MASSACHUSETTS COMMERCIAL AND INDUSTRIAL EVALUATION

Massachusetts Boiler Market Characterization Study

Massachusetts PAs and EEAC Consultants

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1 EXECUTIVE SUMMARY

The high efficiency boiler measure of Massachusetts prescriptive gas efficiency program is a large contributor to natural gas program savings on both an annual basis and lifetime basis when the 25 year life is considered. Several years of boiler measure evaluation studies have quantified savings values used in the prescriptive program. Technological advances in boiler equipment continue at a fast pace and have created a complex and quickly evolving boiler market. This study employed a boiler manufacturer outreach effort to first "test the waters" of manufacturer responsiveness in providing information such as boiler sales data and forecasted growth rates that has traditionally been considered confidential because of the highly competitive market place. Boiler manufacturers, especially ones that were leveraged in the Prescriptive Program, were responsive and provided information that is distilled in this study to provide Massachusetts boiler market characterization.

Market segments are defined with a focus on the small commercial and industrial boiler market that is linked to the prescriptive gas program. The results of twenty boiler manufacturer interviews are combined with an existing building database analysis and a state-wide gas billing analysis to provide details of the size of the State’s installed boiler inventory, annual commercial boiler sales, prescriptive boiler program penetration and feedback from distributors and manufacturers on the State’s prescriptive boiler efficiency program.

Key Findings:

1. A total of 1,500-3,000 gas-only boilers in the 90 – 2,000 MBH size range were sold in 2012 in the Massachusetts small commercial market. While the total range of boiler sales is relatively wide, additional research tasks can be conducted to provide a more finite estimate of sales. These research activities are identified below.1

2. The state-wide small commercial boiler inventory is approximately 121,040 units with 28% of the inventory installed “side-by-side” with one or more boilers at the same site.

3. The availability of natural gas distribution infrastructure limits the sales of high efficiency boilers which are growing at a faster rate (5-9% annual sales growth) than standard and mid-efficiency boiler types.

4. The 675 boilers that went through the prescriptive program in 2012 represent a participation rate of 28 – 75% of the high and low estimations of all condensing boilers sold state-wide in 2012. Further research such as boiler product mapping will provide more granularity to the participation rates.

5. Based on interviews that were conducted with boiler manufacturers; the manufacturers responded favourably about the prescriptive boiler program, support continuation and do not suggest there is a need for significant changes.

6. There are significant differences between the interview responses of boiler manufacturers. The manufacturer responses are largely reflective of the types of boilers that they produce. Some boiler manufacturers produce a wide spectrum of large and small standard, mid and high-efficiency models while others produce a single type in a limited size range.

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1 Manufacturers and distributors track sales within a state or region and do not track the specific installation locations of boilers. Therefore, information collected from manufacturers and distributors cannot be broken out by PA. However, for the billing analysis task in Section 3.2.1 the data was reported by PA and results are reported by PA.
Recommendations or next steps:

This study recommends five next steps that will enable program administrators to better understand the evolving boiler market in Massachusetts, more closely define program participation rates, calculate market lift and justify boiler incentive continuation:

- Seek voluntary non-confidential feedback from boiler manufacturers who expressed an interest.
- Conduct comparative research on boiler programs in the Northeast region.
- Initiate “boiler product line mapping” creating a simple matrix where boiler manufactures products are identified for 90-2,000 MBH units.
- Provide an overview of DOE’s current NOPR for Commercial Boiler Standard’s (U.S. Department of Energy Notice of Proposed Rulemaking) which will determine if pre-packaged commercial boilers will have new federally mandated efficiency requirements.
- Conduct a “Massachusetts Boiler Roundtable” (a small-group forum discussion) with a select Massachusetts market-savvy boiler panel that can efficiently provide information on the evolving complex boiler market.
2 OBJECTIVES AND SUMMARY OF APPROACH

2.1 Objectives of the Study

The Massachusetts Boiler Market Characterization Study was conducted as part of the Massachusetts Commercial and Industrial Evaluation (CIEC) contract overseen by the Massachusetts program administrators (PAs) and Energy Efficiency Advisory Council (EEAC) consultants. While the gas boiler market in Massachusetts has been briefly studied as part of a previous CIEC Process Evaluation and in tasks in the Custom Gas Study, it was not originally the primary research focus.

The overarching objective in this study was to provide the PAs and EEAC consultants with an in-depth understanding of the current baseline in the market, historical trends regarding equipment efficiencies and sizes, and assess the remaining savings potential. The study addressed the following research topics:

1. Characterize the current boiler market in Massachusetts:
   a. Quantify the size of the total boiler market and the penetration of high efficiency boilers in Massachusetts
   b. Identify the distribution of boiler sales by efficiency, size and type (e.g., condensing, hydronic, steam) for new units
   c. Identify the distribution of boiler sales by efficiency, size and type for replaced units

2. Compare the data collected in #1 to the PA’s tracking data bases to determine market share affected by the PA’s EE programs
   a. Determine if market share varies by size, efficiency or type
   b. Determine if market share varies by customer type
   c. Assess the level of market transformation attributable to the PA’s programs
   d. Identify remaining savings potential

3. Identify differences in market share between Massachusetts and other states in the northeast.
   a. Determine if market share varies by size, efficiency and/or type
   b. Determine if market share varies by customer type

2.2 Overall Approach

DNV KEMA conducted a series of qualitative and quantitative tasks to address the research issues in the study. The first step, and the key task for Phase One, was to develop a database of manufacturer sales data ideally stratified by:

- Year – ideally current year and four years historically
- State

2 Ibid.
One key objective for Phase One was to assess the feasibility of collecting detailed boiler manufacturer sales data. We reviewed the data and determined if the level of detail and completeness would support a quantitative analysis. Given the challenges in obtaining sales data, we also attempted to quantify the size of the Massachusetts boiler market using two other methods:

- Analysis of a sample of commercial building permits
- Leverage the billing data analysis collected from the Massachusetts PAs as part of the Project 20 CHP Impact Study

The results of the Phase One marketing sizing activities were used to recommend the appropriate research tasks for Phase Two of the Gas Boiler Market Characterization Study. The tasks may include:

- In-depth interviews with additional key market actors
  - Contractors
  - Engineering firms
- Convene an on-going panel of contractors and distributors to meet regularly to discuss market trends
- Follow-up interviews with the market actors interviewed in Massachusetts Process Evaluation
- Regional market comparison
  - Analysis of sales data
  - Interviews with program managers in other states

The first component of the study focused on the boiler manufacturers that were active in the Massachusetts boiler market and information that could be extracted from more than 20 interviews that were conducted with the manufacturers and their distributors. While information such as annual sales numbers for a specific boiler manufacturer was considered proprietary and confidential, the interviews were conducted in a manner that protected all of the sensitive information that was volunteered by each manufacturer. Care was taken to explain and reinforce the confidentiality of the interviews with each manufacturer. This resulted in proactive participation by the majority of boiler manufactures and sharing of such information as: annual boiler sales numbers, sales growth rates for the State, and comparisons in sales for program eligible models (high-efficiency condensing) vs. program non-eligible models (non-high efficiency non-condensing). A summary of the manufacturer’s responses provided the basis for Massachusetts boiler market characterization with the purpose of comparison of Massachusetts boiler market to other surrounding states in the Northeast and nationally as well as investigating the baseline assumptions that is in place in Massachusetts. The interview focused on the following areas:

- General Company Information
- Sales Data
The second component of the study utilized the natural gas commercial and industrial sector billing data for the Massachusetts’ PAs to determine the number of natural gas accounts with boilers as the dominant gas usage load. Each account was analysed to translate from consumption to the number and size of boilers replaced per year.

A third component was the investigation of all existing sources of data or information about the commercial and industrial buildings in Massachusetts and the associated link between the State’s commercial boiler market and its commercial building stock specifically:

- the existing state-wide commercial boiler inventory as a whole (and subsequent breakdown by PA)
- the mix of primary HVAC system types
- the overall geographic availability of the natural gas distribution system within the state.

