of data on the likely compliance costs to meet standards of different stringencies. We converted the costs per model to costs per heater based on assumptions on the annualization period and the average units sold per model.

It is, however, important to note some caveats regarding the data in Appendix A. As noted there, compliance costs may be understated due to potential changes in EPA certification testing methods and the way compliance with the standard is determined. The compliance cost estimates were developed based on current certification requirements, but EPA (2014b, pp. 6343-6347) has proposed a more stringent compliance algorithm which we understand would increase NSPS compliance costs.

2. Hydronic Heater Price and Sales Effects

The social costs of alternative NSPS depend in part on how the market for new hydronic heaters would respond to the added costs related to the emissions standards. We first determine baseline hydronic heater prices and sales using current market prices (described in Appendix B) and historical sales data. We then use estimates of per unit compliance costs to estimate the increase in hydronic heater prices under alternative NSPS.

These price changes in turn affect hydronic heater sales, an effect measured by the price elasticity of demand (i.e., the percentage decrease in sales due to a one percent increase in price). We use an estimate of the price elasticity of -1.0, based upon econometric analysis of historical hydronic heater sales trends in states that have established emission standards for hydronic heaters, as described in Appendix C. The price increase and the price elasticity estimate are used to estimate the change in new hydronic heater sales due to a given NSPS.

The reduction in hydronic heater sales affects the social costs in two ways. First, compliance costs are reduced (relative to unchanged sales quantity) because the "lost sales" do not incur compliance costs. But secondly, consumers who choose not to purchase a hydronic heater because of the higher prices experience a loss or cost, referred to in economic analyses as a "consumer surplus deadweight loss." We take into account this loss as a part of the social cost of alternative NSPS.

3. Emission Reductions

We develop estimates of the changes in annual emissions due to the various NSPS. The estimates are based upon changes in annual emissions relative to a baseline assuming the current number of hydronic heater sales and their emissions. We identify three sources of changes in annual emissions.

1. *Demand effect.* The reduction in new hydronic heater sales would lead to a reduction in annual emissions from new hydronic heaters relative to what they would be in the baseline. This effect leads to emission reduction benefits.

2. *Compliance effect.* The reduced emissions for new hydronic heaters also would lead to a reduction in annual emissions from new hydronic heaters relative to what they would be in the baseline. This effect leads to emission reduction benefits.

3. *Scrappage effect*. Some of the reduction in new hydronic heater sales as a result of higher prices would be accompanied by an increase in the number of existing hydronic heaters (for the reduced heater sales that would have replaced existing heaters). The scrappage effect would lead to greater annual emissions from the existing hydronic heaters than in the baseline. This effect leads to an offset for the annual emission reduction benefits.

Our estimates of emission reduction benefits for a given NSPS take into account all three of these effects.

4. Incremental Cost-Effectiveness Calculations

We calculate cost-effectiveness as the social cost per ton of emission reductions ($/ton) for each of the alternative emission standards. The cost-effectiveness estimates are based upon the annualized costs and annual emission reductions for an illustrative production year.

EPA guidelines for developing economic analyses note the importance of determining the incremental effects of increasingly stringent regulatory alternatives. The incremental annual cost-effectiveness estimates for Step I (0.32 lb/MMBtu) are relative to a baseline with no national NSPS for hydronic heaters, the estimates for Step II (0.15 lb/MMBtu and 0.06 lb/MMBtu) are relative to the Step I standard (0.32 lb/MMBtu), and the estimates for Step III (0.06 lb/MMBtu) are relative to the Step II standard of 0.15 lb/MMBtu.

These incremental annual cost-effectiveness values provide an indication of the additional "bang for the buck" obtained as the NSPS is made more stringent over time. We can use this information along with information on annual emission reductions achievable under the various standards to develop a "marginal cost curve" that shows the additional annual emission reductions achievable and the cost per ton of these additional tons as the potential standard is made more stringent.

C. Caveats

Empirical estimates in this study are based upon the best available data on costs and emissions. Please note the following technical caveats.

1. Costs may be understated because, as discussed below, they are based on the current EPA algorithm for testing hydronic heater emissions under the Voluntary Program and do not reflect EPA's proposed changes to certification testing methods (EPA 2014b, pp. 6343-6347). We understand that the proposed methods would raise certification testing costs relative to levels assumed for cost estimation in this analysis.

2. Emission reductions from tighter standards may be overstated because, as discussed in Houck (2012), certification values for other wood heaters do not necessarily correlate with actual emissions from in-home appliances. Even if they did, due to the inherent variability when burning wood, the EPA test methods cannot reliably distinguish emissions performance differences in the range of the proposed standards.

D. Organization of This Report

The remainder of this report is organized as follows. Chapter II provides information on the development of the annual cost-effectiveness estimates. Chapter III provides the incremental cost-effectiveness estimates. Both of these chapters are based upon our benchmark estimates of costs and other parameters. Chapter IV provides sensitivity analysis to evaluate how the results of the study change under different assumptions regarding compliance costs and the price elasticity of demand. Chapter V provides a summary of the principal conclusions.

II. Development of Cost-Effectiveness Estimates

This chapter provides details on the methods we use to develop estimates of the annualized costs and annual emission reductions under the three alternative NSPS. This information is used in the final section to summarize our estimates of the cost-effectiveness of the three emission standards, in this chapter all costs and emission reduction benefits are measured relative to the baseline conditions.

A. Unit Compliance Costs

An industry expert developed detailed information on the potential costs of modifying hydronic heater models and individual units to comply with the alternative standards, information that was peer reviewed by a panel of industry experts. This information allows us to calculate the annualized cost per heater to comply with the three standards. This section summarizes the cost estimates and our calculation of per heater compliance costs.

1. Compliance Cost Inputs

Appendix A provides ranges of detailed compliance cost components associated with meeting the three NSPS along with the mid-point of the range for each component; we use the mid-point values in our base analysis and the lower and upper values in our sensitivity analysis. Costs per model and variable cost per unit were estimated for different potential emissions levels, and thus our estimates of compliance costs vary with the stringency of the potential NSPS; this variation is essential for any reasonable comparison of the cost-effectiveness of regulatory alternatives. These cost estimates are based on the current EPA algorithm for testing hydronic heater emissions under the Voluntary Program; this would understate costs if EPA adopts a more stringent compliance algorithm (EPA 2014b, pp. 6343-6347). The development and validation of these cost estimates are discussed in Appendix A.

As noted, in our base case analysis, we use the midpoints of the cost ranges developed in Appendix A.[3] Table 1 shows the costs per model and the variable cost per unit that are used in this analysis. Note that all costs and prices in this report are in 2013 dollars.

[3] Sensitivity cases using the lower and upper costs are presented in Chapter IV of this report.

Table 1. Detailed Compliance Costs for NERA Analysis

	Conventional to 0.32	0.32 to 0.15	0.32 to 0.06	0.15 to 0.06
R&D / engineering	$734,000	$869,000	$1,192,750	$994,000
Manufacturing	$84,500	$58,250	$85,550	$68,250
Purchased parts sourcing	$32,250	$32,250	$32,250	$32,250
Testing	$175,000	$175,000	$175,000	$175,000
Equip and integration	$150,000	$75,000	$112,500	$125,000
Facilities	$50,000	$22,500	$37,500	$37,500
Certification	$62,500	$63,750	$71,250	$71,250
Roll-out	$455,500	$455,500	$455,500	$450,500
Total costs per model	$1,743,750	$1,751,250	$2,162,300	$1,953,750
Variable costs per unit	$2,735	$1,025	$1,263	$800

Source: Appendix A and NERA calculations as explained in text

2. Compliance Cost Per Heater

The cost information includes information on the costs per model to modify hydronic heater models to meet the alternative standards as well as the additional variable cost per heater. The information on costs per model from Table 1 is used along with information on indirect costs and variable costs to develop compliance costs per hydronic heater unit. The calculation of compliance costs per unit is shown in Table 2.

Table 2. Compliance Costs Per Heater

	Conventional to 0.32	0.32 to 0.15	0.32 to 0.06	0.15 to 0.06
Total costs per model	$1,743,750	$1,751,250	$2,162,300	$1,953,750
Annualized (10 years)	$248,271	$249,339	$307,863	$278,170
Per unit (300 units)	$828	$831	$1,026	$927
Variable costs per unit	$2,735	$1,025	$1,263	$800
Subtotal per unit	$3,563	$1,856	$2,289	$1,727
Indirect costs (35%)	$1,247	$650	$801	$605
Total costs per unit	$4,809	$2,506	$3,090	$2,332

Source: Appendix A and NERA calculations as explained in text

The costs per model in Table 2 reflect costs that would apply to production in a number of years, and thus it is necessary to determine the costs that would be relevant for a single year of production. Ferguson (Appendix E) surveys woodstove manufacturers and reports that the largest average number of years that models remain in production in his sample was about 10 years (with the average of all surveyed manufacture 8.3 years). We annualize the hydronic heater model costs over 10 years using a 7 percent real annual discount rate. Annualized model costs are then divided by 300 annual hydronic heater sales per model[4] and summed with variable costs

[4] There is some uncertainty about future sales and heater models. To estimate annual sales per model, we conservatively divide 10,443 sales reported to EPA through the Voluntary Program in 2012 (shown in Appendix D) across the 37 typical-home-size hydronic heater models in the pricing survey in Appendix B (a lower bound

per unit. Finally, we add 35 percent indirect costs to capture costs anywhere in the supply chain that were not directly estimated in Appendix A.[5]

B. Sales, Prices, and Total Costs

The *total* compliance cost depends in part on the number of heaters that are actually sold, i.e., the sales of hydronic heaters if the relevant standard were in place. The number of hydronic heater sales, in turn, is a market outcome based upon changes in heater prices and consumers' willingness to pay for new heaters as reflected in the price elasticity of demand. In this section, we present baseline sales and price estimates for the average hydronic heater model in an illustrative future year. We then estimate the impact of three steps of NSPS on hydronic heater prices and sales and calculate the total cost of each potential standard net of any expected changes in sales.

1. Baseline Sales

As noted above, the hydronic heater market currently consists of "conventional" models and "qualified" models with 90 percent lower emissions than "conventional" models. We used information from the HPBA Hydronic Heater Caucus (shown in Appendix D) to estimate baseline sales for "conventional" and "qualified" hydronic heaters. The HPBA Caucus provided sales data for the period 2008-2012, and we used averages over the most recent three-year period (2010-2012) to develop the baseline sales projections. The HPBA Caucus data indicate that total baseline sales for hydronic heaters (based on the average over the period 2010-2012) would be about 13,100 units, with "conventional" models accounting for 87 percent of baseline unit sales and "qualified" models accounting for 13 percent of baseline unit sales.

Figure 2 provides information on recent historical hydronic heater sales based on the HPBA Hydronic Heater Caucus data and two other sources as context (shown in Appendix D). As noted above, the HPBA Caucus data cover the period 2008-2012; the data show a steep decrease in sales from 2008 to 2009 and 2010. This downward sales trend is a reversal from the upward trend estimated by NESCAUM (2006) for the period 1999-2004, which is also included in Figure 2. In addition, the figure includes hydronic heater sales estimates for the period 2010-2012 from manufacturers participating in the EPA Voluntary Program. Note that the two recent data series (from the HPBA Caucus and the manufacturers providing information to EPA) include both "conventional" and "qualified" models. Moreover, since some manufacturers do not participate in the HPBA Caucus or the EPA Voluntary Program, we scaled the sales estimates from these two data series up to reflect hydronic heater sales by other manufacturers.

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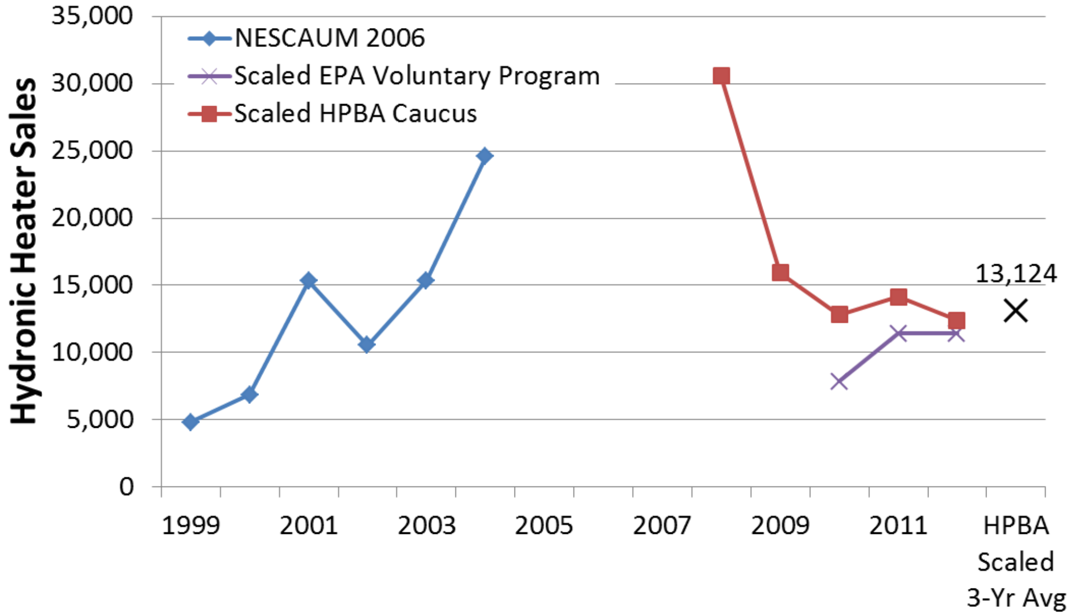
on the number of relevant models). This calculation likely overstates annual sales per model and is subject to future revision.

[5] Indirect cost estimates are used in cost analysis of other EPA regulations (e.g. motor vehicle emissions standards). Our analysis does not include a separate markup for manufacturer profit.

Figure 2. Hydronic Heater Sales



Source: NESCAUM (2006, p. 3-3), HPBA (Appendix D), EPA (Appendix D), and NERA calculations
Note: Scaled up HPBA Caucus sales estimates based on 75 percent representation of total hydronic heater sales and scaled up EPA Voluntary Program based on 90 percent representation of "conventional" heater sales and 100 percent of "qualified" heater sales.

Table 3 shows estimates of baseline sales by model category based on the HPBA Caucus data averaged over the period 2010-2012. We use these baseline sales estimates for the cost-effectiveness calculations.

Table 3. Baseline Sales

	Conventional	Qualified	Total
Percentage of sales	87%	13%	100%
Sales units	11,400	1,700	13,100

Source: HPBA (Appendix D) and NERA calculations as explained in text

2. Baseline Prices

A survey of manufacturers (Appendix B) provides estimates of suggested retail prices for "conventional" and "qualified" hydronic heater models. The survey indicated that "qualified" models are considerably more expensive than "conventional" models. Table 4 shows the average prices for the two model categories based on the survey results.[6] Using the split between "conventional" and "qualified" hydronic heater model sales above in Table 3, the baseline sales-weighted average unit price is $6,719.

[6] Note that these results do not presume that the other hydronic heater characteristics are uniform across the emission categories.

Table 4. Baseline Prices

	Conventional (3.2 lb/mmBtu)	Qualified (0.32 lb/mmBtu)	Total
Baseline price	$6,200	$10,200	
Baseline sales	11,400	1,700	
Weighted average price			$6,719

Source: Appendix B and NERA calculations as explained in text

3. Price and Sales Methodology

The compliance costs of new emissions standards are presumed to be passed on to consumers through higher hydronic heater prices. Higher prices lead to lower sales, an effect that we label the "demand effect." The magnitude of this effect for a given emissions standard depends on the compliance cost per unit (presented in Table 2), any retail markup on the compliance cost, and the consumer price elasticity of demand.

a. Retail Price Markup

We use an industry estimate that retailers generally price hydronic heater units to achieve a 20 percent gross margin (Appendix D), which is equivalent to a 25 percent retail markup.[7] We apply this retail markup to the compliance cost of each alternative NSPS. The total increase in the retail hydronic heater price caused by a new emissions standard is thus the sum of the unit compliance cost and the retail markup on the compliance cost.

b. Price Elasticity of Demand

Price elasticity of demand is an economic measure of the sensitivity of sales to changes in price. The elasticity is approximately equal to the percent change in sales resulting from a 1 percent increase in the price of a good.

As noted above, several states have adopted a hydronic heater emission standard of 0.32 lb/MMBtu since 2007 when EPA established the Voluntary Program. We used hydronic heater sales data from before and after introduction of the emission standard in each state, along with price estimates from the a manufacturer survey (Appendix B), to estimate the average impact of higher prices for low-emission hydronic heater models on sales. This econometric analysis indicates that the price elasticity of demand for hydronic heaters is about -1.0. Additional information on the econometric analysis is provided in Appendix C. We use the estimate of -1.0 in our base case calculations, and we test the sensitivity of our results to alternative demand elasticities in Chapter IV.

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7 Gross margin is margin divided by retail price, and retail markup is margin divided by wholesale cost. For example, if total wholesale cost for a unit is $8,000, a retailer would sell it at $10,000 for 20 percent gross margin ($2,000/$10,000) or a 25 percent retail markup ($2,000/$8,000).

4. Prices and Sales Under Alternative NSPS

This section presents the estimated impacts of each potential NSPS step on hydronic heater prices and sales. We assume that the average price increase for a given standard can be developed using estimates of the costs to modify hydronic heaters from their baseline emissions to the standard.

a. Step I NSPS – 0.32 lb/MMBtu Standard

Under an emissions standard for new hydronic heaters of 0.32 lb/MMBtu, "conventional" heaters would need to be modified for compliance with the new standard. The manufacturers of "conventional" heaters would incur compliance costs for the modifications based on the cost estimates shown above in Table 1 (capital costs per model, other fixed costs per model, and variable costs per unit) and Table 2 (total cost per unit). The price of these units would increase to reflect the unit compliance cost and the 25 percent retail markup on that compliance cost. Table 5 shows that the price of these modified heaters would rise by $6,012, from $6,200 on average for "conventional" hydronic heaters in the baseline to $12,212 under the NSPS.

Table 5. Price of "Conventional" Hydronic Heaters Modified to Meet 0.32 lb/MMBtu Standard

	Compliance Costs	Retail Markup	Price Increase	Original Price	NSPS Price
Modification of conventional models	$4,809	+ $1,202	= $6,012	$6,200	$12,212

Source: NERA calculations as explained in text

To find the impact of this price change on hydronic heater sales, we treat hydronic heaters as a single market and simultaneously calculate the increase in the average hydronic heater price and the resulting decrease in annual sales from the demand effect.[8] To model the interactions between price and sales, we assumed constant elasticity of demand ("log-log" demand curve) using the estimated price elasticity of demand discussed above.

The results are shown in Table 6. The higher prices for modified "conventional" hydronic heaters would reduce sales of this category in the illustrative year by about 5,500 units. Assuming sales of "qualified" heaters stay constant at the baseline level shown above in Table 3 (1,700 units in the illustrative year), the demand effect would reduce total hydronic heater sales from about 13,100 units under baseline conditions to about 7,600 units, a reduction of 42 percent. Since the former "conventional" hydronic heaters would increase significantly in price based on the modification costs and retail markup, average hydronic heater prices (averaged across both model categories) would increase to about $11,800 per unit. This represents an increase of 75 percent in price for the average hydronic heater in Step I.

8 Note that the unit price for "qualified" hydronic heaters is unchanged under the Step I standard (0.32 lb/MMBtu). Note also that information is not available to develop assessments of price effects for hydronic heaters differentiated by characteristics other than their emissions performance or to consider interactions among different types of hydronic heaters.

