Gas Boiler Market Characterization Study Phase II - Final Report

Massachusetts Program Administrators and Energy Efficiency Advisory Council

Date: March 1, 2017

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1 EXECUTIVE SUMMARY

Technological advances in commercial gas boiler equipment continue at a fast pace and have created a complex and quickly evolving market. The objective of the Phase II study was to provide the Program Administrators (PAs) and Energy Efficiency Advisory Council (EEAC) consultants with an understanding of the rate of change in the current baseline efficiency level and provide an analytic comparison to boiler programs in the surrounding Northeast Region. The Evaluation Team ("the Team") completed the following five tasks to address these research objectives:

- Task 1: Seek Boiler Manufacturer Input/Comment on Phase I Final Report
- Task 2: Comparative Research on Condensing Gas Boiler Programs in the Northeast Region
- Task 3: Initiate Boiler Product Line Mapping
- Task 4: Provide Overview of US Department of Energy (DOE) Notice of Proposed Rulemaking (NOPR) for Commercial Boiler Standards
- Task 5: Conduct Open-Dialog Massachusetts Boiler Roundtable

This study defines small C&I boilers as those between 90 and 2,000 MBH (thousand British thermal units per hour) in size that are installed at a business or other nonresidential location. Throughout this report, we use the following definitions of boiler efficiency categories—standard efficiency, mid-efficiency, and high-efficiency (Table 1).

Table 1: Boiler Efficiency Levels

Efficiency Category	Efficiency Level*	Prescriptive Rebate Eligibility**
Standard Efficiency	Less than 85%	No
Mid-efficiency	85% to less than 90%	
High Efficiency	90% and above	Yes

*AFUE for boilers up to 300 MBH and thermal efficiency (E_t) for boilers greater than 300 MBH

**Only natural gas condensing gas boilers are eligible for program incentives

Note that this study was on hold in 2015 and early 2016 because DOE was delayed in releasing the NOPR for commercial boiler standards. The release of the NOPR was considered critical for the completion of Tasks 4 and 5 given the impact that the rulemaking would have on the future baseline requirements for commercial boiler products. When DOE released the draft NOPR in March 2016, the study resumed. In addition, DOE released the final rulemaking for commercial packaged boilers on December 28, 2016.[1]

1.1 Findings

Below, we summarize the key findings from the study.

The commercial boiler market is dominated by a group of large, broad manufacturers, though a contingent of smaller manufacturers exclusively produce higher efficiency models. While the large

[1] DOE Final Rulemaking for Commercial Packaged Boilers: www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=8&action=viewcurrent

manufacturers dominate the market, the smaller high-efficiency manufacturers are also critical in advancing energy efficiency.

- ***A group of large, broad manufacturers dominate the natural gas market.*** Fifteen large manufacturers who produce natural gas boilers of all efficiency levels represent over three-quarters (79%) of all natural gas models available nationwide. They also represent the majority of standard efficiency (88%), mid-efficiency (75%), and high-efficiency models (66%) available. These 15 manufacturers offer larger product lines than others, on average offering 99 models each. Examples of these large, broad manufacturers include Burnham, ECR, SPX (Weil-Mclain), and Mestek.
- ***A contingent of smaller manufacturers exclusively offer mid- and/or high-efficiency models.*** Nine small manufacturers offer mid-efficiency or both mid- and high-efficiency models, representing 23% of all mid-efficiency models and 10% of all high-efficiency models. On average, these nine manufacturers each offer only 14 natural gas models. Examples of these manufacturers include Bradford-White, DDR Americas, and Harsco. In addition, eight small manufacturers offer only high-efficiency boilers, representing 19% of all high-efficiency models. On average, these eight manufacturers each offer only 15 natural gas models. Examples of these manufacturers include NY Thermal, HTP, Aerco, and Triangle Tube. These higher-efficiency manufacturers are most invested in energy efficiency programs and therefore were most engaged in this study.

High-efficiency boilers are widely available in the market. The following findings indicate that program-eligible models are widely available to customers across the U.S.

- ***Most manufacturers produce high-efficiency models***. More manufacturers produce high-efficiency boilers (81% of 42 manufacturers) than either standard (57%) or mid-efficiency (76%) boilers.
- ***One-third of all natural gas boiler models available appear to be program eligible*.** A similar percentage of larger >300 MBH models (32%) and smaller ≤300 MBH models (35%) achieve 90% efficiency and therefore meet program efficiency requirements. While we are unable to verify that these models are condensing units, they most likely are.

The market for gas boilers in Massachusetts is shifting toward high efficiency. Several results from the study indicate that the Massachusetts market is steadily transitioning toward higher efficiency models. Manufacturers believe that this transition is, in part, driven by the Massachusetts PA programs. This connection is explored further in the following sections.

- ***Most of the gas boilers sold in Massachusetts appear to be condensing models.*** Based on manufacturer feedback, we estimate that an average of 74% and a median of 80% of the natural gas boilers sold in Massachusetts are condensing models. These results are on the higher end of the 60% to 80% range provided by the Phase 1 study. In addition, preliminary findings from the existing building market characterization study currently underway in Massachusetts indicate that approximately 70% of gas hot water boilers <2,000 MBH in size installed since 2009 are high-efficiency (condensing) units.[2] However, a smaller share of larger boilers appear to be condensing models, as only 25% of the >2,000 MBH gas hot water boilers are high-efficiency units according to preliminary data from the same study.
- ***The number of rebates for high-efficiency boilers provided to Massachusetts non-residential customers has been steadily increasing.*** The Massachusetts prescriptive gas boiler program provided 675 rebates in 2012, 751 in 2013, and 1,048 in 2014.
- ***Some condensing boilers are likely sold without program rebates.*** A scenario analysis of estimated annual boiler sales (1,500 to 3,000) and the percent which are condensing models (60% to 80%) suggests that some volume of condensing boilers are sold in Massachusetts that do not receive program rebates, likely in the range of several hundred or more units.
- ***Manufacturers project that annual sales in Massachusetts for high-efficiency models will increase, while sales for standard and mid-efficiency models will remain flat.*** All manufacturers anticipate that annual sales of high-efficiency boilers will increase, by an overall average of +10% and a median of +8%. In contrast, manufacturers projected only a 0% to 2% increase in the annual sales of standard and mid-efficiency models.
- ***Demand for higher efficiency models is increasing.*** Several manufacturers noted that customer demand for high-efficiency models is increasing in Massachusetts.

However, the market for non-condensing units will continue to exist given the challenges of retrofitting condensing boilers. Eight of the nine manufacturers who responded to the survey (Task 1) and who currently produce standard efficiency boilers intend to continue producing these models in the future. Seven of these nine manufacturers believe the market for standard efficiency models will persist for replacement situations where venting issues or space constraints preclude the installation of condensing units or where system design considerations may prevent a condensing model from properly condensing.

System design is a key factor in achieving rated efficiencies for condensing boilers. Manufacturers repeatedly emphasized the importance of considering system design as a whole rather than simply the rated efficiency of the boiler itself. Inadequate system design is a major obstacle limiting the operating efficiency of condensing boilers, in particular for replacement applications that were originally designed for non-condensing boilers with higher return water temperatures. According to manufacturers, situations where condensing boilers do not actually condense occur frequently in replacement applications, with old schools and churches being notable examples. The most recent program impact evaluation appears to support the manufacturers concern regarding condensing gas boiler performance. The impact evaluation estimated average operating efficiencies of 92.1% for <300 MBH boilers rated 95%+ AFUE and 89.2% for all boilers rated 90%+ efficiency[3].

[2] Note that these are preliminary estimates and therefore may change prior to completion of the existing building market characterization study.

[3] Impact Evaluation of 2011 Prescriptive Gas Measures. Prepared by KEMA. June 27, 2013.

In addition, the evaluated efficiencies for individual boilers varied from 86% to 95%. These results suggest that the boilers below the average efficiency levels (up to one-half of boilers) may not be condensing as designed.

The final rulemaking for commercial packaged boilers will reduce program savings by nearly one-half for affected boilers. The final rulemaking on commercial packaged boilers, which was issued by DOE on December 28, 2016, will increase the federal minimum standard from 80% to 84% thermal efficiency for 300 to 2,500 MBH gas hot water boilers. As described in more detail below, shifting the Massachusetts baseline assumption to an efficiency level slightly above this new federal standard (85% efficiency rather than 84% efficiency) would more accurately reflect industry trends. If 85% efficiency were adopted as the Massachusetts baseline assumption, it would reduce the incremental efficiency of program-eligible 300 to 2,000 MBH boilers by about one-half—from +10% to +5%. These 300 to 2,000 MBH boilers represent about 57% of boilers that participate in the Massachusetts PA prescriptive rebate program.

Boilers of ≤300 MBH comprise about 35% of all program boilers and have a minimum federal standard of 82% AFUE. In addition, the final rulemaking increases the minimum combustion efficiency from 82% to 85% for gas hot water boilers between 2,500 and 10,000 MBH in size, which are eligible for the custom program.

The federal rulemaking will become effective in 2020. In addition, it appears that most manufacturers are already adjusting their product lines to meet the new standards and therefore do not believe the implementation timeline will pose any significant challenges.

The Massachusetts PA program adopts similar efficiency levels as other programs. Several results from the study indicate that the Massachusetts PA program approaches efficiency levels in a manner similar to other regional commercial gas boiler programs.

- ***Baseline efficiency assumptions are fairly consistent among programs, but expected to change with the federal code.*** Most commercial gas boiler programs, including Massachusetts, adopt baseline assumptions that reflect ASHRAE 90.1-2007 standards for gas-fired hot water boilers, which are 82% AFUE for ≤300 MBH units and 80% E_t for >300 MBH units. The exceptions are Rhode Island and New York, which, based on the 2012 IECC, use a lower baseline of 80% AFUE for smaller boilers; New York also uses a lower baseline of 75% E_t for larger boilers. Most program staff reported that baseline efficiency assumptions would change when state building codes changed, taking into account the timing of federal standards.
- ***Minimum efficiency requirements are fairly consistent among programs.*** Most programs, including Massachusetts, require 90% AFUE for smaller condensing boilers (up to 300 MBH) and 90% E_t for larger condensing boilers (greater than 300 MBH). However, Connecticut and National Grid in New York have established higher standards of 92% AFUE and 92% E_t for their programs.

Feedback on the Massachusetts PA prescriptive program was largely positive. Manufacturers praised the Massachusetts PA prescriptive rebate program as follows.

- ***Rebates are both generous and influential.*** Manufacturers believe that the rebates have a great deal of influence on customer purchasing decisions, and most agreed that the program rebates are generous. However, the Massachusetts PA rebate amounts are generally in the mid-range of the rebates offered by other Northeast boiler programs.

- ***Without the program, manufacturers believe sales of condensing gas boilers would decline substantially.*** Most manufacturers believe there would be a significant reduction (possibly 25% or higher) in sales of condensing boilers if the Massachusetts PA rebates were not available.
- ***However, spillover effects may be minimal.*** Manufacturers did not think that the program induces sales of unrebated program-eligible condensing boilers (spillover). Manufacturers thought contractors would always discuss the available rebates with customers as a way to reduce the overall project cost and to avoid like-for-like replacements, which is the simplest option for replacement situations.

Manufacturers offered a variety of suggestions to improve the Massachusetts PA prescriptive rebate program. Manufacturers offered the following suggestions to consider regarding the program.

- ***Incentivize field efficiency testing.*** Several manufacturers suggested that the Massachusetts PA program offer a small incentive ($50 or $100) to contractors to conduct and provide the results of a combustion efficiency test. This testing would provide data to assess the extent of the issue regarding condensing boilers not achieving rated efficiencies, in particular for retrofit situations.
- ***Contractor education.*** Manufacturers suggested that training contractors on system design and installation is essential. A National Grid staff person reported that the PAs are developing a quality installation program to ensure that contractors and distributors design and pipe condensing boilers correctly.
- ***Offer rebates for low-temperature heat emitters.*** One manufacturer recommended offering rebates for low-temperature heat emitters (such as cast iron radiators that will operate effectively with the lower water temperatures associated with condensing boilers) as part of a system solution to encourage condensing in replacement situations.

1.2 Recommendations

In light of the above findings, we offer the following recommendations to consider for the Massachusetts PA gas boiler prescriptive rebate program.

- **Raise the baseline assumption from 80% to 85% efficiency for boilers less than 2,000 MBH in size.** This study estimates that condensing models represent about 74% of non-residential boilers sold in Massachusetts, which is supported by the ongoing existing building market characterization study that estimates that approximately 70% of gas hot water boilers installed since 2009 are high-efficiency models. In addition, manufacturers anticipate that sales of condensing models will continue growing in the future. The number of condensing gas boiler rebates issued annually by the Massachusetts PA non-residential prescriptive program has been increasing and a scenario analysis indicates there may be several hundred or more condensing boilers sold each year in Massachusetts that do not receive program rebates. Over the course of this study, manufacturers noted a trend towards offering higher efficiency products, and some are already re-tooling to meet mid-range efficiency ratings which they consider to begin at 85%. Lastly, the final rulemaking for commercial packaged boilers, which was issued by the DOE on December 28, 2016, increases the minimum thermal efficiency from 80% to 84% for 300 to 2,500 MBH gas hot water boilers effective in 2020, which manufacturers anticipate meeting without difficulty. Under the new C&I baseline framework, if industry standard practice exceeds code then a blended market average serves as the baseline. Therefore, the program should raise its baseline for <2,000 MBH boilers from 80% to 85% efficiency in order to accurately reflect the current conditions and trajectory of the Massachusetts market.

- **Offer a tiered rebate structure for all program-eligible models.** In order to prepare for the baseline increasing from 80% to 85% efficiency, we recommend offering tiered incentives for all program-eligible models. The program already offers higher incentives for ≤300 MBH models that achieve 95% AFUE. Therefore, we recommend adopting a similar tiered rebate structure for the >300 MBH boilers. There appears to be sufficient availability of 95%+ efficient boilers, as 14% of >300 MBH models achieve 95%+ efficiency, which is slightly less than the 17% figure for ≤300 MBH models.

- **Continue with the planned contractor education effort.** Manufacturers believe that training contractors on boiler system design and installation is essential in order to ensure that condensing boilers actually condense and therefore achieve their rated efficiencies. In addition, the PAs are already developing a quality installation program to ensure that contractors and distributors design and pipe condensing boilers correctly. Based on the results of this study, the evaluation team supports the planned training effort; however, this study did not assess the design or effectiveness of the training effort.

1.3 Considerations

We offer the following considerations for the Massachusetts PA gas boiler programs. These suggestions appear to have merit however it was not a focal point of the study and therefore requires more research before being implemented.

- **Shift the baseline for boilers more than 2,000 MBH in size to a custom approach.** While this study focused on boilers less than 2,000 MBH in size, it did gather some information on larger boilers as well. The final rulemaking for commercial packaged boilers increases the minimum combustion efficiency from 82% to 85% effective in 2020 for gas hot water boilers between 2,500 and 10,000 MBH in size. However, the ongoing existing building market characterization study estimates that only 25% of >2,000 MBH gas hot water boilers installed since 2009 are high-efficiency models. Therefore, the evaluation team recommends that the Massachusetts PA programs consider shifting the baseline assumption for >2,000 MBH models from 80% efficiency to a custom analysis, depending upon the circumstances of the particular application. Because these larger boilers were not a focus of this study, further discussion of this consideration may be warranted.
- **Consider incentivizing contractors to test combustion efficiency**. Several manufacturers suggested that the program offer a small incentive to contractors to conduct and provide the results of a combustion efficiency test in order to assess the operating efficiency of installed boilers, in particular for replacement applications. The evaluation team recommends this suggestion be taken under consideration, however further research into the feasibility of this approach is necessary.

2 INTRODUCTION

Technological advances in boiler equipment continue at a fast pace and have created a complex and quickly evolving boiler market. The objective of the Phase II study was to provide the PAs and EEAC consultants with an understanding of the rate of change in the current baseline efficiency level and provide an analytic comparison to boiler programs in the surrounding Northeast Region. The study addressed the following research topics:

- Further characterize the current market for new boilers in Massachusetts—that is, identify manufacturers of new boilers by efficiency, size, and type.
- Identify differences in program design, participation, and, if feasible, market share, between Massachusetts and other states in the Northeast.
- Facilitate an open dialog event with market-savvy trade allies who wish to contribute information for program development.

The Team conducted a series of qualitative and quantitative tasks to address the research objectives outlined above. These five tasks include the following:

- Task 1: Seek Boiler Manufacturer Input/Comment on Phase I Final Report (completed July 2015)
- Task 2: Comparative Research on Condensing Gas Boiler Programs in the Northeast Region (completed June 2015)
- Task 3: Initiate Boiler Product Line Mapping (completed June 2015)
- Task 4: Provide Overview of US Department of Energy Notice of Proposed Rulemaking for Commercial Boiler Standards (completed May 2016)
- Task 5: Conduct Open-Dialog Massachusetts Boiler Roundtable (completed June 2016)

Note that this study was on hold in 2015 and early 2016 because DOE was delayed in releasing the NOPR for commercial boiler standards. The release of the NOPR was considered critical for the completion of Tasks 4 and 5 given the impact that the rulemaking would have on the future baseline requirements for commercial boiler products. When DOE released the draft NOPR in March 2016, the study resumed. In addition, DOE recently released the final rulemaking for commercial packaged boilers on December 28, 2016.[4]

This study defines small C&I boilers as those between 90 and 2,000 MBH (thousand British thermal units per hour) in size that are installed at a business or other non-residential location. Some results are presented for standard efficiency, mid-efficiency, and high-efficiency models. In addition, the boiler product line mapping task further splits the high-efficiency category by Tier 1 vs. Tier 2. Table 2 lists the four efficiency categories, associated efficiency levels, and Massachusetts PA program eligibility.

[4] DOE Final Rulemaking for Commercial Packaged Boilers: www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=8&action=viewcurrent

Table 2: Boiler Efficiency Levels and Sizes

Efficiency Category		Efficiency Level*	MA PA Program Eligibility**	
			≤300 MBH	301 to 2,000 MBH
Standard Efficiency		Less than 85%	No	No
Mid-efficiency		85% to less than 90%	No	No
High Efficiency	Tier 1	90% to less than 95%	Yes	Yes
	Tier 2	95% or greater	Yes	Yes

*AFUE for boilers up to 300 MBH and thermal efficiency ($E_{t)}$ for boilers greater than 300 MBH

**Only natural gas condensing gas boilers are eligible for program incentives

2.1 Manufacturer Survey (Task 1)

This task involved contacting manufacturers who are active in Massachusetts and the Northeast to seek input and any voluntary feedback about the Phase I report and the current market for boilers sold to small commercial and industrial (C&I) customers in Massachusetts. The task also helped establish a framework for prospective panel members of the Massachusetts Boiler Roundtable (Task 5).

2.1.1 Sample Development

The first step in the manufacturer outreach effort was to develop a sample of gas boiler manufacturers. The sample was, in part, made up of 20 boiler manufacturers who had previously completed interviews for the Phase I study. The remainder of the sample was made up of 20 other manufacturers whom the Team had identified as producing gas boilers for the small C&I market. The Team undertook internet searches and placed telephone calls to help identify appropriate contacts at these manufacturers. In some instances, the sample contained both a parent company as well as its subsidiaries. In these instances, the Team kept the parent company within the sample and removed the subsidiaries (but made sure to capture this information for reference). This resulted in a final sample of 32 manufacturers.