This information was used to define the parameters of the overall state-wide boiler inventory.
3 METHODOLOGY

3.1 Manufacturer and Trade Ally Outreach

3.1.1 Contribution of Boilers to EE Programs

On average, boiler replacements constitute about 15 to 25% of custom and 25 to 50% of the prescriptive program gas savings. The 25 year measure life of boilers typically results in a large contribution of lifetime savings as compared with most other gas measures. Boiler control measures, which could also be influenced by this research, constitute another 3 to 5% of the large commercial and industrial portfolio savings. Table 1 summarizes the contribution of boiler measures by program year.

Table 1: Contribution of Boiler Measures by Program Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Custom Tracking Savings (therms)</th>
<th>Prescriptive Tracking Savings (therms)</th>
<th>Total Tracking Savings for All Measures (therms)</th>
<th>% Boiler of Total Tracking Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>Boiler Replacement 518,026</td>
<td>695,013</td>
<td>2,922,852</td>
<td>42%</td>
</tr>
<tr>
<td></td>
<td>Boiler Controls 126,581</td>
<td>-</td>
<td>2,922,852</td>
<td>4%</td>
</tr>
<tr>
<td>2010</td>
<td>Boiler Replacement 985,524</td>
<td>386,630</td>
<td>5,206,802</td>
<td>26%</td>
</tr>
<tr>
<td></td>
<td>Boiler Controls 568,527</td>
<td>11,715</td>
<td>5,206,802</td>
<td>11%</td>
</tr>
<tr>
<td>2011</td>
<td>Boiler Replacement 881,736</td>
<td>496,803</td>
<td>9,712,067</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>Boiler Controls 254,072</td>
<td>19,880</td>
<td>9,712,067</td>
<td>3%</td>
</tr>
</tbody>
</table>

3.1.2 Background & Prescriptive Program Focus of this Study

The first step in the manufacturer and trade ally outreach was to examine the type and size of the gas boilers implemented in the Prescriptive Gas Boiler Program. This information helped to identify the market segments addressed by current program and applications and/or boiler sizes not captured by the program.

The DNV GL team reviewed the 2012 Massachusetts prescriptive natural gas program data to identify the quantity, types and application of boilers. In 2012, 675 high efficiency condensing boilers and combination condensing boiler/DHW measures were installed under the program. Boilers accounted for total gross program year savings of 514,443 Therms or 23% of total 2012 C&I prescriptive program year savings. Collectively for the two boiler measure types (there are actually two prescriptive measures involving boilers: boilers and combination boiler/DHW), the 25-year measure life for the condensing boiler measure and the 20-year life for the combination condensing boiler/DHW measure accounted for 57% of savings when expanded to consider lifetime savings as shown in Figure 1.

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4Ibid
The Massachusetts Technical Reference Manual (TRM)\textsuperscript{5} describes the prescriptive plan high efficiency boiler measure and provides details for five prescriptive boiler size tiers. The measure description includes thermal efficiency requirements of more than 90% and requires installation of a condensing boiler to take advantage of improved design, sealed combustion and condensing fuel gases in a second heat exchanger to achieve improved efficiency. In the current prescriptive program, the smallest boiler size of less than 300 MBH is divided into two separate prescriptive program tiers: one for Annual Fuel Utilization Efficiency (AFUE) greater than 96% and one for 90% to 96% AFUE. A separate prescriptive measure "Combination Water Heater/Boiler" promotes the installation of a combined high-efficiency boiler and water heating unit that eliminates the standby heat losses of an additional tank. Table 2 shows the quantity of boilers and percentage of boiler measure total based on the size of the boiler unit.

The boiler market in Massachusetts can be segmented into three different market sectors: residential, small commercial and industrial and large commercial. PA sponsored programs are offered to each sector for the purchasing and installing energy efficient boilers. The characteristics of the broader Massachusetts boiler market are segmented by three market sectors and shown in Table 3. The relative size of these market sectors runs from small to large. There are approximately 2.5 million residential homes in the State with their primary heating systems consisting of furnace, boiler or other. The residential sector is approximately four to five times larger based on the quantity of boiler units whereas the large industrial sector represents a smaller quantity of boiler units but with each unit characterized by a substantially larger installed capacity.

The Prescriptive Program that is currently administered by the Massachusetts PAs typically targets the small commercial and industrial (C&I) sector of the boiler market and from a “boiler size perspective” is sandwiched in between the residential market sector and the large industrial sector of the boiler market in the State. Therefore, this study will focus on the less than 200,000 existing commercial and industrial buildings in Massachusetts and specifically the smaller commercial buildings rather than the largest several hundred which constitute the large (C&I) sectors often referred to as “Key Accounts” in the utility arena. While there is not complete clarity with the term “Key Accounts” between Massachusetts PA’s there is consensus agreement that the large sized boilers within the largest facilities in the state such as hospitals, universities, manufacturing plants would be more involved with the custom program track. It seemed viable as a first step to focus on the small C&I sector.

Table 2: Size Distribution of 2012 Prescriptive Boilers

<table>
<thead>
<tr>
<th>2012 Prescriptive Program Boiler and Boiler/DHW Heater Combination</th>
<th>Quantity (Boiler Units)</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=300 MBH</td>
<td>242</td>
<td>36%</td>
</tr>
<tr>
<td>301 - 499 MBH</td>
<td>202</td>
<td>30%</td>
</tr>
<tr>
<td>500-999 MBH</td>
<td>120</td>
<td>18%</td>
</tr>
<tr>
<td>1000 - 1700 MBH</td>
<td>54</td>
<td>8%</td>
</tr>
<tr>
<td>&gt;1701 MBH</td>
<td>14</td>
<td>2%</td>
</tr>
<tr>
<td>Boiler/DHW Combination</td>
<td>43</td>
<td>6%</td>
</tr>
<tr>
<td>2012 Program Year Totals</td>
<td>675</td>
<td>100%</td>
</tr>
</tbody>
</table>
Several previous evaluation studies focused on the deemed savings values for boiler measures in the prescriptive program. The current baseline for the prescriptive program assumes compliance with the efficiency requirements mandated by Massachusetts State Building Code. These minimum efficiency requirements are detailed in the current Massachusetts TRM shown in Figure 2 below\(^6\).

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**Table 3: Boiler Market Sectors**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Residential</th>
<th>Small Commercial &amp; Industrial</th>
<th>Large (C&amp;I) Industrial &quot;Key Accounts&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Utility Rate</td>
<td>Residential Heating</td>
<td>C&amp;I</td>
<td>Large (C&amp;I) or Interruptible Rate</td>
</tr>
<tr>
<td>Typical Boiler Capacity</td>
<td>30 - 90 MBH</td>
<td>90 - 2,000 MBH</td>
<td>2 - 200 MMBH</td>
</tr>
<tr>
<td>Energy Efficiency Program Applicability</td>
<td>Residential</td>
<td>Prescriptive</td>
<td>Custom</td>
</tr>
<tr>
<td>Typical Installation/design Configuration</td>
<td>Single unit at site</td>
<td>Wide variation of small single units to Lead-lag/multiple configuration of units at a single site</td>
<td>More commonly multiple boiler units at site because of steam or hydronic loop design considerations (lead-lag, modular configurations the norm)</td>
</tr>
</tbody>
</table>

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\(^6\) MA TRM, Ibid
The previous boiler evaluation studies quantified savings values that were used in the prescriptive program. Since the savings values analytically are calculated from the baseline assumption it highlights the need to explore the current base line assumptions to the extent possible. An important motivation of this study is the investigation of these boiler baseline assumptions to the extent possible. The simple concept of trying to find out from the boiler manufacturer’s directly what type of boiler and how many units are being sold in Massachusetts provides value by better defining the market and is not something that appears to have been done in the past. Similarly, information from the manufacturers about what they know of the Massachusetts baseline boiler baseline condition was also of interest.

Published data on boilers focuses on the design and operation of boilers and not on sales and shipments of boilers. This is because it is a competitive market place and an individual boiler manufacturer’s sales information is typically guarded and considered confidential to help protect the manufacturer’s market share position. The most comprehensive resource found on boiler market characterization is “Characterization of the U.S Industrial/Commercial Boiler Population”\(^7\) (Energy and Environmental Analysis, May 2005) but focuses almost exclusively on boiler units greater than 10 MMBtu/hr. This report does not consider residential sector boilers at all and only considered commercial and industrial units with capacity greater than 10 MMBtu/hr. which would represent only the largest Massachusetts C&I sites. However, the report identifies that over 70% of the C&I boiler population nationwide are units less than 10 MMBtu/hr.