Table 6. Sales and Price Impacts of Step I Standard

	Modified Conventional	0.32 lb/mmBtu	Total
Demand effect	-5,490	N/A	
Sales with demand effect	5,910	1,700	7,610
Impact from baseline			-5,490
Impact from baseline (%)			-41.9%
NSPS price	$12,212	$10,200	
Weighted avg NSPS price			$11,762
Impact from baseline ($)			+$5,043
Impact from baseline (%)			+75.1%

Source: NERA calculations as explained in text

Note: "Modified Conventional" are "conventional" hydronic heaters modified to meet a 0.32 lb/MMBtu NSPS. The demand effect is assumed to reduce sales of these modified units, which experience an increase in price due to the NSPS. "Qualified" heaters already meeting the 0.32 lb/MMBtu are assumed not to experience a demand effect.

b. Step II – 0.15 or 0.06 lb/MMBtu Standard

In Step II, the starting point is no longer baseline conditions but rather a Step I standard of 0.32 lb/MMBtu (as shown above in Table 6). Thus, the former "conventional" models and the "qualified" models would both require modifications to reduce their emissions from 0.32 lb/MMBtu to 0.15 or 0.06 lb/MMBtu. The modification costs for this transition were shown above in Table 1 and Table 2.

i. 0.15 lb/MMBtu Standard

Table 7 shows the price impacts of reducing hydronic heater emissions from 0.32 lb/MMBtu (90 percent emission control relative to "conventional" heaters) to 0.15 lb/MMBtu. As discussed above in the context of Step I, the price impacts are based on the modification costs per unit and the retail markup. The compliance costs, retail markup, and total price impact are shown below. Based on the modification cost of $2,506 per unit (see above in Table 2) and the retail markup of 25 percent, the price increase would be $3,132. The baseline price to which this price impact is applied is the sales-weighted average price after Step I shown above in Table 6 ($11,762). Thus, under a Step II standard of 0.15 lb/MMBtu the price of new hydronic heaters would be $14,895. This represents an increase of about 27 percent relative to the average price under Step I (and more than doubles the initial baseline average price of $6,719).

Table 7. Price Impacts of Step II Standard of 0.15 lb/MMBtu

	Compliance Costs	Retail Markup	Price Increase	Original Price	NSPS Price
Modification of 0.32 lb/mmBtu models	$2,506	+ $626	= $3,132	$11,762	$14,895
Impact from new baseline ($)					+$3,132
Impact from new baseline (%)					+26.6%

Source: NERA calculations as explained in text

As with modification of "conventional" hydronic heaters discussed above, the price impacts of modifying 0.32 lb/MMBtu heaters to meet a Step II standard would reduce sales through the demand effect. We estimated the sales impacts using the same methodology involving the assumed demand curve specification and price elasticity of demand described above.

Table 8 shows the estimated sales impacts of a Step II standard of 0.15 lb/MMBtu. The modified 0.32 lb/MMBtu hydronic heaters would decrease in sales by 1,558 units, a decrease of 21 percent from the Step I sales level of 7,610 units. The total sales with the demand effect for the 0.15 lb/MMBtu standard would be 6,052 units.

Table 8. Sales Impacts of Step II Standard of 0.15 lb/MMBtu

	Modified 0.32 lb/mmBtu
Demand effect	-1,558
Sales with demand effect	6,052
Impact from new baseline (%)	-20.5%

Source: NERA calculations as explained in text

ii. 0.06 lb/MMBtu Standard

Table 9 shows the price impacts of reducing hydronic heater emissions from 0.32 lb/MMBtu to 0.06 lb/MMBtu. Based on the modification cost of $3,090 per unit (see above in Table 2) and the retail markup of 25 percent, the price increase would be $3,862. The baseline price to which this price impact is applied is the sales-weighted average price after Step I shown above in Table 6 ($11,762). Thus, under a Step II standard of 0.06 lb/MMBtu the price of new hydronic heaters would be $15,625. This represents an increase of about 33 percent relative to the average price under Step I (and 2.3 times the initial baseline average price of $6,719).

Table 9. Price Impacts of Step II Standard of 0.06 lb/MMBtu

	Compliance Costs	Retail Markup	Price Increase	Original Price	NSPS Price
Modification of 0.32 lb/mmBtu models	$3,090	+ $772	= $3,862	$11,762	$15,625
Impact from new baseline ($)					+$3,862
Impact from new baseline (%)					+32.8%

Source: NERA calculations as explained in text

Table 8 shows the estimated sales impacts of a Step II standard of 0.06 lb/MMBtu. The modified 0.32 lb/MMBtu hydronic heaters would decrease in sales by 1,832 units, a decrease of 24 percent from the Step I sales level of 7,610 units. The total sales with the demand effect for the 0.06 lb/MMBtu standard would be 5,778 units.

Table 10. Sales Impacts of Step II Standard of 0.06 lb/MMBtu

	Modified 0.32 lb/mmBtu
Demand effect	-1,832
Sales with demand effect	5,778
Impact from new baseline (%)	-24.1%

Source: NERA calculations as explained in text

c. Step III – 0.06 lb/MMBtu Standard

Under a Step III standard of 0.06 lb/MMBtu, hydronic heaters meeting the 0.15 lb/MMBtu standard from Step II would need to be modified to comply with the new standard. As with the previous two steps, this modification would entail manufacturer costs and retail markups leading to higher product prices. Table 12 shows that these modifications lead to a $2,915 average price increase, which represents about 20 percent of baseline prices from the Step II standard of 0.15 lb/MMBtu. The estimated average price of $17,809 per unit under Step III is 2.6 times the original average hydronic heater price of $6,719.

Table 11. Price Impacts of Step III Standard

	Compliance Costs	Retail Markup	Price Increase	Original Price	NSPS Price
Modification of 0.15 lb/mmBtu models	$2,332	+ $583	= $2,915	$14,895	$17,809
Impact from new baseline ($)					+$2,915
Impact from new baseline (%)					+19.6%

Source: NERA calculations as explained in text

As with the previous two steps, the higher prices under Step III would reduce sales. Table 12 shows that the demand effect would reduce sales by about 963 units, a reduction of about 16 percent from the sales level under a Step II standard of 0.15 lb/MMBtu.

Table 12. Sales Impacts of Step III Standard

	Modified 0.15 lb/mmBtu
Demand effect	-963
Sales with demand effect	5,089
Impact from new baseline (%)	-15.9%

Source: NERA calculations as explained in text.

1. Social Cost Methodology

The social cost of alternative NSPS for hydronic heaters has two components: (1) compliance costs; and (2) consumer surplus deadweight loss. Both components depend upon the market impacts of alternative standards discussed above.

a. Compliance Costs

Compliance costs are calculated after taking into account the reduced sales due to the demand effect. As discussed above, sales decrease as a result of higher average hydronic heater prices under alternative NSPS. Only units that are sold after taking into account the demand effect contribute to compliance costs.

b. Consumer Surplus Deadweight Loss

The social costs due to the demand effect include the loss of consumer surplus due to the reduced sales. A consumer would only buy a new hydronic heater if the value of the heater to that consumer were greater than the heater price. Consumer surplus measures, in this case, the value of heaters to consumers *beyond* the market price they pay.

If, under an alternative NSPS, the price of a heater were to rise to more than the value for a certain customer, then that customer would no longer purchase the heater. Put another way, the customer would receive no "consumer surplus" from the purchase and would spend his/her money on other goods and services. This "lost" sale reduces direct compliance costs due to the NSPS since there would be no costs to modify the hydronic heater to comply with NSPS; but the consumer who would otherwise benefit (acquire consumer surplus) from the heater purchase would be worse off. This cost or lost value to consumers who are priced out of the hydronic heater market is termed consumer surplus deadweight loss.

In market diagrams like Figure 3, total consumer surplus is the area under the demand curve (which represents consumers' willingness-to-pay) and above purchase expenditures (the rectangle from multiplying price paid by quantity purchased). The shaded triangle represents the loss of value to consumers who would have purchased hydronic heaters under baseline conditions, but are priced out of the market when the price of heaters rises to reflect the additional costs of the NSPS.

The importance of consumer surplus deadweight loss is evident when compliance costs are very large; if all consumers were priced out of the hydronic heater market by an alternative NSPS, there would be no direct compliance costs associated with the standard. Far from resulting in no social costs, however, this situation would mean that all of the social costs would take the form of lost consumer surplus.[9]

To estimate consumer surplus deadweight loss, we assume a constant-elasticity, "log-log" demand curve (as in our calculations of the demand effect).

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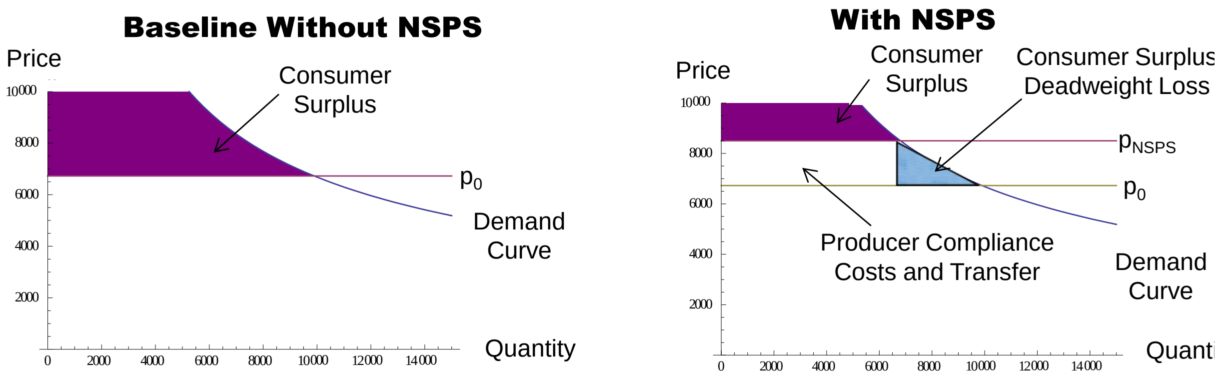
[9] Note that consumer surplus is reduced for consumers who continue to purchase new heaters when prices increase; but in this case, there is a corresponding transfer to producers and thus no additional net social costs.

Figure 3. Consumer Surplus Deadweight Loss



Source: Illustrative results. Consumer surplus above $10,000 is not shown.

2. Social Costs Under Alternative NSPS

The tables below show the calculation of compliance costs and consumer surplus deadweight loss under each alternative NSPS. The social cost is the sum of the compliance costs (accounting for the demand effect) and the consumer surplus deadweight loss. These calculations illustrate the importance of modeling market impacts prior to estimating the social cost of regulatory alternatives.

a. Step I – 0.32 lb/MMBtu Standard

As shown in the following two tables, compliance costs for the Step I standard (accounting for the demand effect) would be about $28 million in the illustrative future year, and consumer surplus deadweight loss would be about $11 million. Thus, the total cost of the Step I standard in the illustrative future year would be about $39 million.

Table 13. Compliance Cost of Step I Standard

	Units	Cost/Unit	Cost
Modify conventional without demand effect	11,400	$4,809	$54,827,941
Modify conventional with demand effect	5,910	$4,809	$28,423,629

Source: NERA calculations as explained in text

Table 14. Consumer Surplus Deadweight Loss of Step I Standard

Price impact from baseline ($)	+$5,043
Price impact from baseline (%)	+75.1%
Sales impact from baseline	-5,490
Sales impact from baseline (%)	-41.9%
Consumer surplus deadweight loss	$11,324,362

Source: NERA calculations as explained in text

b. Step II – 0.15 or 0.06 lb/MMBtu Standard

i. 0.15 lb/MMBtu Standard

As shown in the following two tables, compliance costs for a Step II standard of 0.15 lb/MMBtu (accounting for the demand effect) would be about $15 million in the illustrative future year, and consumer surplus deadweight loss would be about $2 million. Thus, the total cost of the Step II standard of 0.15 lb/MMBtu in the illustrative future year would be about $17 million.

Table 15. Compliance Cost of Step II Standard of 0.15 lb/MMBtu

	Units	Cost/Unit	Cost
Modify 0.32 without demand effect	7,610	$2,506	$19,068,766
Modify 0.32 with demand effect	6,052	$2,506	$15,165,797

Source: NERA calculations as explained in text

Table 16. Consumer Surplus Deadweight Loss of Step II Standard of 0.15 lb/MMBtu

Price impact from new baseline ($)	+$3,132
Price impact from new baseline (%)	+26.6%
Sales impact from new baseline	-1,558
Sales impact from new baseline (%)	-20.5%
Consumer surplus deadweight loss	$2,250,605

Source: NERA calculations as explained in text
Note: Price and sales impacts are incremental to the previous standard; in this case, the "baseline" is the Step I standard.

ii. 0.06 lb/MMBtu Standard

Compliance costs for a more stringent Step II standard of 0.06 lb/MMBtu would be higher than the compliance costs for 0.15 lb/MMBtu shown in Table 15. Accounting for the demand effect, compliance costs for a Step II standard of 0.06 lb/MMBtu would be about $18 million in the illustrative future year, and consumer surplus deadweight loss would be about $3 million. Thus, the total cost of the Step II standard of 0.06 lb/MMBtu in the illustrative future year would be about $21 million.

Table 17. Compliance Cost of Step II Standard of 0.06 lb/MMBtu

	Units	Cost/Unit	Cost
Modify 0.32 without demand effect	7,610	$3,090	$23,512,846
Modify 0.32 with demand effect	5,778	$3,090	$17,852,201

Source: NERA calculations as explained in text

Table 18. Consumer Surplus Deadweight Loss of Step II Standard of 0.06 lb/MMBtu

Price impact from new baseline ($)	+$3,862
Price impact from new baseline (%)	+32.8%
Sales impact from new baseline	-1,832
Sales impact from new baseline (%)	-24.1%
Consumer surplus deadweight loss	$3,208,935

Source: NERA calculations as explained in text

Note: Price and sales impacts are incremental to the previous standard; in this case, the "baseline" is the Step I standard.

c. Step III – 0.06 lb/MMBtu Standard

A Step III standard of 0.06 lb/MMBtu would have social costs beyond a Step II standard of 0.15 lb/MMBtu. As shown in the following two tables, compliance costs for the Step III standard (accounting for the demand effect) would be about $12 million in the illustrative future year, and consumer surplus deadweight loss would be about $1 million. Thus, the total cost of the Step III standard in the illustrative future year would be about $13 million.

Table 19. Total Compliance Cost of Step III Standard

	Units	Cost/Unit	Cost
Modify 0.15 without demand effect	6,052	$2,332	$14,112,639
Modify 0.15 with demand effect	5,089	$2,332	$11,866,393

Source: NERA calculations as explained in text

Table 20. Consumer Surplus Deadweight Loss of Step III Standard

Price impact from new baseline ($)	+$2,915
Price impact from new baseline (%)	+19.6%
Sales impact from new baseline	-963
Sales impact from new baseline (%)	-15.9%
Consumer surplus deadweight loss	$1,321,607

Source: NERA calculations as explained in text
Note: Price and sales impacts are incremental to the previous standard; in this case, the “baseline” is the Step II standard.

C. Emission Reductions

This section describes our estimates of the annual particulate matter emission reduction benefits due to the alternative NSPS. The Office of Air Quality and Standards (“OAQPS”) at EPA typically has relied on analysis of annual emission reductions to develop its cost-effectiveness estimates.[10] The emission benefits developed in our report similarly are emission changes in an illustrative year.

1. Baseline Emissions

Emissions benefits are estimated relative to a baseline developed using historical data. We have updated from previous analyses to use EPA (2014c) estimates of the annual emissions per hydronic heater for different emission categories. The EPA emissions are shown in Table 21. “Qualified” heaters (which meet the proposed Step I emission standard of 0.32 lb/MMBtu) achieve 90 percent emission control relative to “conventional” heaters. Tighter standards of 0.15 and 0.06 lb/MMBtu achieve 95 percent and 98 percent control relative to “conventional” heaters.

Table 21. Annual PM Emissions per Heater

	Conventional	Qualified	0.15 lb/mmBtu	0.06 lb/mmBtu
Annual emissions (tons/unit)	0.1383	0.0138	0.0069	0.0028

Source: EPA (2014c), Table 4-3.

The sales data for “conventional” and Voluntary Program “qualified” (0.32 lbs/MMBTU) hydronic heaters under baseline conditions shown above in Table 3 and the annual emissions per unit shown above in Table 21 imply that baseline total annual emissions from new hydronic heaters are about 1,600 tons, as shown in the table below.

[10] See, e.g., EPA (2012a) Table 3-4 comparing costs and emission reductions for oil and natural gas controls in 2015 and EPA (2012b) Table 1-1 comparing costs and emission reductions for petroleum refinery flare regulations in 2017.

Table 22. Baseline Total Emissions

	Conventional	Qualified (0.32 lb/mmBtu)	Total
Units	11,400	1,700	13,100
Annual emission rate (tons/unit)	0.1383	0.0138	0.1222
Annual emissions (tons)	1,577	24	1,600

Source: NERA calculations as explained in text

2. Components of Emission Reductions

There are three components of annual emissions changes resulting from alternative NSPS.

1. *Demand Effect*: The rise in heater prices causes sales to fall, so fewer units emit.

2. *Compliance Effect*: Units converted to comply with alternative NSPS emit less.

3. *Scrappage Effect*: Reduced scrappage of existing units leads to more emissions.

These three components of emission reductions are described in the following sections.

a. Demand Effect

When hydronic heater prices rise because of compliance costs associated with a new emissions standard, there is a decrease in sales through the demand effect. The demand effect results in fewer units emitting particulate matter than under baseline conditions (ignoring for the moment the implications of increased prices for new heaters on the scrappage of existing heaters).

b. Compliance Effect

After accounting for the demand effect, some units will be modified to comply with the new emissions standard. The compliance effect is the improved emissions performance of these units that did not comply with the new standard in the baseline and would be sold under the alternative NSPS. Note that if there were no market responses to the compliance cost of alternative NSPS, the compliance effect would be the only change in emissions.

c. Scrappage Effect

Our analysis is focused on emission reductions from modifying new hydronic heaters introduced in an illustrative future year; but there is also a large stock of existing hydronic heaters, most of which are "conventional" models with much higher emissions than heaters meeting the potential new standards. A survey of hydronic heater manufacturers (Appendix D) indicates that 4 percent of new hydronic heater sales are replacements of existing hydronic heaters; assuming the replaced heaters would be "scrapped" (i.e., taken out of use), these existing heaters would have no emissions. But as a result of price increases for new hydronic heaters under alternative NSPS, fewer existing hydronic heaters would be replaced and scrapped.[11] The increase in emissions from these existing hydronic heaters (relative to what they would be if there were no NSPS) is called the "scrappage effect." Scrappage effects are often included in analyses of regulations that affect the price of new products (see, e.g. Goulder et al. 2009 analysis of emission standards for new motor vehicles). In this analysis, we assume that existing hydronic heaters that would be scrapped under baseline conditions are "conventional" hydronic heaters.

The increase in annual emissions from existing hydronic heaters through the scrappage effect partly offsets the emissions decrease from the demand and compliance effects. Table 21 shows that "conventional" existing hydronic heaters have average annual emissions ten times larger than "qualified" hydronic heaters.