2.1.2 Initial Letter

To garner cooperation from the manufacturers, the Team developed a letter using PA logos and mailed it to the manufacturers in early February 2015. The letter briefly described the Phase I study and indicated that the manufacturers would soon be contacted by members of the Team to solicit their feedback about the Massachusetts boiler market for the Phase II study.

2.1.3 Feedback Form

In order to structure the feedback from the manufacturers, the Team developed a data collection instrument that included a short set of questions that the Team anticipated manufacturers would be willing to complete. The form began with a summary of the key findings from the Phase I Report. Manufacturers were asked to estimate the annual sales of small C&I gas boilers in Massachusetts. Subsequent questions asked manufacturers to identify which boilers they offer by efficiency level, which type represented most of their sales in Massachusetts, and what their projections of percent changes in annual sales were. Manufacturers who produce standard efficiency boilers were asked if they intend to continue producing them and what might trigger them to discontinue production. Lastly, the final questions asked respondents if they were interested in participating in a boiler Roundtable discussion and to provide any feedback they might have about the Massachusetts program, the Phase I Final Report, or the Phase II study.

The final version of the feedback form is included in Appendix A – Manufacturer Survey.

2.1.4 Data Collection

Manufacturers were contacted either by email, if the email addresses were available, or by telephone if email was not available. Regular follow-up calls were made and emails sent to encourage participants to respond.

Multiple contact attempts were made with respondents when needed, with an average of seven attempts per contact over the course of the task. Data collection proved to be challenging for a number of reasons, with some manufacturers refusing to participate because they did not have time or it was their company's policy not to provide comments related to market share estimates, while others were simply unresponsive to the Team's repeated requests.

The Team collected responses between February 10, 2015, and April 20, 2015. Of the 32 manufacturers that the Team reached out to, 13 provided responses to the questions, which equates to a 41% response rate. A final Task 1 memo summarizing the findings was provided to the PAs on July 2, 2015.

2.2 Program Review (Task 2)

This task provided an analytic comparison of prescriptive programs targeting commercial condensing gas boilers in the Northeast region. It summarizes the key findings derived from data collected from websites, evaluation reports, annual reports, program plans, and telephone interviews with program staff from the Northeast region program administrators between February 23 and March 30, 2015 (Table 3).[5]

Table 3: Northeast Region Program Administrators Interviewed

State	Program Administrators
Connecticut	UIL Holdings (UIL[6]) including Southern Connecticut Gas (SCG) and Connecticut Natural Gas (CNG)
	Eversource, formerly Yankee Gas
Maine	Efficiency Maine
New Hampshire	Unitil
	Liberty Utilities
New York	New York State Energy Research and Development Authority (NYSERDA)
	Iberdrola USA including New York State Electric & Gas (NYSEG) and Rochester Gas and Electric (RG&E)
	National Grid including Niagara Mohawk Power Corporation (Upstate), Keyspan Energy Delivery (New York) and Keyspan Energy Delivery (Long Island)
Rhode Island	National Grid

This task compared prescriptive program design characteristics, boiler savings assumptions, and boiler rebate

[5] Vermont Gas Systems declined to be interviewed. The results of a web search for relevant program information are included for this program.

participation from 2012 to 2014, as well as available boiler market information among these prescriptive programs. It also presents a summary of findings and consideration of whether and to what extent program participation in Massachusetts differs from that of nearby states.

2.3 Boiler Product Line Mapping (Task 3)

The purpose of this task was to explicitly identify all boiler manufacturers and the full spectrum of standard, mid-, and high-efficiency models offered in Massachusetts. For this task, the Team relied on publicly available data from the Air-Conditioning Heating and Refrigeration Institute (AHRI) product directory[7] as well as from boiler manufacturers.

The Team downloaded data from the AHRI database on commercial boiler models on February 20, 2015. AHRI classifies boilers under 300 MBH as residential and boilers greater than 300 MBH as commercial. The Team downloaded data from both the residential and commercial AHRI databases because the Massachusetts PA prescriptive rebate program offers rebates for boilers above 90 MBH installed in nonresidential buildings.

In total, the AHRI database contains information for 53 boiler manufacturers and 3,142 active[8] boiler models ranging from 90 to 2,000 MBH input.[9] From this initial list, we removed 47 boilers that were listed as not being sold in the United States. We also attempted to refine the list of manufacturers based on a web search to exclude manufacturers that do not offer products in Massachusetts. However, the web search confirmed that all 53 manufacturers have distributors located in the Northeast—in fact, all but one of the manufacturers have distributors located directly in Massachusetts.[10] Finally, based on a web search, we consolidated 14 manufacturers that are owned by three separate parent companies, thereby reducing the total number of manufacturers to 42.[11] A list of consolidated manufacturers can be found in Appendix C – Boiler Product Line Mapping.

2.4 NOPR Review (Task 4)

This task provided a summary of the draft NOPR that DOE published in the Federal Register on March 24, 2016, concerning energy conservation standards for commercial packaged boilers.[12] The Team compared the draft NOPR to current federal standards as well as to the 2016 Massachusetts PA prescriptive program efficiency level. A memo detailing the Team's findings was provided to the PAs on May 17, 2016. Note that this task (as well as Task 5) was completed about a year after the first three tasks were completed because DOE delayed the release of the draft NOPR.

2.5 Boiler Roundtable (Task 5)

The final task of this study, the Boiler Roundtable, was held by the Team on May 9, 2016, and a summary of the Roundtable's findings was provided in a draft memo dated June 30, 2016. The Roundtable webinar was attended by manufacturers of commercial gas boilers who are active in Massachusetts as well as several

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[6] Iberdrola USA and UIL Holdings announced an agreement to merge operations on February 26, 2015. The merger was completed in December 2015.

[7] https://www.ahridirectory.org/ahridirectory/pages/home.aspx

[8] Only boiler models with a status of "active" were included in this analysis; models listed as either "obsolete" or "discontinued" were excluded.

[9] The Phase 1 report assumed that 90 – 2,000 MBH was the typical size range for small commercial & industrial boilers in Massachusetts.

[10] Allied Engineering Company does not have a distributor location listed in Massachusetts but does have a location in New York which could reasonably serve the greater Northeast region, including Massachusetts.

[11] This consolidation is not meant to be comprehensive, and the Team acknowledges that other corporate relationships may exist within the database that could not be identified through a simple web search.

[12] While the draft NOPR was released on March 11, 2016, it was not officially published in the federal register until March 24, 2016.

program staff members from the Massachusetts PAs. The intent of the Roundtable was to provide an interactive forum for manufacturers and program staff to discuss the Massachusetts gas boiler market and the Massachusetts PA prescriptive gas boiler rebate program. An open dialogue was encouraged, with NMR staff facilitating the discussion. The Team shared the webinar slides with all participants prior to the call to help them prepare. Thirteen individuals attended the Roundtable webinar, including three members from DNV GL and NMR Group, two staff from National Grid, and eight manufacturers and manufacturer representatives of commercial gas boilers (Table 4).

Table 4: Roundtable Attendees

Attendee Type	Company Name	Attendee Count	Products Manufactured	Manufacturer Attendee Titles	Total # Natural Gas Boiler Models[1]	Percent of Natural Gas Boiler Models[1] that are High Efficiency
Manufacturers and their representatives	DE Deitrich Process Systems	1	Boiler Mfr	National Sales Manager	21	33%
	ECR International	1	Mfrs boilers and other heating products; distributes under brands such as Pennco, Dunkirk, Utica	Director of US Sales	170	22%
	FIA Inc. (Lochinvar)	1	Mfr rep in MA for Lochinvar (mfr of boilers and water heaters)	Regional Sales Manager	84[2]	48%[2]
	Heat Transfer Products	1	Mfrs boilers, water heaters, combination systems	Senior Vice President of Business Development	29	100%
	Laars Heating Systems	1	Mfrs boilers, water heaters, combination systems	Regional Sales Manager	162[3]	48%[3]
	Navien	1	Mfrs boilers, water heaters, combination systems	Northeast Territory Manager	4	100%
	Parker Boiler	1	Boiler Mfr	National Sales Manager	10	60%
	Velocity Boiler Works (Crown)	1	Sales/Marketing for Crown (mfrs boilers, furnaces, indirect water heaters)	National Sales Manager	68	19%
MA Program Administrators	National Grid	2	--	--	--	--
Evaluation Team	DNV GL	1	--	--	--	--
	NMR Group	2	--	--	--	--

[1] Estimates from Task 3, the Boiler Product Line Mapping memo.

[2] Boiler model estimates for Lochinvar.

[3] Boiler model estimates from parent company, Mestek.

3 MARKET CHARACTERIZATION

This section provides an overview of boiler model availability, sales information, and other market characterization details.

3.1 Boiler Availability

We first present the boiler availability results at the model level, followed by the manufacturer level. Availability refers to the number of boiler models offered nationwide by manufacturers per AHRI.

3.1.1 Boiler Models Available

Nearly one-half (49%) of all boilers are standard efficiency,[13] 27% are mid-efficiency, and almost one-quarter (24%) are high efficiency (Table 5). As shown, the majority (59%) of boilers contained in the AHRI database are natural gas models.[14] While the database does not contain data specifically identifying condensing boilers, in the Team's experience, boilers with a combustion efficiency of 90% or greater are generally condensing units. Therefore, we assume that any models listed as high efficiency are condensing units.

Table 5: Boiler Models by Fuel Type and Efficiency

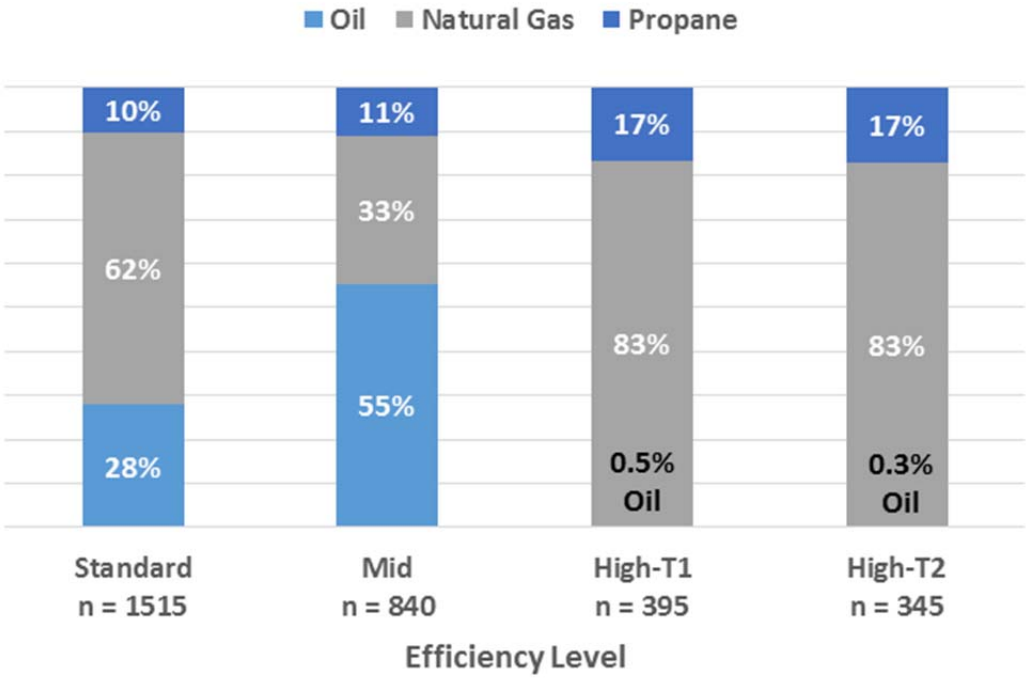
Fuel Type	Efficiency Level				
	Standard	Mid	High Efficiency		Percent All
			High-Tier 1 (T1)	High-Tier 2 (T2)	
	≤84%	85%-89%	90%-94%	≥95%	
Oil	422	465	2	1	29%
Natural Gas	938	281	327	285	59%
Propane Only	155	94	66	59	12%
All	**1,515**	**840**	**395**	**345**	**3,095**
Percent of Total	49%	27%	13%	11%	100%

[13] The standard efficiency category includes 130 steam boilers with efficiencies of less than 80%.

[14] Throughout this section, natural gas boiler counts include those boilers that were listed as operating on either propane or gas. Propane boilers are those listed as propane only.

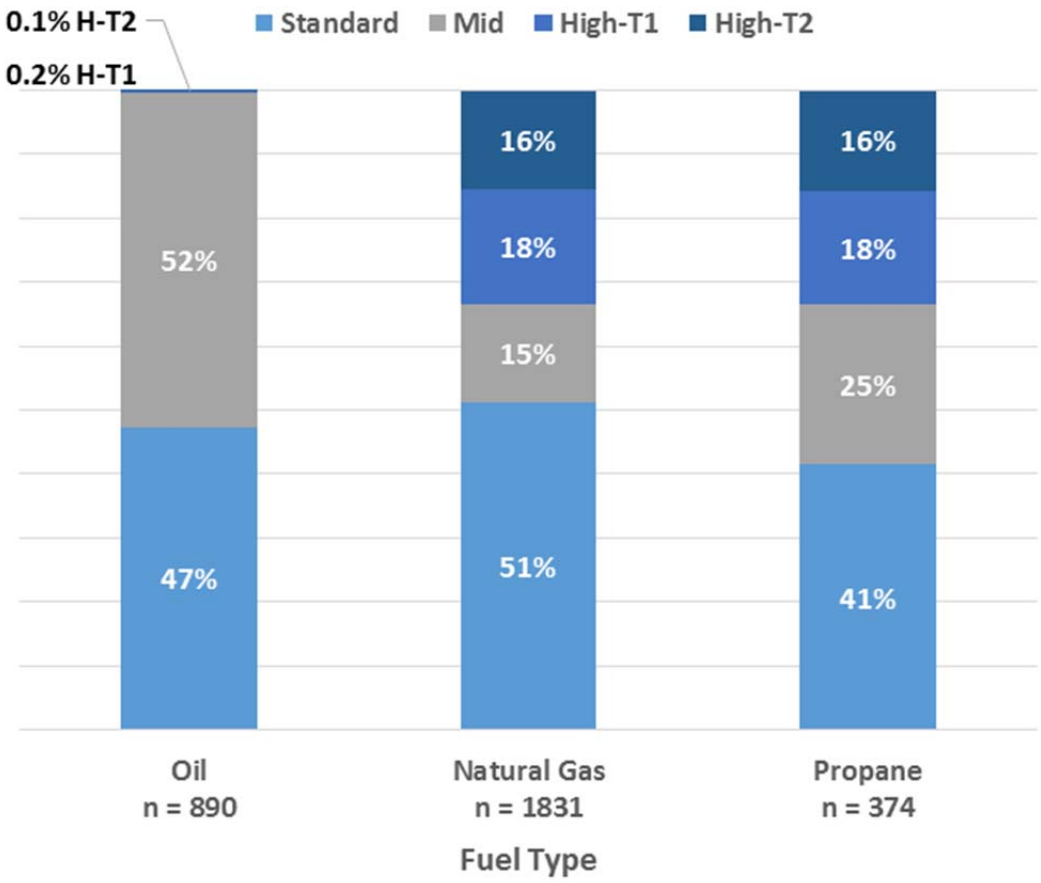
Not surprisingly, as Figure 1 illustrates, natural gas boilers dominate the high efficiency category, comprising 83% of high-efficiency models; natural gas boilers also represent 62% of the standard efficiency models and 33% of mid-efficiency boilers.

Figure 1: Natural Gas Dominates High-Efficiency Models
(Percent of Boilers by Fuel Type and Efficiency)



As Figure 2 makes clear, high-efficiency boilers represent only a very small portion of oil boilers (less than 1%). In contrast, high-efficiency models comprise about one-third of all natural gas and propane boilers. Interestingly, among natural gas boilers, mid-efficiency models represent the lowest number of available boilers (15%) compared to one-quarter of all propane models and over one-half of all oil models.

Figure 2: Standard and Mid-Efficiency Models Eclipse High-Efficiency Models
(Percent of Boilers by Efficiency and Fuel Type)



3.1.2 Boiler Models Available by Size

Table 6 provides a summary of the boilers contained in the AHRI database by size. Just over one-half of all boilers (55%) and nearly one-half of natural gas boilers (48%) are ≤300 MBH, although a much greater share of oil boilers (77%) are ≤300 MBH. The share of gas boilers in each efficiency level is similar regardless of size category.

The shaded cells meet the efficiency criteria for the Massachusetts PA program[15] and would be eligible if the models are condensing units. Assuming all of these models are condensing, an estimated 33% of all natural gas boilers are program eligible, including 32% of >300 MBH models and 35% of ≤300 MBH models.

Table 6: Boiler Models by Size and Efficiency

Boiler Size (MBH)	Efficiency Level				Total
	Standard	Mid	High Efficiency		
			High-T1	High-T2	
	≤84%	85%-89%	90%-94%	≥95%	
All Boilers					
90 to 300	48%	32%	11%	9%	1,698 (55%)
301 to 1,700+	50%	21%	15%	14%	1,397 (45%)
Natural Gas Boilers					
90 to 300	54%	11%	18%	17%	871 (48%)
301 to 1,700+	49%	19%	18%	14%	960 (52%)
Oil					
90 to 300	38%	61%	<1%	--	685 (77%)
301 to 1,700+	78%	22%	0%	0%	205 (23%)
Propane Only					
90 to 300	54%	20%	18%	7%	142 (38%)
301 to 1,700+	33%	28%	18%	21%	232 (62%)

[15] The following link provides information about the Massachusetts PA rebate program: www.masssave.com

3.1.3 Manufacturer Product Lines Offered

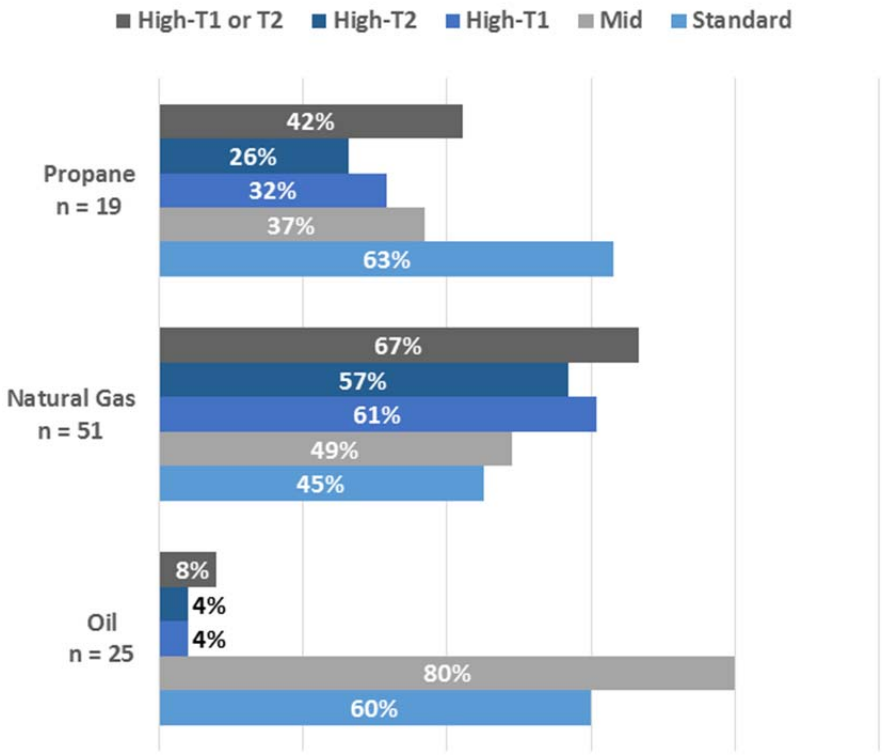
Examining the number of consolidated manufacturers by fuel type and efficiency level reveals that a mix of manufacturers produce standard, mid-, and high-efficiency boilers. More than one-half of manufacturers offer standard efficiency boilers (24 of 42) and most offer high-efficiency boilers (34 out of 42). In fact, more manufacturers produce high-efficiency boilers than either standard or mid-efficiency boilers, although there are far fewer high-efficiency models available (Table 7).