The American Boiler Manufacturer’s Association (ABMA) provides an internal report to its members of boilers sales collected on a voluntary basis from members. Membership in the ABMA and therefore inclusion in the report is characterized by manufacturers of boilers with input ratings greater than 4 MMBtu/hr. This data even if it were made available would not provide useful information about the Massachusetts prescriptive boiler program because we are focusing on smaller size boilers. Some of the manufacturers included in this

study’s interviews were ABMA members and some were not. Some of the ABMA members who were interviewed relayed that they choose not to provide their sales data for their larger size boilers to the ABMA.

### 3.1.3 Prescriptive Boiler Manufacturer Outreach

Since Massachusetts specific market information was not available for boilers with nameplate ratings from 90 to 2,000 MBH the DNV GL team conducted direct outreach efforts to boiler manufacturers.

Industry databases such as the Air Conditioning, Heating, Refrigeration Institute (AHRI) - Directory of Certified Product Performance \(^8\) (Air-Conditioning, 2014), Industrial Manufacturer Directory, (Program, 2011) provide information on a total of 35 manufacturers of commercial boilers in the 90 – 2,000 MBH size range. The 2012 Massachusetts Prescriptive Gas Program tracking data showed that approximately 20 manufacturers accounted for virtually all of the eligible boilers in the program. In addition, program records from the tracking data for the 2010 and 2011 prescriptive boiler programs were reviewed to ensure the list of manufacturers represented a comprehensive list of companies active in the boiler program. Furthermore, since the program incentives helped to promote the boiler sales for these manufacturers it was reasoned that these manufacturers would be more likely to be willing to share sales and other information to benefit the gas efficiency program going forward.

Identifying the manufacturers of “program eligible” or high-efficiency condensing type models was only “half the battle”. The next step in developing the boiler baseline was to obtain information on standard-efficiency non-condensing boilers that were not eligible for the boiler program. The DNV GL team interviewed distributors, installers and suppliers to gain an understanding of the “non-eligible” non-condensing models were actually being sold in Massachusetts. It is important to note that the largest boiler manufacturers in the market place produce both “program eligible” and “program non-eligible” models. Emphasis was then placed to include as large a representation of manufacturers who produced both “program eligible” and “program non-eligible” models since they would be able to compare the sales numbers of both types and contrast the Massachusetts sales with surrounding States and the national average. While information from a manufacturer that produced “program eligible” only models would be valuable it would not be as informative with regard to collecting baseline assumption information.

During planning meetings, the PAs, the EEAC consultants and DNV GL determined that a Request for Information (RFI) would be used to explain the study and obtain information from the manufacturers most active the Massachusetts boiler market. The RFI Letter attempted to leverage the value of the gas efficiency program with the manufacturers and also reinforced that all information would be treated confidentially. Care was taken to never link individual sales numbers with a particular manufacturer at any point in the study. Comments made about the Massachusetts boiler program would also be “blind” and sanitized. Twenty six personalized RFI Letters were sent out to boiler manufacturers during late October 2013.

In addition, the DNV GL team identified the key individuals who we believed to be most “Massachusetts boiler market savvy” individuals within each of the 20 top boiler manufacturers. The contact list served as the initial point of contact for the surveys and was typically an executive level person within the boiler companies. However, based on a combination of direct phone conversations and emails, the identified contact individual often expanded to be more than one individual and often ended up being a combination of

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manufacturer executive and the regional distributor/representative for the boiler product line. This proved to be beneficial since the interview questions attempted to query both Massachusetts and regional/national sales trends with the hope of deriving comparisons.

The survey instrument was developed with review and contributions from the PAs and EEAC. The interview focused on the following areas:

- General Company Information
- Sales Data
- Massachusetts Market Information
- New Product Offerings
- Massachusetts Baseline Assumptions
- Energy Efficiency Program Implementation

Twenty interviews were conducted during November and December 2013 which lasted an average of 62 minutes each. The outreach process is further summarized in Table 4. The results of the interviews are presented in Section 3.

Table 4: Boiler Manufacturer Outreach

<table>
<thead>
<tr>
<th>Boiler Manufacturers</th>
<th>Identified MA Market Savvy Contacts</th>
<th>Confirmed Phone Interest</th>
<th>Sent &quot;RFI Letter&quot;</th>
<th>Interviews Completed</th>
<th>&quot;Denied&quot; - No further follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22</td>
<td>25</td>
<td>20</td>
<td>26</td>
<td>20</td>
</tr>
</tbody>
</table>

3.1.4 Trade Organization Outreach

In addition to the manufacturer outreach, the DNV GL team also contacted three trade organizations who were knowledgeable about the boiler market. The following describes each trade organization and an explanation of the reasons they were included in the study.

Northeast Gas Association (NGA): NGA represents natural gas distribution companies, transmission companies, liquefied natural gas importers, and associate member companies. These companies provide natural gas to over 10 million customers in eight states (Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont). NGA was established on January 1, 2003. Its predecessor organizations were The New England Gas Association (founded in 1926) and the New York Gas Group (founded in 1973). All of the Massachusetts program administrators exist as LDC’s (Local Distribution Company’s) in the State. Many of the boiler manufacturers have also been long-time associate members of this trade association. A key to getting manufacturer's direct sales data which is a rarity in the competitive HVAC market was leveraging the state-wide industry need for information. NGA has a long history of representing the regional natural gas industry and served as a viable partner in helping to identify the most knowledgeable boiler market individuals who provided valuable information during the interviews. NGA
which helped administer some of the recent Massachusetts Department of Energy Resources meetings conducted on gas expansion (Second Stakeholder Meeting, Natural Gas Expansion Study, October 25th) made available the summary of natural gas distribution facility availability that was used in the existing building database analysis.

Gas Technology Institute (GTI): Leading U.S. research, development, and training organization serving the natural gas industry and energy markets has managed the US DOE funded “Super Boiler Development” Project which has been a major driver in the majority of development of new high efficiency technology and commercial product offerings since 2000. GTI offered possible project support in the area of evolving technology research and forecasting commercially available efficiency trends and the timing of new product releases which is another item that is often closely guarded by manufacturers but very important to program administration. GTI assisted by providing introductions to the contact information at the commercial developer of the Super Boiler project. This information was presented and discussed during the bi-weekly meetings of the Massachusetts gas evaluation team and it was decided that while of interest was largely out of the scope of the prescriptive program. Further details have been archived and are available to the gas evaluation team.

American Boiler Manufacturers Association (ABMA): In addition to an extensive boiler equipment manufacturer’s directory no other organization attempts to gather sales data or maintains and distributes the same quantity or quality of product sales data. ABMA also maintains data on boiler registrations, information provided by The National Board of Boiler and Pressure Vessel Inspectors. ABMA data is targeted to attract manufacturer membership as an essential tool for manufacturer market evaluation. Analysis of the usefulness of this data showed that the targeted boiler size was boilers larger than 4MMBH for the ABMA data and the purposes of this Study was for the range of commercial boiler included in the Prescriptive Program in Massachusetts which is the 85 to 2,000MBH range.

3.2 Sizing the Massachusetts Boiler Market

The direct market outreach described above is a critical component in understanding the proportion of eligible and ineligible boilers sold, but because each manufacturer can only report their sales with certainty, and not all manufacturers provided data, it is not possible to know for certain that a major piece of the market is not being overlooked. Two additional analytic activities were undertaken to provide an envelope around the entire boiler market, including an estimate of the number of boilers currently installed as well as number of new boiler sold each year. These two methods are:

- The first method is based on an analysis of data set of all Massachusetts C&I gas company accounts. The analysis has an algorithm for determining heating system size for each of the 240,000 natural gas accounts included in the commercial state-wide dataset. The results provide a basis for aggregation by PA, by business type, and by other convenient categories. Since this method focuses on gas accounts the results yield information on gas-only boilers and does not provide information on other types of boilers.

- The second method focuses on using information from existing commercial building databases. The state-wide inventory of all boilers is calculated by starting with the number of commercial buildings and then allocating where boilers represent the primary heating system versus other types of HVAC systems. This method produces a boiler count for all boilers (both gas-only and other fuel type boilers) and is therefore a greater quantity than the first method.
These two methods were done independently and then the results were compared as a check for reasonableness.