3. Annual Emission Reductions under Alternative NSPS

The tables below show the three components of annual emissions change resulting from three steps of alternative NSPS. We can explain the calculations using the example of the Step I standard in Table 23. As shown in that table, the Step I demand effect reduces sales of "conventional" units by 5,490; these units had annual emissions of 0.138 tons per unit in the baseline but are no longer sold and have "Policy Annual Emissions" of 0. There are 5,910 hydronic heaters with the same annual emissions (0.138 tons per unit) in the baseline that are now modified to 0.014 tons per unit (corresponding to 0.32 lb/MMBtu) to comply with the NSPS (the compliance effect). Finally, 220 "conventional" existing units (4 percent of 5,490) were replaced in the baseline ("Baseline Annual Emissions" of 0 tons/unit) but continue to emit 0.138 tons per unit annually under the new standard through the scrappage effect. Thus, the net change in annual hydronic heater emissions under the Step I standard would be a reduction of 1,465 tons. The calculations for Step II and Step III are analogous.

a. Step I – 0.32 lb/MMBtu Standard

Table 23. Annual Emissions Impact by Component for Step I Standard

	Emissions Impact	Number of Units	Baseline Annual Emissions (tons/unit)	Policy Annual Emissions (tons/unit)	Emissions Change (tons)
Demand effect	-	5,490	0.138	0	-759
Compliance effect	-	5,910	0.138	0.014	-736
Scrappage effect	+	220	0	0.138	+30
Net effect	-				-1,465

Source: NERA calculations as explained in text

[11] Imagine a demand effect in which 100 fewer hydronic heaters are sold. Under baseline conditions, 4 of those 100 heaters (4 percent) would have replaced existing hydronic heaters that presumably would be scrapped. Those four old hydronic heaters are no longer replaced and scrapped, so their emissions are higher under alternative NSPS than in the baseline. Put another way, continuing use of an existing heater is a "replacement" for purchase of a new heater.

b. Step II – 0.15 or 0.06 lb/MMBtu Standard

i. 0.15 lb/MMBtu Standard

Table 24. Annual Emissions Impact by Component for Step II Standard of 0.15 lb/MMBtu

	Emissions Impact	Number of Units	New Baseline Annual Emissions (tons/unit)	Policy Annual Emissions (tons/unit)	Emissions Change (tons)
Demand effect	-	1,558	0.014	0	-22
Compliance effect	-	6,052	0.014	0.007	-42
Scrappage effect	+	62	0	0.138	+9
Net effect	-				-55

Source: NERA calculations as explained in text
Notes: Emissions impacts are incremental to the previous standard; in this case, "Baseline Annual Emissions" are annual emissions per heater under the Step I standard.

ii. 0.06 lb/MMBtu Standard

Table 25. Annual Emissions Impact by Component for Step II Standard of 0.06 lb/MMBtu

	Emissions Impact	Number of Units	New Baseline Annual Emissions (tons/unit)	Policy Annual Emissions (tons/unit)	Emissions Change (tons)
Demand effect	-	1,832	0.014	0	-25
Compliance effect	-	5,778	0.014	0.003	-64
Scrappage effect	+	73	0	0.138	+10
Net effect	-				-79

Source: NERA calculations as explained in text
Notes: Emissions impacts are incremental to the previous standard; in this case, "Baseline Annual Emissions" are annual emissions per heater under the Step I standard.

c. Step III – 0.06 lb/MMBtu Standard

Table 26. Annual Emissions Impact by Component for Step III Standard

	Emissions Impact	Number of Units	New Baseline Annual Emissions (tons/unit)	Policy Annual Emissions (tons/unit)	Emissions Change (tons)
Demand effect	-	963	0.007	0	-7
Compliance effect	-	5,089	0.007	0.003	-21
Scrappage effect	+	39	0	0.138	+5
Net effect	-				-22

Source: NERA calculations as explained in text
Notes: Emissions impacts are incremental to the previous standard; in this case, "Baseline Annual Emissions" are annual emissions per heater under the Step II standard of 0.15 lb/MMBtu.

III. Incremental Cost-Effectiveness

This section summarizes our previous estimates and presents incremental cost-effectiveness calculations for the three alternative hydronic heater NSPS. The incremental cost per ton of each alternative is the incremental annualized social costs divided by the incremental annual emission reductions (both relative to the appropriate baseline). We look at three separate sets of calculations to develop the appropriate incremental cost per ton results.

1. Step I standard of 0.32 lb/MMBtu compared to baseline “conventional” models
2. Step II standards of 0.15 or 0.06 lb/MMBtu compared to Step I standard of 0.32 lb/MMBtu
3. Step III standard of 0.06 lb/MMBtu compared to Step II standard of 0.15 lb/MMBtu

A. Price and Annual Sales Impacts

Table 27 provides a summary of price and annual sales impacts of the alternative NSPS. The table shows the significant increase in price and significant decrease in annual sales from introduction of the Step I standard. The Steps II and III standards would increase price further and decrease sales further.

Table 27. Summary of Price and Annual Sales Impacts of Alternative NSPS

	BASELINE	STEP I	STEP II		STEP III
	No Standard	No Standard → 0.32 lb/mmBtu	0.32 → 0.15 lb/mmBtu	0.32 → 0.06 lb/mmBtu	0.15 → 0.06 lb/mmBtu
Weighted Average Price	$6,700	$11,800	$14,900	$15,600	$17,800
Sales	13,100	7,600	6,100	5,800	5,100

Source: NERA calculations as explained in text

Figure 4 illustrates the severe contraction in hydronic heater sales from the alternative NSPS, particularly relative to the high sales level in 2008.

Figure 4. Summary of Annual Sales Impacts of Alternative NSPS

Note: The "Scaled HPBA Caucus Historical" series is based on sales data from HPBA Hydronic Heater Caucus manufacturers and scaled to reflect market sales. "Baseline" sales is the average of 2010 – 2012 historical sales.

B. Incremental Social Costs

Table 28 summarizes the annualized social costs of alternative NSPS on an incremental basis, distinguishing between compliance costs and consumer surplus deadweight loss. As noted above, the Step I standard would have annualized social costs around $40 million in the illustrative future year (relative to no current standard), the Step II standards would have annualized social costs around $17 million for 0.15 lb/MMBtu and $21 million for 0.06 lb/MMBtu (both relative to Step I), and the Step III standard would have annualized social costs around $13 million (relative to a Step II standard of 0.15 lb/MMBtu).

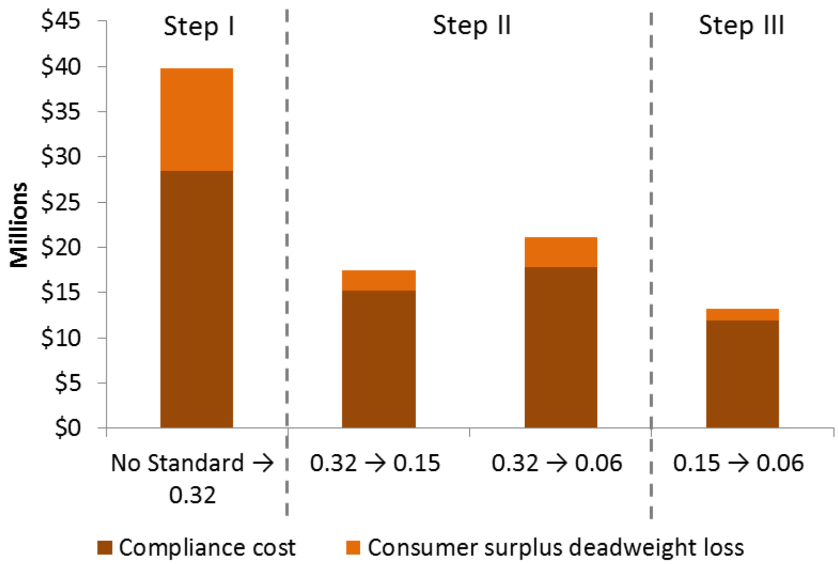
Table 28. Incremental Social Costs of Alternative NSPS

	STEP I	STEP II		STEP III
	No Standard → 0.32 lb/mmBtu	0.32 → 0.15 lb/mmBtu	0.32 → 0.06 lb/mmBtu	0.15 → 0.06 lb/mmBtu
Incremental social cost				
Compliance cost	$28,424,000	$15,166,000	$17,852,000	$11,866,000
Consumer surplus deadweight loss	$11,324,000	$2,251,000	$3,209,000	$1,322,000
Total cost	$39,748,000	$17,416,000	$21,061,000	$13,188,000

Source: NERA calculations as explained in text

Figure 5 summarizes the incremental annualized social costs of alternative NSPS, distinguishing between additional compliance costs and additional consumer surplus deadweight loss.

Figure 5. Total Social Costs of Alternative NSPS



Source: NERA calculations as explained in text

C. Incremental Emission Changes

Table 29 summarizes the incremental change in annual particulate matter emissions in the illustrative year under each alternative NSPS. The net result of the demand, compliance, and scrappage effects is a reduction of 1,465 tons of particulate matter in Step I. There are additional Step II reductions of 55 tons with a 0.15 lb/MMBtu standard or 79 tons with a 0.06 lb/MMBtu standard. A Step III standard of 0.06 would reduce another 22 tons relative to a Step II standard of 0.15 lb/MMBtu. Note that the Step II and Step III standards would achieve relatively few tons of additional reductions beyond the level achieved by the Step I standard.

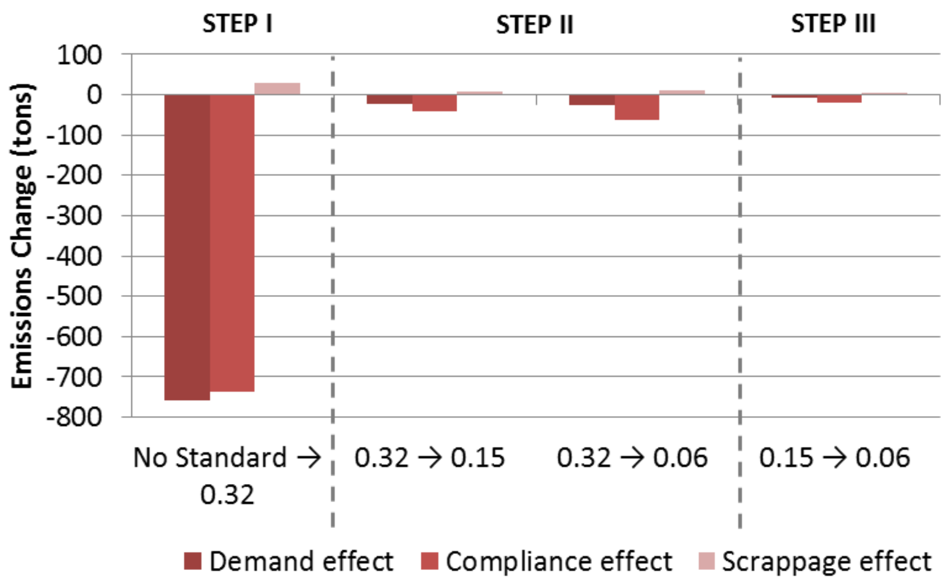
Table 29. Incremental Change in Annual Emissions of New Heaters Under Alternative NSPS (Tons of PM)

	STEP I	STEP II		STEP III
	No Standard → 0.32 lb/mmBtu	0.32 → 0.15 lb/mmBtu	0.32 → 0.06 lb/mmBtu	0.15 → 0.06 lb/mmBtu
Demand effect	-759	-22	-25	-7
Compliance effect	-736	-42	-64	-21
Scrappage effect	+30	+9	+10	+5
Net emission change	-1,465	-55	-79	-22

Source: NERA calculations as explained in text
Note: Net emissions may not equal the sum of rows due to independent rounding.

Figure 6 illustrates the incremental change in particulate matter emissions under each alternative NSPS, distinguishing between the demand effect, compliance effect, and scrappage effect.

Figure 6. Incremental Emission Changes Under Alternative NSPS



Source: NERA calculations as explained in text

D. Incremental Cost-Effectiveness

The incremental annual cost-effectiveness results are presented in Table 30. The Step I standard of 0.32 lb/MMBtu is most cost-effective at about $27,100 per ton. The additional emission reductions achieved by a Step II standard of 0.15 lb/MMBtu would be less cost-effective at about $317,900 per ton, where costs and emission reductions are relative to Step I. A tighter Step II standard of 0.06 lb/MMBtu would have a cost per ton of $266,100 (again relative to Step I), also much higher than the Step I standard. Using a three-step approach, the additional emission reductions achieved by a Step III standard of 0.06 lb/MMBtu relative to a Step II standard of 0.15 lb/MMBtu would be even less cost-effective at about $587,400 per ton.

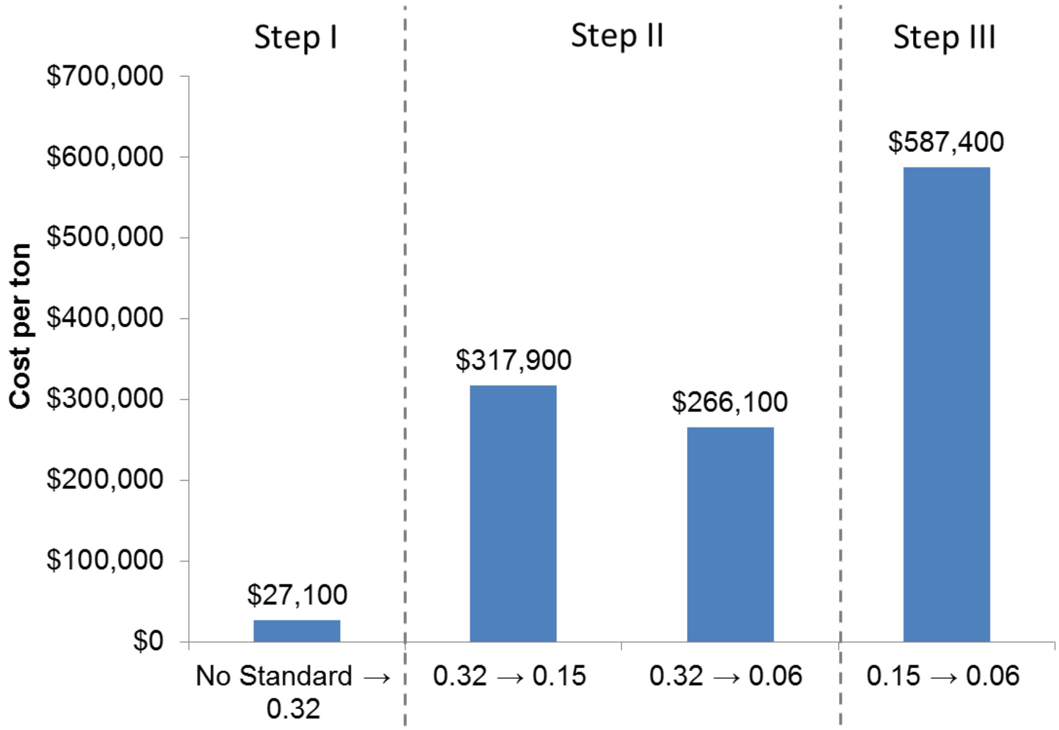
Table 30. Incremental Cost-Effectiveness of Alternative NSPS

	STEP I	STEP II		STEP III
	No Standard → 0.32 lb/mmBtu	0.32 → 0.15 lb/mmBtu	0.32 → 0.06 lb/mmBtu	0.15 → 0.06 lb/mmBtu
Incremental social cost	$39,748,000	$17,416,000	$21,061,000	$13,188,000
Incremental emission change	-1,465	-55	-79	-22
Cost per ton	$27,100	$317,900	$266,100	$587,400

Source: NERA calculations as explained in text

Figure 7 illustrates the incremental annual cost-effectiveness of the alternative NSPS. The figure shows that the Step II and Step III standards would be much less cost-effective than the Step I standard.

Figure 7. Cost-Effectiveness of Alternative NSPS



Source: NERA calculations as explained in text

IV. Sensitivity Analyses

The cost-effectiveness results presented thus far can be thought of as "base" case results. They were developed using the available information on compliance costs and hydronic heater market characteristics provided by industry experts as well as reasonable assumptions and best professional judgment.

Any analyses of future costs and market behavior are subject to some uncertainty. In this chapter we test the robustness of our base case results by accounting for uncertainty in compliance costs and the demand elasticity. We first discuss the role of uncertainty analysis and specifically sensitivity analysis. We then show the sensitivity of our results to alternative assumptions. These sensitivity cases support our finding that the more stringent hydronic heater emissions standards (Step II and Step III) are much less cost-effective than the Step I standard.

A. Background on Uncertainty Analysis

Economists and policy analysts have long recognized that analyses of costs and market modeling, no matter how careful and thorough, inevitably are subject to some degree of uncertainty. A robust cost-effectiveness analysis will include either a discussion of the major uncertainties or a formal quantitative analysis of uncertainty.

Sensitivity analysis is a widely used approach to considering uncertainty in a quantitative manner in economic analyses (see, e.g., EPA 2010). Sensitivity analysis helps to determine which uncertainties are most critical and whether plausible changes in the parameter values and assumptions could change the conclusions reached using base-case assumptions.

1. Guidelines on the Treatment of Uncertainty in Benefit-Cost Analysis

Guidelines on benefit-cost analysis from EPA and Office of Management and Budget (OMB) address the importance of uncertainty analysis and the conditions under which quantitative uncertainty analysis should be undertaken.

a. EPA *Guidelines*

EPA's *Guidelines* state that "[E]very analysis should address uncertainties resulting from the choices the analyst has made" (EPA 2010, p. 11-11). EPA stresses the importance of assessing and describing uncertainty in economic analyses and notes that the impact of using alternative assumptions or alternative models can be assessed quantitatively. EPA notes that sensitivity analyses can be useful to assess how a model's output changes as its input parameters change (EPA 2010, p. 11-11).

EPA's *Guidelines* also recognize that consideration of all possible uncertainties is not possible or even desirable. As a result, uncertainty analyses should focus on the most critical uncertainties, those most likely to make a material difference to decision makers:

> Because performing an alternative analysis on all the assumptions in an analysis is prohibitively resource intensive, the analyst should focus on the assumptions that have the largest impact on the final results of the particular analysis (EPA 2010, p. 11-11).

b. OMB Guidelines

In its most recent guidance for regulatory agencies, OMB stresses that important uncertainties connected with regulatory decisions need to be analyzed and presented as part of an overall regulatory analysis (OMB 2003).

OMB provides specific guidance on when a quantitative analysis of uncertainty is appropriate. For "major rules" involving "annual economic effects" of $1 billion or more, a formal uncertainty analysis is required. OMB also recommends a rigorous approach to uncertainty in regulations for which "net benefits are close to zero" (OMB 2003).

In other situations (when economic effects are less than $1 billion and net benefits are not close to zero), OMB suggests the following:

> Disclose qualitatively the main uncertainties in each important input to the calculation of benefits and costs. These disclosures should address the uncertainties in the data as well as in the analytical results (OMB 2003).

2. Sensitivity Analysis

Sensitivity analyses help to determine which uncertainties are most critical and whether plausible changes in the parameter values and assumptions could change the overall results and conclusions—in this case, the cost-effectiveness of alternative hydronic heater emissions standards.

Sensitivity analysis involves varying key input parameters, typically one at a time over appropriate ranges to determine their effects on net costs (Boardman et al. 2011). Such analyses are often more appropriately termed "partial" sensitivity analysis. "Partial sensitivity is most appropriately applied to what the analyst believes to be the most important and uncertain assumptions" (Boardman et al. 2011, p. 178).

One of the advantages of using sensitivity analysis is its computational ease. It is relatively easy to modify the values of key inputs to see how they affect the results. For each parameter considered, typically "low" and "high" values are tested in addition to the base-case value.

B. Sensitivity Analyses

We evaluated the effects of two major factors that could significantly affect our cost-effectiveness results and that are subject to some degree of uncertainty: [12]

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[12] Our calculations include some assumptions (e.g., number of production years over which capital and fixed costs would be amortized) that seem likely to understate the likely cost per ton.

1. Compliance costs; and

2. Price elasticity of demand.

1. Compliance Costs

The specific costs of modifying heaters to meet different emission levels are uncertain. Our base case compliance costs use the midpoint values of detailed compliance cost ranges provided in Appendix A. We use the lower and upper compliance cost values in Appendix A as sensitivity cases. The costs per unit in these cases as well as the base case (mid-point values) are summarized in Table 31.

Table 31. Cost per Heater for Compliance with Alternative Emissions Standards: Lower, Mid-Point and Upper Values

	Conventional to 0.32	0.32 to 0.15	0.32 to 0.06	0.15 to 0.06
Cost per Heater				
Lower	$3,240	$1,699	$1,942	$1,718
Mid-point	$4,809	$2,506	$3,090	$2,332
Upper	$6,379	$3,312	$4,237	$2,946

Source: NERA calculations as explained in text

2. Price Elasticity of Demand

The impacts of any significant regulatory action like new hydronic heater emissions standards also depend in part on the result of market forces and consumer purchase decisions. One key parameter for modeling these impacts is the price elasticity of demand, which describes the responsiveness of sales to changes in price (in this case as a result of new regulatory costs). In our base case analysis, we use an elasticity of demand of -1.0 estimated by NERA in Appendix C. We performed sensitivity analyses using smaller and greater elasticities of -0.5 and -1.5. A 10 percent increase in price would lead to a roughly 5 percent decrease in sales with an elasticity of -0.5 and a roughly 15 percent decrease in sales with an elasticity of -1.5.

3. Sensitivity Analysis Results

The results of our sensitivity analyses are shown in Table 32. These sensitivity results do not alter the general conclusion that the Step II and Step III standards are much less cost-effective than the Step I standard.