Table 7: Number of Manufacturers by Fuel Type and Efficiency

Fuel Type	Efficiency Level					
	Standard	Mid	High Efficiency			Count (%)
			High-T1	High-T2	*High-T1 & High-T2 Combined*	
	≤84%	85%-89%	90%-94%	≥95%	*≥90%*	
Oil	15	20	1	1	*2*	21 (50%)
Natural Gas	23	25	31	29	*34*	40 (95%)
Propane Only	12	7	6	5	*8*	17 (40%)
All	**24**	**32**	**31**	**29**	***34***	**42**
Percent Total	57%	76%	74%	69%	*81%*	100%

As Figure 3 shows, natural gas manufacturers are much more likely to produce high-efficiency models than either propane or oil manufacturers. Two-thirds of natural gas manufacturers produce high-efficiency models (Tier 1 or 2), and over one-half (57%) produce a Tier 2 high-efficiency model.

Figure 3: Natural Gas Manufacturers More Likely to Produce High-Efficiency Models
(Percent of Manufacturers by Fuel Type and Efficiency)



We further examined the efficiency level of natural gas models offered by manufacturers. As Table 8**Error! Reference source not found.** shows, over three-quarters (79%) of all natural gas boiler models are produced by 15 manufacturers who produce boilers of all efficiency types. These 15 natural gas manufacturers offer larger product lines than others, on average offering 99 models each. They represent the majority of standard efficiency (88%), mid-efficiency (75%), and high-efficiency models (65%) available in the market. Examples of these large, broad manufacturers include Burnham, ECR, SPX (Weil-Mclain), and Mestek.

However, there is a contingent of smaller manufacturers that exclusively offer mid- and/or high-efficiency models, likely because they anticipate an expanding high-efficiency market. Nine manufacturers offer mid-efficiency or both mid- and high-efficiency models, representing 23% of all mid-efficiency models and 10% of all high-efficiency models. On average, these nine manufacturers each offer only 14 natural gas models. Examples of these manufacturers include Bradford-White, DDR Americas, and Harsco.

There are also eight small manufacturers that only offer high-efficiency models, which represent 19% of all high-efficiency models. On average, these eight manufacturers each offer only 15 natural gas models. Examples of these manufacturers include NY Thermal, HTP, Aerco, and Triangle Tube.

Table 8: Boiler Efficiency Levels offered by Natural Gas Manufacturers

Models Offered	Consolidated Natural Gas Manufacturers	Avg. # Boiler Models	Natural Gas Boiler Models			
			Total	Std.	Mid	High (T1 or T2)
N	**40**		**1,831**	**938**	**281**	**612**
All Efficiency Levels	15	99	79%	88%	75%	65%
Standard Only	3	11	2%	3%	--	--
Standard + Mid	1	9	1%	<1%	2%	--
Standard + High	4	26	6%	8%	--	5%
Mid Only	2	5	<1%	--	4%	--
Mid + High	7	16	6%	--	19%	10%
High Only	8	15	6%	--	--	19%

As illustrated in Table 26 in Appendix C – Boiler Product Line Mapping, 13 manufacturers produced natural gas condensing boilers that received a Massachusetts PA rebate in 2013. Seven of these 13 participating manufacturers were from the group of 15 large, broad manufacturers described above. One participating manufacturer was from the group of seven manufacturers that produce both mid- and high-efficiency models, and five were from the group of eight manufacturers that produce only high-efficiency models.

Additional details on manufacturer product lines are available in Appendix C – Boiler Product Line Mapping, including the number of models offered by each manufacturer by efficiency level and fuel type.

3.2 Gas Boiler Sales

This section provides an overview of the size and projected sales increases for the commercial gas boiler market in Massachusetts.

3.2.1 Annual Gas Boiler Sales

The Phase I report estimated that annual sales of 90 to 2,000 MBH gas boilers to C&I customers in Massachusetts in 2012 ranged from 1,500 to 3,000 units for all gas boilers and from 900 to 2,400 units for condensing models.[16] The Team asked manufacturers who participated in the Manufacturer Survey (Task 1) to help refine and update this estimate by providing their estimates of 2013 annual sales.

However, the Team received a wide disparity in responses and therefore was unable to calculate an overall estimate of 2013 annual sales based on the feedback provided by manufacturers. The Team believes that the higher figures (i.e., >10,000 units) likely include residential sales (in particular, multifamily buildings) because some manufacturers indicated that it was difficult to split out residential versus commercial sales. Several manufacturers indicated that the lower figures (i.e., <500 units) are likely specific to the individual manufacturer rather than the entire Massachusetts market. In addition, three manufacturers explicitly said they did not know how to estimate the size of the market. The Team reached out to all respondents who did not appear to accurately answer these questions in order to clarify or refine their responses; however, in most instances the Team did not receive any further information.

Given that no industry-wide sales estimates are available, it may be the case that manufacturers simply do not know, for the most part, whether their boilers are sold to commercial or residential customers (particularly for smaller units) or where the boilers may be installed (inside or outside of Massachusetts), and therefore they lack accurate information about the overall market. Thus, they cannot provide reliable estimates regarding the commercial market size. In this context, the widely varying nature of the responses seems reasonable and indicates that the Phase 1 report figures may be the most accurate estimates available for the size of the Massachusetts market.

However, we were able to leverage the data to calculate the proportion of gas boiler sales in Massachusetts that are condensing models, based on the responses provided by seven manufacturers (Table 9). Overall, these responses were much more consistent, resulting in an average value of 74% and a median value of 80%. These results are on the high end of the 60% to 80% range provided by the Phase 1 Report.

Table 9: Proportion of Condensing Model Sales in Massachusetts based on Manufacturer Estimates

90 – 2,000 MBH gas boilers in Massachusetts	Percent Condensing Models
n	7
Average	74%
Median	80%
Minimum	46%
Maximum	90%

[16] http://ma-eeac.org/wordpress/wp-content/uploads/CI-Boiler-Market-Characterization-Study-Final-Report.pdf

In addition, preliminary findings from the existing building market characterization study currently underway in Massachusetts indicate that approximately 70% of gas hot water boilers less than 2,000 MBH in size installed since 2009 are high-efficiency (condensing) units.[17] Of the 128 gas hot water boilers <2,000 MBH in size installed since 2009, 69% (86 units) were condensing models (above 90% efficiency), 30% (29 units) were not condensing, and 1% (13 units) were unknown efficiency.[18] There was a small share of units with unknown efficiencies due both to the difficulty of collecting make and model numbers and in finding information on unit efficiency. If the distribution of the units with unknown efficiencies is the same as those with known efficiencies, 70% of units are condensing models.

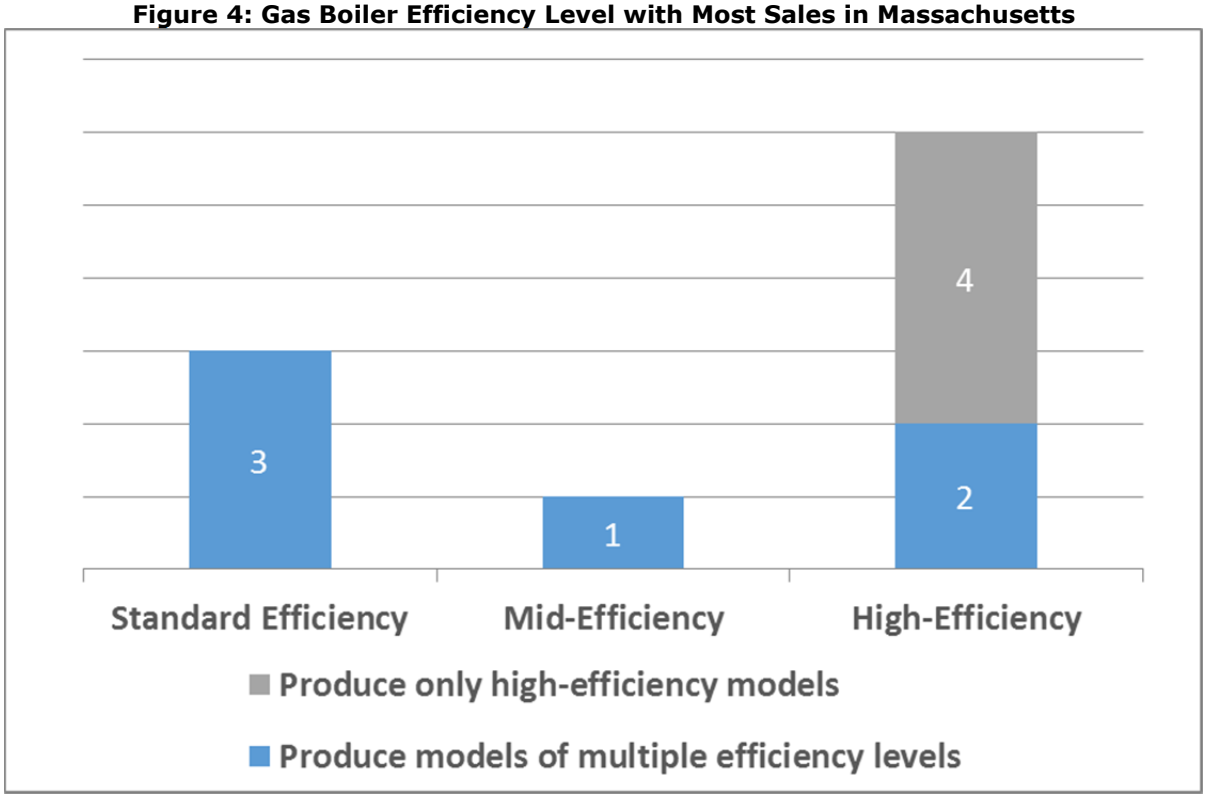
Of the 61 gas hot water boilers >2,000 MBH in size installed since 2009, 23% (18 units) were condensing models (above 90% efficiency), 69% (38 units) were not condensing, and 8% (5 units) were unknown efficiency. If the distribution of the units with unknown efficiencies is the same as those with known efficiencies, 25% of units are condensing models.

3.2.2 Annual Sales Forecasts

Manufacturers who participated in the Manufacturer Survey (Task 1) were asked which types of 90 to 2,000 MBH gas boilers represent the most sales for their company in Massachusetts (Figure 4). Six respondents reported that high-efficiency models represent the most sales for their company, although four of these six manufacturers only sold high-efficiency models. Three respondents reported that standard efficiency models represent the most sales for their company, and one reported that mid-efficiency models represent the most sales for their company. Three respondents did not provide feedback to this question—each had reported manufacturing a mix of standard, mid-, and high-efficiency models.

[17] Note that these are preliminary estimates and therefore may change prior to completion of the existing building market characterization study.
[18] Note that the percentage of units are weighted in order to reflect the population.

Figure 4: Gas Boiler Efficiency Level with Most Sales in Massachusetts



These same manufacturers were asked to provide estimates of the forecasted annual increase or decrease that their company is currently using for 90 to 2,000 MBH gas boiler sales to C&I customers in Massachusetts (Table 10). If they could not speak to the Massachusetts market specifically, manufacturers were asked to provide estimates for New England or the Northeast U.S. They were also asked to provide a specific point estimate (e.g., +3%), if possible, though a range was acceptable as well (e.g., +2% to +4%).

Overall, manufacturers projected a flat or small increase in the annual sales of standard efficiency and mid-efficiency models; some manufacturers projected increased sales, while others projected decreased sales. The overall average and median sales increase is +2% for standard efficiency models, and an average of 0% and a median of +2% for mid-efficiency models.[19]

In contrast, all manufacturers expect that annual sales of high-efficiency boilers will increase, with estimates ranging between +5% and +30% and an average of +10% and median of +8%.

Table 10: Forecasted Annual Sales Increase or Decreases by Efficiency Level

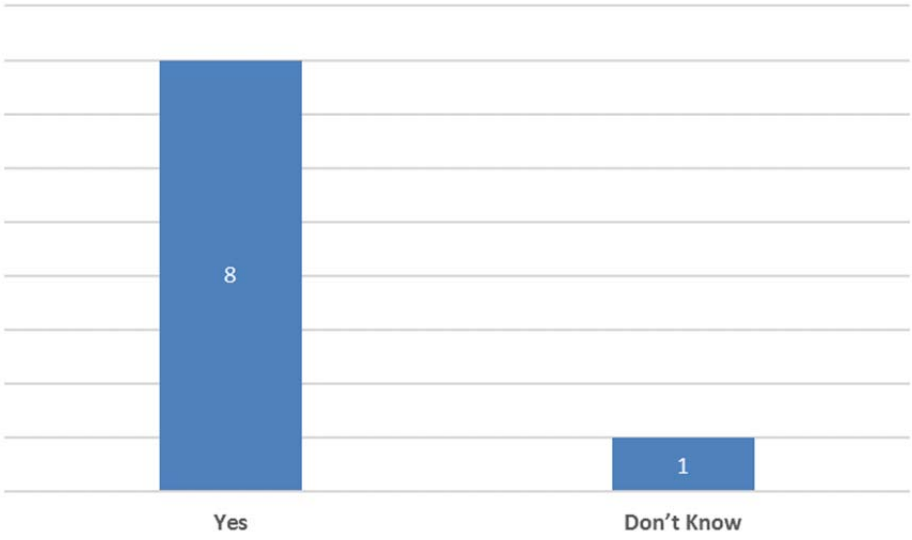
Forecasts by Boiler Types	Standard Efficiency	Mid-Efficiency	High-Efficiency
n	**9**	**8**	**11**
Average	*+2%*	*0%*	*+10%*
Median	*+2%*	*+2%*	*+8%*
-10% decrease	2	1	--
-5% decrease	--	1	--
0% (Flat)	3	2	--
1% to 5% increase	3	4	2
6% to 10% increase	1	--	7
20% to 30% increase	--	--	2

[19] When respondents provided a range of estimates, the midpoint value was used to calculate the average and median figures.

3.3 Manufacturer Production Plans for Standard Efficiency Boilers

Manufacturers who participated in the Manufacturer Survey (Task 1) were asked whether their company intends to continue producing standard efficiency boilers in the future (Figure 5). Of the nine manufacturers who reported that their company currently produces standard efficiency boilers, all but one respondent (who said he did not know) reported that they plan to continue doing so.

Figure 5: Manufacturers' Plans for Standard Efficiency Models



Eight manufacturers believe that the market will continue to persist for standard efficiency models, at least in certain scenarios (Table 11).[20] Some of these scenarios include existing building retrofits where venting issues or space constraints present a challenge to the installation of condensing units, issues with upfront costs of higher efficiency boilers, or other design challenges that might make it difficult to ensure that a condensing unit will properly condense, such as return water temperature issues.[21] One respondent provided the following context about why he believes standard efficiency units will persist:

> We don't see these unit(s) being discontinued because there are still so many older boilers in retrofit situations out there. Those types of situations are not always appropriate for condensing units because of the system challenges. [You] need return water temperature to be low to condense, and this just might never be possible in the older retrofit systems. Rebates can sometimes push customers into purchasing condensing when it's not effective/appropriate because the rebate allows them to be cost competitive. It's important to continue offering the lower efficiency unit for those retrofit scenarios.

[20] Note that ten respondents provided feedback to this question, with one respondent providing a response even though his company did not produce these standard efficiency units.

[21] The term *return water temperature* refers to the temperature of the water returning to the boiler (also the inlet water temperature), which dictates the efficiency of the boiler.

Another stated his thoughts as follows:

> There are still a few applications where high efficiency won't work—specifically in existing buildings with limited venting options. Cost can play into it as well, but the rebates offset a tremendous portion of the initial difference.

Other key factors mentioned by manufacturers include the fact that the market is changing at a rapid pace as demand increases for high-efficiency models (n=4), industry rulemaking (n=1), and that rebates will help to move the market toward high efficiency (n=1).

Table 11: Key Factors that May Trigger Discontinuation of Standard Efficiency Boilers (Multiple Response)

Key Factors for Discontinuation of Standard Efficiency	Count
n	**10**
Market will persist for certain applications (some existing buildings with venting issues or space constraints, return water issues, upfront cost)	8
Changes in marketplace as demand increases for higher efficiency	4
Industry rulemaking	1
Rebates will continue to move majority of market toward high efficiency	1
No response	1

3.4 Condensing Boiler Challenges

Manufacturers who participated in the study repeatedly emphasized system design challenges that high-efficiency condensing boilers face, particularly in retrofit situations.

Importance of System Design. Several manufacturers noted that condensing boilers will often not reach their intended efficiencies due to challenges with system design when installed in existing buildings. One manufacturer provided the following feedback:

> The industry is very hung up on boiler efficiency and combustion efficiency, but no one is having a conversation about the system efficiency and how well the heat is being delivered up through the structure. Why are we not pushing design efficiency and proper system efficiency? A 20°F change in return water temperature is not enough to properly bring a system back into condensing mode. Installation technique is also important. Outdoor reset controls are not effective if you don't have a perfectly designed system; indoor reset controls or smarter systems are key.

Another manufacturer suggested that they can produce the most efficient boiler, but if the system is not properly designed, the equipment will not be able to condense and reach its intended efficiency. The only real benefit will be the modulating burner technology, which is common in higher efficiency boiler equipment.[22] He noted that system efficiency is just as or more important than boiler efficiency.

22 Modulating burners are designed to control the burner output to match the boiler's variable load requirements. Because of this, modulation will lead to some increases in boiler efficiency regardless of whether the system is in condensing mode because the boiler is not firing at full capacity all of the time.

Another manufacturer stressed the importance of return water temperatures for condensing systems:

> [The] system needs to be designed for return water temperatures to be <131°F, or a condensing boiler will not condense.

Other manufacturers echoed these concerns about system design issues in retrofit situations.

Retrofit Challenges. Manufacturers agreed that retrofit situations can be challenging for condensing systems. One manufacturer reported that old churches and schools that are still on old radiator systems that require higher return water temperatures are the most common applications where this issue arises. He said these types of applications are a huge portion of the market and will always need to operate at high temperatures. Another manufacturer noted:

> The biggest opportunity is new construction because not only is the boiler one component of the heating system, but all your coils are going to be downsized, or sized appropriately for 140 degrees F rather than 180 degrees F. It is a lot easier to do it right when the whole system is designed that way.