### 3.2.1 Massachusetts C&I Billing Analysis

The size of the boilers is largely driven by the building design load that it serves, which is the theoretically maximum amount of heat required to maintain building temperature on a design day. Using techniques developed in the Massachusetts 2011 CHP Impact Evaluation Study, a design thermal load was calculated for every gas account. Once the design thermal load was defined, a boiler was sized to meet that load using standard engineering assumptions. Additional factors were applied to account for those accounts that are likely to be boilers vs. those that are not. This process ended in a final data set of ‘virtual’ boilers that were linked to specific gas accounts, and hence to a PA and a building type.

Boiler replacements rates are the inverse of the mean life of a boiler. Therefore, since boilers have a mean life of 25 years, on average, 1/25 or 4% of all boilers will be replaced in any one year. This factor was applied to the overall number of boilers determined in the previous steps to arrive at the size of the boiler replacement market.

The linkage to specific gas accounts provides a high level of certainty as to the fuel type, location, customer type, and magnitude of the boiler size. While there is error in the application to a particular site of a factor such as heating system type of ‘boiler’ vs. ‘direct fired’, the statewide proportions will correctly match the expected statewide allocation. The analysis includes a sensitivity analysis to examine the effect of uncertainty on the results.

The analytic approach of this analysis involves defining the number of boilers replaced per year through analyzing one year (2010) of monthly billing data for all commercial and industrial gas accounts. Each account is analyzed in a step by step manor to translate from yearly consumption to number and size of boilers replaced per year. The steps used to achieve this result are as follows:

1. Determine the design thermal load (maximum hourly usage) for each account (MBH) as a proxy for boiler size.
2. Filter out accounts not served by a boiler.
3. Account for facilities with multiple boilers per account.
4. Use a typical lifetime to determine the number of boilers replaced per year.
5. Summarize results by program administrator, boiler size and facility type.

A detailed description of each step is provided below.

**Determine design thermal load**

The theoretical optimal boiler size for any facility is equal to the maximum hourly usage during the most extreme outside conditions. This ensures that at all times the required heating load can be met. For this analysis the maximum hourly usage is calculated as the total usage divided by the facility’s respective full load hours (FLH). Since FLH are different for the base and weather dependent loads, the following equation was used to calculate the optional design thermal load:

\[
\text{Design thermal load} = \left( \frac{\text{Base usage}}{\text{Base FLH}} + \frac{\text{Weather usage}}{\text{Weather FLH}} \right) \times \text{Over size Factor}
\]
**Base usage.** For each account, the base usage was determined as the average monthly billed usage during the summer multiplied by twelve months.

**Weather dependent usage.** The weather dependent usage was the difference between the annual and base usages.

**Base FLH.** The base full load hours were calculated using a repetitive one day hourly profile. Eleven separate profiles were used based on the respective facility type.

**Weather dependent FLH.** The weather dependent full load hours were calculated using an 8760 TMY3 profile. For each hour there was considered to be 0% loading at the base temperature and 100% loading at lowest temperature of the year with a linear relationship for each temperature in-between. For each account the closest TMY3 station was used to determine the outside air temperature and the facility type was used to determine the respective base temperature.

**Oversize factor.** Each account’s maximum capacity was multiplied by the ASHREA stated oversize factor of 120%. This ensures that boiler is adequately sized even under the most extreme outside conditions.

**Remove non-boiler accounts**

The current dataset represents all natural gas accounts. Hence the natural gas accounts not served by a boiler were then removed using the following three step approach.

1. Accounts with a design thermal capacity too small to be a boiler were removed. A review of prescriptive program data indicated that all accounts with less than 90 MBH are likely non-boiler accounts.

2. Small accounts (<100 MBH) with high base load were identified as likely to be hot water heaters and removed. High base load is defined as a base load that makes up at least 60% of the total annual gas use.

A 30% reduction was applied to the total number of larger accounts (>300 MBH) to eliminate non-boiler heating. This factor was determined during the CHP market study. This is based on CBECs survey data which was used to identify the portion of systems served by boilers.

**Account for multiple and redundant boilers**

The current dataset represents the total number of accounts served by boilers. Interviews with vendors indicated that 28% of sites involved a multi-boiler configuration, and hence the number of accounts was then converted to number of boilers by increasing the current count by 128%. Additionally, interviews indicated smaller boilers (<300 MBH) were less often placed into multi-boiler configurations. Therefore, to maintain the overall 128% adjustment, a factor of 5% was applied to small boilers (<300 MBH) and a factor of 62% was applied to larger boilers (>300 MBH).

**Determine replacement schedule**

The analysis thus far presents the total number of boilers and the optimal design thermal load they serve. This figure was then divided by the boiler life of 25 years (ASHRAE) to determine the average number of boilers replaced per year.
Summarize results

A summary of results by program administrator, boiler size and facility type is presented in Section 3.3.1. Furthermore, a sensitivity analysis was performed to assess the magnitude of uncertainty within each analysis step above. The sensitivity analysis is presented in Section 4.2.2.

3.2.2 Existing Commercial Building Databases (US Census, CBECS, etc.)

The third component of the Boiler Market Study was to investigate existing sources of C&I Massachusetts building data. Initially it was thought that boiler market information could be gleaned from construction permit data that is available in databases such as: Dodge Construction Leads, Reed Construction Data or McGraw Hill Construction by filtering on key words such as “boiler” or “HVAC”. The results of initial investigation of this approach did not lead to results that produced practical information on the boiler market and was not pursued farther.

A more straightforward approach was the investigation of existing data on Massachusetts commercial buildings. This follows from the link between the Massachusetts commercial boiler market and its commercial buildings. The relationship of: the existing state-wide commercial boiler inventory, the mix of primary HVAC system types and the overall geographic availability of the natural gas distribution system within the state provide defining parameters of the overall state-wide boiler market.

The first step was an examination of the C&I building stock in Massachusetts. In Table 5 below, historical data was taken from the (US Census Bureau, 2014) to show the number of buildings in Massachusetts from 2000-2014⁹. For business data the United States Census Bureau utilizes the NAICS (North American Industry Classification System) for classifying business establishments and replaces the older vintage SIC system. The 2011 County Business Patterns for Massachusetts identify the number of C&I establishments or “business premises” which represent non single or multi-family dwellings and provides the best data for C&I buildings state wide.

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It is important to understand that the US Census data information is available for 2000-2011\(^{10}\). The values for 2012-2014 are forecasted. It was first difficult to do a pure regression based approach as the data exhibited a strong amount of autocorrelation due mainly to economic recession that began in 2008, and was still felt through 2011. This caused the forecast to show a continual decrease in the number of buildings over the years which did not seem accurate based on the market and the economic rebound experience in Massachusetts. The most reasonable assumption was that the market has rebounded to post-recession levels to 175,000 buildings, and the additions of 2,500 new buildings per year were assumed from 2012-2014. It is important to note that the economic trends may vary between and within PA territories however, this study did not address variations in economic growth within Massachusetts.

The data from our analysis of the building stock in Massachusetts can be seen in Figure 3 below\(^{11}\):

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Establishments</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>176,222</td>
</tr>
<tr>
<td>2001</td>
<td>177,434</td>
</tr>
<tr>
<td>2002</td>
<td>175,991</td>
</tr>
<tr>
<td>2003</td>
<td>178,675</td>
</tr>
<tr>
<td>2004</td>
<td>175,993</td>
</tr>
<tr>
<td>2005</td>
<td>175,291</td>
</tr>
<tr>
<td>2006</td>
<td>175,463</td>
</tr>
<tr>
<td>2007</td>
<td>176,701</td>
</tr>
<tr>
<td>2008</td>
<td>174,290</td>
</tr>
<tr>
<td>2009</td>
<td>170,473</td>
</tr>
<tr>
<td>2010</td>
<td>169,790</td>
</tr>
<tr>
<td>2011</td>
<td>169,146</td>
</tr>
<tr>
<td>2012*</td>
<td>170,000</td>
</tr>
<tr>
<td>2013*</td>
<td>172,500</td>
</tr>
<tr>
<td>2014*</td>
<td>175,000</td>
</tr>
</tbody>
</table>

\(^{10}\)US Census Bureau, County Business Patterns, http://censtats.census.gov/cgi-bin/cbpnaic/cbpsect.pl  
\(^{11}\)Ibid
Knowing the total number of C&I buildings in the state, attention shifts to what types of buildings these are and specifically which of these building categories use boilers as their primary heating source. In order to determine the building categories two data sources were used: Massachusetts Commercial and Industrial (C&I) Customer Profile Study and the Energy Information Administrations (EIA) Commercial Building Energy Consumption Survey (CBECS) of 2003\(^{12}\). The two sources contained roughly the same building categories therefore the categories in both sources were used for our analysis. While the US Census database contains a NAICS system of building categorization; it was decided to not use the Census categories as they were much larger and encompassed multiple end-use categories as opposed to the more specific building types than provided in the CBECS or the D&I Customer Profile Study.