Table 32. Sensitivity of Cost-Effectiveness Results to Alternative Parameter Values

	Base Case	Lower Costs	Upper Costs	Lower Elasticity	Upper Elasticity
Model Parameters					
Cost Inputs	Mid-point	Lower	Upper	Mid-point	Mid-point
Elasticity of Demand	-1	-1	-1	-0.5	-1.5
Social Costs					
No Standard → 0.32	$39,748,000	$29,368,800	$48,504,300	$46,399,500	$33,473,200
0.32 → 0.15	$17,416,400	$13,769,900	$20,304,500	$23,578,500	$12,538,200
0.32 → 0.06	$21,061,100	$15,586,500	$25,289,800	$28,782,100	$15,002,800
0.15 → 0.06	$13,188,000	$11,724,300	$14,310,500	$19,746,300	$8,452,100
Net Emissions Change (tons)					
No Standard → 0.32	-1,465	-1,456	-1,471	-1,446	-1,480
0.32 → 0.15	-55	-62	-49	-70	-42
0.32 → 0.06	-79	-92	-70	-106	-58
0.15 → 0.06	-22	-27	-19	-34	-14
Cost Effectiveness ($/ton)					
No Standard → 0.32	$27,100	$20,200	$33,000	$32,100	$22,600
0.32 → 0.15	$317,900	$221,300	$411,700	$338,300	$296,800
0.32 → 0.06	$266,100	$169,700	$360,600	$272,800	$257,900
0.15 → 0.06	$587,400	$431,000	$744,300	$575,300	$600,600

Source: NERA calculations as explained in text
Note: Parameters differing from base case assumptions are in red.

V. Conclusions

This study has evaluated the cost per ton of increasingly stringent NSPS for hydronic heaters. Using detailed information on compliance costs and economic methodology consistent with EPA guidelines for economic analysis, we have developed estimates of the incremental cost per ton for three alternative new source performance standards (NSPS).

1. Step I standard of 0.32 lb/MMBtu (the current Voluntary Program standard);

2. Step II standards of 0.15 and 0.06 lb/MMBtu; and

3. Step III standard of 0.06 lb/MMBtu (from a Step II standard of 0.15 lb/MMBtu).

Our analysis indicates that the Step II standards (reflecting a tightening from 0.32 lb/MMBtu to 0.15 or 0.06 lb/MMBtu) would cost about ten times as much per ton of emission reduction as the Step I standard (reflecting a transition from no standard currently to 0.32 lb/MMBtu), and the Step III standard (reflecting a tightening from 0.15 lb/MMBtu in Step II to 0.06 lb/MMBtu) would cost nearly twice as much per ton as the Step II standard of 0.15 lb/MMBtu. The large costs for the Step II and Step III standards would cause large price increases for hydronic heaters and severe contractions in hydronic heater sales quantities as well as reductions in the scrappage of older higher-emitting heaters.

We estimate that the Step I standard would reduce annual emissions from new hydronic heaters by about 1,500 tons. Tightening the standard to 0.15 lb/MMBtu in Step II would reduce annual heater emissions by only 55 more tons, and it would cost over ten times as much as the Step I standard. Tightening the standard further to 0.06 lb/MMBtu in Step II or Step III would reduce annual emissions by about 20 more tons (beyond a 0.15 lb/MMBtu standard).

We considered the implications of uncertainties related to compliance costs and the price elasticity of demand. Although the specific estimates change under alternative parameters, none of the sensitivity cases modified our basic conclusions, i.e., that the Step II and Step III standards would be much less cost-effective than the Step I standard, would cause large increases in hydronic heater prices and severe contractions in hydronic heater sales quantities, and would lead to reductions in the scrappage of older higher-emitting heaters.

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Proposed Wood Heater NSPS Incremental Cost Effectiveness Analyses

Appendix A

Hydronic Heater Cost Modeling

Prepared for the Hearth, Patio & Barbecue Association

By Robert Ferguson

Ferguson, Andors & Company

May 2014

I. Introduction and Overview

This appendix describes the methodology for estimating the costs of modifying hydronic heater models to comply with potential changes to the EPA New Source Performance Standards for hydronic heaters. The Hearth, Patio & Barbecue Association (HPBA) engaged Ferguson, Andors & Company to develop the cost estimates and provide them to NERA Economic Consulting for cost-effectiveness analysis. As discussed below, a "bottom-up" approach was used to identify the relevant components of compliance costs and to develop a range of cost estimates for each cost component based on our extensive experience in wood-burning heater product development, testing and manufacturing. The cost estimates were focused on whole house hydronic heaters with outputs in the 100,000 to 150,000 Btu/h range. In developing the cost estimates, detailed comments from a review panel consisting of industry experts from five hydronic heater manufacturers were incorporated. The range of cost estimates resulting from this process are representative of typical manufacturers and typical hydronic heater models, but actual costs for particular manufacturers could lie outside the range. NERA used the midpoints (averages) of the cost ranges for the cost-effectiveness analysis.

The following subsections of this introductory section provide brief background on Robert Ferguson (of Ferguson, Andors & Company) and the expert reviewers, an overview of the emission rate categories used in the cost-effectiveness analysis, an overview of the cost categories, a summary of the cost estimates, and discussion of omitted costs. The second section of this appendix identifies the components of each cost category and presents tables with the detailed cost estimates. The appendix concludes with a section describing the expert review process. CVs for Robert Ferguson and each of the expert reviewers are included at the end.

A. Background on Robert Ferguson and Expert Reviewers

Robert Ferguson has worked in the hearth product industry for over thirty-three years and is now among the foremost experts in the country for the hearth industry, particularly with regard to product development, testing and manufacturing. He holds a degree in chemical engineering, worked as a senior manager for a major woodstove manufacturer from 1980 to 1990, and founded Ferguson, Andors & Company in 1991. The company provides a full range of product development consulting and regulatory compliance services. Clients include small and large companies from around the world. This extensive experience and unparalleled expertise allowed development of accurate compliance cost estimates that reflect actual input requirements and the diversity of hydronic heater manufacturers. Mr. Ferguson's CV appears at the end of this appendix.

Experts from five hydronic heater companies were consulted to ensure that the cost estimates were accurate and reflected the wide range of potential costs for hydronic heater manufacturers. As shown in their CVs appearing at the end of this appendix, the industry experts have many years of experience designing, manufacturing and marketing hydronic heaters (ranging from 3.5 years to almost 33 years) and represent small and larger companies.

For most cost components, the initial estimates were provided to the expert panel for independent review. Their feedback was incorporated into the final cost estimates (preserving the confidentiality of any sensitive business information). Additional information on the expert review process is provided in the final section of this appendix.

B. Overview of Emissions Rate Categories

As discussed in the NERA Report, hydronic heaters were divided into categories based on emission rate for this cost-effectiveness analysis. The first category is uncontrolled hydronic heaters being brought into compliance with the Step 1 standard of 0.32 lb/mmBtu Output. The next two categories include hydronic heaters complying with potential new standards of 0.15 lb/mmBtu Output and 0.06 lb/mmBtu Output. The final category evaluates the incremental cost impacts of a 0.06 standard relative to a 0.15 standard.

Consistent with the EPA proposal, the cost-effectiveness analysis assumes that the EPA regulations would be implemented in two or three steps. In the first step, all hydronic heaters would have to comply with the 0.32 lb/mmBtu Output standard. In the second step, the analysis evaluates the impacts of tightening the standard to either 0.15 lb/mmBtu Output or 0.06 lb/mmBtu Output. The impacts of the three step approach with Step 2 at 0.15 lb/mmBtu Output and Step 3 at 0.06 lb/mmBtu Output are also assessed by the incremental cost analysis (a 0.06 standard relative to a 0.15 standard).

Cost estimates were developed for each of these steps in regulatory implementation. For the first step, the costs of modifying uncontrolled models to comply with a 0.32 lb/mmBtu Output standard were estimated. For the second step, the costs of modifying 0.32 lb/mmBtu Output models to comply with new standards of 0.15 lb/mmBtu Output or 0.06 lb/mmBtu Output were estimated. For the potential third step, the costs of modifying 0.15 lb/mmBtu Output models to comply with a 0.06 lb/mmBtu Output standard were estimated. Costs reflect additional labor and materials for technological modifications to improve the emission performance of the hydronic heater models while leaving the other features of the models essentially unchanged.

C. Overview of Cost Categories

The first step was to identify and catalogue the numerous components of compliance costs to design, manufacture, certify and market modified hydronic heater models that would be anticipated to achieve compliance with the proposed emission standards. The cost components can be grouped into three categories:

1. *Capital costs per model*. These include costs for research and development (R&D), engineering labor, tooling, equipment, integration, preliminary testing, and other costs to design and manufacture the modified hydronic heater models. Capital costs per heater

model were estimated for each relevant modification (e.g., 0.32 lb/mmBtu Output to 0.15 lb/mmBtu Output).

2. *Other fixed costs per model*. These include costs for certification testing (EPA and safety listing) and roll-out of the modified products (including display models and burn programs, brochures, user manuals). Fixed costs per heater model were estimated for each relevant modification scenario (e.g., 0.32 lb/mmBtu Output to 0.15 lb/mmBtu Output).
3. *Variable costs per unit*. These include incremental costs for materials associated with the improved emission performance plus machining, assembly and inspection labor for each unit produced. Variable costs per unit produced were estimated (in contrast to costs per model as with capital and fixed costs).

Each cost component was estimated as incremental costs for compliance with new emission standards beyond baseline costs that would be incurred for existing models. As noted above, estimates for each cost component typically depend on the modification scenario (e.g., 0.32 lb/mmBtu Output to 0.15 lb/mmBtu Output), but some cost components have similar estimates for all relevant modifications meaning that the overall cost estimates and levels of the standards do not necessarily have a linear relationship. Subsequent sections of this appendix present detailed information on the cost estimates by category and modification scenario.

D. Summary of Cost Estimates

The table below presents a summary of the cost estimates for the four relevant modification scenarios. As noted above, a range of estimates for each cost category were developed, and NERA used the midpoint (average) of each range for the cost-effectiveness analysis.

In the table below, the first column for each modification scenario shows the lower end of the cost range, the second column shows the upper end of the cost range, and the third column shows the midpoint of the cost range (the value used by NERA). Capital costs and fixed costs are per model, while variable costs are per unit. The cost estimates are in 2013 dollars. Detailed information on the cost estimates appears in subsequent sections of this appendix.

Table 1. Summary of Cost Estimates

	Uncontrolled to ≤0.32			≤0.32 to ≤ 0.15		
	Lower	Upper	Midpoint	Lower	Upper	Midpoint
Capital Costs per Model	$ 942,500	$1,509,000	$1,225,750	$950,500	$1,513,500	$1,232,000
Fixed Costs per Model	$279,500	$756,500	$518,000	$279,500	$759,000	$519,250
Total Costs per Model	$1,222,000	$2,265,500	$1,743,750	$1,230,000	$2,272,500	$1,751,250
Variable Costs per Unit	$1,820	$3,650	$2,735	$675	$1,375	$1,025
	≤0.32 to ≤ 0.06			≤0.15to ≤ 0.06		
	Lower	Upper	Midpoint	Lower	Upper	Midpoint
Capital Costs per Model	$1,329,500	$1,941,600	$1,635,550	$1,137,500	$1,726,500	$1,432,000
Fixed Costs per Model	$279,500	$774,000	$526,750	$279,500	$764,000	$521,750
Total Costs per Model	$1,609,000	$2,715,600	$2,162,300	$1,417,000	$2,490,500	$1,953,750
Variable Costs per Unit	$675	$1,850	$1,263	$600	$1,000	$800

Note: All Costs are in 2013 dollars.

E. Omitted Costs

The cost estimates do not include the impacts of EPA's proposed revisions to the testing requirements or to the algorithm used to determine compliance with Step 2/3 standards. These revisions, if included in the final rule, can only be expected to cause an increase to both development and certification costs over what is reflected.

II. Cost Components

This section provides details on the three categories of costs to modify hydronic heaters to comply with new standards: (1) capital costs per model; (2) other fixed costs per model; and (3) variable costs per unit. The tables below show the lower and upper ends of the cost estimate ranges for components within each cost category.

A. Capital Costs per Model

Capital costs to modify hydronic heater models for the four relevant modification scenarios were estimated. Capital costs were divided into three subcategories:

1. *Research and Development (R&D) and Engineering*. This subcategory includes capital costs for product research, product design, prototype construction and extensive in-house testing.
2. *Tooling*. This subcategory includes capital costs for acquiring and installing the machinery to produce the modified hydronic heaters. *Other capital cost components*. This subcategory includes miscellaneous capital costs, including sourcing and qualifying parts purchases, testing first production models, integrating equipment, and preparing facilities.

The following subsections present detailed information on these subcategories of capital costs.

1. Research and Development (R&D) and Engineering

The following table presents the ranges of cost estimates per model for R&D and engineering costs within the capital cost category. Many of these components would be the same for all modification scenarios (e.g., market research, aesthetic design, and initial prototype design), but the costs of some components would differ significantly by modification scenario (e.g., repeating the design/modify/test cycle until the emission target is met). If manufacturers must reduce the emission rates of their hydronic heaters by large increments, their costs for designing and testing new hydronic heater models would increase roughly in proportion.

Table 2 - Capital Costs per Model: R & D and Engineering

	Uncontrolled to ≤ 0.32		≤ 0.32 to ≤ 0.15		≤ 0.32 to ≤ 0.06		≤ 0.15 to ≤ 0.06	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
R & D/Engineering								
Preliminary Product Research and Scoping	$ 50,000	$ 70,000	$ 20,000	$ 30,000	$ 20,000	$ 30,000	$ 20,000	$ 30,000
Initial Prototype Design (with Drawings)	$ 20,000	$ 30,000	$ 10,000	$ 20,000	$ 10,000	$ 20,000	$ 10,000	$ 20,000
Initial Prototype Construction								
Steel Fabrication	$ 5,000	$ 10,000	$ 5,000	$ 10,000	$ 5,000	$ 10,000	$ 5,000	$ 10,000
Prototype Refractory Molds	$ 5,000	$ 7,500	$ 2,500	$ 5,000	$ 5,000	$ 10,000	$ 5,000	$ 10,000
Mechanical Systems (Blowers, Pump(s), Actuators, etc.)	$ 2,500	$ 7,500	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 2,500	$ 5,000
Breadboard Electronic Controls (or simulation)	$ 7,500	$ 15,000	$ 5,000	$ 10,000	$ 5,000	$ 12,500	$ 5,000	$ 15,000
Baseline Testing on First Development Prototype	$ 25,000	$ 40,000	$ 25,000	$ 40,000	$ 25,000	$ 40,000	$ 25,000	$ 40,000
Formulate Design Changes - Initial and Subsequent								
Combustion System (incl. firebox components & mechanicals)	$ 500	$ 1,000	$ 500	$ 1,000	$ 500	$ 1,000	$ 500	$ 1,000
Heat Exchange System	$ 500	$ 1,000	$ 500	$ 1,000	$ 500	$ 1,000	$ 500	$ 1,000
Mechanical Systems (Blowers, Pump(s), Actuators, etc.)	$ 500	$ 1,000	$ 500	$ 1,000	$ 500	$ 1,000	$ 500	$ 1,000
Electronic Control System	$ 1,000	$ 1,500	$ 1,000	$ 1,500	$ 1,000	$ 1,500	$ 1,000	$ 1,500
Modify Prototype - Initial and Subsequent								
Combustion System	$ 1,000	$ 1,500	$ 1,000	$ 1,500	$ 1,000	$ 1,500	$ 1,000	$ 1,500
Refractory Material Trials	$ 5,000	$ 10,000	$ 5,000	$ 10,000	$ 5,000	$ 10,000	$ 5,000	$ 10,000
Heat Exchange System	$ 1,000	$ 1,500	$ 1,000	$ 1,500	$ 1,000	$ 1,500	$ 1,000	$ 1,500
Electronic Control System (Control Board Logic Mods, etc.)	$ 2,000	$ 3,000	$ 2,000	$ 3,000	$ 2,000	$ 3,000	$ 2,000	$ 3,000
Test Modified Prototype - Initial and Subsequent	$ 10,000	$ 15,000	$ 10,000	$ 20,000	$ 10,000	$ 25,000	$ 10,000	$ 25,000
Repeat Design/Modify/Test Cycle Until Emission Target is Met	$ 400,000	$ 600,000	$ 500,000	$ 800,000	$ 800,000	$ 1,100,000	$ 600,000	$ 900,000
Construct Final Prototype(s) for Certification Testing	$ 15,000	$ 20,000	$ 15,000	$ 20,000	$ 15,000	$ 20,000	$ 15,000	$ 20,000
Refined Refractory Molds and Final Material	$ 5,000	$ 10,000	$ 5,000	$ 10,000	$ 7,500	$ 15,000	$ 7,500	$ 15,000
Refined Electronic Control System	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 2,500	$ 5,000
Final Mechanicals	$ 1,000	$ 1,500	$ 1,000	$ 1,500	$ 1,000	$ 1,500	$ 1,000	$ 1,500
Confirm Final Prototype Performance (In-House Testing)	$ 60,000	$ 90,000	$ 60,000	$ 90,000	$ 75,000	$ 100,000	$ 75,000	$ 100,000
Safety Test Check	$ 5,000	$ 7,000	$ 5,000	$ 7,000	$ 5,000	$ 7,000	$ 5,000	$ 7,000
Document Final Design Changes -Eng. Drawings and Part Specs.	$ 6,000	$ 8,000	$ 6,000	$ 8,000	$ 6,000	$ 8,000	$ 6,000	$ 8,000
R & D/Engineering Total Cost Ranges	$ 581,000	$ 887,000	$ 666,000	$ 1,072,000	$ 986,000	$ 1,399,500	$ 786,000	$ 1,202,000

Note: All costs are in 2013 dollars.

2. Manufacturing Engineering and Tooling

The following table presents the ranges of cost estimates per model for tooling within the capital cost category. As with R&D and engineering costs, many tooling components have the same costs for all modification scenarios, but some components have higher costs for large increments between the model's current and new emission rates. Refractory molds are a good example as most of the combustion improvements seen in today's voluntary program models have involved significant amounts of custom refractory components as part of their firebox and secondary combustion system designs.

Table 3 - Capital Costs per Model: Manufacturing/Manufacturing Engineering (Including Tooling)

Manufacturing/Manufacturing Engineering	Uncontrolled to ≤ 0.32		≤ 0.32 to ≤ 0.15		≤ 0.32 to ≤ 0.06		≤ 0.15 to ≤ 0.06	
Programming and Tooling - Steel Parts	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Translate Eng. Part Drawings into Production Part Drawings	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 4,500	$ 7,500	$ 3,500	$ 6,000
NC Programming Steel Parts	$ 4,000	$ 6,000	$ 3,000	$ 5,000	$ 5,000	$ 8,000	$ 4,000	$ 6,500
Preliminary Jigs and Fixtures	$ 2,500	$ 5,000	$ 1,500	$ 3,000	$ 2,000	$ 4,000	$ 1,500	$ 3,000
Make Test Parts	$ 4,000	$ 6,000	$ 3,000	$ 4,000	$ 5,000	$ 5,200	$ 4,000	$ 5,000
Tooling - Refractory								
Translate Eng. Part Drawings into Production Part & Mold Dwgs	$ 2,500	$ 5,000	$ 3,000	$ 4,500	$ 5,000	$ 7,500	$ 4,000	$ 6,000
Produce Initial Production Molds	$ 20,000	$ 30,000	$ 15,000	$ 20,000	$ 20,000	$ 30,000	$ 15,000	$ 25,000
Make Test Parts	$ 3,000	$ 5,000	$ 2,500	$ 3,500	$ 4,500	$ 6,000	$ 3,500	$ 4,500
Refine and Finalize Refractory Molds	$ 2,500	$ 5,000	$ 2,000	$ 4,000	$ 4,000	$ 5,200	$ 3,000	$ 5,000
Electronic Control System								
Translate Prototype Control into Production Part	$ 5,000	$ 10,000	$ 2,000	$ 4,000	$ 4,000	$ 5,200	$ 3,000	$ 5,000
Obtain Final Production Samples - All Fab. & Purch. Parts	$ 10,000	$ 15,000	$ 5,000	$ 7,000	$ 6,500	$ 9,000	$ 5,000	$ 7,000
Confirm Production Part Fit-up	$ 5,000	$ 10,000	$ 5,000	$ 7,500	$ 6,500	$ 9,500	$ 5,000	$ 7,500
Create QA/QC Specs	$ 2,000	$ 4,000	$ 1,500	$ 3,000	$ 3,000	$ 4,000	$ 1,500	$ 3,000
Manufacturing/Manufacturing Engineering Total Cost Ranges	$ 63,000	$ 106,000	$ 46,000	$ 70,500	$ 70,000	$ 101,100	$ 53,000	$ 83,500

Note: All costs are in 2013 dollars.