Frequency of Issues and Alternatives. Roundtable participants agreed that system design issues, particularly in retrofit applications, occur often, with one manufacturer noting:

> I see it a lot. People misapply condensing appliances on a regular basis, then complain that they are not getting the efficiency. When they do a combustion test, they are getting 85% and it was advertised as 95% or 97%. It's because they're misapplying it. It happens all the time… What people don't do is go back and look at the design criteria for the building when it was originally built.

One manufacturer commented that if the building is not designed to bring the return water temperature down, it will simply not condense. One of the National Grid staff said that this issue arises frequently and noted that system design issues need to be addressed with the help of a knowledgeable contractor.

The 2013 impact evaluation of prescriptive C&I gas measures provides results that appear to support the manufacturers concern regarding condensing gas boilers performance[23]. This study estimated an average operating efficiency of 92.1% for <300 MBH boilers rated 95%+ AFUE and an average operating efficiency of 89.2% for all boilers rated 90%+ efficiency. In addition, the evaluated efficiencies for individual boilers varied from 86% to 95%. While this impact evaluation did not specifically measure the extent to which condensing boilers are or are not condensing, these efficiencies suggest that the boilers below the average efficiency level (up to one-half of boilers) may not be condensing as designed.

Improving System Design. Roundtable participants were asked if they have suggestions to help the Massachusetts PA program encourage well-designed systems. A National Grid staff person reported that the PAs are developing a quality installation program that will involve the education of contractors and distributors to ensure the proper design and piping of condensing boilers. He believes this is the most important way that the program can address the issue, though there may also be other approaches.

One manufacturer reported that a gas utility in California had required a field verification of the energy efficiency level using a combustion analyser. The rebate was not paid until the efficiency level was verified. However, another manufacturer believes that it is not fair to deny the customer a rebate if the boiler does not

[23] Impact Evaluation of 2011 Prescriptive Gas Measures. Prepared by KEMA. June 27, 2013.

meet its rated efficiency level in the field. A third manufacturer supported the idea of requesting that a combustion report be included with the rebate application.

A National Grid staff person stated that the PAs require combustion tests as part of the custom program but not as part of the prescriptive program in order to keep it as simple as possible so that customers will participate. Another manufacturer suggested that the Massachusetts PA program could consider incentivizing the combustion report with a gift card of $50 or $100 for the contractor. This suggestion was supported by a second manufacturer.

3.5 Other Factors That Affect the Market

During the Roundtable webinar, manufacturers were asked if there are other factors besides the NOPR[24] that may affect the efficiency of boilers available in Massachusetts over the next few years.

Oil Boilers. Roundtable participants were asked how the limited availability of natural gas service in Massachusetts and the consequent need for oil boilers might affect the efficiency level of gas boilers that are available. One manufacturer commented that there are not many manufacturers who make oil boilers that will operate in condensing mode because of the high sulphur content of the oil, which would ruin the boiler. A National Grid staff person attending the Roundtable did not think that the prevalence of oil boilers in Massachusetts affects the availability of natural gas boilers.

Residential Market. Roundtable participants were asked how the residential gas boiler market affects the commercial market in Massachusetts. Manufacturers agreed that the residential market did not have a great deal of influence on the commercial market. One manufacturer thought that the residential and commercial sectors are two independent markets, and others on the call agreed. A National Grid staff person attending the Roundtable noted that when they begin offering gas service to residential neighbourhoods, it affects commercial buildings in the area because it provides an opportunity to convert to gas as well.

Market Differences. Roundtable participants were asked if and how the Massachusetts market differs from that of other states in New England. There were a variety of responses, with some manufacturers suggesting that the Massachusetts market does not differ, while others pointed out that Massachusetts offers larger rebates than other states. One manufacturer mentioned that Massachusetts requires a registration fee of $10 for each boiler model, so they have to select which models they will offer in Massachusetts in a particular efficiency range. Another manufacturer noted that Massachusetts is most similar to Connecticut and Rhode Island. Two manufacturers suggested that Massachusetts is more aggressive in terms of the level of the rebates offered for high-efficiency equipment. Another manufacturer thought that the market is much greater in Massachusetts because there are more buildings that present good opportunities for installing condensing boiler systems.

[24] See the section on Federal Rulemaking below for more details about the NOPR.

4 FEDERAL RULEMAKING

This section summarizes the draft NOPR that preceded the final federal rulemaking, the manufacturers' feedback that was received over the course of the study about the draft NOPR, and the final rulemaking that was issued on December, 28, 2016.

4.1 Rulemaking Summary

Findings from the review of the draft NOPR and the final rulemaking are presented below. Additional details about the related rulemaking proceedings can be found in the final Task 4 memo (dated May 17, 2016), as well as in Appendix D - NOPR Summary.

4.1.1 Rulemaking Background

The DOE Appliances and Equipment Standards Program undertook a notice of proposed rulemaking for commercial packaged boilers, which helped to determine that these boilers should have new federally mandated efficiency standards. In addition, DOE conducted a test procedure rulemaking for commercial packaged boilers; however, the rulemaking related to *efficiency standards* will be the only rulemaking discussed in this report.

As shown in Table 12, on March 24, 2016, DOE published a Federal Register notice of proposed rulemaking concerning energy conservation standards for commercial packaged boilers (81 FR 15836). As part of that process, DOE analysed potential amendments to the standards to determine whether they were technologically feasible and economically justified and would result in significant energy savings.

Prior to this publication, DOE had issued a Framework Document in 2013 and Preliminary Analysis documentation in 2014 to support the rulemaking process. The purpose of these documents was to describe the procedural and analytical approaches DOE anticipated using to evaluate potential amended energy conservation standards for commercial packaged boilers.

DOE had initially expected to issue a proposed rule in June 2014 and a final rule in July 2015. However, DOE was delayed in issuing these rulings, with the final rule issued on December 28, 2016. Compliance with this amended standard is required by 2020 (three years after the publication in the Federal Register).[25]

Table 12: Commercial Packaged Boiler Rulemaking Documentation

Rulemaking Process	Item	Original Time Frame	Actual Time Frame
Standards	Framework Document	--	September 3, 2013
	Preliminary Analysis	--	November 13, 2014
	Proposed rule	June 2014	March 24, 2016
	Final rule	July 2015	December 28, 2016
	Effective date	--	2020

DOE has regulated the energy efficiency of commercial packaged boilers since 1994. Every six years, DOE must publish either a notice of the determination that standards for the equipment do not need to be amended, or a NOPR that includes new proposed energy conservation standards. DOE's last final rule for

[25] DOE Final Rulemaking for Commercial Packaged Boilers: www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=8&action=viewcurrent

commercial packaged boilers was issued on July 22, 2009, so DOE was required to act by July 22, 2015, to update the standard. As noted above, the publication of the draft NOPR was delayed until March 24, 2016.

4.1.2 Comparison of Current Standards, Proposed Standards, and Massachusetts PA Program Requirements

DOE's current regulations for commercial packaged boilers separate equipment classes based on input capacity (i.e., size category). DOE refers to units with an input capacity of between 300 MBH and 2,500 MBH as "small" and units with an input capacity greater than 2,500 MBH as "large." The current standards for commercial boilers require a minimum efficiency of 77% to 84%, depending on the specific type, size, and fuel.

Table 13 shows the current efficiency levels required for hot water commercial gas boilers compared to the newly issued standard that will come into effect in 2020 and to the 2016 Massachusetts PA program requirements. Note that *only* hot water commercial gas boilers in the range of 300 to 2,000 MBH range are eligible for the Massachusetts PA prescriptive program rebates. Current and proposed standards for boilers in other input ranges can be found on DOE's Office of Energy Efficiency and Renewable Energy website.[26]

Table 13: Comparison of Current Standard, New 2020 Standard, and Program Efficiency Level

Equipment Type	Size Category (input)	Energy Conservation Standard		2016 Massachusetts PA Prescriptive Rebate Efficiency Level*
		Current*	2020 Standard*	
Gas-Fired Hot Water Commercial Packaged Boilers	>300 MBH and ≤2,500 MBH	80.0% E_T	84.0% E_T	90.0% E_T
	>2,500 MBH and ≤10,000 MBH	82.0% E_C	85.0% E_C	Not eligible for prescriptive rebates
	>10,000 MBH		82.0% E_C†	

*Where E_T is thermal efficiency and E_C is combustion efficiency.

† For very large equipment classes DOE will retain the existing standards, which had a compliance date of March 2, 2012.

The new federal standard coming into effect in 2020 will pose a significant increase in the required minimum efficiency levels—from 80% to 84% thermal efficiency (E_t) for hot water gas-fired boilers in the 300 to 2,500 MBH range.[27] Note that Massachusetts PA rebated equipment must utilize "condensing" technologies to reach the required efficiencies. In addition, Massachusetts PA prescriptive rebates are available for commercial boilers up to 2,000 MBH, which is less than the 2,500 MBH size category outlined in the final standard.

While the Massachusetts PA program offers rebates for boilers of less than or equal to 300 MBH that are 90%+ AFUE, these boilers are not covered by this final rulemaking. From 2012 through 2014, about 35% of all Massachusetts PA prescriptive commercial rebates issued were for gas boilers less than or equal to 300

[26] U.S. DOE Office of Energy Efficiency and Renewable Energy. www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=8

[27] Note that these final standards include only non-condensing technologies for gas-fired hot water equipment classes.

MBH. Effective September 1, 2012, the minimum federal standard for gas-fired hot water boilers ⩽300 MBH is 82% AFUE.[28]

4.2 NOPR Feedback from Roundtable

During the Roundtable webinar, which was held by the Team on May 9, 2016, the manufacturers in attendance were asked to discuss the possible effects of the proposed NOPR standards. Note that this Roundtable occurred prior to the release of the final rulemaking in December 2016.

Effect of Proposed Standards on Boiler Efficiency. The NMR facilitator asked the manufacturers to describe how the proposed standards might affect the efficiency of boilers available in Massachusetts. Manufacturers agreed that the proposed standards would likely encourage more customers to choose high-efficiency equipment. One manufacturer mentioned that they come across many installations where it is not possible to reach 85% operational efficiency with their boilers. Another attendee agreed that manufacturers may have a hard time achieving 85% installed efficiencies, especially with cast iron boilers. He noted that poor system sizing is the primary cause of these issues.

Adjustment of Product Lines and Timeline Challenges. Manufacturers agreed that DOE's proposed timeline would not pose any significant challenges and that most manufacturers are already working to adjust their product lines. One manufacturer reported that they are already beginning to increase pricing of standard and mid-efficiency models to encourage customers to choose condensing models instead.

Proposed and Final Standards. Manufacturers provided a variety of responses when asked how they thought the final standards might differ from the proposed standards. One manufacturer thought that a minimum efficiency of 85% is realistic because there has been a movement to reach 90%. Another manufacturer mentioned that in Ontario there is a regulation coming into effect next year that will require new buildings with boilers to meet a 90% minimum efficiency requirement and existing buildings with boilers to meet an 85% minimum efficiency requirement. He noted that this type of rulemaking is where he would like to see the U.S. requirements go as well. A third manufacturer thought that DOE's separate and currently ongoing rulemaking process for the boiler testing procedure will be more important than the final efficiency standards. He said that most every product, including the 85% models, will have to be fan assisted and will have different venting criteria, which will push more people toward high-efficiency rather than mid-efficiency models because of the rebate structure.

[28] U.S. DOE Office of Energy Efficiency and Renewable Energy. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=45&action=viewcurrent#current_standards

5 PROGRAM REVIEW & FEEDBACK

This section summarizes the findings from the review of regional gas boiler programs (Task 2) as well as feedback from manufacturers about the Massachusetts PA program.

5.1 Comparative Research on Condensing Gas Boiler Programs

In this section, the Massachusetts PA program is compared to other regional gas boiler programs regarding program design, participation, and savings assumptions.

5.1.1.1 Minimum Efficiency Levels

Condensing boiler performance levels required by gas programs varied slightly (Table 14). For condensing boilers with capacities up to 300 MBH, most programs require a minimum of 90% AFUE, though a few programs use minimum criteria of 87% or 92%. In addition, the GasNetworks affiliated programs in Massachusetts, New Hampshire, and Rhode Island all offer a second tier at 95%. Vermont also offers a two-tier standard for all boilers, not restricted to condensing boilers: 87% AFUE and 92% AFUE with multistage burner and outdoor air temperature control.

For large boilers with capacities greater than 300 MBH,[29] most programs have established a performance requirement of 90% or greater thermal efficiency (E_t). The exceptions are Connecticut and NY-National Grid, which have set the standard at 92% E_t or greater.

The Massachusetts and New Hampshire programs also apply the two-tier small boiler performance standards of 90% AFUE and 95% AFUE to integrated condensing boiler/water heater units. Rhode Island has established a single performance standard of 90% AFUE, while NY-National Grid sets a single, slightly higher standard of 92% AFUE.

[29] Connecticut includes 300 MBH boilers in the large boiler category.

Table 14: Boiler Performance Required to Qualify for Prescriptive Rebate

Capacity Range	Required Performance	MA	NH	RI	ME	NY-NYSERDA	NY-Iberdrola	NY-National Grid	CT [b]	VT [a]
Condensing Boiler ≤ 300 MBH	AFUE ≥ 87%	Not Eligible								Eligible
	AFUE ≥ 90%	Eligible						Not Eligible		
	AFUE ≥ 92%[c]	Not Eligible						Eligible		
	AFUE ≥ 95%	Eligible			Not Eligible					
Condensing Boiler > 300 MBH	E_t ≥ 90%	Eligible						Not Eligible		
	E_t ≥ 92%	Not Eligible						Eligible		Not Eligible
Integrated Condensing Boiler / Water Heater	AFUE ≥ 90%[d]	Eligible			Not Eligible					
	AFUE ≥ 92%	Not Eligible						Eligible	Not Eligible	
	AFUE ≥ 95%	Eligible	Not Eligible							

[a] All boiler types
[b] Outdoor temperature reset required
[c] Multistage burner and outdoor air temp controller required for VT
[d] Or 0.90 Energy Factor for RI

5.1.1.2 Incentive Levels

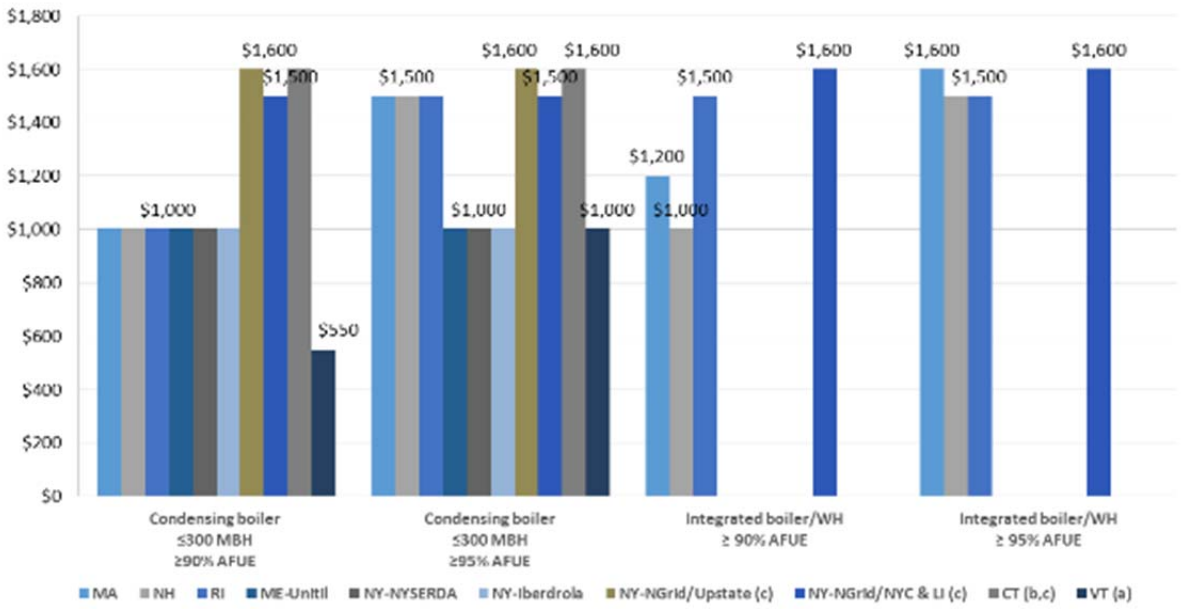
Incentives for commercial gas condensing boilers vary among the Northeast programs and within programs based on boiler capacity and performance levels. Figure 6 illustrates the incentives for small boilers and integrated condensing boiler/water heaters.

Rebates for ≤300 MBH boilers that meet 90% AFUE are generally $1,000 per unit, although rebates are higher for units with slightly higher efficiency criteria of 92% AFUE ($1,500-$1,600 for NY-National Grid & CT) and lower for units with slightly lower efficiency criteria ($550 for Vermont at 87% AFUE). Above 95% AFUE, the condensing boiler rebates increase to $1,500 for the GasNetworks affiliated programs in Massachusetts, New Hampshire, and Rhode Island, but remain the same for most other programs.

The programs that include separate rebates for integrated condensing boiler/water heater units offer rebates of $1,000 to $1,600 per unit at the lower tier and $1,500 to $1,600 per unit at the higher tier.

For the most part, the Massachusetts boiler rebates are in the mid-range of all program rebates.

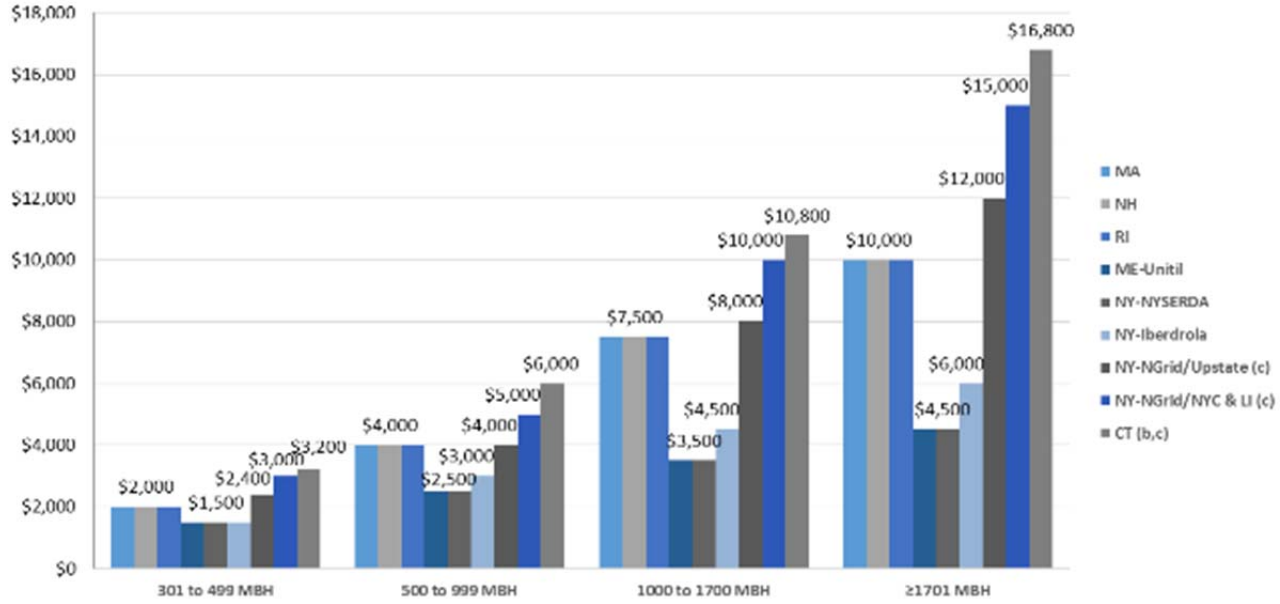
Figure 6: Prescriptive Small Commercial Condensing Boiler and Integrated Condensing Boiler/Water Heater Incentives by Program



[a] Vermont incentives are for all small boilers with efficiencies of 87% and 92% AFUE versus 90% and 95% AFUE for other two-tier small boiler rebate programs. They also require a multistage burner and outdoor air temp controller at the higher performance level.
[b] UIL and Eversource programs in Connecticut provide incentives at $8/MBU. Incentives for mid-range capacities are illustrated.
[c] Connecticut programs and National Grid programs in New York require a condensing boiler efficiency of 92% AFUE for smaller boilers versus 90% as required by all other programs. CT also requires outdoor temperature reset controls for all boilers.
[d] National Grid programs in New York require 92% AFUE for integrated boiler/water heater units.