The building categories from the three databases are graphically illustrated in Figure 4. The relationship between the number of buildings and boilers is from information the Massachusetts C&I Customer Profile study (KEMA M. L., June 2013). \(^{13}\)This study combined energy efficiency program tracking data with the billing usage data for the Massachusetts C&I gas and electric customers served by the PAs. Furthermore, it provides a link to how often a boiler is the primary heating system in Massachusetts C&I buildings as compared to other primary heating systems.

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\(^{12}\) US Census Bureau, NAICS website, http://www.census.gov/eos/eos/sss/naics  
\(^{13}\) MA LCIEC Project 18 *Massachusetts C&I Customer Profile Study, DNV GL, 2013
The Customer Profile Study used a telephone survey instrument and on-site field inspections to identify the primary heating equipment by building category. The survey asked respondents what is the primary heating equipment used in the building.

### Table 6: Results of Massachusetts C&I Customer Profile Study

<table>
<thead>
<tr>
<th>Primary Heating Equipment</th>
<th>EDUCATION</th>
<th>FOOD SALES</th>
<th>FOOD SERVICE</th>
<th>HEALTHCARE</th>
<th>LODGING</th>
<th>MANUF/INDUS</th>
<th>OFFICE</th>
<th>OTHER</th>
<th>PUBLIC ASSEMBLY</th>
<th>RETAIL</th>
<th>WAREHOUSE</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - None</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>2 - Boilers</td>
<td>35</td>
<td>3</td>
<td>14</td>
<td>18</td>
<td>7</td>
<td>13</td>
<td>38</td>
<td>6</td>
<td>12</td>
<td>18</td>
<td>3</td>
<td>167</td>
</tr>
<tr>
<td>3 - Furnace</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>14</td>
<td>4</td>
<td>4</td>
<td>18</td>
<td>0</td>
<td>58</td>
</tr>
<tr>
<td>4 - Rooftop</td>
<td>2</td>
<td>5</td>
<td>14</td>
<td>4</td>
<td>3</td>
<td>16</td>
<td>6</td>
<td>1</td>
<td>3</td>
<td>16</td>
<td>2</td>
<td>72</td>
</tr>
<tr>
<td>5 - Split-system heat pumps</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>27</td>
</tr>
<tr>
<td>Total</td>
<td>39</td>
<td>14</td>
<td>37</td>
<td>27</td>
<td>15</td>
<td>39</td>
<td>61</td>
<td>12</td>
<td>22</td>
<td>58</td>
<td>5</td>
<td>329</td>
</tr>
</tbody>
</table>

This information provided a representation of the heating profile for Massachusetts customers, however, the breakdown of boilers by building type, percent of total boilers by building type and the percentage of buildings by building type required further analysis. The overall breakdown of primary heating system types for
Massachusetts C&I buildings is shown in Figure 5 for the total number of buildings or as an average across the eleven individual building classifications.\textsuperscript{14}

**Figure 5: Type of Primary Heating System for Massachusetts C&I Buildings**

The next step in the analysis was to determine the percent of buildings based on building type using the C&I Customer Profile survey data. The results can be seen in Table 7 below\textsuperscript{15}:

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Percent of Buildings by Building Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDUCATION</td>
<td>12%</td>
</tr>
<tr>
<td>FOODSALES</td>
<td>4%</td>
</tr>
<tr>
<td>FOODSERVICE</td>
<td>11%</td>
</tr>
<tr>
<td>HEALTHCARE</td>
<td>8%</td>
</tr>
<tr>
<td>LODGING</td>
<td>5%</td>
</tr>
<tr>
<td>MANUF/INDUS</td>
<td>12%</td>
</tr>
<tr>
<td>OFFICE</td>
<td>19%</td>
</tr>
<tr>
<td>OTHER</td>
<td>4%</td>
</tr>
<tr>
<td>PUBLIC ASSEMBLY</td>
<td>7%</td>
</tr>
<tr>
<td>RETAIL</td>
<td>18%</td>
</tr>
<tr>
<td>WAREHOUSE</td>
<td>2%</td>
</tr>
</tbody>
</table>

The C&I market in Massachusetts is largely dominated by retail stores, office buildings, educational facilities, restaurants, and manufacturing/industry. These building types are some of the largest users of energy.

\textsuperscript{14} This commercial building classification was taken from a combination of DOE CBEC’s and Massachusetts Project 18 data which correlated but not identical. It is provided on a statewide basis.

\textsuperscript{15} Ibid.
primarily due to the high number of annual operating hours; therefore, we need to identify the usage that is associated with heating loads versus non-heating loads.

The next step in the analysis focused on calculating the breakdown of boilers by building type. The breakdown of boilers by building type was calculated by taking the number of boilers and dividing that number with the total number of respondents per building category (ex. Food Service is 35/39 x 100). The results can be seen in Table 8 below:

Table 8: Prevalence of Boilers by Building Type

<table>
<thead>
<tr>
<th>Building Type</th>
<th>Percentage of Boilers by Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDUCATION</td>
<td>90%</td>
</tr>
<tr>
<td>FOODSALES</td>
<td>21%</td>
</tr>
<tr>
<td>FOODSERVICE</td>
<td>38%</td>
</tr>
<tr>
<td>HEALTHCARE</td>
<td>67%</td>
</tr>
<tr>
<td>LODGING</td>
<td>47%</td>
</tr>
<tr>
<td>MANUF/INDUS</td>
<td>33%</td>
</tr>
<tr>
<td>OFFICE</td>
<td>62%</td>
</tr>
<tr>
<td>OTHER</td>
<td>50%</td>
</tr>
<tr>
<td>PUBLIC ASSEMBLY</td>
<td>55%</td>
</tr>
<tr>
<td>RETAIL</td>
<td>31%</td>
</tr>
<tr>
<td>WAREHOUSE</td>
<td>60%</td>
</tr>
</tbody>
</table>

The data in Table 8 above shows the prevalence of boilers compared to the total heating equipment in all of the 11 major building categories sampled from the Customer Profile data set. For example, the table shows the percent of food service buildings that use a boiler as their primary heating source.

DNV GL team also examined the consumption by building type data reported in CBECS. This data was used as a comparison source, between Massachusetts and the rest of the country. The data is shown in Table 9 below:
In Table 9 above, the same building categories as the Customer Profile data are used to obtain the gas consumption by building type. It is important to note that this data pertains to total 2013 natural gas consumption (trillion Btu) for all commercial buildings throughout the US, not specific to Massachusetts or end use. However, the data does provide a basis for comparison to allow further detail the Massachusetts boiler market.