3. Other Capital Cost Components

The following table presents the ranges of cost estimates per model for other components within the capital cost category. These include sourcing and qualifying parts purchases, testing first production models, durability testing, integrating equipment, and preparing facilities. Each of these other capital cost components varies depending on the modification scenario.

Table 4 - Capital Costs per Model - Other Cost Componets

Purchasing	Uncontrolled to ≤ 0.32		≤ 0.32 to ≤ 0.15		≤ 0.32 to ≤ 0.06		≤ 0.15 to ≤ 0.06	
New Major Purchased Parts Sourcing	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Refractory Components								
Specify and Source Parts	$ 5,000	$ 10,000	$ 5,000	$ 10,000	$ 5,000	$ 10,000	$ 5,000	$ 10,000
Obtain and Qualify Samples	$ 5,000	$ 10,000	$ 5,000	$ 10,000	$ 5,000	$ 10,000	$ 5,000	$ 10,000
Electronic Control System								
Specify and Source Parts	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 2,500	$ 5,000
Obtain and Qualify Samples	$ 8,000	$ 10,000	$ 8,000	$ 10,000	$ 8,000	$ 10,000	$ 8,000	$ 10,000
QA/QC Specs	$ 2,000	$ 4,000	$ 2,000	$ 4,000	$ 2,000	$ 4,000	$ 2,000	$ 4,000
Order Initial Production Quantities	$ 1,000	$ 2,000	$ 1,000	$ 2,000	$ 1,000	$ 2,000	$ 1,000	$ 2,000
Purchased Parts Sourcing Total Cost Ranges	$ 23,500	$ 41,000	$ 23,500	$ 41,000	$ 23,500	$ 41,000	$ 23,500	$ 41,000
Test First Production Heaters for Form, Fit, Function	$ 25,000	$ 50,000	$ 25,000	$ 50,000	$ 25,000	$ 50,000	$ 25,000	$ 50,000
Test First Production Heaters for Durability	$ 125,000	$ 150,000	$ 125,000	$ 150,000	$ 125,000	$ 150,000	$ 125,000	$ 150,000
Equipment and Integration	$ 100,000	$ 200,000	$ 50,000	$ 100,000	$ 75,000	$ 150,000	$ 100,000	$ 150,000
Facilities	$ 25,000	$ 75,000	$ 15,000	$ 30,000	$ 25,000	$ 50,000	$ 25,000	$ 50,000
Other Capital Costs Total Cost Ranges	$ 298,500	$ 516,000	$ 238,500	$ 371,000	$ 273,500	$ 441,000	$ 298,500	$ 441,000

Note: All costs are in 2013 dollars.

4. Summary of Capital Costs per Model

The following table provides a summary of capital costs per model divided into the three subcategories: (1) R&D/engineering; (2) tooling; and (3) other components. For the midpoints of these cost ranges that NERA used in the cost-effectiveness analysis, see **Error! Reference source not found.** above.

Table 5 - Capital Costs per Model - Summary

	Uncontrolled to ≤ 0.32		≤ 0.32 to ≤ 0.15		≤ 0.32 to ≤ 0.06		≤ 0.15 to ≤ 0.06	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
R & D/Engineering	$ 581,000	$ 887,000	$ 666,000	$ 1,072,000	$ 986,000	$ 1,399,500	$ 786,000	$ 1,202,000
Manufacturing/Manufacturing Engineering /Tooling	$ 63,000	$ 106,000	$ 46,000	$ 70,500	$ 70,000	$ 101,100	$ 53,000	$ 83,500
Other Capital Costs	$ 298,500	$ 516,000	$ 238,500	$ 371,000	$ 273,500	$ 441,000	$ 298,500	$ 441,000
Total Capital Cost per Model	$ 942,500	$ 1,509,000	$ 950,500	$ 1,513,500	$ 1,329,500	$ 1,941,600	$ 1,137,500	$ 1,726,500

Note: All costs are in 2013 dollars.

B. Fixed Costs per Model

The capital costs to modify hydronic heater models for the four relevant modification scenarios were estimated. Capital costs are divided into two subcategories:

1. *Certification*. This subcategory includes fixed costs for EPA emission rate testing, safety testing, labeling, and related costs.
2. *Roll-out*. This subcategory includes fixed costs for marketing materials (e.g., brochures, training materials, and trade show booths), training costs, display models, and product obsolescence (including product discounts while manufacturer clears inventory and continuing support for discontinued products).

The following subsections present detailed information on these subcategories of fixed costs.

1. Certification

The following table presents the ranges of cost estimates per model for certification components within the fixed cost category. As with components of capital costs shown above, several elements of the certification process are more costly when the increment between current emission rate and new emission rate is large (partly because of the likely need for multiple rounds of testing for new tighter standards).

Table 6 - Fixed Costs per Model -Certification

	Uncontrolled to ≤ 0.32		≤ 0.32 to ≤ 0.15		≤ 0.32 to ≤ 0.06		≤ 0.15 to ≤ 0.06	
Certification Testing (EPA and Safety Listing) + Certification	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
EPA Certification Testing	$ 20,000	$ 40,000	$ 20,000	$ 40,000	$ 20,000	$ 50,000	$ 20,000	$ 50,000
Confirmation Safety Testing or Full Safety Testing	$ 15,000	$ 30,000	$ 15,000	$ 30,000	$ 15,000	$ 30,000	$ 15,000	$ 30,000
Shipping of Prototype(s) (if applicable)	$ 1,000	$ 2,500	$ 1,000	$ 4,000	$ 1,000	$ 5,000	$ 1,000	$ 5,000
Personnel at Lab (or Lab Personnel at Factory Lab)	$ -	$ 2,500	$ -	$ 2,500	$ -	$ 5,000	$ -	$ 5,000
Travel Expenses	$ 1,500	$ 2,500	$ 1,500	$ 3,500	$ 1,500	$ 5,000	$ 1,500	$ 5,000
Owner's Manual (Revised or New)	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 2,500	$ 5,000
Labeling (Revised or New)	$ 1,000	$ 1,500	$ 1,000	$ 1,500	$ 1,000	$ 1,500	$ 1,000	$ 1,500
Certification - Total Cost Ranges	$ 41,000	$ 84,000	$ 41,000	$ 86,500	$ 41,000	$ 101,500	$ 41,000	$ 101,500

Note: All costs are in 2013 dollars.

2. Roll-Out

The following table presents the ranges of cost estimates per model for roll-out components within the fixed cost category. The sets of components within roll-out costs in the table are (1) marketing materials; (2) training; (3) marketing and sales programs; and (4) product obsolescence. The latter two sets of components are large parts of total fixed costs.

Table 7 - Fixed Costs per Model -Roll Out

Roll Out (excludes Owner's Manual and Labeling)	Uncontrolled to ≤ 0.32		≤ 0.32 to ≤ 0.15		≤ 0.32 to ≤ 0.06		≤ 0.15 to ≤ 0.06	
Marketing Materials	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Brochure: Stand Alone for revised or new product	$ 5,000	$ 15,000	$ 5,000	$ 15,000	$ 5,000	$ 15,000	$ 5,000	$ 15,000
Training Materials (Rep & Dealer presentations, handouts, etc.)	$ 7,500	$ 15,000	$ 7,500	$ 15,000	$ 7,500	$ 15,000	$ 7,500	$ 15,000
Point of Purchase Materials	$ 7,500	$ 10,000	$ 7,500	$ 10,000	$ 7,500	$ 10,000	$ 7,500	$ 10,000
Web site changes & development Assumption	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 2,500	$ 5,000
Newsletters & Product Updates (Dealer and Rep)	$ 1,000	$ 2,000	$ 1,000	$ 2,000	$ 1,000	$ 2,000	$ 1,000	$ 2,000
Press Releases (Trade and Consumer)	$ 500	$ 1,000	$ 500	$ 1,000	$ 500	$ 1,000	$ 500	$ 1,000
Distribution of marketing materials (Printed and electronic)	$ 1,000	$ 2,500	$ 1,000	$ 2,500	$ 1,000	$ 2,500	$ 1,000	$ 2,500
National & regional trade show booths	$ 10,000	$ 20,000	$ 10,000	$ 20,000	$ 10,000	$ 20,000	$ 10,000	$ 20,000
Training								
Course Development	$ 1,000	$ 2,000	$ 1,000	$ 2,000	$ 1,000	$ 2,000	$ 1,000	$ 2,000
Regional Technical Training	$ 5,000	$ 7,500	$ 5,000	$ 7,500	$ 5,000	$ 7,500	$ 5,000	$ 7,500
Dealer meetings	$ 5,000	$ 7,500	$ 5,000	$ 7,500	$ 5,000	$ 7,500	$ 5,000	$ 7,500
Rep meetings	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 2,500	$ 5,000	$ 2,500	$ 5,000
National & regional trade show costs (shipping & staff costs)	$ 25,000	$ 50,000	$ 25,000	$ 50,000	$ 25,000	$ 50,000	$ 25,000	$ 50,000
Product, sales and technical training videos:	$ 7,500	$ 10,000	$ 7,500	$ 10,000	$ 7,500	$ 10,000	$ 7,500	$ 10,000
Marketing and Sales Programs								
Display Models (Burning)	$ 50,000	$ 150,000	$ 50,000	$ 150,000	$ 50,000	$ 150,000	$ 50,000	$ 150,000
Traveling Display Models	$ 7,500	$ 15,000	$ 7,500	$ 15,000	$ 7,500	$ 15,000	$ 7,500	$ 15,000
Coop Advertising	$ 25,000	$ 50,000	$ 25,000	$ 50,000	$ 25,000	$ 50,000	$ 25,000	$ 50,000
Launch promotions (dealer & consumer discounts, saleman Spiffs)	$ 25,000	$ 75,000	$ 25,000	$ 75,000	$ 25,000	$ 75,000	$ 25,000	$ 75,000
Product Obsolescence								
Product Discounts (while manufacturer clears inventory)	$ -	$ 100,000	$ -	$ 100,000	$ -	$ 100,000	$ -	$ 100,000
Product Buy-backs (from retailers if obsolete product not sold)	$ -	?	$ -	?	$ -	?	$ -	?
Unusable WIP/Purchased Parts/Raw Materials:	$ -	$ 30,000	$ -	$ 30,000	$ -	$ 30,000	$ -	$ 20,000
Continuing support for discontinued product (i.e., replacement parts)	$ 50,000	$ 100,000	$ 50,000	$ 100,000	$ 50,000	$ 100,000	$ 50,000	$ 100,000
Roll-out Total Cost Ranges	$ 238,500	$ 672,500	$ 238,500	$ 672,500	$ 238,500	$ 672,500	$ 238,500	$ 662,500

Note: All costs are in 2013 dollars.

3. Summary of Fixed Costs per Model

The following table provides a summary of fixed costs per model divided into the two subcategories: (1) certification; and (2) roll-out. For the midpoints of these cost ranges that NERA used in the cost-effectiveness analysis, see **Error! Reference source not found.** above.

Table 8 - Fixed Costs per Model - Summary

	Uncontrolled to ≤ 0.32		≤ 0.32 to ≤ 0.15		≤ 0.32 to ≤ 0.06		≤ 0.15 to ≤ 0.06	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Certification	$ 41,000	$ 84,000	$ 41,000	$ 86,500	$ 41,000	$ 101,500	$ 41,000	$ 101,500
Roll Out	$ 238,500	$ 672,500	$ 238,500	$ 672,500	$ 238,500	$ 672,500	$ 238,500	$ 662,500
Total Fixed Cost per Model	$ 279,500	$ 756,500	$ 279,500	$ 759,000	$ 279,500	$ 774,000	$ 279,500	$ 764,000

Note: All costs are in 2013 dollars.

C. Variable Costs per Unit

The following table shows the cost ranges for variable costs per unit produced. Variable costs include materials, labor (machining, assembly, quality assurance / quality control ("QA/QC")), and warranty costs associated with adding new technology and new materials to an otherwise proven design. These estimates reflect variable costs beyond the level for current models. The variable costs increase as the increment between current and new emission rate increases, based on direct experience at Ferguson, Andors & Company with the actual cost impacts on the factory floor. These variable costs per unit have a direct effect on the price of new hydronic heaters (whereas capital costs and fixed costs per model must be converted into costs per unit, as described in the NERA report). For the mid-points of these cost ranges that NERA used in the cost-effectiveness analysis, see **Error! Reference source not found.** above.

Table 9 - Variable Costs per Unit

(Incremental Costs over Starting Point)	**Uncontrolled to ≤ 0.32**		**≤ 0.32 to ≤ 0.15**		**≤ 0.32 to ≤ 0.06**		**≤ 0.15 to ≤ 0.06**	
	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper
Materials	$ 1,000	$ 2,000	$ 500	$ 1,000	$ 500	$ 1,500	$ 500	$ 750
Machining	$ 200	$ 500	$ 50	$ 150	$ 50	$ 100	$ 25	$ 100
Assembly	$ 200	$ 500	$ 25	$ 75	$ 25	$ 100	$ 25	$ 50
Testing	$ 20	$ 50	$ -	$ -	$ -	$ -	$ -	$ -
Warranty	$ 400	$ 600	$ 100	$ 150	$ 100	$ 150	$ 50	$ 100
Total Variable Cost Ranges	$ 1,820	$ 3,650	$ 675	$ 1,375	$ 675	$ 1,850	$ 600	$ 1,000

Note: All costs are in 2013 dollars.

III. Expert Review Process

This section provides information on the expert review process in which we solicited, received, and incorporated feedback from other industry experts (the "Expert Panel") for estimating the costs of modifying hydronic heater models to comply with the tighter standards that EPA has proposed.

The Expert Panel was selected to provide both great depth in product development and manufacturing experience and to be representative of a broad range of manufacturers. The identity and background of the members of the Experts Panel is provided at the end of this appendix.

Each Expert Panelist was given a briefing over the telephone, which outlined what was expected of the panelists in detail as well as providing an opportunity for answering any questions. On that call, the panelists were also briefed on the forms that were used to record responses, and the form that was used to document the panelists' backgrounds as industry experts. Panelists agreed to provide specific feedback during this process but as a condition of participating were promised that individual company information would be protected as Confidential Business Information and would not be disclosed as part of this modeling effort.

The Experts Panel was asked to evaluate the cost ranges in the models from the perspective of whether they pass the "reasonableness" test for a typical hydronic heater, based on their experience in the industry. The panelists were asked to first consider the "macro" ranges presented for each of the main cost categories, and then consider each item in the breakdown within each category. If a panelist felt that some element of the modeling was not appropriate, they were asked to provide an alternate cost range that they felt was more representative, along with an explanation of their rationale. They were also asked to consider if any significant cost categories or sub-categories had been omitted from the model and to comment if that was the case, and to provide recommended representative cost values for the categories/subcategories in question.

The comments and suggestions ranged from broad to very detailed in nature. In some cases, the comments reflected individual company experience with some of the larger cost items. In other cases, some of the individual values in particular cells in a category in the model were questioned, while at the same time offering support for the aggregated costs in the category.

Issues like product development cycle costs and testing costs were among the items more commonly addressed. In all cases, each comment or suggestion received was considered on its merits with particular focus on whether it seemed too company-specific or had broader application to the industry.

In evaluating comments, additional weight was appropriately given when similar comments were received from more than one panelist. In the end, we used our expert judgment in weighing the comments and to make adjustments to modeled values where needed to insure the modeling was as representative as possible of the industry as a whole. As mentioned previously, in order to maintain confidentiality of company-specific feedback, suggested revisions and comments received from individual panelists are considered as CBI and are not discussed.

It must be noted that several of the expert panel companies questioned whether they could even develop a marketable model meeting the proposed Step 2/3 standards under any circumstances. They expressed their concerns, based on their investment and level of effort in in achieving Voluntary Program Phase 2 qualification for some of their models, over whether they could find adequate development resources and design improvements to meet the more stringent standards and, even if they could, whether the resultant designs would be affordable or reliable and durable in the field. The cost estimates, as presented, assume that those hurdles can ultimately be overcome but this assumption is not universally accepted by the experts.

IV. Curricula Vitae for Mr. Ferguson and Expert Panelists

The CVs of Mr. Ferguson and members of the Expert Panels are provided below.

HPBA NSPS Economic Modeling Engineering Consultant

Name: Robert W. Ferguson

Total Years in the Hearth Products Industry: 33

Companies and Dates of Affiliation:
Vermont Castings 1980-1990
Ferguson, Andors & Company 1991 - Present

Positions Held and Description of Responsibilities:
Vermont Castings

- Director of Research and Development
  - Responsible for all aspects of product development, product performance and product safety.

Ferguson, Andors & Company

- President
  - Founded Ferguson, Andors & Company in 1991, offering a full range of product development consulting and regulatory compliance services focused on the hearth, patio and barbecue industry. Clients include both small and large companies from around the world. Products developed include solid fuel and gas-burning appliances.
  - Providing HPBA with technical consulting services for the NSPS review/revision process that is now in the proposal stage at EPA.

Significant Accomplishments (include US Patents if applicable):

- Co-inventor for a number of patents related to the hearth product performance and combustion technology.

Trade and Professional Group Affiliations and Positions Held:

- Wood Heating Alliance (HPA/HPBA) Board of Directors
- Hearth Education Foundation Board of Directors/Treasurer
- WHA/HPA Government Affairs Committee Chair
- Represented the manufacturers' interests during the Regulatory Negotiations (RegNeg) that resulted in the current EPA New Source Performance Standards for Wood Heaters.
- ASTM Member, Task Group and Working Group Chairs
  - Chaired or acted as facilitator during the development of the ASTM solid fuel particulate measurement, fireplace PM emissions, wood heater PM emissions, pellet heater PM emissions and partial thermal storage hydronic heater PM emissions test methods. CSA B365 and B415.1 Technical Committee Member.

Other Relevant Information:

- BS Chemical Engineering, Clarkson University, 1972

Expert Panel

A list of the Expert Panelists and their credentials follows.

HPBA NSPS Economic Modeling Review Panelist 1

Name: Tammara Kennedy
Total Years in the Hearth Products Industry: 6 years
Companies and Dates of Affiliation: Hardy Manufacturing Co., Inc.- June 2006 to Present
Positions Held and Description of Responsibilities: Chief Financial Officer, Hardy Manufacturing Co., Inc.

- Responsible for the financial decisions including capital acquisitions, improvements, reconciliation's, reviews, adequate cash flow procedures, tax exemptions, tax reporting & filing, loan preparation and insurance considerations.
- Prepare weekly financial reports for review of financial concerns and analysis.
- Prepare, organize, and update internal controls relevant to business operations.
- Responsible for the implementation of an Inventory Control System.
- Integrated the Inventory Control System with Financial Accounting System to ensure accuracy and efficiency in Financial Reporting.
- Audit and analyze accounting systems, as needed to ensure adequate controls.
- Assist President and management as needed on special projects and concerns.

Trade and Professional Group Affiliations and Positions Held:
Member of Mississippi Association of Public Accountants (MAPA) June 2006 to Present
Other Relevant Information:
Education
2001 MASTER OF PROFESSIONAL ACCOUTANCY, MSU
1994 BACHELOR OF PROFESSIONAL ACCOUNTANCY, MSU
Other Financial Experience
Internal Audit Manager, Mississippi Band of Choctaw Indians (2001 – 2005)

- Performed all functions to administer the operation of the Choctaw Gaming Commission Audit Division.
- Reviewed and analyzed monthly financial statements for Gaming Operations for Pearl River Resort.
- Prepared audit programs and revised audit programs based on evolving systems and regulations.
- Analyzed and assessed all compliance reviews, investigations, and other projects assigned to the division.
- Determined the staffing assignments based on staff experience, professional development and the audit department's needs and time constraints.
- Monitored staff's work through examination of their audit papers, inquiries, and filing of reports.