All of the programs base their incentives for boilers that are greater than 300 MBH on boiler capacity, as illustrated in Figure 7. Most programs have established four size ranges for large condensing boilers and offer fixed incentives that increase with capacity. The exceptions among the programs reviewed are the Connecticut programs, which offer a variable incentive proportional to boiler input MBH. The range of rebates offered varies from $1,500 to $3,200 for 301 to 499 MBH units, from $2,500 to $6,000 for 500 to 999 MBH units, from $3,500 to $10,800 for 1,000 to 1,700 MBH units, and from $4,500 to $16,800 for ≥1,700 MBH units. For the most part, the Massachusetts boiler rebate levels are in the mid-range of all program rebates.

Figure 7: Prescriptive Large Commercial Condensing Boiler Incentives by Program



[b] UIL and Eversource programs in Connecticut provide incentives at $8/MBU. Incentives for mid-range capacities are illustrated.
[c] Connecticut programs and National Grid programs in New York require a condensing boiler efficiency of 92% E_t for larger boilers versus 90% as required by all other programs. CT also requires outdoor temperature reset controls for all boilers.

5.1.1.3 Recent and Planned Changes to Program Design

There have not been significant changes in Northeast gas boiler programs in recent years except for the expansion of the Maine program to gas customers outside the Unitil service territory in 2015. Many program staff members reported that the most sensitive program parameter is incentive levels, which they assess frequently. Program planning for future changes has included discussions in Rhode Island about an upstream program for water heaters in 2016 and possibly for boilers at a later date. The Maine program reported that they are considering eliminating rebates for non-condensing gas boilers. The process for considering program changes varies somewhat among the states, as described below.

For Massachusetts and New Hampshire, which participate in the GasNetworks prescriptive commercial gas program, program design parameters are generally determined in committee. Some customization of rebates for state-specific applications does occur, as illustrated by the slightly lower incentives for integrated condensing boiler/water heater units for New Hampshire compared to Massachusetts in 2015. New Hampshire program staff did not identify any recent or planned changes in the GasNetworks program.

Rhode Island also participates in the GasNetworks committee and adopts nearly identical commercial boiler program parameters to those in Massachusetts. Relative to condensing boilers, its program varies in that it has no maximum condensing boiler capacity and a single- versus two-tier performance standard as well as a higher incentive for integrated condensing boiler/water heater units. A Rhode Island program staff member reported that the staff had discussed incentive levels in December 2014 and considered increases for furnaces, boilers, and water heaters, but decided against them in light of incremental cost data and potentially negative financial impacts on smaller participating programs in the region. He indicated that a program committee would continue to assess rebate levels, looking at new baselines and incremental cost data as they were available. The Rhode Island staff member also stated that there was movement within a state committee to go upstream with water heaters in 2016 and possibly with boilers in two to three years.

The Maine prescriptive natural gas program was launched at the end of 2012. The interviewed program staff member sees the program as being cost-effective but anticipates that changes in avoided energy costs would result in changes in the value of savings that could lead to an increase in efficiency requirements. He also reported that the program was close to discontinuing non-condensing gas boilers for which the program has issued very few rebates. The program will instead go after the highest performance boilers to make the most of rebate dollars and maximize energy savings.

When asked about changes in program design parameters, one Connecticut PA noted that the most important parameter is incentives. He reported that the staff had considered reducing incentives for boilers due to efficiency program budget cuts for one program administrator, but decided to constrain project work to save money for rebates instead. This program staff member noted that he did not expect changes in other savings and program parameters in the near future.

Among the NY PAs interviewed, a NYSERDA staff member noted that they revisit the program design every couple of years because of market changes. He does not expect boiler program requirements to change much in the near future. The program staff looks primarily at market value and evaluates whether the program is providing appropriate incentives relative to the real-world cost.

5.1.2 Program Savings Assumptions

5.1.2.1 Baseline Efficiency

Baseline boiler efficiency assumptions vary among the Northeast states' savings reference documents, as summarized in Table 15. Most programs, including Massachusetts, adopt baseline assumptions that reflect ASHRAE 90.1-2007 standards for gas-fired hot water boilers, which are 82% AFUE for less than 300 MBH units and 80% E_t for above 300 MBH units.

Massachusetts, Maine, and Connecticut savings documents that apply for the 2015 program year reflect ASHRAE 90.1-2007 standards for gas-fired hot water boilers. These baseline standards have been in effect for several years. However, Rhode Island updated its standard from the 2009 IECC to the 2012 IECC in 2014. New York's most recent standard approach document[30] refers to the 2010 Energy Conservation Construction Code of New York State (ECCCNYS), although a 2014 version of the ECCCNYS has been published.

[30] New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs – Residential, Multi-Family, and Commercial/Industrial Measures, Version 2, New York State Department of Public Service. December 10, 2014.

Integrated condensing boiler/water heater units offered as a separate measure by Massachusetts, New Hampshire, and Rhode Island use the same deemed savings and reference a baseline efficiency of 80% AFUE for space heating and a separate baseline efficiency (0.594 EF) for gas-fired storage water heating.

Table 15: 2015 Condensing Boiler Savings Baseline Performance by State

Capacity Range	Units	MA TRM[a]	NH	ME TRM	CT PSD	RI TRM[a]	NY Standard Approach
≤300 MBH	AFUE	82%				80%	
301 to 2,500 MBH	E_t = Thermal efficiency	80%					75%
	E_c = Combustion efficiency						80%
>2,500 MBH	E_c = Combustion efficiency					82%	
Reference		MA Building Code, IECC 2009 (ASHRAE 90.1-2007)	MA TRM	Stricter of federal and Maine codes (ASHRAE 90.1-2007).	ASHRAE 90.1-2007	2012 IECC	2010 Energy Conserv. Constr. Code of New York State (ECCCNYS)
State Code in Effect[b] (effective date)		2012 IECC (7/1/14)	IECC 2009; ASHRAE 90.1-2007 (4/1/10)	ASHRAE 90.1-2007 (12/1/10)	2009 IECC w/ amend. (10/7/11)	2012 IECC (7/1/13)	2014 ECCCNYS; 2012 IECC w/ suppl. that increases minimum boiler efficiencies to 92% AFUE/E_t. (1/1/15)

[a] The deemed savings methodology used by Massachusetts and Rhode Island does not require specific baseline data, but the baseline information is provided for reference.
[b] http://www.energycodes.gov/adoption/states accessed 3/20/2015.

5.1.2.2 Recent and Planned Changes to Savings Assumptions

There have been only a few changes to boiler savings parameters in program savings documents over the past few years, as described below. Otherwise, boiler savings calculations have been stable in recent years for all programs.

- As noted previously, Rhode Island changed from a 2009 IECC to a 2012 IECC basis for boiler baseline efficiency in mid-2014.
- Updates to the NY 2014 PSD include tables of large commercial building and multifamily high-rise building EFLH values as a function of location and heating system type.
- The Connecticut PSD added an adjustment factor to proposed case efficiency for condensing (1.0) vs. non-condensing (0.97) boilers to account for reduced savings when condensing units are not operating in condensing mode.

Plans for future changes to gas boiler savings parameters vary somewhat among the states as described below, driven mostly by recent or pending changes to state and federal commercial building codes. Most program staff reported that baseline efficiency was the savings parameter most likely to change—when state building codes changed, taking into account the timing of the federal standards and market conditions. Despite there being a substantial range in boiler measure life among the programs, the program staff members reported that they did not expect to make any changes in measure life or EFLH in the near future.

- Massachusetts – Massachusetts developed its TRM for the 2013 to 2015 program years, so the planning process for the 2016 to 2018 program cycle provides an opportunity to update applicable savings parameters. Massachusetts program plans suggest that deemed savings for boilers will be updated to reflect the findings of the 2013 Prescriptive Gas Program evaluation report.[31]
- Rhode Island and New Hampshire – The baseline boiler efficiencies reflected in the current program savings documents are consistent with the building code standards in effect, so program staff do not anticipate near-term baseline adjustments.
- Maine – The baseline boiler efficiencies reflected in the current Maine savings documents are consistent with the building code standards in effect. Maine program staff reported that they were conducting a review of their TRM for Program Year 2016 and that they will make changes to the baseline when new federal standards take effect. They will also consider the market so as not to disrupt or inhibit market channels.
- Connecticut – The baseline boiler efficiencies reflected in the Connecticut savings documents are consistent with the building code standards in effect. The Connecticut PAs noted that they review and submit new PSDs annually. They anticipate a change to the ASHRAE 2010 standards when Connecticut adopts IECC 2012 and will adjust the baseline to reflect the code in effect.
- New York published an updated Standard Approach document; however, it references the 2010 rather than the newer 2014 version of the ECCCNYS. The new 2014 building code imposes more stringent boiler performance standards than the earlier version. As of January 1, 2015, the 2014 ECCCNYS requires 92% AFUE and 92% Et, respectively, for boilers smaller than 300 MBH and equal to or larger

[31] KEMA (2013). Project 25 Prescriptive Gas Program Final Evaluation Report. Prepared for Massachusetts Energy Efficiency Program Administrators; Page 1-5.

than 300 MBH. These New York standards are higher than the 2012 IECC standard recently adopted by Massachusetts and Rhode Island.

5.1.3 Program Participation

As Table 14 shows, the Massachusetts prescriptive gas boiler program provided 675 rebates in 2012, 751 in 2013, and 1,048 in 2014. Over one-half (57%) of all rebates issued from 2012 through 2014 were for boilers greater than 300 MBH, 35% were for boilers less than or equal to 300 MBH, and 8% were for integrated boiler/hot water units.

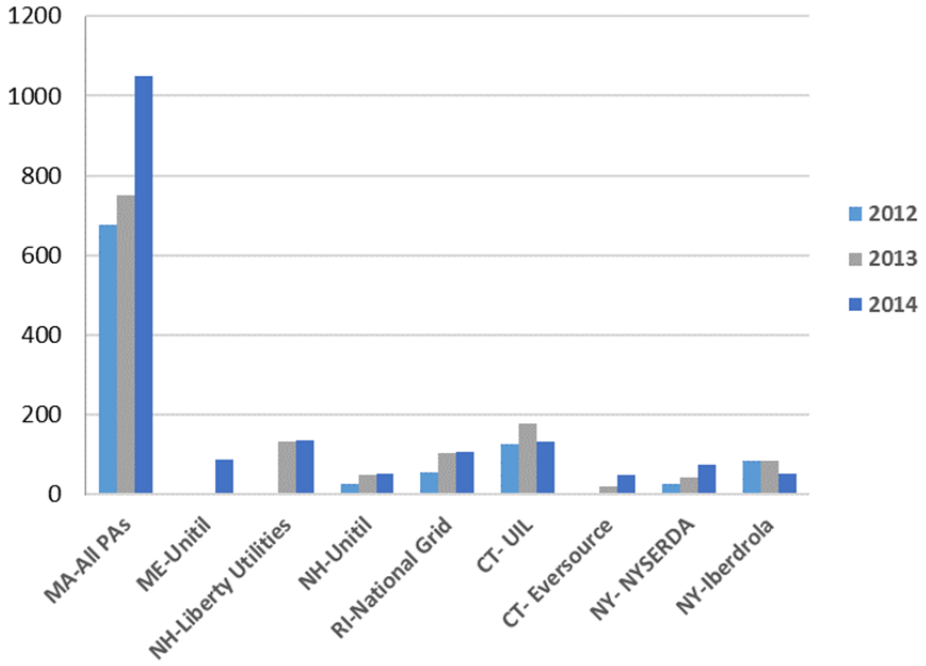
Table 16: Massachusetts PA Commercial Prescriptive Rebates Issued by Size

Boiler Size (MBH)	2012		2013		2014		2012 - 2014 Combined	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
≤300	242	36%	258	34%	360	35%	860	35%
301 – 2,000	390	58%	431	57%	578	57%	1,399	57%
Boiler / DHW Combo	43	6%	62	8%	79	8%	184	8%
Total	**675**		**751**		**1,017**		**2,443**	

Figure 8 illustrates the total number of condensing boilers rebated by each of the Northeast gas programs, including integrated condensing boiler/water heater units, as reported by the interviewed program staff members.[32] The Massachusetts program provided far more prescriptive rebates for condensing boilers from 2012 through 2014 than did other programs in the Northeast, although Massachusetts had the largest number of customers eligible for those rebates other than NYSERDA (where multiple programs exist). The following section puts these rebated boiler counts into perspective.

[32] National Grid was not able to provide the number of rebates for their NY programs.

Figure 8: Number of Condensing Boilers Receiving Prescriptive Program Rebates by Year



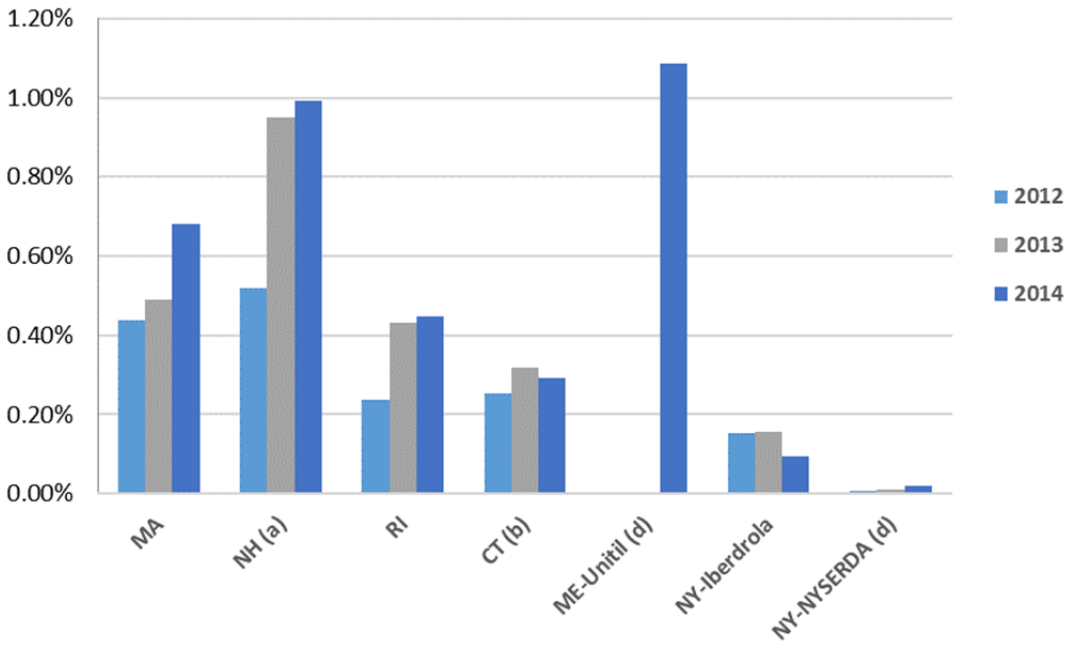
5.1.4 Program Market Impact

Northeast program managers were unable to estimate the annual market-level sales of either commercial condensing gas boilers or all commercial gas boilers in their areas nor the percentage of market-level sales that received rebates from their programs**.** Hence, there is no valid basis for estimating the true market impact of the condensing boiler programs on their local boiler markets.

However, program staff members were able to provide estimates of the number of non-residential gas customers in their service territories. The number of commercial gas customers purchasing gas boilers each year is a percentage of the commercial gas customers who currently use or plan to use gas boilers, which in turn can be approximated as a percentage of the total number of non-residential gas customers. The percentages vary as a function of the type of buildings and businesses served by gas within the territory as well as other factors, including fuel conversion rates and new gas connections. These percentages are generally not known for the Northeast states.

In the absence of specific information that would more clearly define the size of the market, the relative impact of rebated boilers as a percentage of the number of non-residential gas customers serves as a rough indicator of the relative rate of program participation. Figure 9 presents these percentages for the Northeast programs that provided data.

Figure 9: Estimated Number of Condensing Boilers Rebated by Year as a Percentage of Non-Residential Gas Customers



[a] 2012 boiler count for Eversource estimated based on Eversource-to-UIL boiler count ratios in 2013 and 2014 and known number of UIL boiler rebates in 2012.
[b] Not including Norwich Public Utilities.
[c] Maine's first full program year was from June 31, 2013, to July 1, 2014.
[d] Only customers paying SBC are eligible for NYSERDA rebates. Analysis assumed 90% of non-residential gas customers in the state pay SBC.

The percentage of condensing gas boilers rebated relative to the number of non-residential gas customers ranged from approximately 0.1% to 0.2% for NYSERDA to 1.1% for Maine. The Massachusetts participation rate appears to be in the mid-range compared to other Northeast states, at approximately 0.4% to 0.7%. Each of the states has offered rebates for condensing gas boilers for at least three years except Maine, which completed its first full program year.

The NYSERDA and New York utility efficiency programs overlap and thus compete to address the same efficiency opportunities with gas customers across the state. This situation might explain the relatively low participation rates for NYSERDA's and Iberdrola's programs in New York.

It is interesting to note that although Massachusetts, New Hampshire, and Rhode Island have almost identical program designs, including rebate levels, the relative level of participation is much higher for New Hampshire in 2013 and 2014 than for Massachusetts and Rhode Island. While the program design parameters examined for this study do not explain this variation in results for such similar programs, it may be due to differences in program promotion and delivery, the types of buildings and businesses that are non-residential gas customers in the state, the length of time that condensing gas boiler rebates have been offered, or other factors.

Maine's large percentage in its first program year is on par with New Hampshire's, despite having lower incentives for the full range of larger boilers. Maine's large percentage may be due to customers taking advantage of the new program incentives to upgrade their boilers. Maine's PA expects additional program participation due to equipment fuel conversions in their expanding natural gas market.