Information from all sources is used to define the state wide boiler inventory based on the information above and bring in the Census data and specifically the 175,000 state wide building basis predicted for 2014. The information is displayed in 10 below:
Table 10: Summary of Boiler Market Sizing

<table>
<thead>
<tr>
<th>Building Type</th>
<th>CBECs Number of Buildings</th>
<th>CBECs Percentage of Buildings by Type</th>
<th>Project 18 Number of Buildings</th>
<th>Project 18 Percentage of Buildings by Type</th>
<th>Total Number of Massachusetts Boiler Sites (high - low range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDUCATION</td>
<td>24,516</td>
<td>14%</td>
<td>20,745</td>
<td>12%</td>
<td>18,617 - 22,064</td>
</tr>
<tr>
<td>FOODSALES</td>
<td>3,568</td>
<td>2%</td>
<td>7,447</td>
<td>4%</td>
<td>1,595 - 749</td>
</tr>
<tr>
<td>FOODSERVICE</td>
<td>18,570</td>
<td>11%</td>
<td>19,681</td>
<td>11%</td>
<td>7,446 - 7,057</td>
</tr>
<tr>
<td>HEALTHCARE</td>
<td>22,229</td>
<td>13%</td>
<td>14,362</td>
<td>8%</td>
<td>13,172 - 9,574</td>
</tr>
<tr>
<td>LODGING</td>
<td>19,668</td>
<td>11%</td>
<td>7,979</td>
<td>5%</td>
<td>9,244 - 3,723</td>
</tr>
<tr>
<td>MANUF/INDUS</td>
<td>24,151</td>
<td>14%</td>
<td>20,745</td>
<td>12%</td>
<td>7,970 - 6,914</td>
</tr>
<tr>
<td>OFFICE</td>
<td>24,608</td>
<td>14%</td>
<td>32,447</td>
<td>19%</td>
<td>20,212 - 15,257</td>
</tr>
<tr>
<td>OTHER</td>
<td>7,959</td>
<td>5%</td>
<td>6,383</td>
<td>4%</td>
<td>3,980 - 3,191</td>
</tr>
<tr>
<td>PUBLIC ASSEMBLY</td>
<td>9,331</td>
<td>5%</td>
<td>11,702</td>
<td>7%</td>
<td>6,382 - 5,132</td>
</tr>
<tr>
<td>RETAIL</td>
<td>8,325</td>
<td>5%</td>
<td>30,851</td>
<td>18%</td>
<td>9,574 - 2,581</td>
</tr>
<tr>
<td>WAREHOUSE</td>
<td>12,075</td>
<td>7%</td>
<td>2,660</td>
<td>2%</td>
<td>7,446 - 7,245</td>
</tr>
<tr>
<td>Total</td>
<td>175,000</td>
<td>100%</td>
<td>175,000</td>
<td>100%</td>
<td>105,638 - 83,487</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>94,563 (+/- 12%)</td>
</tr>
</tbody>
</table>

Table 10 presents the estimated number of total boilers in Massachusetts in 2014. Included in this table also are the CBECs data values compared side by side to the Massachusetts Customer Profile Study data, which illustrates the national data as a whole compared to Massachusetts only data. The number of buildings by category the percentage of boilers by building type is multiplied by that percentage times 175,000, the total number of buildings which was identified earlier as the number of commercial buildings in 2014 from US Census data. The total number of boilers was calculated by taking the percentages of boilers as the primary heating type and multiplying that percentage by the number of buildings in that particular building type.

In 2014, there are an estimated 94,563 boiler sites in C&I buildings in Massachusetts. Approximately 51% of C&I buildings in Massachusetts use a boiler as their primary heating source. It is important to note that this 51% value is consistent with the percentage of total boilers by building type derived from the Massachusetts Customer Profile data.

With the total number of boilers in the State identified, next is the identification of the fuel type of the boilers in the state. Research suggested that the most current and accurate information on the percentage of Massachusetts boiler market is fuelled with natural gas and the percentage is fuelled with liquid fuel (oil or any petroleum distillate) and other fuel sources came from the recent regulatory initiatives associated with the Natural Gas Expansion Plan. New proposed legislation that would allow for faster natural gas distribution system expansion has empowered both studies and stakeholder meetings during 2013. A Report that has been commissioned by Massachusetts Department of Energy Resources: “(MA DOER Natural Gas Expansion Plan, 2013)” and a second Stakeholder Meeting which was held on October 25, 2013 with presentations from the report authors, Sussex Economic Advisors with comments from a variety of involved parties such as Massachusetts DOER, NGA, the gas utilities operating within the State and other interested parties. The Report

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which has not yet been finalized cites similar US Census data as used above from the commercial building data bases but focuses on homes. During the October 25th DOER Stakeholder Meeting it was presented that 1.3 million homes in Massachusetts were not heating with natural gas and 1.2 million homes were heating with natural gas. The Northeast Gas Association which is participating in the on-going Massachusetts proceedings provides the summarized information for Massachusetts on a state-wide basis shown in Figure 6.

Figure 6: NGA's 1-Page Massachusetts Summary (2013)

While a complex analytic approach may be possible, simple geographic association of regions where natural gas distribution system exists and where distribution piping does not exist provide the single major factor to the boiler market and existing boiler inventory in the State. The assumption that 50 -70% of commercial boilers in the prescriptive range of 90 – 2,000 MBH range are gas fired and the majority of the rest being liquid fuel (oil), a smaller amount propane with a few other units being other alternate fuel types. The current commodity market that exists for commercial customers today commonly results in natural gas fuel costs for a facility being half that of oil fuel costs for the same facility. This is driving significant fuel switching in the region which means the ratio of gas to oil boilers is changing with respect to time. Motivated by lack of a more accurate statewide gas to oil fuel ratio this study will utilize a 50% natural gas to other fuel type ratio ("half") for the overall boiler inventory in the State which is the current value cited in the MA DOER Natural Gas Expansion Plan, 2013. The "saturation rate" is a term that all Massachusetts gas companies Sales & Marketing groups have been working on collectively and individually for some time there exists a number of individual gas utility studies in recent years that were reviewed and are franchise area specific. Based on the specific PA distribution

17 Ibid
system the residential and commercial/industrial saturation rate will vary with the specific franchise system demographics. The statewide 50% natural gas fuel utilization value is a "best answer" that is used by DOE and EPA for 2013 for energy and air compliance regulatory purposes which was also cited during the Massachusetts Regulatory Stakeholder meeting that was held in 2013. This issue was also discussed during the bi-weekly PA meeting to get consensus thought on this item. The most comprehensive summary of natural gas statistics and trends related to the Northeast United States region’s natural gas industry exists in the Statistical Guide to the Northeast U.S. Natural Gas Industry and is updated annually. (Stephen Leahy, Northeast Gas Association, December 2013). The rate that natural gas as a fuel is displacing other fuel sources in the State can be analyzed by using the number of statewide commercial and industrial accounts compared to the total number of commercial and industrial premises over a period of years. The billing analysis used in this study was limited to a single year. The calculation of growth rate of natural gas on a statewide basis is outside of the scope of this study but is an important factor that plays into the boiler market and is an issue identified in the study’s recommendations and next steps.

18NGA, Statistical Guide to the Northeast U.S. Natural Gas Industry, 2013,
4 ANALYSIS AND RESULTS

4.1 Boiler Manufacturer Outreach Results

4.1.1 Participating Manufacturer demographics:

DNV GL conducted 20 interviews representing 16 boiler manufacturers. Each of the manufacturers interviewed represents a company that is active in the current Massachusetts boiler market. It is believed that these 16 manufacturers represent a substantial market share of the total population of 35 possible manufacturers. The DNV GL team also attempted to contact 17 of the other manufacturers but these manufacturers indicated that they are not active in the Massachusetts market or were reluctant to participate. Approximately, thirteen of the manufacturers who participated in the interviews did provide information regarding the “number of units sold, sales growth and market share”.

Characteristics of the Manufacturers who were interviewed:

- All of boiler manufacturers included in the interviews produce boilers in the 90 MBH to 2MMBH capacity range which characterizes the Prescriptive Program track.
- Two thirds of boiler manufacturers interviewed have a product line that allows them to participate in both residential and commercial markets in Massachusetts.
- Half of the manufacturers interviewed have product lines that include both eligible and non-eligible boilers (condensing and non-condensing models). The interview questions for these manufacturers were targeted to extract the most information about the mix of standard, mid and high efficiency units for each boiler type.
- More than a quarter of the manufacturers produce large steam and hydronic boilers larger than 3MMBH size and were familiar with the Custom Program track but also made products that fell in the Prescriptive Program.

While interviews were conducted with both participating and non-participating manufacturers, proactive participation in this study came from manufacturers that were leveraged through participation in the efficiency program. These manufacturers with strong distribution in the State participated and manufacturers with production in the Northeast region participated. It was common that the manufacturers that refused were not local and do not appear to be large Massachusetts market players.

For some interviews, both the manufacturer representative and the distributor participated. Furthermore, it was common for a distributor in the Northeast to participate at the request of the manufacturer to provide us with the most accurate Massachusetts market information. While each manufacturer’s distribution network is slightly different; it is interesting that a President or Vice President of a boiler company was able to provide a better prospective on regional sales where the distributor’s perspective often presented more accurate details on the Massachusetts market and feedback on efficiency programs.