HPBA NSPS Economic Modeling Review Panelist 2

Name: Kenneth R. Partridge

Total Years in the Hearth Products Industry: 7 Years

Companies and Dates of Affiliation:

Hardy Manufacturing Co., Inc. November 2005 - Present

Positions Held and Description of Responsibilities:

- Office Manager
- R&D Manager
- Technical Support
- Test Engineer
- New Product Development

Significant Accomplishments (include US Patents if applicable):

- Existing products improvements.
- New product development.
    - Development of a Phase I EPA Voluntary Program Compliant Outdoor Wood Burning Heater
    - Development of Two (2) Phase II EPA Voluntary Program Compliant Outdoor Wood Burning Heaters
    - Development of a Phase II EPA Voluntary Program Compliant Outdoor Biomass Pellet Burner

Other Relevant Information:

25 years experience in the HVAC industry in numerous management positions.

HPBA NSPS Economic Modeling Review Panelist 3

Name: Frank L. Moore

Total Years in the Hearth Products Industry: 27 Years

Companies and Dates of Affiliation:

Hardy Manufacturing Co., Inc. January 1986 - Present

Positions Held and Description of Responsibilities:

- Sales Engineer 1986 - 1987
- Product Engineer 1987 - 1991
- President 1991 - 1996
- CEO 1996 - 2012

Significant Accomplishments (include US Patents if applicable):

- Improvements to Standard product line
- Changes to increases production efficiency
- Safety listings with UL and the University of Maine Safety Listing
- On Development Team of Waste Oil Furnaces and Outside Fuel Oil Furnaces
- On Development Team of a UL listed Propane Stainless Steel Grill
- On Development Team of 2nd Generation Outdoor Wood burning Gasification Appliance.

Trade and Professional Group Affiliations and Positions Held:

- NFPA 20 Secondary Member
- NFPA 25 Principle Member
- ASTM E06.54.08 (ASTM E2618) – Chairman during development process through 1st publication
- HPBA Outdoor Hydronic Heater Caucus – Chairman
- Central Electric Power Association – Board of Directors

Other Relevant Information:

- Worked with HPBA, EPA and NESCAUM during the development stages of the Voluntary Program for Outdoor Hydronic Heaters.
- Worked with EPA as the Hydronic Heater Representative during the initial NSPS Process.
- Worked with EPA and The Small Business Administration during the SBREFA process.

HPBA NSPS Economic Modeling Review Panelist 4

Name: Gerry Reed

Total Years in the Hearth Products Industry: 30 Years

Companies and Dates of Affiliation:

Heatmor, Inc., Inc. 1984 - Present

Positions Held and Description of Responsibilities:

- Owner
  - Responsible for overall development of products including clean-burning technology

Significant Accomplishments (include US Patents if applicable):

- Introduction of 409 stainless steel to the industry
- Among the first to manufacture a stand-alone, enclosed unit that would ultimately be known as and outdoor hydronic heater
- First to develop logic control for a hydronic heater.

Trade and Professional Group Affiliations and Positions Held:

Other Relevant Information:

- Have tested wood-burning equipment to the point of having a clear understanding of the parameters of burning wood as a home-heating fuel.

HPBA NSPS Economic Modeling Review Panelist 5

Name: Robin Weaver

Total Years in the Hearth Products Industry: 18

Companies and Dates of Affiliation:
Mahoning Outdoor Furnace 1995 to present

Positions Held and Description of Responsibilities:
- Accounting & Office Manager 1995 – 2002
- Owner & President 2002 to present

Significant Accomplishments (include US Patents if applicable):
- Still in business despite bad economy and rising prices.

Trade and Professional Group Affiliations and Positions Held:
- HPBA, Hydronic Heater Caucus 1997 to present
- ASTM E06.54.08 Hydronic Heater Task Group

Other Relevant Information:
- Developed EPA Phase II Qualified OWHH product

HPBA NSPS Economic Modeling Review Panelist 6

Name: Richard "Jiggs" Blackburn

Total Years in the Hearth Products Industry: 34 years

Companies and Dates of Affiliation:

Jøtul USA, Inc., Portland, Maine	1980 to 1984
Vermont Castings, Inc., Randolph, Vermont	1984 to 1985
Shelton Research, Santa Fe, New Mexico	1985 to 1986
Omni Environmental Services, Beaverton, Oregon	1987
Vermont Castings, Inc., Bethel, Vermont	1987 to 1994
CFM US Corporation, Stove Group, Bethel, Vermont	2003 to 2005
Rising Stone, Inc., Woodstock, Vermont	1994 to 2003, 2005 to Present

Positions Held and Description of Responsibilities:

Jøtul USA, Inc.	Director of New Product Development
Vermont Castings, Inc.	Product Manager, Stoves and Fireplaces
Shelton Research	Vice President and General Manager
Omni Environmental Services	Director of Testing Services
Vermont Castings, Inc.	Director of Research and Development
Vermont Castings, Inc.	Director of Development Engineering
Vermont Castings, Inc.	Vice Pres., New Business Development, *Board Member*
Vermont Castings, Inc.	Managing Director, VCW International, *Board Member*
CFM US Corporation, Stove Group	Director of R & D and Engineering
Rising Stone, Inc.	President/Owner

Significant Accomplishments (include US Patents if applicable):
Patents
- Pellet Burning Stove, Des. 327, 734, 1992
- Fireplace Front, Des. 327,735, 1992
- Gas Log Fireplace with High Output, #5,092,313, 1992
- Pellet Burning Stove, #5,137,012, 1992

CFM US Corporation, Stove Group
- Developed three of the top five low emissions non-catalytic EPA certified woodstoves produced in the industry.
- Created a new non-catalytic wood burning technology for company. 2003-2005.

Trade and Professional Group Affiliations and Positions Held:

Underwriters Laboratories Fire Council 1982-1983

Other Relevant Information:

Rising Stone, Inc.	Clients include: Lennox, HVAM, Harman Stove Co., EnterpriseVITA, NESCAUM & Mahoning Outdoor Furnace

HPBA NSPS Economic Modeling Review Panelist 7

Name: Chuck Gagner

Total Years in the Hearth Products Industry: 25

Companies and Dates of Affiliation:
Northwest Manufacturing, Inc 1989 to present

Positions Held and Description of Responsibilities:

- Owner & President

Significant Accomplishments (include US Patents if applicable):

- Northwest Manufacturing is leading company in the alternative heating industry with indoor, outdoor, residential and commercial heating appliances

Trade and Professional Group Affiliations and Positions Held:

- HPBA, Hydronic Heater Caucus 1997 to present
- ASTM E06.54.08 Hydronic Heater Task Group

Other Relevant Information:

- Company employs nearly 100 people
- 200 dealers across US and Canada
- Chuck Gagner designed and built a furnace to heat his home in 1989. When his neighbors asked him to build one for them, he partnered with his two brothers, Ron and Bruce. They decided to purchase a building and start what is now Northwest Manufacturing, Inc. Chuck is actively involved with the Hearth, Patio & Barbeque Association and stays on top of the ever-changing heating industry. Based in Red Lake Falls, Minnesota, Northwest Manufacturing has grown to nearly 100 employees and a network of more than 200 dealers across the United States and Canada. With indoor and outdoor, commercial and residential furnace models available and continuous operation for over twenty-five years, Northwest Manufacturing, Inc. is one of the leaders in the alternative heating industry.

HPBA NSPS Economic Modeling Review Panelist 8

Name: Mark Reese

Total Years in the Hearth Products Industry: 23 Years

Companies and Dates of Affiliation: Central Boiler, Inc.

Positions Held and Descriptions of Responsibilities:

- Engineering – Product design, testing of wood boilers.
- R&D Engineer – Product design, research and development. Gas fireplaces, boilers, wood fuel and multi-fuel boilers.
- Chief Engineer – Oversee new product development, emission and efficiency testing, compliance, test method development for boilers.

Significant Accomplishments (include US Patents if applicable):

- Several patents related to combustion and construction of heating appliances.
- Involved in designing many different heating appliances from pressurized gas boilers and fireplaces to biomass pellet/stick burning boilers.

Trade and Professional Group Affiliations and Positions Held:

- ASTM – E2618 – 13 Sub-Committee Chairman/Technical Contact
- HPBA – Technical Committee Member
- Collaborated with EPA on their voluntary program for Hydronic Heaters

Other Relevant Information:

- Degrees in Mechanical Engineering/Industrial Technology with a core concentration on Product Development

HPBA NSPS Economic Modeling Review Panelist 8

Name: Chris Tureson

Total Years in the Hearth Products Industry: 3.5 years

Companies and Dates of Affiliation: Central Boiler, Inc. 2010 - Current

Positions Held and Descriptions of Responsibilities:

- Corporate Relations: Communicate with local, state and federal agencies and government regarding regulations, research and advise on developing regulations.

Significant Accomplishments (include US Patents if applicable):

Trade and Professional Group Affiliations and Positions Held:

- Licensed Attorney – State of Colorado - Since 1995
- Board Member – Biomass Thermal Energy Council

Other Relevant Information:

- 1992 Graduate of Concordia College - B.A. Business Administration and Political Science
- 1995 J.D. University of North Dakota
- Licensed Attorney – Colorado – Since 1995

HPBA NSPS Economic Modeling Review Panelist 8

Name: David McDonald

Total Years in the Hearth Products Industry: 8

Companies and Dates of Affiliation: Central Boiler, Inc. – March 2006 - present

Positions Held and Description of Responsibilities:

- Eight years of experience in the outdoor hydronic heater industry and currently serves in Environmental Relations for Central Boiler, Inc.
- Works with State air regulators, local and State lawmakers, and lobbyists to support reasonable regulations for outdoor hydronic heaters.
- Works with dealers and consumers on State regulations.
- Ensure reasonable regulations are passed for current and future consumers of outdoor hydronic heaters and unreasonable regulations are not passed or overturned.
- Educating and transitioning Central Boiler, the extensive dealer network and public regarding the NSPS rulemaking process for hydronic heaters.

Significant Accomplishments (include US Patents if applicable):
When the original NSPS was enacted in 1988 it was based upon work being done in one State regulation. Since my involvement with State regulatory issues began at Central Boiler the States of Vermont, Maine, New Hampshire, Massachusetts, Maryland, Pennsylvania, Rhode Island, New York, Indiana and Oregon have specifically regulated outdoor hydronic heaters.

Trade and Professional Group Affiliations and Positions Held:

- Member of the Hearth, Patio and Barbeque Association's Outdoor Furnace Manufacturers Caucus.
- ASTM International member and participated in the development of a hydronic heater test standard
- HPBA’s Government Affairs Academy Graduate 2011.
- Government Affairs Chairman/Co-Chairman of NCHPBA (North Central Hearth Patio and Barbecue Association) – 2011 - present.

Other Relevant Information:

- Bachelor of Science degree in Criminal Justice Studies from the University of North Dakota
- Prior to joining Central Boiler, worked as a Senior Code Enforcement Officer and as an ICC Certified Building Inspector and Disaster Service Worker.
- Certified in USEPA Test Method 9 (opacity).

Proposed Hydronic Heater NSPS Incremental Cost Effectiveness Analyses

Appendix B

Hydronic Heater Retail Price Survey

Prepared for the Hearth, Patio & Barbecue Association

By Robert Ferguson
Ferguson, Andors & Company

May 2014

HPBA Hydronic Heater Pricing Survey

The purpose of this survey was to identify 2013 retail pricing for Hydronic Heater models sold by manufacturers with EPA Hydronic Heater Voluntary Program Phase 2 qualified models.

The survey was done by Ferguson, Andors & Company under the supervision of Robert Ferguson. Full details on his background are provided in Appendix A.

The results of the survey were used by NERA Economic Consulting in cost effectiveness analyses for evaluating emission performance standards in the 2014 EPA Hydronic Heater New Source Performance Standard (NSPS) proposal.

Survey Methodology

The pricing information was developed from manufacturers' price lists. Manufacturer's Suggested Retail Price (MSRP) is used in all cases. Discounting or other incentive programs were not considered in the survey. MSRP's were obtained by on-line searches or by contacting manufacturers. The list of EPA qualified models as of June 2013 was the starting point. That list was then amended to include cordwood models only. Unqualified cordwood models from the same manufacturers were then added. The list was then filtered again to include only models that were appropriate in heat output for typically-sized single family homes. A summary of the cordwood model pricing information is presented in Tables 1A and 1B. A summary of the filtered data is presented in Table 2. Manufacturers and models have been masked. The manufacturers included in the survey represent the majority of the dominant brands on the market, but not all brands.

Table 1A

EPA Hydronic Heater Voluntary Program Phase 2 Models and Conventional Models from Same Manufacturers
Cordwood Models Only
All Heat Outputs
As of 6/7/2013

Phase 2 Qualified (white)
Unqualified (blue)
Not Being Made (grey)

Mfr Code	Model Code	Heat Output[1,2] Rating - Btu/hr	PM[3] lb/mmBtu Out	PM g/hr	MSRP	Storage Incld in MSRP	EPA Qualified	Square Ft. Heated (Up to)	Gallons On-Board
I	A	117022	0.04	1.5	$15,395	$5,000	Yes	N/A	N/A
	B	219831	0.04	2.6	$19,340	$5,000	Yes	N/A	N/A
	1	N/A			$5,495		No	2000	105
	2	N/A			$6,695		No	5000	117
	3	N/A			$8,495		No	10000	194
	4	N/A			$14,995		No	20000	487
	5	90000			$4,459		No		120
II	C	73573	0.31	3.9	$9,495		Yes	N/A	130
	D	77135	0.31	4.5	N/A		Yes	N/A	
	6	120000			$5,050		No	N/A	100
	7	180000			$6,295		No	N/A	130
III	E	142533	0.08	2	$12,400		Yes	14000	250
	F	66897	0.19	3.5	$10,300		Yes	6000	160
	8	150000			$7,900		No	N/A	
	9	250000			$8,900		No	N/A	
	10	500000			$10,900		No	N/A	
IV	G	76887	0.14	2.2	$6,800		Yes	3500	107
	11	100000			$5,595		No	4000	150
	12	200000			$6,895		No	10000	368
V	13	360000	N/A		$8,280		No	8000	220
	14	500000	N/A		$9,780		No	12000	300
	H	100959	0.22	5.7	$8,980		Yes	6000	250
	15	220000			$5,780		No	4000	175
	16	300000			$6,780		No	6000	250
	17	460000			$8,480		No	10000	325
VI	I	80368	0.27	5.6	$9,095		Yes	5000	140
	18	175000			$7,200		No	3000	100
	19	250000			$7,600		No	5000	150
	20	N/A			$8,000		No		
	21	500000			$9,200		No	10000	265
VII	J	66842	0.18	3.7	$10,720		Yes	5000	377
	K	160599	0.28	10.7	$13,495		Yes	10000	488
	22	N/A			$6,150		No	3000	85
	23	N/A			$7,545		No	5000	114
	24	N/A			$9,454		No	10000	150
VIII	L	78252	0.23	4.7	$10,500		Yes	5000	240
	35	225000			$7,900		No	7000	120
	26	30000			$9,200		No	10000	190
	27	500000			$10,600		No	15000	240
	28	400000			$15,300		No	15000	350
	M	160421	0.31	7.3	?		Yes	15000	350
	29	150000			N/A		No	3000	60

Table 1B

Mfr Code	Model Code	Heat Output[1,2] Rating - Btu/hr	PM[3] lb/mmBtu Out	PM g/hr	MSRP	Storage Incld in MSRP	EPA Qualified	Square Ft. Heated (Up to)	Gallons On-Board
IX	N	116597	0.23	8.0	$ 10,900		Yes	7000	400
	30	165000			$ 7,500		No	3000	150
	31	240000			$ 7,800		No	5000	200
	32	365000			$ 9,100		No	10000	380
X	O	48721	0.24	2.5	$ 6,495		Yes	N/A	60
	P	64047	0.31	6.4	?		Yes	N/A	112
	Q	66290	0.27	8.4	$ 9,995		Yes	4000	75
	R	177333	0.31	6.1	$ 11,495		Yes	8000	115
	33	N/A			$ 5,995		No	4000	125
	34	N/A			$ 8,295		No	6000	250
	35	N/A			$ 8,395		No	4000	150
	36	N/A			$ 10,795		No	8000	300
XI	S	107459	0.27	5.5	$ 9,630		Yes	8000	195
	T	120529	0.18	4.7	$ 10,475		Yes	N/A	200
	U	186453	0.12	3.3	$ 12,275		Yes	12000	340
	V	261506	0.08	3.3	$ 16,065		Yes	N/A	410
	W	160001	0.31	6.4	N/A				
	37	N/A			$ 5,490		No	3000	140
	38	N/A			$ 7,100		No	6000	196
	39	N/A			$ 9,170		No	12000	393
	40	N/A			$ 15,700		No	N/A	764
XII	X	44502	0.32	4.2	N/A		Yes		
	Y	112655	0.26	6.1			Yes		
	41	150000					No		32
	42	200000					No		90
XIV	Z	87577	0.19	3.6	$ 10,000		Yes	6500	321
	43	N/A			N/A		No	5000	163
	44	N/A			N/A		No	10000	215
	45	N/A			N/A		No	2500	137
XV	AA	65336	0.26	3.8	?		Yes		
XVI	BB	82594	0.18	2.4	$ 14,500		Yes		230
	46	75000			$ 4,800		No		
	47	150000			$ 5,500		No		228
	48	225000			$ 6,700		No		290
XVII	CC	77308	0.25	4.5	$ 7,500		Yes		448
	49				$ 4,299		No	3000	
	50				$ 5,199		No	3000	
XVIII	DD	45787	0.29	5.1	$ 9,895		Yes		
	51	140000			$ 3,595		No		120
	52	250000			$ 4,595		No		235
	53	300000			$ 4,595		No		235
	54	275000			$ 4,995		No		217
	55	325000			$ 4,995		No		235
	56	325000			$ 5,595		No		315
	57	375000			$ 5,595		No		315

[1]8-hour rating for EPA qualified cordwood heaters. Source: EPA Qualified Hydronic Heater List.

[2]Manufacturers advertised rating for maximum heat output or square feet heated for unqualified heaters.

[3]Includes qualifications based on both EPA Method 28 OWHH and EPA Method 28 WHH.