5.1.5 Market Analysis

Based on the results of Phase 1 and Phase II of the Boiler Market Characterization study, we estimate the number of condensing gas boilers and non-condensing boilers sold in Massachusetts. Because there is some degree of uncertainty regarding the figures used in this analysis, we present multiple scenarios to reflect different possible situations. Each row assumes a different level of annual boilers sales ranging from 1,500 to 3,000. Within each row, we calculate results for two different levels of condensing boiler sales: 60% and 80% of all sales. Each scenario utilizes the same count of 938 program-rebated condensing boilers from 2014.

At the lowest level of annual sales (1,500), the estimated number of condensing boilers sold outside the program vary from essentially zero to over 250. At the medium level of sales (2,250), the estimated number of outside-program condensing boiler sales varies from about 400 to over 850. At the highest annual sales (3,000), estimated outside-program condensing boiler sales increases to between 850 and about 1,450, which almost equals or exceeds, respectively, the volume of condensing boilers rebated by the program in 2014.

This analysis suggests there is some volume of condensing boilers that are sold in Massachusetts that do not receive program rebates, likely in the range of several hundred or more units.

Table 17: Massachusetts PA Commercial Prescriptive Rebates Issued by Size

Annual Sales in Massachusetts	60% of Sales are Condensing			80% of Sales are Condensing		
	# Cond. Boiler Sales Total	# Cond. Boiler Sales Outside Program	# Non-Cond. Boiler Sales	# Cond. Boiler Sales Total	# Cond. Boiler Sales Outside Program	# Non-Cond. Boiler Sales
1,500	900	(38)	600	1,200	262	300
2,250	1,350	412	900	1,800	862	450
3,000	1,800	862	1,200	2,400	1,462	600

5.2 Massachusetts Program Feedback

This section includes Massachusetts PA program feedback from manufacturers who participated in the study.

5.2.1 Program Feedback

Positive Aspects. Manufacturers who participated in the Roundtable agreed that the rebate was the most positive aspect of the prescriptive program. Another manufacturer believes that the $10,000 rebate is generous, and some customers might even put in larger boilers (maybe oversized) in order to receive the larger rebate. One manufacturer provided the following feedback about the Massachusetts PA program:

> [It is a] good program; haven't heard any negative feedback from commercial customers; good stimulus for high efficiency.

Program Opportunities. Manufacturers offered a variety of suggestions about opportunities for the Massachusetts PA prescriptive rebate program, including field testing requirements, contractor education, offering rebates on equipment that helps ensure a well-designed system, and providing separate rebates for new construction and retrofit.

One manufacturer provided comments about the size range and types of burners and controls that he would like to see included in the Massachusetts PA prescriptive program:

> The prescriptive rebate program should continue from 2,000 MBH input up to 12,000 MBH input. The …program should also include burner/control retrofits of existing boilers in a prescriptive type format. Our sales people, and especially our customers, find the "custom" (non-prescriptive) format too cumbersome for the retrofits and larger boilers.

Another manufacturer encouraged the program to continue to offer incentives for lower efficiency units:

> It is important to focus on the system design, and the way the rebates are segmented is also important. Keeping the lower efficiency rebate available for the 85% models is useful for replacement situations where the old boiler might be 60% efficient, for example.

One manufacturer thought it was important for Massachusetts to include additional criteria, such as a field test, to verify that the boiler is operating as designed. Another manufacturer recommended that the program develop a more in-depth screening process before providing rebates to customers to ensure that the systems that receive rebates are actually condensing properly.

Another manufacturer recommended offering rebates for low-temperature heat emitters (such as cast iron radiators that will work well with the lower water temperatures associated with condensing boilers) as part of a system solution to encourage condensing year round.

Another suggestion for the Massachusetts PA program (which currently bases eligibility solely on AHRI efficiency ratings) was to take into account or require outdoor reset controls. This manufacturer noted the controls are typically installed with commercial boilers anyway, but it is a factor in affecting the operating temperatures.

One manufacturer recommended that the Massachusetts PA program may want to consider separating out the program with respect to new construction and existing buildings because it is more difficult for boilers to reach condensing mode in existing buildings.

Another manufacturer mentioned the importance of contractor training on system design considerations:

> As an industry, we have to do a better job of helping contractors understand the system side of the boiler… If they don't understand why a boiler condenses… they're not going to understand the whole system. And system education, from the manufacturing standpoint, is as important as anything. We need to step back to help make the condensing appliances operate to the best of their ability.

Similarly, one manufacturer also stressed the importance of training and support:

> The good contractors out there really know what they're doing—there are a lot of components needed to help make sure a boiler condenses, not just the boiler themselves. Offering continued training is key for all industry professions, and a sensitivity to this through rebate offerings is also important.

A National Grid program staff person who attended the Roundtable agreed that system design is an important issue that they are working with contractors on quality installation to address. The program currently provides training for gas fitters that test systems. The PAs also offer some training with contractors and would like to do more trainings for the commercial boiler market to help address the challenges related to system design.

5.2.2 Freeridership & Spillover

During the Roundtable webinar, manufacturers were asked about sales of condensing gas boilers in the absence of the Massachusetts PA program and the potential for program spillover and other perceived market effects of the Massachusetts PA program.

Influence of Rebates. Manufacturers who participated in the Roundtable agreed that the rebates have a great deal of influence on customer purchasing decisions. One manufacturer noted:

> I think it's huge, at least an 80% factor in the decision, because if a contractor tells the customer he can put in either a 90% or 85% [efficiency] unit… the rebate drops the price down [for the 90% efficiency unit] to where it's competitive with the 85% [efficiency] unit. It's more competitively priced and… the customer can see themselves saving money.

Other manufacturers agreed, with one manufacturer mentioning that it is part of the selling package.

Boilers sold without Massachusetts PA Rebates. Most manufacturers believe there would be a significant reduction in the sales of condensing gas boilers in Massachusetts if the Massachusetts PA rebates were not available. One manufacturer thought there would be a substantial reduction because the first costs on a non-

condensing model are so much less than on a condensing model. A second manufacturer agreed and noted that the vast majority of boilers are replacements. The contractor's easiest job is to replace like for like and use the existing chimney and venting that is available. He suggested that maybe 25% to 40% of program sales would no longer be condensing (40% being generous). Two other manufacturers agreed with this comment.

However, another manufacturer had a somewhat different perspective. Over the last five years, he has seen more customers actively choosing high-efficiency boilers because of the operational savings associated with both maintenance and energy efficiency.

A National Grid program staff person mentioned that GasNetworks offers significant prescriptive rebates and therefore does drive many customers to purchase higher efficiency models. He estimated that the program might account for a 25% uptick in high-efficiency sales.

Boiler Models Likely Purchased without Massachusetts PA Rebates. The NMR facilitator asked the manufacturers what models customers would most likely purchase if program rebates for condensing boilers were not available. Most manufacturers think that customers would choose mid-efficiency boiler models. One manufacturer noted that the contractor is going to do like for like because it is simpler. A second manufacturer agreed and thinks that customers would likely choose mid-range efficiency products if rebates were not available because they often only think of the initial cost, not the monthly operating cost. Another manufacturer believes that what customers are willing to buy is tied to their fuel costs.

Potential for Spillover. The manufacturers do not think that the program induces the sale of unrebated program-eligible units. One manufacturer mentioned that the rebate gives the customer the incentive to go to the condensing boiler. Another manufacturer mentioned that the rebates give the contractor and owner an opportunity to discuss replacing the boiler proactively instead of reactively. If it is an emergency replacement situation, they are much more likely to install what is available and easiest to install—which is often lower efficiency. Another manufacturer also did not think the program helps sell unrebated boilers. Instead, the rebate serves as a way for the contractor to upsell to the higher efficiency model. He thought that the contractors would always encourage the owners to apply for a rebate. A National Grid staff person did not think the program influences anything other than the products listed on the application form, including non-rebated condensing boilers.

APPENDIX A – MANUFACTURER SURVEY

Manufacturer Survey Methodology

Sample Development

The first step in the manufacturer outreach effort was to develop a sample of gas boiler manufacturers. The sample was, in part, made up of 20 boiler manufacturers who had previously contributed feedback to the Phase I Report. The remainder of the sample was made up of 20 other manufacturers whom the Team had identified as producing gas boilers for the small C&I market. The Team undertook internet searches and placed telephone calls to help identify appropriate contacts at these manufacturers. In some instances, the sample contained both a parent company as well as its subsidiaries. In these instances, the Team kept the parent company within the sample and removed the subsidiaries (but made sure to capture this information for reference). This left a final sample of 32 manufacturers.

Initial Letter

To garner cooperation from the manufacturers, the Team developed a letter using PA logos and mailed it out to the manufacturers in early February 2015. The letter informed the manufacturers that they would soon be contacted by members of the Team to solicit their feedback about the Massachusetts boiler market. The letter also briefly described the Phase I study and provided a Web link to the full report.

Feedback Form

In order to structure the feedback from the manufacturers, the Team developed an editable PDF form including a short set of questions that the Team anticipated manufacturers would be willing to complete. A longer form requiring more time to complete would likely mean that fewer manufacturers would participate. In addition, due to confidentiality concerns, the Team only asked questions that they expected manufacturers would be willing to answer.

The PDF form began with a summary of the key findings from the Phase I Report. The form then asked manufacturers to estimate the annual sales of small C&I gas boilers in Massachusetts. Subsequent questions asked manufacturers to identify which boilers they offer by efficiency level, which type represented most of their sales in Massachusetts, and what their projections of percent changes in annual sales were. The next question asked those manufacturers who produce standard efficiency boilers if they intend to continue producing them and what might trigger them to discontinue production. Lastly, the final questions asked respondents if they were interested in participating in a boiler Roundtable discussion and to provide any feedback they might have about the Massachusetts PA program, the Phase I Final Report, or the Phase II study.

The form noted that, by sharing their company's experience and knowledge, the manufacturers would be helping inform the Massachusetts PA programs. It also assured manufacturers that the Team would maintain the confidentiality of their responses and would only present aggregate results in the Phase II Report after removing all identifying information.

Data Collection

The Team emailed the final feedback form to those manufacturer contacts for whom the Team had email addresses. The email briefly described the purpose of the study and invited the manufacturers to provide their

feedback by answering the questions in the PDF form, which was attached to the email. They were assured that the information they provided would only be reported in aggregate in the Phase II Report, which would in turn help inform the Massachusetts PA rebate programs. They were encouraged to either complete the form themselves or to call the Team member responsible for the data collection to discuss the questions over the phone.

The Team called those manufacturers for whom an email address was not available. If the Team member left a voicemail, he or she briefly described the request for information and encouraged the manufacturer to reach out to Team members if they would like to participate. Regular follow-up calls were made and emails sent to encourage participants to respond.

The Team collected responses between February 10, 2015, and April 20, 2015. Of the 32 manufacturers that the Team reached out to, 13 provided responses to the questions, which equates to a 41% response rate. Table 18 provides an overview of the sample size and disposition.

Table 18: Sample Disposition

Sample Disposition	Counts
Initial sample size	40
Sample size after targeting parent companies only	32
Completes	13
Refusals	3
Non-respondents	16

Multiple contact attempts were made with most respondents, with an average of seven attempts per contact over the course of the study. The Team attempted to follow up with a respondent every five to seven days through email, telephone, or both. Data collection proved to be challenging for a number of reasons, with some manufacturers refusing to participate because they did not have time or it was their company's policy not to provide comments related to market share estimates, while others were simply unresponsive to the Team's repeated requests.

Manufacturer Survey - Feedback Form Template

The feedback form below was sent to the sample of respondents through email to gather feedback about the C&I gas boiler market in Massachusetts. The form was tailored to include the contact name and information of each respondent and was then sent to respondents as an editable PDF document.

John Smith
ABC Boilers
123 Street Address
Somewhere, MA 01234

Dear John Smith:

Recently, you should have received a letter from the Massachusetts Energy Efficiency Program Administrators—which includes National Grid, NSTAR, Columbia Gas, Berkshire Gas, Unitil, Blackstone Gas, New England Gas, and Cape Light Compact—requesting your participation in a study regarding the Massachusetts commercial gas boiler market. Your company's experience and knowledge of the Massachusetts boiler market will help inform this study as well as the future design of the Mass Save programs.

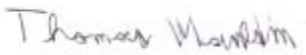
As noted in the initial letter, each year the Mass Save programs provide millions of dollars in financial incentives to Massachusetts commercial and industrial customers to invest in new energy-efficient gas boilers. In 2015, the Mass Save programs provide rebates of between $1,000 and $10,000 per qualifying boiler. If you are interested in the details of the Mass Save program, please visit the following link: http://www.masssave.com/~/media/Files/Business/Applications-and-Rebate-Forms/New-Construction/Commercial-Equipment-Gas-Form-Mass-Save.pdf

This document contains a summary of the key findings from the first phase of this study, as well as a series of questions to help refine selected results. At this time, we request that you review and reflect on the summary and then provide responses to the subsequent questions. We appreciate your time and expect that completing these questions will take about 15 minutes. Please be assured that we will maintain the confidentiality of your responses and will only present results in aggregate after removing all identifying information.

If you have any questions about this document, please contact Joanne O'Donnell from NMR Group at 617-284-6230 x41 or jodonnell@nmrgroupinc.com. If you have any questions about this study or about NMR Group, please contact Erik Mellen from NSTAR (now Eversource) at 781-441-8554 or erik.mellen@nstar.com.

Thank you for your time.

Sincerely,



Thomas Mauldin
NMR Group
50-2 Howard St, Somerville MA 02144
617-284-6230 x8
tmauldin@nmrgroupinc.com

Summary of Phase One report findings

The Phase One report yielded the following key findings (shown in the table below) regarding the small commercial & industrial (C&I) gas boiler market in Massachusetts. The Phase One study defined small C&I boilers as those boilers that range in size from 90 to 2,000 MBH and are installed at a business or other non-residential location. We recognize that different manufacturers may employ different definitions of commercial boilers; however, we request that you use our definition when preparing your responses to the questions.

Characteristic	Estimated Value	Estimated Percentage Value
Estimated annual sales of all 90 – 2,000 MBH gas boilers to C&I customers in Massachusetts in 2012 (all manufacturers combined)	1,500 - 3,000 boilers	
Estimated annual sales of 90 – 2,000 MBH ***condensing*** gas boilers to C&I customers in Massachusetts in 2012 (all manufacturers combined)	900 – 2,400 boilers	60% to 80% of all C&I gas boiler sales were condensing models in 2012
Number of Mass Save program rebates provided for 90 – 2,000 MBH condensing gas boilers to C&I customers in Massachusetts …		
… in 2012	675 rebates	23% to 45% of all C&I gas boiler sales received rebates in 2012
… in 2013	835 rebates	

The following link provides access to the entire Phase One report: http://ma-eeac.org/wordpress/wp-content/uploads/CI-Boiler-Market-Characterization-Study-Final-Report.pdf

Questions

The Massachusetts Energy Efficiency Program Administrators are seeking to improve the Mass Save program design and to better understand the type and efficiency of small C&I gas boilers available in the market. Your company's experience and knowledge of the Massachusetts boiler market will help inform this study as well as the future design of the Mass Save programs.

Please review each of the following questions and provide a response in the box where indicated. Please be assured that we will maintain the confidentiality of your responses and will only present results in aggregate after removing all identifying information.

All Gas Boiler Sales

The Phase One report estimated that annual sales of 90 – 2,000 MBH gas boilers to C&I customers in Massachusetts in **2012** ranged from 1,500 to 3,000 units.

1a. What is your best estimate of the annual sales of 90 – 2,000 MBH gas boilers to C&I customers in Massachusetts in **2013**?
Please provide a specific point estimate (i.e., 15) if possible, though a range is useful as well (i.e., 10 to 20).

Please type your response here:

1b. What key factors did you consider in developing this estimate?

Please type your response here:

Condensing Gas Boiler Sales

The Phase One report estimated that annual sales of 90 – 2,000 MBH condensing gas boilers to C&I customers in Massachusetts in **2012** ranged from 900 to 2,400 units.

2a. What is your best estimate of the annual sales of 90 – 2,000 MBH condensing gas boilers to C&I customers in Massachusetts in **2013**?
Please provide a specific point estimate (i.e., 15) if possible, though a range is useful as well (i.e., 10 to 20).

Please type your response here:

2b. What key factors did you consider in developing this estimate?

Please type your response here:

Annual Sales Forecasts

3a. Which types (i.e., efficiency tier) of 90 – 2,000 MBH gas boilers does your company currently produce for C&I customers?

3b. Which type (i.e., efficiency tier) of 90 – 2,000 MBH gas boiler represents the most sales to C&I customers in Massachusetts?

3c. What is the forecasted annual sales increase or decrease your company is currently using for future sales of 90 – 2,000 MBH gas boilers to C&I customers in Massachusetts (or alternatively for New England or the northeastern U.S.)?

Please provide a specific point estimate (i.e., +3%) if possible, though a range is useful as well (i.e., +2% to +4%).

Boiler type, among 90 – 2,000 MBH gas boilers for C&I customers	**3a. Does your company currently produce this type of boiler?**	**3b. Which type of boiler does your company sell most of in Massachusetts?** *(Check only one box in this column)*	**3c. What is the annual forecasted sales increase or decrease for Massachusetts?** *(for example: +3% or -3%)*
Standard-efficiency models (<85% efficiency)	*Yes / No / Don't Know*		Please type your response here:
Mid-efficiency models (85%-90% efficiency)	*Yes / No / Don't Know*		Please type your response here:
High-efficiency condensing models (>90% efficiency)	*Yes / No / Don't Know*		Please type your response here:

Standard Efficiency Boiler Production

4a. If your company currently produces 90 – 2,000 MBH gas boilers of 85% efficiency or less, does your company ***intend to continue*** producing these models in the future?

Yes / No / Don't Know

4b. What key factors might trigger a decision to discontinue production of <85% efficient 90 – 2,000 MBH gas boilers?

Please type your response here:

Additional Feedback

5. Would you or someone from your company be interested in participating in a "Massachusetts Boiler Roundtable" meeting this Spring where stakeholders and program administrators discuss the commercial gas boiler programs and market for a few hours?

Yes / No / Don't Know

6. Do you have any other comments or feedback you would like to share about this study, the Phase One report, or the Mass Save programs?

Please type your response here:

Please save this document and email it to Joanne O'Donnell from NMR Group at jodonnell@nmrgroupinc.com.

Thank you for your time! We appreciate and value your feedback.

APPENDIX B – COMPARATIVE RESEARCH ON CONDENSING GAS BOILER PROGRAMS

Boiler Categorization

All Northeast commercial prescriptive gas rebate programs provided rebates for small condensing boilers with input ratings of 300 MBH or less, and all programs except Vermont's offer rebates for large condensing boilers with rated capacities greater than 300 MBH (Table 19). While some programs limit capacities to 2,000 – 3,000 MBH, other programs offer rebates for all sizes of condensing boilers. In general, the programs with a maximum capacity for prescriptive rebates allow customers to submit rebate applications through a custom program.

A few programs offered a separate rebate for integrated condensing boiler/water heater units, including the three states (MA, NH, and RI) that follow the GasNetworks initiative and NY-National Grid. However, most managers of the other programs believe that these units are eligible for their program's condensing boiler rebates as long as the units meet the program's requirements.

Most programs offer rebates for non-condensing boilers and steam boilers, with the exception of the three GasNetworks states.