4.1.2 Manufacturer Sales Data

Boiler manufacturer’s segmentation between small commercial and residential markets is nebulous. Some manufacturers’ product lines distinguish between residential and commercial product types while others do not. Therefore, most manufacturers and distributor’s sales data are not categorized as residential or commercial. An added complication is that a particular model number is used for both residential and small commercial
applications. Since the each manufacturer’s segmentation was based on their own preferences and was related to their own product line, DNV GL asked additional questions to clarify the interpretation of the data.

**Important interview responses are presented as bullets:**

- **3 Manufacturers produced smaller units only...** (Two were <300 MBH, one was <400 MBH).

For the remaining manufacturers that produce a wide-spectrum product line of big and small units it was relayed:

- **Many smaller units are sold (<300 MBH size) than larger units.**

There was considerable diversity between boiler manufacturer product lines; for example, a few large manufacturers offered a wide variety of boiler types and sizes while other smaller manufacturers produced a limited product line featuring one or two models/size ranges.

**Table 11: Product Line - Boiler Sizing Variation**

<table>
<thead>
<tr>
<th>Prescriptive Program Size Tier</th>
<th>Manufacturers that are Selling Models in this Size Range</th>
<th>Range of Percent of Total Company Boiler Sales Resulting From Sales Of This Size Tier</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 300 MBH</td>
<td>12</td>
<td>11%-100%</td>
</tr>
<tr>
<td>301-499 MBH</td>
<td>8</td>
<td>9%-65%</td>
</tr>
<tr>
<td>500-999 MBH</td>
<td>8</td>
<td>8%-35%</td>
</tr>
<tr>
<td>1000-1700 MBH</td>
<td>9</td>
<td>4%-45%</td>
</tr>
<tr>
<td>&gt; 1700 MBH</td>
<td>7</td>
<td>4%-80%</td>
</tr>
</tbody>
</table>

- **10 Manufacturers responded that they sold 200+ units in 2012.**
- **1 Manufacturer responded that they sold 25 – 50 units in 2012.**
- **2 Manufacturers responded that they sold 51 - 100 units in 2012.**

When manufactures were pushed for residential sales units vs. commercial sales units split:

- **80 - 90% units are residential vs. 10 - 20% commercial sales units sold annually.** (Note we did not directly include this question in the interview but found that it became a necessary follow-up with each question that queried a sales number or sales percentage.)

Several manufacturers of the small commercial boiler models base their market share estimations on a 10,000 to 22,000 total units sold in 2012 in Massachusetts which include the residential or residential and C&I sector. One manufacturer volunteered that their company estimates they have a 12% market share of the total 15,566 annual 2012 Massachusetts sales. Note that this was their company’s estimate of Massachusetts annual market and again this market share includes both residential units and small commercial units. Two other manufacturers said that 10,000 sales units annually were their estimates of the commercial market share. Manufacturers when asked to further qualify between residential and commercial markets estimated that the small commercial market represented between 10 to 20% when the commercial boiler market was defined as what the utilities refer to as commercial sector. Market share estimations between the different manufacturers would vary based on their particular product line depending on the fuel type of boilers they produced.
1,500 – 3,000 annual Massachusetts C&I boiler sales units (this includes gas-only boilers, both "program-eligible-condensing" and "non-program-non-eligible" types)

This range is based on two factors. The first factor is their estimate of annual sales quantity and the second, based on which type of boiler manufacturer they were and what each of the boiler manufacturers based their gas boiler market share estimations on. The manufacturers’ sales quantity or market share would fall into one of six possible product lines:

- Both gas/oil-fired, both commercial/residential, both gas-only condensing/non-condensing,
- Both gas/oil-fired, both commercial/residential, gas-only condensing (no non-condensing),
- Both gas/oil-fired, commercial only, gas-only condensing (no non-condensing),
- Gas only, commercial only, both gas-only condensing/non-condensing,
- Gas only, both commercial/residential, condensing (no non-condensing),
- Gas only, commercial only, condensing (no non-condensing),

The most common type of manufacturer in this market sector (both in the marketplace and among companies interviewed) produced gas fuelled only high efficiency condensing boilers. There was however, diversity in the size ranges offered by these "condensing only" types of manufacturers. The largest manufacturers’ sold a wide range of product lines including both program eligible and program non-eligible models. Table 12 illustrates the diversity of sizes and types of boilers for manufacturers who participated in the interview and their respective market sector participation.
There was general consensus among respondents that the gas-only market for boilers accounted for slightly more than half of the total gas and oil boiler market in Massachusetts. This was attributed to the natural gas availability being dictated by distribution system. There was consensus agreement voiced from both manufacturers of gas and oil boilers as well as gas-only boilers that due to a combination of commodity, prices and natural gas infrastructure growth the gas-fuelled market sector was expanding faster than the oil-fired sector. A complexity influencing each manufacturer’s responses was if the residential sector was represented in their responses on their company’s annual sales. The interview questions queried for commercial sales but each company’s ability to “filter” between the utility definition of commercial and residential varied.

The simple addition of gas commercial-only manufacturers was straightforward but realizing that for three of the manufacturers the sales numbers had a mixture of residential and C&I quantities meant therefore that the quantities could not be treated as absolute values but rather representative of a range. The gas/oil manufacturers where queried for gas-only and commercial-only quantities. While it was not an interview question, any manufacturer that mentioned their estimated market share was asked to provide more detail on their estimation of the size of Massachusetts market.

- **675 Program boilers in 2012 represent 23 – 34% of annual gas-only Massachusetts boiler sales.** (this includes gas-only, program-eligible-condensing and non-program-non-eligible types)

In conjunction with the quantity of boiler units and the sizes of boiler units sold in 2012, the manufacturers were also asked about the rated efficiency of boiler units sold. The interview question asked: “What percentage of your 2012 sales were for boilers in the following three ranges of rated efficiency: under 90 AFUE or 88% thermal efficiency, between 90 – 94 AFUE (88 – 92% thermal efficiency), over 94 AFUE (94% thermal efficiency or over)?” The responses from the half of manufactures that produced only condensing boilers were always in
the two higher efficiency tiers. It was not possible to weight the manufacturers by the number of units sold so the responses are not representative of true efficiency distribution. Figure 7 shows the manufacturer interview responses but it is important to note that since there were more manufacturers of high efficiency type boilers in the pool of interviewed manufactures the graph does not represent the true market distribution.

Figure 7: Manufacturers Responses on Efficiency of Units Sold in 2012

- A few large manufacturers that produce and sell the largest number of non-condensing boilers in the State represent the non-condensing type or lower efficiency tier of boiler.
- There are more active market participants producing higher efficiency boilers. In addition to a small number of large manufacturers that produce both condensing and non-condensing boiler models there are a larger number of smaller manufacturers that are producing only the condensing type of boilers.

4.1.3 Massachusetts Market and Base line Boiler Assumptions

Perhaps the most important interview question asked during the manufacturer interviews with respect to providing information relative to the baseline assumption was what percentage of annual sales were condensing boilers and what percentage were non-condensing boilers.

- Half of boiler manufacturers interviewed responded that 100% of sales are condensing boilers in 2012. This is because their product line only includes condensing type only.

This included all three of the manufacturer that reported less than 200 boiler sales annually; these were three of the smaller "condensing only" manufacturers. Of more important significance were four other manufacturers that reported over 200 annual sales of condensing type only.

Since the remaining half of the manufacturers interviewed produce both condensing and non-condensing type of boilers these provided more market insight. These were the largest manufacturers with the largest number of available models all of which reported annual sales over 200 units.
For manufacturers that produced both condensing and non-condensing types, 2012 Massachusetts Sales:

- 2 manufacturers reported: Less than 40% Condensing
- 2 manufacturers reported: 50% Condensing, 50% Non-condensing
- 2 manufacturers reported: 90% Condensing, 10% Non-condensing
- “Best assumption from the manufacturers included in the interviews” of 2012 gas-only boiler Sales: 60-80% Condensing, 20-40% Non-condensing.