Table 2

EPA Hydronic Heater Voluntary Program Phase 2 Models and Unqualified Models from Same Manufacturers
Cordwood Models Only
Heaters appropriate for typically-sized home.
As of 6/7/2013

Voluntary Program Phase 2 Qualified Models Sorted by Increasing PM - lb/mmBtu Output

ID Code	EPA Qualified	Heat Output[1, 2] Rating - Btu/hr	PM[3] lb/mmBtu Out	PM g/hr	MSRP	Storage Included in MSRP	Square Ft. Heated (Up to)[2]
I-A	Yes	117022	0.04	1.5	$ 15,395	$ 5,000	N/A
III-E	Yes	142533	0.08	2	$ 12,400	N/A	N/A
IV-G	Yes	76887	0.14	2.2	$ 6,800	N/A	N/A
VII-J	Yes	66842	0.18	3.7	$ 10,720	N/A	N/A
XI-T	Yes	120529	0.18	4.7	$ 10,475	N/A	N/A
XVI-BB	Yes	82594	0.18	2.4	$ 14,500	N/A	N/A
III-F	Yes	66897	0.19	3.5	$ 10,300	N/A	N/A
V-H	Yes	100959	0.22	5.7	$ 8,980	N/A	N/A
VIII-L	Yes	78252	0.23	4.7	$ 10,500	N/A	N/A
IX-N	Yes	116597	0.23	8.0	$ 10,900	N/A	N/A
X-O	Yes	48721	0.24	2.5	$ 6,995	N/A	N/A
XVII-CC	Yes	77308	0.25	4.5	$ 7,500	N/A	N/A
VI-I	Yes	80368	0.27	5.6	$ 9,095	N/A	N/A
X-Q	Yes	66290	0.27	8.4	$ 9,695	N/A	N/A
XI-S	Yes	107459	0.27	5.5	$ 9,630	N/A	N/A
XVIII-DD	Yes	45787	0.29	5.1	$ 9,895	N/A	N/A
II-C	Yes	73573	0.31	3.9	$ 9,495	N/A	N/A
	Average	86389	0.21	4.3	$ 10,193		
	Stdev ±	26824	0.07	2.0	$ 2,295		

Unqualified Models

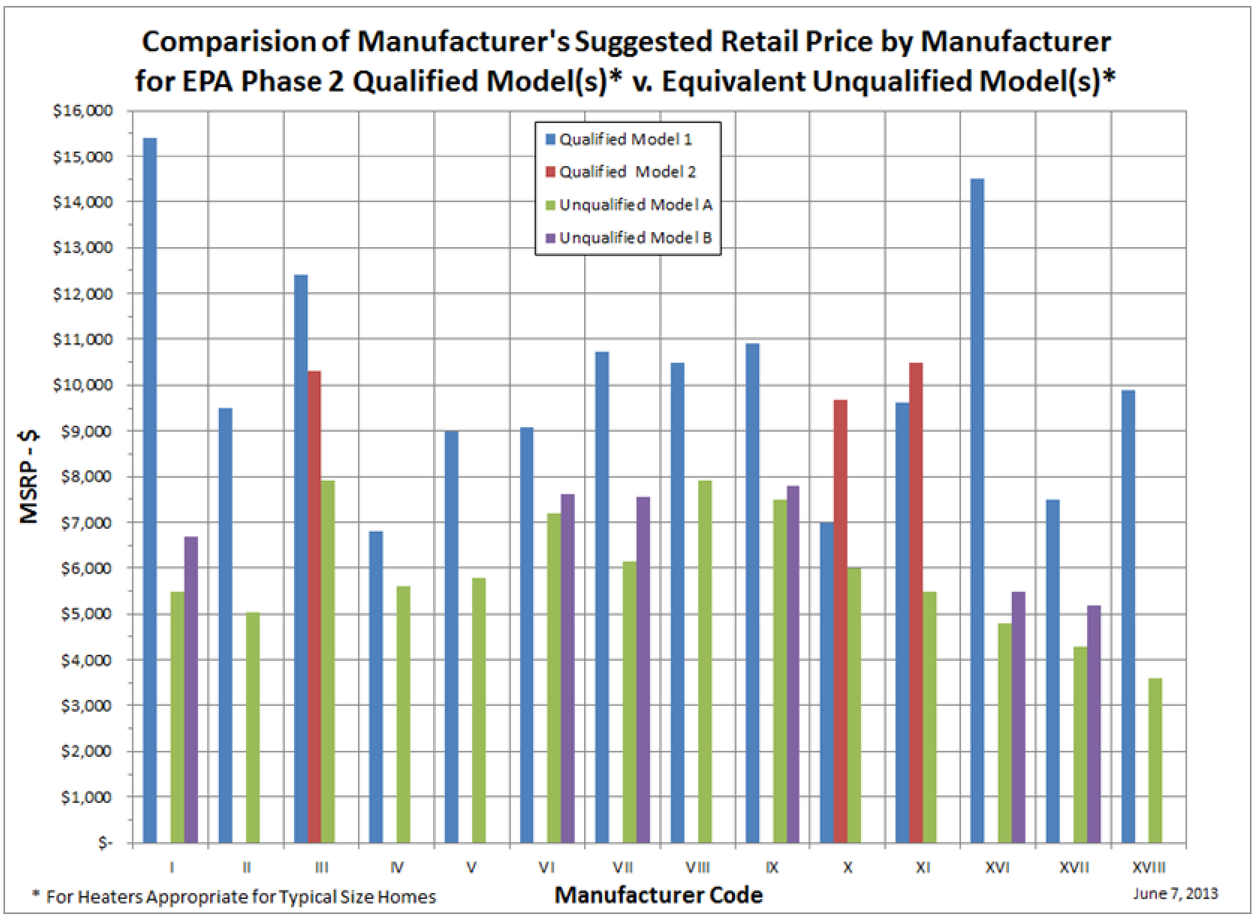
ID Code	EPA Qualified	Heat Output Rating - Btu/hr	PM lb/mmBtu Out	PM g/hr	MSRP	Storage	Square Ft. Heated (Up to)
I-1	No	N/A			$ 5,495		2000
I-2	No	N/A			$ 6,695		5000
II-6	No	120000			$ 5,050		N/A
III-8	No	150000			$ 7,900		N/A
IV-11	No	100000			$ 5,595		4000
V-15	No	220000			$ 5,780		4000
VI-18	No	175000			$ 7,200		3000
VI-19	No	250000			$ 7,600		5000
VII-22	No	N/A			$ 6,150		3000
VII-23	No	N/A			$ 7,545		5000
VIII-35	No	225000			$ 7,900		7000
IX-30	No	165000			$ 7,500		3000
IX-31	No	240000			$ 7,800		5000
X-33	No	N/A			$ 5,995		4000
XI-37	No	N/A			$ 5,490		3000
XVI-46	No	75000			$ 4,800		N/A
XVI-47	No	150000			$ 5,500		N/A
XVII-49	No	N/A			$ 4,299		3000
XVII-50	No	N/A			$ 5,199		3000
XVIII-51	No	140000			$ 3,595		N/A
	Average				$ 6,154		3933
	Stdev ±				$ 1,293		1280

[1]8-hour rating for EPA qualified cordwood heaters. Source: EPA Qualified Hydronic Heater List.
[2]Manufacturers advertised rating for maximum heat output or square feet heated for unqualified heaters.
[3]Includes qualifications based on both EPA Method 28 OWHH and EPA Method 28 WHH.

Survey Analyses

The results from the survey have been analyzed in several ways. However, for the purpose of determining retail pricing for qualified versus unqualified (i.e., conventional) models used in conjunction with other inputs in the NERA analysis, the analyses focused on models that are intended to provide whole-house heating for typically-sized homes since they represent the majority of models produced and sold. Price data for higher heating capacity models was excluded from retail price analyses.

The difference between qualified and unqualified model MSRP was analyzed, again for heaters intended to provide whole-house heating for typically-sized homes. The following figure presents the results of that analysis.



Conclusions

This pricing survey indicates that for hydronic heaters with heat output capacities in the range needed to provide whole-house heating for a typically-sized home, the average price for unqualified (i.e., conventional) models is about $6,200 and the average price for Phase 2 qualified models is about $10,200 (about $4,000 higher than for unqualified models).

Appendix C: Elasticity of Demand

The market impacts estimated in our main report depend in part on the price elasticity of demand for hydronic heaters. Price elasticity of demand is approximately equal to the percentage decrease in sales due to a one percent increase in price. Combined with baseline sales and prices, we use price elasticity to specify a “log-log” demand curve for hydronic heaters and to estimate two key results – the effect of price changes on heater sales quantities (demand effect) and the associated consumer surplus deadweight loss.

To estimate the elasticity, NERA studied the sales response to past “events” when hydronic heater prices rose. For this study, we used the early adoption of a 0.32 lb/mmBtu emission standard in nine states between 2008 and 2011.[1]

We developed a fixed effects regression model in which we regress state sales on regulated status while using unregulated states to control for a general price trend (unrelated to the new emissions standard). Confidential 2005-2012 sales data representing a significant share of total hydronic heater sales was used for both the nine regulated states and other unregulated states. Our model specification and regression results are shown below. The coefficient estimates are statistically significant at the 1 percent level.

$$\log(SALES_{i,t}) = \alpha_i + \beta \log(SALES_{other,\,t}) + \gamma REGULATED_{i,t} + \epsilon_{i,t}$$

i indexes states
t indexes years
$REGULATED_{i,t}$ is a dummy variable =1 if state i is regulated in year t
$\hat{\gamma} =$ effect of hydronic heaters regulation on $\Delta\log(SALES)$

Table 1. Fixed Effects Regression Estimates: Early Adoption of 0.32 lb/mmBtu Emission Standard

	Coefficient	Standard Error	t-statistic	P>|t|
$\log(SALES_{other})$	1.220	0.130	9.39	0.000
REGULATED	-0.485	0.127	-3.8	0.000
constant	-5.576	1.179	-4.73	0.000

Source: NERA calculations as explained in text

Note: Dependent variable is log(SALES). N = 9 groups, n = 72 observations.

Throughout our cost-effectiveness analysis, we assume a demand function with a

[1] Vermont, Maine, and New Hampshire adopted a 0.32 lb/mmBtu standard in 2008; Massachusetts and Maryland adopted in 2009; and New York, Pennsylvania, Rhode Island, and Indiana adopted in 2011.

constant elasticity of demand (“log-log” form). Under this assumption, the price elasticity of demand is equal to $\frac{\Delta \log(SALES)}{\Delta \log(PRICE)}$. In our regression model above, we estimated $\Delta \log(SALES)$ as $\hat{\gamma}$=-0.485. We further estimated the change in heater price in the nine regulated states using the difference in average prices between “conventional” heaters ($6,200) and “qualified” 0.32 lb/mmBtu heaters ($10,200) in the Ferguson (2013b) pricing survey. This gives a $\Delta \log(PRICE)$ of 0.498 and an elasticity estimate of -0.974.

Proposed Hydronic Heater NSPS Incremental Cost Effectiveness Analyses

Appendix D

Hydronic Heater Manufacturer Survey Results

- Annual Hydronic Heater Sales
- Total Hydronic Heaters Sold
- % EPA Qualified Models Sold as Replacements for Unqualified Models
- Typical Hydronic Heater Retailer Gross Margin
- Sales Trends in States with Hydronic Heater Regulations

Prepared for the Hearth, Patio & Barbecue Association

By Robert Ferguson

Ferguson, Andors & Company

May 2014

HPBA Hydronic Heater Company Survey

The survey and data analyses were conducted for the Hearth, Patio & Barbecue Association (HPBA) by Ferguson, Andors & Company under the supervision of Robert Ferguson. Full details on his background are provided in Appendix A. The surveying was conducted in several steps and included a written questionnaire as well as telephone or e-mail questions.

The results of the surveying were used by NERA Economic Consulting in cost effectiveness analyses for the evaluating the potential standards in the 2014 EPA Hydronic Heater New Source Performance Standard (NSPS) proposal.

Specific company information was provided only under the condition that it would be treated as Confidential Business Information (CBI) and, therefore, survey results are presented only in aggregate or as trends.

The purpose of the surveying was:

1. To quantify historical sales for Hydronic Heater models including both conventional (unqualified) models plus those models qualified by the EPA Hydronic Heater Voluntary Program.
2. To verify the EPA estimate of the cumulative total number of hydronic heaters sold/installed/in use nationwide.
3. To determine the percentage of new "qualified" hydronic heaters sold that are replacements for existing "unqualified" hydronic heaters. This is the "scrappage" value used as part of the NERA analyses.
4. To determine typical hydronic heater retailer gross margin (or mark-up).
5. To determine post-regulation sales trends in states with hydronic heater regulations.

Background on EPA Hydronic Heater Voluntary Program

To quote from the Voluntary Program Partnership Agreement:[1]

"The Program is aimed at reducing emissions from new hydronic heaters sooner than could be achieved by Federal regulation. The Phase 1 Program included an average air emission level of 0.60 pounds of fine particles per million Btu (lbs/MMBtu) heat input as a goal. This Phase 1 emission level was considered to be a first step in a two-phased program, with Phase 2 including a lower emission level, to be identified later. Twenty-one OWHH manufacturers became partners with EPA, and 10 models were qualified during the Phase 1 Program.

The Phase 1 Program was terminated and the Phase 2 Program was initiated by

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[1] U.S. Environmental Protection Agency ("EPA"). 2011. EPA Hydronic Heater Program: Phase 2 Partnership Agreement. October 12. http://www.epa.gov/burnwise/pdfs/owhhphase2agreement.pdf.

EPA on October 15, 2008. As of that date, hydronic heater manufacturers were invited to join/rejoin the Program by signing this Phase 2 Partnership Agreement with EPA. The Phase 2 Program includes an average air emission level of 0.32 lbs/MM Btu heat output, where no individual test run that is used in the calculation of the average exceeds 18.0 grams of fine particles per hour.

As part of the Phase 2 Program, models qualified to meet the Phase 1 average emission level (0.60 lbs/MMBtu heat input) continued to qualify until March 31, 2010. Phase 2 qualification is for year round use only. After March 31, 2010, models that achieve the 0.60 lbs/MMBtu heat input average emission level, but that do not achieve the 0.32 lbs/MMBtu heat output average emission level with 18.0 grams per hour cap are no longer considered "qualified models" under the Program."

Hydronic Heater Written Survey Questions

For the purposes of determining hydronic heater sales trends, data have been gathered in two ways.

First, HPBA hydronic heater caucus members were surveyed and asked to respond to the series of questions. The following outlines the information requested.

Hydronic Heater Cordwood Model Information Needed. Do not include pellet models.

- Current HHs in use– EPA Estimate = 243,000 units. Can you confirm this and if so, by what means?
    - Estimate the number or fraction of the total cordwood units that are in use that are unqualified units.
        - Providing your total sales of unqualified units will be helpful.
    - Estimate the number or fraction of the total units that are in use that are controlled, further broken down by EPA Qualified Phase I v. Phase II units, if possible.
        - Providing your total sales of controlled units (Phase I and Phase II) would be helpful.
- Baseline Sales Estimates – Annual industry-wide sales for last 5 years (or longer, if possible),
    - Unqualified units sold per year for your company plus industry-wide estimate.
    - EPA qualified units sold per year for your company plus industry-wide estimate.
    - Your estimate of the fraction of new sales of qualified units sold that replaced existing unqualified units – again for the past 5 years if possible.

Secondly, Amanda Aldridge, EPA Hydronic Heater Voluntary Program Liaison, was contacted and asked to provide aggregated sales data that is required to be reported by EPA Hydronic Heater Voluntary Program Partners on an annual sales year basis. Those data reporting requirements are outlined in manufacturer obligations in the Voluntary Partnership Agreement:

"Provide sales information to the EPA Program liaison by August 15 each year. Sales data during the period from August 1-July 31 should be reported.
Reports should include the following information:

- the number of units of wood-burning Phase 2 qualified models sold; also identify how many of these units were indoor models, how many were models equipped with full heat storage, and how many models were equipped with partial heat storage;
- the number of units of continuous feed biomass Phase 2 qualified models sold; also identify how many of these continuous feed biomass units were indoor models, how many were models equipped with full heat storage units, and how many models were equipped with partial heat storage; and
- the total number of hydronic heater units including Phase 2 qualified models as well as models that do not qualify under the Program."

EPA provided available aggregated sales data for all program years through the 2011/2012 sales year. It should be noted that total sales data (Qualified plus Unqualified models) for the first two years of the voluntary program was not available from EPA. Sales figures only for qualified units for those years were available. It should also be noted that Phase 1 and Phase 2 qualified units are included in the first two years of aggregate qualified unit sales. The figures that EPA provided were further broken down by each Phase.

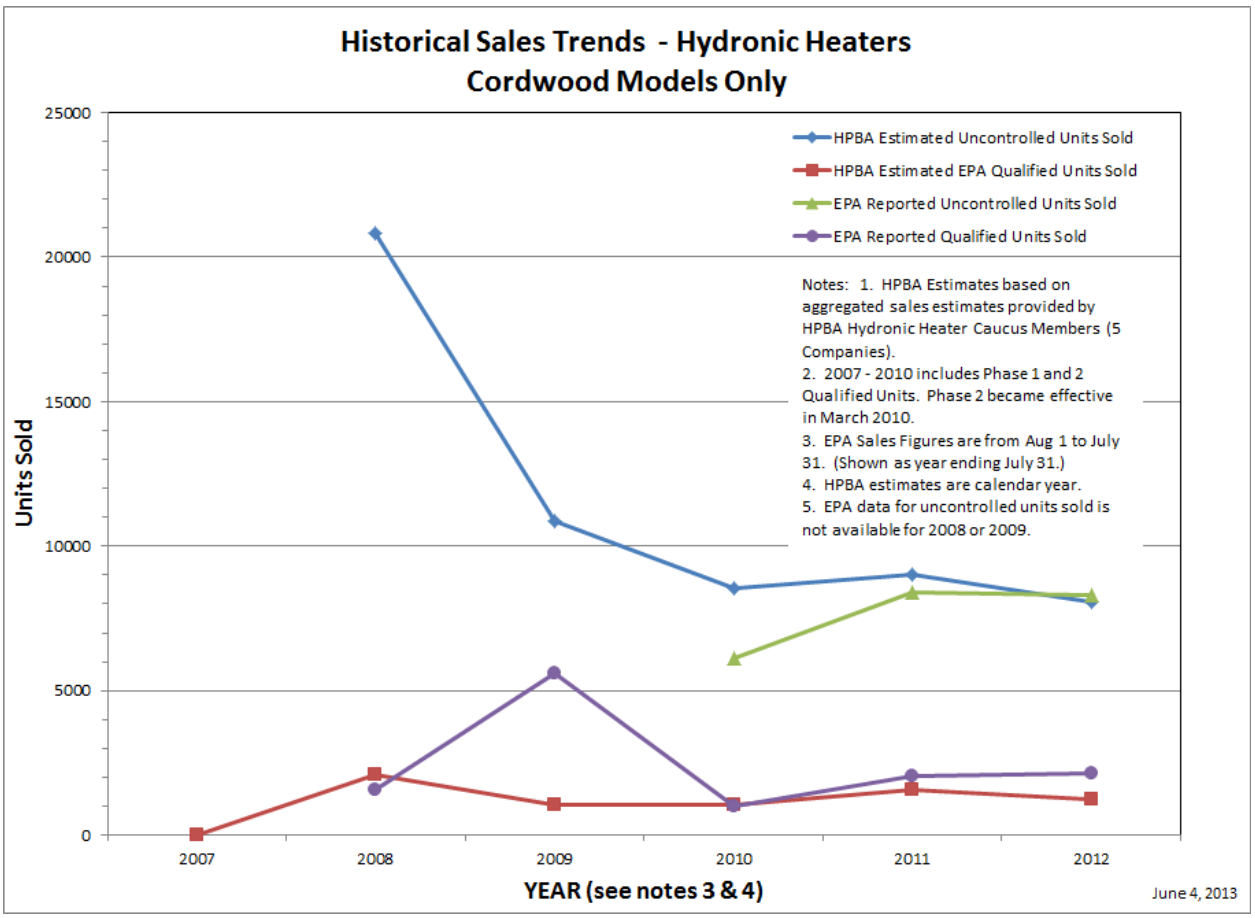
Trend results were calculated for the EPA and HPBA data and are presented in Table 1. The information is presented graphically in Figure 1.

Table 1 - Hydronic Heater Sales and Trends[2]

Source	Calendar Years						Most Recent Available			
HPBA HH Caucus	2007	2008	2009	2010	2011	2012	5 yr Tot	5 yr Ave	3 yr Tot	3 yr Ave
Total		22930	11940	9623	10612	9293	64398	12880	29528	9842.667
Un-Controlled		20842	10875	8567	9032	8065	57381	11476	25664	8555
EPA Qualified	3	2088	1065	1056	1580	1228	7017	1403	3864	1288

Source	Sales Years (Aug. 1 - Jul. 31)					Most Recent Available			
EPA Vol. Program	2007/8	2008/9	2009/10	2010/11	2011/12	5 yr Tot	5 yr Ave	3 yr Tot	3 yr Ave
Total	NA	NA	7163	10469	10443	NA	NA	28075	9358
Un-Controlled	NA	NA	6145	8407	8612	NA	NA	23164	7721
EPA Qualified Tot	1580	5618	1018	2062	1831	12109	2422	4911	1637
Phase 1	580	1363							
Phase 2	1000	3982	1018	2062	1831				

Figure 1 – Hydronic Heater Sales



[2] It should be noted that EPA recently provided slightly amended sales figures plus figures for the 2012/2013 sales year. The revised and new sales data did not change the conclusions of this report or of the NERA analyses and therefore the table and figures were not updated.

Additional information was gathered from the survey participants by telephone interviews and e-mail questions.

- Participants were asked to provide typical hydronic heater retailer gross margin (or mark-up).