Table 19: Commercial Gas Boiler Types and Capacities Eligible for Prescriptive Rebates by State-Program Administrator

Boiler Type	MA	NH	RI	CT	NY-National Grid	NY-Iberdrola	NY-NYSERDA	ME	VT
Condensing Boiler	≤2,000 MBH		all sizes	≤2,500 MBH	NYC: ≤3,000 MBH Upstate: all sizes	all sizes			≤300 MBH
Integrated Condensing Boiler / Water Heater	all sizes			Not Eligible	all sizes	Not Eligible			
Non-Condensing Boiler	Not Eligible			≤2,500 MBH	NYC: ≤3,000 MBH Upstate: all sizes	all sizes			≤300 MBH
Steam Boiler	Not Eligible				NYC: ≤999 MBH Upstate: ≤300 MBH	≤300 MBH	≤10,000 MBH		≤300 MBH

Condensing Gas Boiler Savings Assumptions

Gross savings assigned to prescriptive condensing gas boiler measures are estimates of the annual energy savings obtained by the installation of high efficiency versus lower efficiency standard or code-compliant condensing boilers. The methods used by the Northeast PAs to calculate commercial gas

measure savings are documented in state-specific documents[33], which are typically updated on an annual basis.

- Massachusetts - Uses a state Technical Reference Manual (TRM) updated and applied to savings calculations on a three-year program cycle.
- Rhode Island – Uses a state Technical Reference Manual.
- New Hampshire – Adopted the Massachusetts TRM as its reference savings document until a New Hampshire TRM is developed.
- Maine – Uses a state Commercial Technical Reference Manual.
- Vermont – Efficiency Vermont is tasked with updating the Vermont TRM annually, according to the Vermont Department of Public Services website; however, the most recent savings reference document found online is the 2013 version and it does not include calculation documentation for gas measures.
- Connecticut – Uses a state Program Savings Document (PSD).
- New York - The three New York programs use the New York Standard Approach for Estimating Energy Savings from Energy Efficiency Programs. The most recent version of this document (Version 2), dated December 10, 2014, is an update to the previous NY Standard Approach document (Version 1) dated October 1, 2010. The NY Public Service Commission (PSC) issues key updates to the document as needed in between complete versions based upon input from a technical manual committee.

Deemed or Calculated Savings

A few Northeast states (MA, NH, RI) have established deemed savings values for specific capacity ranges and efficiency requirements of program-eligible boilers. These states have determined that commercial condensing boilers rebated by their programs have well known and consistent performance characteristics that allow for a simplified estimation of savings derived from evaluations. The 2015 deemed boiler savings specified in the Rhode Island TRM are from an updated version[34] of an original study[35] used by the Massachusetts and New Hampshire programs. The three states (MA, NH, RI) that offer separate rebates for integrated condensing boiler/water heater units assume the same deemed savings value recommended by a 2009 Massachusetts potential study.[36] Although Massachusetts and New Hampshire offer rebates for integrated units at two performance tiers (≥90% AFUE and ≥95% AFUE), the same deemed savings value is used for both tiers.

The remaining Northeast programs reviewed for this comparison calculate savings based on a mix of installation-specific variables and deemed variables developed in studies or established by code. The following expression illustrates the parameters used in boiler savings calculations as documented in the Maine TRM and NY standard approach document.

[33] Table 21 provides links to the states' reference savings documents.

[34] KEMA (2013). Project 25 Prescriptive Gas Program Final Evaluation Report. Prepared for Massachusetts Energy Efficiency Program Administrators; Page 1-5.

[35] KEMA (2012), Prescriptive Gas Program Final Evaluation Report. Prepared for Massachusetts Energy Efficiency Program Administrators; page 1-2.

[36] GDS Associates, Inc. and Summit Blue Consulting (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks

Gross Annual Energy Savings = Units x $(CAP_{input} \times \eta_{ee}) \times [1/\eta_{baseline} - 1/\eta_{ee}) \times EFLH_{heating}$

where

Units = Number of units installed through the program

CAP_{input} = New equipment input capacity per unit (e.g., MBH = kBtu/h)

$EFLH_{heating}$ = Equivalent full load heating hours

η_{ee} = Efficient equipment Annual Fuel Utilization Efficiency (AFUE), thermal efficiency (E_t), or combustion efficiency (E_c), depending on equipment type and capacity

$\eta_{baseline}$ = Baseline equipment Annual Fuel Utilization Efficiency (AFUE), thermal efficiency (E_t), or combustion efficiency (E_c), depending on equipment type and capacity

Unit conversion factors are applied as necessary to present results in terms of therms/year or MMBtu/year. The rated boiler output in the equation above is represented by the terms $CAP_{input} \times \eta_{ee}$.

The Connecticut Program Savings Document is the only program savings reference that applies an oversize factor to reflect industry practice and an adjustment factor for boiler type to account for the impact of condensing units not operating in condensing mode.

Gross Annual Energy Savings = Units x $(CAP_{out} /OF) \times [1/\eta_{baseline} - 1/(AF \times \eta_{ee})] \times EFLH_{heating}$

where

OF[37] = Oversize factor (1.15 for single boiler/furnace installations and 1.3 for multiple boiler/furnace installation)

AF[38] = Adjustment factor (1.0 for non-condensing units and 0.97 for condensing units)

All programs that use calculated rather than deemed savings include the actual capacity and rated efficiency of the installed boiler as site-specific savings variables. The Connecticut PSD also requires facility type as a calculation input in order to obtain boiler equivalent full load hours (EFLH) as a function of facility type based on a study[39] that correlated the two parameters. Similarly, the New York standard approach requires building type and location for all boiler installations, building vintage for multi-family installations, and HVAC system type for large commercial installations in order to obtain the applicable EFLH for the savings analysis.

Variations among program savings assumptions are discussed below.

Equivalent Full Load Hours

Condensing boiler equivalent full load hours (EFLH) assumptions vary among the Northeast states' savings reference documents, as summarized in Table 20. Several of the states obtained EFLH values from recent studies of prescriptive gas measures conducted by DNV GL (formerly KEMA). Connecticut and New York derived building- and location-dependent EFLH values from data and building models developed in earlier studies and adapted for state-specific building conditions and climates.

The Massachusetts and Rhode Island TRMs do not document an EFLH value for integrated condensing boiler/water heater units.

[37] Connecticut Program Savings Document, 10th Edition for 2015 Program Year. Note [2] page 41.
[38] Connecticut Program Savings Document, 10th Edition for 2015 Program Year. Note [5] page 42.
[39] "…full load hours were developed by third party engineers (Fuss & O'Neill, Manchester, CT) in 2008 using a temperature bin analysis." Connecticut Program Savings Document 10th Edition for 2015 Program Year, page 41.

Table 20: 2015 Condensing Boiler Equivalent Full Load Hours by State

	MA TRM[a]	NH	RI TRM[a]	ME TRM	CT PSD	NY Standard Approach
EFLH	1,400	1,400	1,400	1,600	1,141 to 1,520 by building type	200 to 3,600 by building type and location
Reference	KEMA 2012[b]	MA TRM	KEMA 2013[c]	Assumed based on Massachusetts value.	2008, Fuss & O'Neil	Adapted from commercial building prototypes used in the 2004-2005 DEER study.

[a] The deemed savings methodology used by Massachusetts and Rhode Island does not require specific EFLH data, but the EFLH information is provided for reference.
[b] KEMA (2012), Prescriptive Gas Program Final Evaluation Report. Prepared for Massachusetts Energy Efficiency Program Administrators; page 1-2.
[c] KEMA (2013). Project 25 Prescriptive Gas Program Final Evaluation Report. Prepared for Massachusetts Energy Efficiency Program Administrators; Page 1-5.

Measure Life

The measure life assumed in order to calculate lifetime energy savings for condensing boilers ranges from 15 years to 25 years among the Northeast program boiler savings documents (Table 21). Massachusetts and Rhode Island savings documents use 25 years for condensing boiler measure life, referencing the 2003 ASHRAE Application Handbook[40] and a 2009 GDS Associates and Summit Blue Consulting potential study[41]. Maine and New York references a 2009 measure Life study conducted for Wisconsin Focus on Energy[42] and DEER[43], respectively, as the sources of their 20-year measure life for condensing gas boilers. Connecticut assumes a 15-year boiler life but does not provide a reference for that value.

Massachusetts and Rhode Island TRMs assume a measure life of 20 years for integrated condensing boiler/water heater units, similar to the measure life of a typical boiler, as specified by the 2003 ASHRAE Application Handbook.

Table 21: 2015 Condensing Boiler Measure Life by State

	MA TRM	NH	RI TRM	ME TRM	NY Standard Approach	CT PSD
Measure Life (years)	25	25	25	20	20	15
Reference	2003 ASHRAE Application Handbook	MA TRM	GDS Associates and Summit Blue Consulting 2009 potential study	PA Consulting 2009 for Wisconsin	DEER	Estimate

Supporting Tables

Table 22, Table 23, and Table 24 summarize program design observations and provide details about the numbers of boilers rebated by Northeast prescriptive gas programs by year and by boiler capacity.

[40] ASHRAE Applications Handbook (2003), page 36.3.
[41] GDS Associates, Inc. and Summit Blue Consulting (2009). Natural Gas Energy Efficiency Potential in Massachusetts. Prepared for GasNetworks.
[42] PA Consulting Group for the State of Wisconsin Public Service Commission, Focus on Energy Evaluation. Business Programs: Measure Life Study. August 25, 2009. Appendix B.
[43] No reference detail provided.

Table 22: Prescriptive Boiler Program Design Comparison by State

State	MA			ME			NH					
Program Administrator (PA)	All PAs			Efficiency Maine			Liberty Utilities			Unitil		
Program Name	Prescriptive Gas Efficiency Program			Efficiency Maine Business Program - Prescriptive Natural Gas			Gas Large Business Energy Solutions Gas Small Business Energy Solutions			Gas Large Business Energy Solutions Gas Small Business Energy Solutions		
Condensing Gas Boiler Capacity	Required Rating	Rebate	Deemed Savings (MMBtu)	Required Rating	Rebate	Calculated Savings	Required Rating	Rebate	Deemed Savings (MMBtu)	Required Rating	Rebate	Deemed Savings (MMBtu)
Up to 300 MBH	≥90% AFUE	$1,000	22.8		$1,000	Installation specific. Function of input capacity and rated efficiency.	SAME AS MA (GasNetworks: High Effficiency Commercial & Industrial Natural Gas Equipment Rebates)		SAME AS MA	SAME AS MA (GasNetworks: High Effficiency Commercial & Industrial Natural Gas Equipment Rebates)		SAME AS MA
Up to 300 MBH	≥95% AFUE	$1,500	29.3	NA								
MA: 301 to 499 MBH	≥ 90% E_t	$2,000	56.1	301 to 500 MBH ≥ 90% E_t	$1,500							
MA: 500 to 999 MBH		$4,000	103.0	501 to 1000 MBH ≥ 90% E_t	$2,500							
MA: 1000 to 1700 MBH		$7,500	189.2	1001 to 1700 MBH ≥ 90% E_t	$3,500							
MA: 1701 to 2000 MBH		$10,000	331.2	> 1700 MBH ≥ 90% E_t	$4,500							
>2000 MBH	NA											
Integrated Condensing Boiler/Water Heater Unit	≥90% AFUE	$1,200	24.6	Not separate rebate.			SAME AS MA	$1,000		SAME AS MA	$1,000	
	≥95% AFUE	$1,600						$1,500			$1,500	
Boiler Rebate Source	http://www.masssave.com/~/media/Files/Business/Applications-and-Rebate-Forms/New-Construction/Commercial-Equipment-Gas-Form-Mass-Save.pdf			http://www.efficiencymaine.com/docs/Natural-Gas-Fact-Sheet-1_13.pdf			http://www.liberty-utilities.com/east/gas/my_business/documents/NH_LU_Commercial_Equipment_Rebate.pdf			http://unitil.com/sites/default/files/pdfs/2015%20Unitil%20NH%20GN%20CI%20Equipment%20Rebate%20011215.pdf		
Other natural gas equipment rebated by program	Furnaces, condensing unit heaters, infrared heaters, boiler reset controls, steam traps, programmable thermostats, water heating equipment.			Furnaces, non-condensing hot water boilers, steam boilers, warm-air unit heaters, infrared heaters, commercial kitchen equipment.			Furnaces, condensing unit heaters, infrared heaters, boiler reset controls, steam traps, programmable thermostats, water heating equipment.			Furnaces, condensing unit heaters, infrared heaters, boiler reset controls, steam traps, programmable thermostats, water heating equipment.		

State	MA			VT			RI		
Program Administrator (PA)	All PAs			Vermont Gas Systems			National Grid		
Program Name	Prescriptive Gas Efficiency Program			High Efficiency Equipment Rebate Program for Small Business			High-efficiency Commercial Gas Equipment Incentives		
Condensing Gas Boiler Capacity	Required Rating	Rebate	Deemed Savings (MMBtu)	Required Rating	Rebate	Calculated / Deemed Savings	Required Rating	Rebate	Deemed Savings (MMBtu)
Up to 300 MBH	≥90% AFUE	$1,000	22.8	*All boilers* 87%+ AFUE	$550	Not specified in TRM	SAME AS MA		30.6
Up to 300 MBH	≥95% AFUE	$1,500	29.3	*All boilers* 92%+ AFUE w/ multistage burner & outdoor air temp controller	$1,000				27.8
MA: 301 to 499 MBH	≥ 90% E_t	$2,000	56.1	Equipment types considered for custom Incentives include high efficiency hot water boilers > 300 MBH					58.4
MA: 500 to 999 MBH		$4,000	103.0						107.3
MA: 1000 to 1700 MBH		$7,500	189.2						197.2
MA: 1701 to 2000 MBH		$10,000	331.2				1701 and larger ≥ 90% E_t	$10,000	345.1
>2000 MBH	NA								
Integrated Condensing Boiler/Water Heater Unit	≥90% AFUE	$1,200	24.6	Not separate rebate.			0.90 EF **or** ≥90% AFUE	$1,500	24.6
	≥95% AFUE	$1,600					NA		
Boiler Rebate Source	http://www.masssave.com/~/media/Files/Business/Applications-and-Rebate-Forms/New-Construction/Commercial-Equipment-Gas-Form-Mass-Save.pdf			https://vermontgas.com/wp-content/uploads/2015/02/2015-Vermont-Gas-WorkPlace-Equipment-Replacement-Form.pdf			https://www1.nationalgridus.com/files/AddedPDF/POA/RI%20CI%20HEHE%20-%20FINAL.pdf		
Other natural gas equipment rebated by program	Furnaces, condensing unit heaters, infrared heaters, boiler reset controls, steam traps, programmable thermostats, water heating equipment.			Furnaces, all boilers <= 300 MBH, unit heaters, infrared heaters, water heating equipment, CO2 sensor control, commercial kitchen equipment.			Furnaces, condensing unit heaters, infrared heaters, boiler reset controls, steam traps, programmable thermostats, water heating equipment.		

State	MA			CT					
Program Administrator (PA)	All PAs			UIL (Connecticut Natural Gas & Southern Connecticut Gas)			Eversource (formerly Yankee Gas)		
Program Name	Prescriptive Gas Efficiency Program			Natural Gas Heating Equipment Rebate Program			Natural Gas Heating Equipment Rebate Program		
Condensing Gas Boiler Capacity	Required Rating	Rebate	Deemed Savings (MMBtu)	Required Rating	Rebate	Calculated Savings	Required Rating	Rebate	Calculated Savings
Up to 300 MBH	≥90% AFUE	$1,000	22.8	< 300 MBH outdoor T reset req'd ≥92% AFUE	$8.00/input MBH	Installation specific. Function of input capacity, rated efficiency and facility type.	< 300 MBH outdoor T reset req'd ≥92% AFUE	$8.00/input MBH	Installation specific. Function of input capacity, rated efficiency and facility type.
Up to 300 MBH	≥95% AFUE	$1,500	29.3						
MA: 301 to 499 MBH	≥ 90% E_t	$2,000	56.1	300 to 2500 MBH outside T reset req'd ≥92% E_t			300 to 2500 MBH outside T reset req'd ≥92% E_t		
MA: 500 to 999 MBH		$4,000	103.0						
MA: 1000 to 1700 MBH		$7,500	189.2						
MA: 1701 to 2000 MBH		$10,000	331.2						
>2000 MBH	NA								
Integrated Condensing Boiler/Water Heater Unit	≥90% AFUE	$1,200	24.6	Not separate rebate.			Not separate rebate.		
	≥95% AFUE	$1,600							
Boiler Rebate Source	http://www.masssave.com/~/media/Files/Business/Applications-and-Rebate-Forms/New-Construction/Commercial-Equipment-Gas-Form-Mass-Save.pdf			http://www.uinet.com/wps/wcm/connect/aabbc6804c4c5301a7a5a7c151d964eb/FINAL+C0222+2015+C%26I+Gas+Heating+Equip+Rebate+2015-02+WEB+FF.pdf?MOD=AJPERES&CACHEID=aabbc6804c4c5301a7a5a7c151d964eb			http://www.energizect.com/sites/default/files/FINAL%20C0222%202015%20C%26I%20Gas%20Heating%20Equip%20Rebate%202015-01%20FF.pdf		
Other natural gas equipment rebated by program	Furnaces, condensing unit heaters, infrared heaters, boiler reset controls, steam traps, programmable thermostats, water heating equipment.			Non-condensing gas boilers, condensing gas furnaces, condensing gas unit heaters, gas fired absorption heat pumps, infrared heaters.			Non-condensing gas boilers, condensing gas furnaces, condensing gas unit heaters, gas fired absorption heat pumps, infrared heaters.		