And finally, one large company volunteered to provide detailed historical sales for states with hydronic heater regulations. This data includes pre- and post-regulation sales information for unqualified and qualified models for nine states and for the years 2005 - 2012. Since this information is from only one company, the information can only be presented in terms of trends.

<u>Conclusions</u>

1. Quantification of historical sales through 2012 for Hydronic Heater models including both conventional (unqualified) models plus those models qualified by the EPA Hydronic Heater Voluntary Program.
   a. The average estimated total annual sales volume of <u>unqualified</u> heaters for the past 5 years for the five HPBA caucus companies has been ~11,500 units/year.
   b. The average estimated total annual sales volume of EPA <u>Qualified</u> heaters for the past 5 years for the five HPBA caucus companies has been ~1400 units/year.
   c. The average estimated total annual sales volume of <u>unqualified</u> heaters for the past 3 years for the five caucus companies has been ~8600 units/year.
   d. The average estimated total annual sales volume of EPA <u>Qualified</u> heaters for the past 3 years for the caucus companies has been ~1300 units/year.
   e. The EPA Voluntary Program reported total sales figures for all partner companies are not available for sales years 2007/8 and 2008/9.
   f. The total EPA <u>Qualified</u> sales reported through sales years from 2007/8 to 2011/12 is 12109 units. This includes 2216 Phase 1 units.
   g. The average total annual sales volume of EPA <u>Qualified</u> heaters for the past 5 years for EPA Voluntary Program Partner companies has been 2422 units/year.
   h. The average total annual sales volume of <u>unqualified</u> heaters for the past 3 years for EPA Voluntary Program Partner companies has been 7721 units/year.
   i. The average total annual sales volume of EPA <u>Qualified</u> heaters for the past 3years for EPA Voluntary Program Partner companies has been 1637 units/year.

2. Verification of the EPA estimate of the cumulative total number of hydronic heaters sold/installed/in use nationwide.
   a. Regarding the industry-wide installed base, HPBA hydronic heater caucus company estimates ranged from 180,000 - 250,000 industry wide.
   b. The estimated total installed base for the five HPBA caucus companies is ~199,000. Approximately 7000 are EPA <u>Qualified</u> including Phase 1 and Phase 2 models.
   c. EPA is using an estimated total installed base of 243,000 units. Based on HPBA Caucus estimates, and those companies not represented but the caucus, the EPA estimate seems reasonable.

3. Determination of the percentage of new "qualified" hydronic heaters sold that are replacements for existing "unqualified" hydronic heaters.
   a. HPBA Caucus company estimates of qualified heater sales that are replacing unqualified heaters range from 1% to 12% with a mean of 4%.
      - This replacement percentage is probably not a robust value. Only one of the caucus companies has sold any significant quantities of qualified models. The information they all provided is more of a gut feel than based on actual tracking. The 4% average value represents a conservative estimate.

4. Determination of typical hydronic heater retailer gross profit margin.
   a. Based on the survey, hydronic heater retailers typically operate with a gross profit margin of 20% (equivalent to a price markup of 25%). Hydronic heater retailers are less likely to have the same financial commitment to "brick and mortar" stores as is typical for hearth specialty retailers focused on woodstoves, pellet stoves, fireplaces and the attendant accessories and are not likely to have any significant inventory of hydronic heaters they sell. Also, hydronic heaters have higher retail prices than most other hearth products and, therefore, margin dollars are higher for each heater sold. Hydronic heater installations can also provide additional revenue for each sale. For these reasons, hydronic heater retailers can operate at lower gross margin levels than many other hearth product retailers.

5. Determination of post-regulation sales trends in nine states with hydronic heater regulations.
   a. In the years after individual state hydronic heater regulations went into effect, sales of hydronic heaters in each state dropped precipitously. In 2005 through 2008, the sales in the nine states represented an average of 57% of total hydronic heater sales (with a range of 49% to 67%). In 2012, the first year with regulations in effect for all nine states, sales in those states dropped to 20% of total sales. Sales reductions in individual states with regulations ranged from -47% to -89% compared to historical sales levels before regulation. And total hydronic heater sales nationwide also decreased significantly. The sales lost in the nine regulated states were not replaced with sales in states without regulation.

Proposed Hydronic Heater NSPS Incremental Cost Effectiveness Analyses

Appendix E

EPA Certified Wood Heater Design Life Assessment

Prepared for the Hearth, Patio & Barbecue Association

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In the NSPS proposal preamble, EPA states that many models developed to meet the current NSPS requirements are still being sold today and that many new models only have had cosmetic changes and still have the same internal working parts (presumably referring to emission reduction technology):

> "To develop estimates of potential unit cost increases, we used major variables including the estimated number of units shipped per year, the costs to develop new models, baseline costs of models, and the schedule by which the proposed revised NSPS would be implemented. Both the number of shipped units and the baseline costs of models were based on data from the Frost & Sullivan report with modifications to address additional appliances or subsets of appliances. The 20-year model design life span and 20- year use/emitting appliance life span are based on actual historical design certification and heater use data. That is, the data show that many models developed for the current 1988 NSPS are still being sold (after 25 years), many ''new'' models still have the same internal working parts with merely exterior cosmetic changes,…."[1]

We find this presumption to be flawed for several reasons. First, many of the models that were offered for sale twenty years ago are no longer in production and many manufacturers on EPA's certified woodstove list are no longer in business (or at least not in the woodstove business). The EPA certified stove database[2] included 790 woodstove models from 91 manufacturers when Hearth, Patio & Barbecue Association (HPBA) undertook the Enhanced EPA Certified Wood Heater Database Project[3] that culminated in February 2010. The HPBA database identified 125 woodstove models actually in production at that time in 2010. Those 125 models were thought to represent well over 90% of all U. S. woodstove sales. The number of manufacturers has also declined appreciably since 1988 although it was hard make an exact count. Of current HPBA manufacturer members, 30 identify themselves as woodstove manufacturers. The data from the Enhanced Database Project alone, when compared with the total number of appliances that have been certified over the now twenty-five year life-span of Subpart AAA program by itself strongly refutes EPA's twenty year design life finding, since the total number of certified models identified as being produced in 2010 (125) is less than 15% or the total certified during the life of the program (790).[4] Speaking in broadly general terms, it is safe to say that the surviving

[1] 6351 Federal Register /Vol. 79, No. 22 /Monday, February 3, 2014 / Proposed Rules
[2] List of EPA Certified Wood Heaters, http://www.epa.gov/Compliance/resources/publications/monitoring/caa/woodstoves/certifiedwood.pdf
[3] Hearth, Patio and Barbecue Association (HPBA) Enhanced EPA Wood Heater Database - 2/25/2010 Docket ID**:** EPA-HQ-OAR-2009-0734-0266, Agency: Environmental Protection Agency
[4] Unfortunately, some stakeholders continue to rely on the raw EPA certified stove list, and play a "numbers game" by counting any models that had certification scores less than the proposed Step2/3 emission limit. These are meaningless exercises that essentially beg the question for a number of reasons. For example, some models may have been discontinued because of technical problems resulting in unacceptable warranty return rates; others may be previous generations of a frequently upgraded model, so the "count" effectively involves double counting. Concerns like these motivated the exhaustive review which produced the HPBA Enhanced Database. It was intended to inform

manufacturers have continued to add new models, upgrade popular models and retire models over the past 20 years. The new models and upgraded models have included aesthetic and other user feature upgrades but the fact that the upgraded models predominantly needed to be certified/recertified shows that they have also included technology upgrades involving emissions-critical components. In addition, many models were redesigned and re-certified when Washington State imposed their lower emission limits.

Today's woodstoves do contain many of the same "parts" that the first certified stoves included 25 years ago. Besides the necessary four sides, top, bottom and load door including a glass panel, all of today's woodstoves contain a primary air delivery system, a secondary air delivery system and some form of combustion technology. Catalytic models, at a minimum, include a catalytic element, some means to shield the catalyst from flame impingement, and a bypass damper. Typical non-catalytic stoves include an insulated baffle and secondary air tubes. Some other non-catalytic models include a separate secondary combustion chamber, special firebox bricks and a bypass damper. These parts, among numerous others, are the generically designated parts that comprise all the various stove models being produced today.

However, one must look at the specific details before is appropriate to assume that these parts and other emission critical have not evolved over time for many of today's models. In accordance with the current NSPS requirements, changes presumed to affect emissions are codified in the commonly denoted "k-list"[5]. This is a broad list that includes many stove

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this rulemaking proceeding; stakeholders that aren't using it are making misleading arguments that should be ignored.

[5] **40 CFR 60 Subpart AAA—Standards of Performance for New Residential Wood Heaters, §60.533(k)**
§60.533(k)(1) A model line must be recertified whenever any change is made in the design submitted pursuant to §60.533(b)(3) that is presumed to affect the particulate emission rate for that model line. The Administrator may waive this requirement upon written request by the manufacturer, if he determines that the change may not reasonably be anticipated to cause wood heaters in the model line to exceed the applicable emission limits. The granting of such a waiver does not relieve the manufacturer of any compliance obligations under this subpart.
(2) Any change in the indicated tolerances of any of the following components (where such components are applicable) is presumed to affect particulate emissions if that change exceeds ±0.64 cm (±1⁄4 inch) for any **linear** dimension and ±5 percent for any cross-sectional area relating to air introduction systems and catalyst bypass gaps unless other dimensions and cross-sectional areas are previously approved by the Administrator under paragraph (e)(1)(ii) of this section:
(i) Firebox: Dimensions,
(ii) Air introduction systems: Cross-sectional area of restrictive air inlets, outlets, and location, and method of control,
(iii) Baffles: Dimensions and locations,
(iv) Refractory/insulation: Dimensions and location,
(v) Catalyst: Dimensions and location,
(vi) Catalyst bypass mechanism and, for model lines certified to meet the emissions limits in § 60.532(b), catalyst bypass gap tolerances (when bypass mechanism is in closed position): Dimensions, cross-sectional area, and location,
(vii) Flue gas exit: Dimensions and location,
(viii) Door and catalyst bypass gaskets: Dimensions and fit,
(ix) Outer shielding and coverings: Dimensions and location,
(x) Fuel feed system: For wood heaters that are designed primarily to burn wood pellets and other wood heaters equipped with a fuel feed system, the fuel feed rate, auger motor design and power rating, and the angle of the auger to the firebox, and

components. Changes of just about every kind can easily implicate exceeding allowable "k-list" tolerances. Changes to features or accessories like the addition of an ash pan or change in convection air blower, firebox firebrick or insulation or catalyst bypass all implicate revisions that are presumed to affect emissions. And these are in addition to other on-going improvements to the emission control technology that can only be expected to be implemented as manufacturers gain more and more experience in the art and science of combustion technology.

EPA's position also is completely incompatible with the reality that manufacturers have to deal continually with real world issues concerning the profitability and sustainability of their businesses. As such, they are constantly assessing ways to minimize costs and risks, and enhance profitability. These pressures can implicate retirement or significant modification of a model for a number of reasons. For example, a model currently being produced may be having an unacceptable degree of warranty returns, which could lead to a decision to redesign the product. Or a redesign could be motivated by a desire to improve manufacturing efficiency or costs. Or a desire to improve the emissions performance of the model so that its performance was more consistent and predictable could be a motivation. Improving emissions performance to provide a marketing "edge" over a competitor's product is another factor. And there may be other reasons why a manufacturer could launch a product redesign effort for sound business reasons. The point is a simple one: in this business, like any other, innovation is seen by many manufacturers as a prime component of business success.

EPA only revealed the 20-year "design life" assertion when the NSPS proposal was first made public on January 3, 2014. HPBA realized that an industry-wide survey was simply not feasible within the time available and with resource limitations. Instead, a survey of a small number of key manufacturers was conducted and information about 53 specific models was obtained. Some of the models are currently in production and others have been discontinued. One of the manufacturers is the largest woodstove producer in the industry. The others offer a good industry cross-section representing cast-iron and steel stove producers, diverse retail pricing and all forms of distribution. Some models have had as many as four technology upgrades over their lifespans. The results of this survey are at least indicative of industry trends that run counter to the EPA blanket assumption. Manufacturers do modify their emission control technology for various reasons and at various intervals.

By surveying these manufacturers, we have been able to obtain historical information showing the evolution of a number of stove models that have been sold for many years. We were especially interested to know the average "design life" span across full ranges of models from the responding manufacturers. We also requested information about the specific reasons that for any changes.

(xi) Forced air combustion system: For wood heaters so equipped, the location and horsepower of blower motors and the fan blade size.
(3) Any change in the materials used for the following components is presumed to affect emissions:
(i) Refractory/insulation or
(ii) Door and catalyst bypass gaskets.
(4) A change in the make, model, or composition of a catalyst is presumed to affect emissions, unless the change has been approved in advance by the Administrator, based on test data that demonstrate that the replacement catalyst is equivalent to or better than the original catalyst in terms of particulate emission reduction.

The participating manufacturers were given a form that would allow them to track the progression of modifications to models they have produced or are still producing. They were asked to indicate why the changes were made. The tabulated results, coded to protect manufacturer identity as agreed as a condition of participation are provided in Tables 1A and 1B.

Table 1A

Stove Technology Life Cycle												
Mfr. Code	**Model Line Code**	**Beg Mfg (mon-yr)**	**End Mfg (mon-yr)**	**Technology Life (yrs)**	**grams/hr**	**Improve Reliability**	**Cost Savings**	**Improve Emissions**	**Market Demand Requirement**	**Improve Manufacturability**	**Warranty Reduction**	**Improve Performance**
A	1	Jul-07	Jan-16	8.4	2.1			x	x	x		x
A	1	Jan-02	Jul-07	5.4	2.0	x		x				
A	1	Mar-90	Dec-01	11.7	3.6	x		x				
A	1	Jan-87	Jan-90	3.1	6.1			x				x
A	2	Jul-09	Jan-16	6.5	2.0			x	x	x		x
A	2	Mar-01	Jul-09	8.3	1.3	x		x				
A	2	Feb-90	Mar-01	11.1	2.1	x		x				
A	2	Jan-87	Jan-90	3.1	6.5			x				x
A	3	Oct-06	Jan-16	9.2	1.1			x	x	x		x
A	3	Apr-02	Oct-06	4.5	1.2	x		x				
A	3	Dec-94	Mar-01	6.3	1.1	x		x				
A	3	Mar-90	Oct-94	4.6	4.0			x				x
A	4	May-09	Jan-16	6.7	2.3			x	x	x		x
A	4	May-02	May-09	7.0	4.2			x				x
A	5	Jan-10	Jan-16	6.0	3.5			x	x	x		x
A	5	Jun-03	Jan-10	6.6	4.2			x				x
A	6	Aug-09	Jan-16	6.4	1.1			x	x	x		x
A	6	Aug-01	Aug-09	8.0	1.3	x		x				
A	6	Apr-90	Jul-01	11.3	2.1	x		x				
A	7	Sep-11	Jan-16	4.3	4.2			x	x	x		x
A	7	Jul-02	Aug-11	9.1	3.1			x				x
A	8	Aug-11	Jan-16	4.4	4.3			x	x	x		x
A	8	Nov-04	Jul-11	6.7	2.0	x		x				
A	8	Jan-93	Apr-03	10.2	2.7	x		x				
Mfr. A Average				**7.0**								
B	1	Jul-92	Jan-94	1.5	6.5			x				
B	2	Jul-92	Jan-94	1.5	7.0			x				
B	3	Jul-92	Jan-94	1.5	3.2			x				
B	4	Jul-93	Current	25.0	4.1			x		x		x
B	5	Jul-93	Current	25.0	3.5			x		x		x
B	6	Jul-93	Current	25.0	2.9			x		x		x
B	7	Jul-04	May-06	1.8	4.5				x			
B	8	Mar-01	Current	14.0	5.4	x		x				x
B	9	Aug-03	Aug-03	0.0	4.9			x	x			x
B	9	Sep-04	Current	11.0	7.1							x
B	10	Sep-08	Current	10.0	7.2				x			
B	11	Nov-08	Current	10.0	2.4				x			
B	12	Dec-10	Current	5.0	2.1		x	x	x	x		x
B	13	Jul-09	Current	10.0	3.9	x			x	x	x	
B	14	Jul-09	Current	10.0	3.6	x			x	x	x	
B	15	Jul-12	Current	5.0	2.6			x	x			x
Mfr. B Average				**9.8**								

Table 1B

C	1	1988	1998	10.0	3.0							
C	2	1988	1994	6.0	3.3							
C	3	1989	1993	4.0	3.7			x	x			x
C	4	1989	1993	4.0	3.7			x	x			x
C	5	2008	Current	10.0	3.1			x	x			x
C	6	2006	Current	10.0	5.9			x	x			x
C	7	2004	Current	10.0	1.5			x	x			x
C	8	2005	Current	10.0	1.6				x			
C	9	1990	1996	6.0	3.0							
C	10	1990	Jun-05	15.0	3.8							
C	11	2011	Current	5.0	5.4				x			
C	12	2008	Current	10.0	4.6				x			
C	13	2010	Current	10.0	3.7				x			
C	14	2008	Current	10.0	1.1				x			
C	15	2011	Current	5.0	1.9				x			
C	16	2013	Current	5.0	3.2				x			
C	17	2013	Current	5.0	2.5				x			
C	18	2012	Current	5.0	3.9				x			
C	19	2011	Current	5.0	4.0				x			
C	20	2012	Current	5.0	3.6				x			
C	20	2011	2012	5.0	3.8				x			
C	21	2011	Current	5.0	3.2				x			
C	22	2014	Current	5.0	3.2			x	x			x
C	23	2013	Current	5.0	3.1				x			
C	24	2013	Current	5.0	1.8				x			
C	25	2007	Current	10.0	3.6							
Mfr. C Average				**7.1**								
D	1	Dec-08	Dec-18	10.0	4.5			x	x			
D	1	Dec-07	Dec-08	1.0	7.5							
D	2	Sep-00	Sep-15	15.0	3.8			x	x			
D	2	Mar-96	Sep-00	4.5	7.2							
D	3	Sep-11	Sep-16	5.0	3.4			x	x			
D	3	Jul-94	Sep-11	17.1	5.2							
D	4	Jun-03	May-18	14.9	3.2	x					x	x
D	4	May-99	Jun-03	4.1	3.0							
D	5	Mar-04	Mar-19	15.0	4.1			x				
D	5	May-99	Mar-04	4.9	4.4							
Mfr. D Average				**9.2**								

It should be noted that for models currently in production, it was assumed that eligible EPA certificates would be renewed up to 3 months before the effective date of the revised NSPS meaning design life was extended to the end date of any renewable certificate.

For the surveyed manufacturers, the number of years that models remain in production without "k-list" revisions ranged from less than 1 to 25 years. The average for the 53 models was 8.3 years. For the largest manufacturer, the average design life was 7 years. For the other manufacturers, the range was from just over 7 years to just under 10 years.

Reasons for the combustion technology modifications included all seven categories on the survey form. These are ranked here in order according to the survey results with counts in parentheses.

1. Improve Emissions (44)
2. Market Demand Requirement (40)
3. Improve Performance (29)
4. Improve Reliability (14)
5. Improve Manufacturability (14)
6. Warranty Reduction (3)
7. Cost Savings (1)

Improving emissions, meeting market demand requirements (including responding to competitive pressure) and improving overall performance and product reliability (customer satisfaction) were most common reasons given for revising and upgrading models over time.

<u>Conclusions</u>

This survey cannot categorically define the average “design life” for all models across all wood heater manufacturers but is does clearly show that the combustion technology that manufacturers employ in their products has hardly been static for the past 25 years as asserted by EPA in the NSPS proposal. While some manufacturers have left some models unchanged through several EPA certificate renewal cycles, technology has indeed continued to evolve and many other models have been through multiple revision cycles including new certifications as technological improvements have been implemented. Customers and competitors help drive the need to keep products fresh in the marketplace including showing improvements in performance. While emissions performance may not be a factor that heavily influences all consumer purchasing decisions, some manufacturers do use emission performance in their marketing as a point of differentiation between their products and those from their competitors. And product differentiation is an important factor when trying to gain market share and retailer floor space. This motivation has driven the largest manufacturer to a commitment to constant improvement in emission performance as well as overall performance and that has resulted in regular model line upgrades.