State	MA			NY								
Program Administrator (PA)	All PAs			NYSERDA			National Grid (Niagara Mohawk, Keyspan NY, Keyspan LI)			Iberdrola USA (New York State Electric and Gas, Rochester Gas and Electric)		
Program Name	Prescriptive Gas Efficiency Program			Existing Facilities Program: Pre-qualified Natural Gas Efficiency			Metro/LI: NYC Commercial / Industrial Buildings Incentive Services [a] Upstate (UNY): Upstate NY High-efficiency Natural Gas Heating Incentives for Commercial Buildings [b]			Commercial and Industrial Rebate Program - Natural Gas Furnaces, Boilers and Controls		
Condensing Gas Boiler Capacity	Required Rating	Rebate	Deemed Savings (MMBtu)	Required Rating	Rebate	Calculated Savings	Required Rating	Rebate	Calculated Savings	Required Rating	Rebate	Calculated Savings
Up to 300 MBH	≥90% AFUE	$1,000	22.8		$1,000	Installation specific. Function of input capacity, rated efficiency, facility location and building type (also building vintage for MF and HVAC system type for large commercial).	≥ 92% AFUE	Metro/LI: (≤150 MBH) $1,000 (151 to 300 MBH) $2,000 UNY 2014: (≤300 MBH) $1,600	Installation specific. Function of input capacity, rated efficiency, facility location and building type (also building vintage for MF and HVAC system type for large commercial).		$1,000	Installation specific. Function of input capacity, rated efficiency, facility location and building type (also building vintage for MF and HVAC system type for large commercial).
Up to 300 MBH	≥95% AFUE	$1,500	29.3	NA						NA		
MA: 301 to 499 MBH	≥ 90% E_t	$2,000	56.1	301 to 500 MBH ≥ 90% E_t	$1,500		≥ 92% E_t	Metro/LI: $3,000 UNY: $2,400			$1,500	
MA: 500 to 999 MBH		$4,000	103.0	501 to 1000 MBH ≥ 90% E_t	$2,500			Metro/LI: $5,000 UNY: $4,000			$3,000	
MA: 1000 to 1700 MBH		$7,500	189.2	1001 to 1700 MBH ≥ 90% E_t	$3,500			Metro/LI: $10,000 UNY: $8,000			$4,500	
MA: 1701 to 2000 MBH		$10,000	331.2	> 1700 MBH ≥ 90% E_t	$4,500			Metro/LI: (1701 to 3000 MBH) $15,000 UNY: (≥1701 MBH) $12,000			> 1701 MBH $6,000	
>2000 MBH	NA											
Integrated Condensing Boiler/Water Heater Unit	≥90% AFUE	$1,200	24.6	Not separate rebate.			≥92% AFUE/ CA-AFUE	$1,600	NYC only	Not separate rebate.		
	≥95% AFUE	$1,600										
Boiler Rebate Source	http://www.masssave.com/~/media/Files/Business/Applications-and-Rebate-Forms/New-Construction/Commercial-Equipment-Gas-Form-Mass-Save.pdf			http://www.nyserda.ny.gov/efp-pre-qualified			Metro: https://www1.nationalgridus.com/files/AddedPDF/POA/Commercial%20NYC%20EE4743%202015_brochure.pdf https://www1.nationalgridus.com/files/AddedPDF/POA/Commercial%20Multifamily%20Natural%20Gas_NYC_EE4796.pdf UNY 2014: https://www1.nationalgridus.com/files/AddedPDF/POA/UNY%20Heating%20EE4619%20BROCHURE.pdf [c]			http://www.nyseg.com/MediaLibrary/2/5/Content%20Management/NYSEG/Usage%20and%20Safety/PDFs%20and%20Docs/NYSEG_NaturalGas_App.pdf		
Other natural gas equipment rebated by program	Furnaces, condensing unit heaters, infrared heaters, boiler reset controls, steam traps, programmable thermostats, water heating equipment.			Furnaces, non-condensing boilers, steam boilers, unit heaters, infrared heaters, water heater insulation & circulation controls, commercial kitchen equipment, vent dampers, pipe insulation, duct insulation demand control ventillation.			Furnaces, condensing unit heaters, infrared heaters, steam boilers, hydronic boilers, indirect water heaters, boiler reset controls, programable thermostats, thermostatic radiator valves (MF only), insulation measures, steam traps, integrated water heater/ non-condensing boilers.			Furnaces, hydronic boilers, steam boilers, boiler reset controls, programmable thermostats, thermal equalizer unit(destratification fan).		

[a] National Grid/Upstate gas C&I prescriptive program suspended March 25, 2015.
[b] LI gas C&I prescriptive program suspended for 2015.
[c] 2015 National Grid/Upstate rebate form not posted online.

Table 23: Prescriptive Boilers Rebated by Year Relative to Number of Non-residential Customers Served

State - PA		MA-All PAs	ME-Unitil	NH-Liberty Utilities	NH-Unitil	RI-National Grid	CT- UIL	CT-Eversource	NY-NYSERDA	NY-Iberdrola
Condensing Boilers Rebated	2012	675	0	NA	27	56	127	NA	27	84
	2013	751	NA	133	48	102	176	20	41	85
	2014	1,048	86	136	53	106	131	49	75	52
Non-Residential Gas Customers [PA estimate]		153,700	7,915	13,202	5,822	23,607	34,000	27,605	346,775	54,684
C&I Gas Customers in State [2013 AGA]		153,665	10,286	18,224		23,607	58,554		385,306	

Table 24: Size Distribution of Condensing Boilers with Rebates from Prescriptive Commercial Gas Programs

Prescriptive Program - Boiler Capacity Range	MA				RI				CT-UI			
	2012 Boiler Units	2013 Boiler Units	2014 Boiler Units	Overall Average Percentage of Total (2012 - 2014)	2012 Boiler Units	2013 Boiler Units	2014 Boiler Units	Overall Average Percentage of Total (2012 - 2014)	2012 Boiler Units	2013 Boiler Units	2014 Boiler Units	Overall Average Percentage of Total (2012 - 2014)
≤300 MBH	242	258	371	35%	13	52	22	33%	59	83	77	50%
301 - 499 MBH	202	191	176	23%	20	8	15	16%	30	42	13	20%
500-999 MBH	120	103	275	20%	20	19	28	25%	28	47	25	23%
1000 - 1700 MBH	54	84	88	9%	0	4	2	2%	2	0	8	2%
≥1701 MBH	14	53	57	5%	0	1	16	6%	8	4	8	5%
Integrated Condensing Boiler/Water Heater	43	62	81	8%	3	18	23	17%	0	0	0	0%
Program Year Total	**675**	**751**	**1,048**	**100%**	**56**	**102**	**106**	**100%**	**127**	**176**	**131**	100%

Common Program Requirements

Most PAs offer prescriptive rebates for commercial gas condensing boilers through programs targeted at small and large commercial customers.[44,45] They generally also allow multi-family customers on commercial rates to take advantage of these rebates. Eligible multi-family buildings generally contain four or five units per building on a single meter with a single boiler serving multiple units. National Grid's NY gas programs in New York City and on Long Island offer condensing gas boiler rebates through a separate multi-family program restricted to buildings with 5 to 75 units in New York City and 5 to 50 units on Long Island.

Massachusetts, New Hampshire, Connecticut, and Rhode Island programs provide prescriptive rebates for all qualifying boilers that customers purchase for new construction, major renovation, equipment replacement, or new equipment installations. One Connecticut program staff member indicated that his program considers any new boiler that replaces equipment at more than 75% of its useful life to be a replacement and not a retrofit installation, and it therefore is eligible for a prescriptive rebate. He also reported that they do not see any boiler retrofit applications because it is generally not cost-effective to replace a major piece of equipment that is functioning. In Maine, they do not promote early replacement of boilers so the applications they see for new boilers are primarily due to new construction and new boilers in existing buildings in expanded gas territories. NY-NYSERDA and NY-Iberdrola programs limit their incentives to boilers going into existing buildings. Customers can submit rebate applications for new construction condensing boilers through NYSERDA's custom process and NY-Iberdrola's Custom Measures C&I Rebate Program. Vermont provides prescriptive incentives for all types46 of small commercial boilers installed in an existing building and may consider a custom approach for new construction or new gas customers.

Rebate eligibility requirements also generally include the following:

- Natural gas customer on a qualifying commercial rate code
- Customer paying state SBC or equivalent program funding source
- Equipment installed in the program year
- Installation by licensed heating or plumbing contractor at account address
- Completed and signed rebate applications submitted online or mailed
- Copy of a dated work order/invoice/receipt that identifies equipment or measure installed, manufacturer, model number, AFUE/EF/thermal efficiency rating, contractor, contractor address, equipment and installation costs
- Applications postmarked within 60 or 90 days of installation date.
- Conditions that require pre-approval, if any (e.g., exceeding a specific number of units or a rebate limit)
- Manufacturer technical specification sheets for each type of eligible equipment purchased or eligible equipment included on www.ahridirectory.org

[44] NY-National Grid's Long Island, NY, commercial and industrial energy efficiency program was suspended in 2015 due to overwhelming customer participation, according to the program website. https://www1.nationalgridus.com/EnergyEfficiencyPrograms accessed 3/17/2015.

[45] NY-National Grid's Upstate NY commercial and industrial energy efficiency program was suspended on March 25, 2015, according to the program website. https://www.smartenergy-zone.com/nationalgridny/ accessed 3/30/2015.

[46] Condensing, non-condensing, and steam boilers.

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APPENDIX C – BOILER PRODUCT LINE MAPPING

There has been consolidation in the boiler industry and some of the manufacturers listed in the AHRI database are owned by other manufacturers. As mentioned in the body of the report section above, based on a simple web-search the Team was able to identify ownership relationships between several manufacturers. In total, we identified 14 manufacturers owned or operated by three separate parent companies. Collapsing these companies reduces the total number of manufacturers included in the AHRI database from 53 to 42. This consolidation is not meant to be comprehensive and other relationships may exist within the database that could not be identified through a simple web-search (Table 25).

Table 25: Consolidated Manufacturers

Consolidated Manufacturer Name	Companies Included
Burnham Holdings	Burnham Commercial
	New Yorker Boiler Company, Inc.
	U.S. Boiler Company, Inc.
Mestek, Inc	Advanced Thermal Hydronics
	Embassy Industries, Inc.
	Hydrotherm, Division of Mestek, Inc.
	LAARS Heating Systems Company
	Mestek, Inc.
	RBI Water Heaters Division of Mestek, Inc.
	Smith Cast Iron Boilers
	Spacepak
	Sterling HVAC Products
SPX Corporation	Weil-McLain
	Williamson-Thermoflo

Table 26 lists each manufacturer along with a count of the boiler models offered by fuel type and efficiency level. As the data shows, there are a number of large manufacturers that offer a variety of models ranging from standard to high efficiency and there is an emerging group of smaller manufacturers that focus exclusively on high efficiency models. Overall, 13 of these 42 manufacturers produced natural gas condensing boilers that received a Massachusetts PA rebate in 2013.

Table 26: Number of Models Offered By Manufacturer

Consolidated Manufacturer	Total Models	Participated in 2013 Program	Natural Gas Boilers by Efficiency				Oil Boilers by Efficiency				Propane Boilers by Efficiency			
			Std.	Mid	H-T1	H-T2	Std.	Mid	H-T1	H-T2	Std.	Mid	H-T1	H-T2
BURNHAM HOLDINGS	365	Yes	138	22	10	10	85	68			24	8		
ECR INTERNATIONAL	325	Yes	129	3	16	22	73	60			22			
CAMUS HYDRONICS LTD.	262		5	51	38	37					5	51	35	40
SLANT/FIN CORPORATION	230		75	4	11	6	75	59						
SPX CORPORATION	221	Yes	91	1	20	7	25	72			4	1		
MESTEK, INC.	211	Yes	66	41	25	30	27	14			4	4		
LOCHINVAR, LLC	157	Yes	25	19	22	18					25	19	20	9
PB HEAT, LLC	155		65	6	6	9	30	21	2		7		2	7
RAYPAK, INC.	138		76	12	7	6					36			1
CROWN BOILER CO.	122		46	9	10	3	28	26						
CARRIER CORPORATION	106		36		5	7	20	20			18			
THERMAL SOLUTIONS PRODUCTS LLC.	101		53	18	19	11								
SEARS, ROEBUCK AND COMPANY	75		21	3	6	4	21	14			6			
BOSCH THERMOTECHNOLOGY CORP	64	Yes	18	4	12	9	5	13					3	
COLUMBIA HEATING PRODUCTS INC.	51		17				22	10			2			
VIESSMANN MANUFACTURING COMPANY, INC.	47	Yes	3	5	11	13		15						
NY THERMAL INC.	45				20	8	2	15						
BRADFORD WHITE	41			13	4	20						4		

Consolidated Manufacturer	Total Models	Participated in 2013 Program	Natural Gas Boilers by Efficiency				Oil Boilers by Efficiency				Propane Boilers by Efficiency			
			Std.	Mid	H-T1	H-T2	Std.	Mid	H-T1	H-T2	Std.	Mid	H-T1	H-T2
CORPORATION														
HAMILTON ENGINEERING, INC.	41		20	14		7								
LENNOX INDUSTRIES, INC.	36		22		1	3	3	5			2			
HTP, INC.	33	Yes			16	13							4	
F.W. WEBB COMPANY	24		3	6			3	12						
NATIONAL HVAC MANUFACTURING COMPANY, LLC	23		12				3	8						
DDR AMERICAS, INC.	21			14	3	4								
A.O. SMITH WATER PRODUCTS CO.	18		10		8									
ALLIED ENGINEERING COMPANY	18			7	2							7	2	
AERCO INTERNATIONAL, INC.	17				14	3								
GRANBY FURNACES, INC.	17							17						
HARSCO INDUSTRIAL, PATTERSON-KELLEY	17	Yes		9	7	1								
TRIANGLE TUBE PHASE III INC.	17	Yes			5	10								2
PNA, INC. / PENSOTTI	16			5	4			7						
FULTON HEATING SOLUTIONS	15			4	7	3				1				
IBC TECHNOLOGIES, INC.	13	Yes			6	7								
BOYERTOWN FURNACE CO.	11			3				8						
PARKER BOILER COMPANY	10		4		6									

Consolidated Manufacturer	Total Models	Participated in 2013 Program	Natural Gas Boilers by Efficiency				Oil Boilers by Efficiency				Propane Boilers by Efficiency			
			Std.	Mid	H-T1	H-T2	Std.	Mid	H-T1	H-T2	Std.	Mid	H-T1	H-T2
NATIONAL COMBUSTION CO., INC.	7			7										
RINNAI CORPORATION	6	Yes				6								
THERMAL HYDRONIC SUPPLY LTD.	6			1	5									
CLEAVER-BROOKS	5				1	4								
NAVIEN, INC.	4	Yes				4								
TDC MANUFACTURING, INC.	3		3											
DUNKIRK BOILERS	1							1						

Cast iron is the most common material for boilers in the AHRI database (55%) followed by copper (21%) and stainless steel (16%) (Table 27). Not surprisingly, the majority (82%) of high-efficiency boilers are constructed from aluminium or stainless steel—out of 740 high-efficiency boilers 608 are listed as aluminium (118) or stainless steel (490). This is in keeping with the preferred materials for use with condensing boilers which require materials that can withstand the acidic nature of condensate.

Table 27: Number of Boilers by Material and Efficiency

Material Type	Efficiency Level				
	Standard	Mid	High Efficiency		Percent All
			High-T1	High-T2	
	≤84%	85%-89%	90%-94%	≥95%	
Aluminium	--	7	101	17	4%
Cast Iron	1,166	509	19	--	55%
Copper	287	273	27	74	21%
Stainless Steel	--	--	239	251	16%
Steel	62	51	9	3	4%
All	**1,515**	**840**	**395**	**345**	**3,095**

Table 28 provides an overview of boiler models by heating medium and efficiency. Water is the most common heating medium (80%) followed by steam (17%).

Table 28: Number of Boilers by Heating Medium and Efficiency

Heating Medium	Efficiency Level				
	Standard	Mid	High Efficiency		Percent All
			High-T1	High-T2	
	≤84%	85%-89%	90%-94%	≥95%	
Steam	493	29	--	--	17%
Water only	933	806	395	345	80%
Water or Steam	89	5	--	--	3%
All	**1,515**	**840**	**395**	**345**	**3,095**
Percent of Total	49%	27%	13%	11%	100%

As Table 29 shows, forced (48%) or natural (43%) are the most common draft types with just under one in ten models operating with induced drafts.

Table 29: Number of Boilers by Draft Control and Efficiency

Draft Type	Efficiency Level				
	Standard	Mid	High Efficiency		Percent All
			High-T1	High-T2	
	≤84%	85%-89%	90%-94%	≥95%	
Forced	362	486	343	287	48%
Induced	121	64	48	58	9%
Natural	932	290	--	--	43%
Unknown	--	--	4	--	<1%
All	**1,515**	**840**	**395**	**345**	**3,095**
Percent of Total	49%	27%	13%	11%	100%

APPENDIX D - NOPR SUMMARY

Meetings and Comment Periods

DOE held a public meeting to discuss the rulemaking on April 21, 2016 which the Team attended via webinar. Key takeaways from the meeting include the following:

- Manufacturers and manufacturer trade associations at the meeting agreed there is sufficient product mix available to meet DOEs proposed revisions to the standards under the current test procedure.
- Several manufacturers and manufacturer trade associations at the meeting noted concerns about DOEs cost analysis given the variability in the market.
- The majority of the manufacturers and manufacturer trade associations at the meeting recommended that DOE either suspend the NOPR efficiency standard rule-making or extend the comment period until the commercial packaged boiler test procedure revisions (which are being revised concurrently) are finalized.
- The majority of the manufacturers and manufacturer trade associations at the meeting agreed with the NOPR's conclusion that condensing technologies should be excluded from the technical scenario selected to analyse minimum efficiency standards. Common reasons mentioned by manufacturers were cost concerns as well as installation challenges and venting/condensate challenges in some applications. A few organizations, including the Appliance Standards Awareness Project (ASAP), encouraged DOE to reconsider the exclusion of condensing boilers, disagreeing with the claims that their inclusion could not be economically justified.

DOE accepted comments, data, and information regarding this NOPR until May 23, 2016.

Find more information on commercial packaged boilers on DOE's Appliance and Equipment Standards Rulemakings and Notices website.

All notices, public comments, public meeting transcripts, and supporting documents associated with this rulemaking are included in Docket No. EERE-2013-BT-STD-0030.

Savings Potential

Table 30 below shows DOE's estimated impacts to consumers of the proposed standards.

Table 30: Impacts of Proposed Energy Conservation Standards on Consumers of Commercial Packaged Boilers

Equipment Type	Fuel Type	Size Category (input)	Average Life-Cycle Cost Savings in 2014$	Simple Payback Period (years)
Hot Water Commercial Packaged Boilers	Gas-Fired	≥300 MBH and ≤2,500 MBH	$521	9.6
		>2,500MBH	$3,647	11.0
	Oil-Fired	≥300 MBH and ≤2,500 MBH	$7,799	5.7
		>2,500 MBH	$30,834	4.7
Steam Commercial Packaged Boilers	Gas-Fired	≥300 MBH and ≤2,500 MBH	$2,782	7.4
		>2,500 MBH	$16,802	4.7
	Oil-fired	≥300 MBH and ≤2,500 MBH	$4,256	5.3
		>2,500 MBH	$36,128	2.8

According to these estimates, over the life of the equipment consumers will see a life-cycle cost savings of between $521 for small gas-fired hot water boilers and $36,128 for large oil-fired steam boilers. Nationally, the total consumer costs and savings of commercial packaged boilers meeting the proposed standards over the next 30 years range from $0.4 billion to $1.69 billion. Over this time period an estimated 0.39 quadrillion Btu (quads) of lifetime energy savings would be achieved.

DOE evaluated five different Trial Scenario Levels to determine which mix of efficiency standards was both technologically feasible and economically justified. If DOE had chosen the "intermediate" Trial Scenario Level that includes higher cost-effective standards for the popular small gas-fired hot water boilers, the proposed standards would have more than doubled national energy savings by close to 1 quad (0.97) while saving customers $0.33 to 2.59 billion.[47] The Appliance Standard Awareness Project highlighted this in a March 2016 blog post, stating that "Commercial building owners would see savings with new DOE proposal, but

[47] Refer to Table V.45 in the NOPR for a summary of the analytical results from several different consumer impact scenarios (referred to as "Trial Scenario Levels").

stronger standards would save more."[48] The NOPR states that the secretary carefully considered proposing these increased standards, but has tentatively concluded that it is not economically justified.

[48] Mauer, Joanna. "Commercial building owners would see savings with new DOE proposal, but stronger standards would save more." Web blog post. ASAP. March 14, 2016.