This study identified differences that exist between boiler manufacturers. The first manufacturers to offer condensing boilers were European companies. The large established domestic manufacturers began offering condensing models as an option to their cast iron or firetube models. Currently, there is an emerging market evolution of three types of boilers: cast iron, firetube and condensing. Some manufacturers produce all three types. Many new companies in the Northeast are producing the gas-fired condensing only type. The market shares and statewide inventories for standard efficiency, mid-efficiency and high efficiency are three separate values. Additional research in commercial boiler product line mapping will provide better insight into the players are in the Massachusetts boiler market, who manufactures eligible and non-eligible boilers and what the baseline options are available.

A number of interview questions attempted to capture the boiler manufacturers assessment of what lies in the future for the Massachusetts boiler market. Questions in the interview contrasted the future of high-efficiency vs. non-high efficiency model sales.

- Majority of manufacturers responded that Massachusetts is expanding market for high efficiency boilers.
- 33/33/33% split of responses on future of non-condensing boilers (decreasing, flat or no growth, expanding)

One interview question asked about the comparison of Massachusetts market to other surrounding states: “Is the market in Massachusetts for boilers expanding faster, slower, or at the same rate as the Northeast region?”

- 56% of responses said Massachusetts market is expanding faster.

Additional questions about market and baseline assumptions focused on what each manufacturer would share about their internal sales growth rate for the state. The first question asked if they expected that their boiler sales would increase, decrease or stay the same. The second question probed into what percentage of sales growth rate each company used internally for annual forecasting or budgetary planning purposes and the response was most commonly the value in use for 2013 and forward when making projections. Similar to the questions about each manufacturer’s actual sales quantities there was also confidentiality concerns associated with sales growth rate information and there were less answers volunteered. The responses of the boiler manufacturer sales growth rates for Massachusetts are shown in Figure 8. The responses often indicated that the sales growth was known on a Massachusetts-specific basis for some manufacturers but for other manufacturers a single growth estimate across all regions was used.

- All responses indicated that an increase was expected in boiler sales in the future.
When questioned about sales of their boilers being motivated by new construction or replacement of existing boilers in existing buildings the responses were relatively uniform that replacement represents approximately three boilers for every boiler sold associated with new construction.

- **Sales of boilers are driven by:**
  - 76% replacement of existing boilers/buildings
  - 24% new construction of boiler/buildings

Redundancy or whether a boiler is installed alongside other boilers at the same site is more linked to the size and type of application of the boiler. In essence it is more related to the mechanical design configuration of the original building. In general, single boilers are much more common in residential single/multifamily applications. This is true for small commercial applications such as retail, restaurants and small office facilities. Conversely, with large steam or hydronic commercial or industrial applications lead-lag or multiple modular boiler configurations are the norm. The prescriptive program which is characterized by the small C&I boiler market sector truly bisects the big and small boiler spectrum making the question of on average how many boilers exist at a single site a difficult one. The product lines of manufacturers participating in the interviews represented a mix of sizes and types in the prescriptive market sector since some of the manufacturers make big boilers and some of which produce primarily small boilers. The responses to the question: “What percentage of the boilers you sell are placed into redundant or backup situations (meaning... alongside another boiler at the same site)?” produced responses from distributors that were related more to the size and application of the boilers being sold by the particular manufacturer. The manufacturers that had product lines with larger boilers responded with higher values of boiler redundancy. The manufacturers that produced smaller condensing boilers in the less than 400 MBH range responded that their products were rarely placed into redundant configurations which is more typical of a residential or small commercial application. **Figure 9 below shows the spectrum of manufacturer responses that was encountered with regard C&I market sector boiler redundancy.**
The final questions on baseline assumptions queried what each manufacturer thought were on “in-the-field operating efficiencies” taking into consideration the real world conditions encountered in the current Massachusetts market place. The first question probed about nameplate efficiency versus “in-the-field” actual operating efficiencies. The second question asked about what overall efficiency they expected their newly installed high efficiency boilers would operate at given real-world circumstances. And then the same “actual operating efficiency” questions were asked about an “average Massachusetts boiler” that was being replaced by one of the new units sold in 2012 and lastly what efficiency one of their non-eligible non-condensing units would operate at in the field (this last question only applied to half of the manufacturers that had both condensing and non-condensing units in their particular product line).

- Unanimous agreement that boilers operate at less than nametag efficiencies based on “installed conditions”.
- Actual operating efficiency in the field of a 90% boiler: 85 – 90% efficiency.
- Manufacturer’s response to what an average Massachusetts boiler that is being replaced is operating at 71% efficiency. The range varied from 60 – 80%.
- Actual operating efficiency of a newly installed 82-84% (nametag rated) firetube boiler installed in the field is 75 - 80%.
- Actual operating efficiency of a newly installed 80-82% (nametag rated) cast iron boiler is 70 - 75%.

4.1.4 Emerging Boiler Product Offerings

While three quarters of the manufacturers interviewed responded that they have new products that are or will be introduced. It is common in the quickly evolving high-efficiency boiler market for product revisions that make the units lighter and more compact which makes new model releases fairly common. Similarly the trend to integrate more “on-board” controls capabilities that enable small condensing boilers to control lead-lag of modular boilers, optimize burner modulation, outdoor temperature offset control and primary/secondary hydronic pump controls has become common place in the industry. Two types of new product offerings stood out as worthy of consideration from an efficiency program perspective.
New unitized commercial condensing boilers in the 2,000 – 3,000 MBH Range

Four of the interviewed manufacturers have recently or are in the process of introducing new product offerings that feature boiler models sized greater than 3 MMBH and are commercial condensing boilers. When queried about the Custom program each of these particular four manufacturers were aware of the Custom Program and volunteered that in the case where an application and longer incentive application and processing time would be possible it would probably lead to equivalent incentive levels. The manufacturers explained that for the common situation of a failing boiler that is in need of replacement the prescriptive program’s quicker administration is desirable. A suggestion from these manufacturers was why not create a larger prescriptive condensing incentive tier based upon the new commercial condensing product offerings that were entering the market place.

New larger Commercial domestic hot water heating equipment

Manufacturers that produce high efficiency boilers recognize and point out that there is not a corresponding incentive program for their commercial models of condensing hot water heaters. Similarly, these new product offerings for large commercial high efficiency direct-gas-fired condensing water heaters and large boiler and indirect fired hot water heating equipment combinations do not appear to be eligible for incentives in anything other than the custom program track. This may push forward the question of: “prescriptive vs. custom” programs. The topic of prescriptive and custom program tract separation was identified during the evaluation team meetings and may be a topic for further discussion.

4.1.5 Energy Efficiency Program Implementation

Majority of manufacturers on Massachusetts prescriptive boiler program... “If it isn’t broke...”

Virtually all of the manufacturers had positive comments when asked about the Massachusetts prescriptive boiler program citing problems that occur in other programs related to consistency and annual budgeting issues that cause program discontinuities. When probed about possible changes respondents went on to say that since the program was currently being administered in such a positive way they feared that any changes in the program would probably have negative effects.

Additional gains in efficiency will occur “outside the box”

A common theme from a number of manufacturers that produce products with the highest efficiency ratings was that “There are no great improvements that are expected to be made to our highest efficiency condensing units”. Each respondent stated that there is still room for actual efficiency gains which can be attained from “system efficiency” referring to site-specific items outside of their boiler unit or ”outside of the box”.

Additional boiler installer training or condensing boiler installer certification

When interview questions asked what else can be done to improve current efficiency programs several manufacturers of the high efficiency boilers each commented how different the installation of a high efficiency boiler versus standard boiler equipment is. The comment: “the most efficient boiler still needs to be installed correctly to reach its intended energy savings” was voiced by a number of different manufacturers. Manufacturers maintained that the most effective way of training installers would be a combination of each manufacturer focusing on their own product line specifics in combination with efficiency program training that would not be model or manufacturer specific.
Bonus incentives for engineered system approaches or replacement of equipment older than 30 years.

When asked about possible innovative program administration ideas a boiler manufacturer offered that it would be innovative to offer “bonus” incentives (example: an additional incentive) when an engineered approach is applied on the system side of a boiler installation. Or alternatively, it was proposed that more dollars can be appropriated when an installation involves replacement of equipment that is more than 30 years old since the actual energy savings would likely be maximized in this situation.
<table>
<thead>
<tr>
<th><strong>PA3. Suggestions to efficiency program administrators to improve the boiler market</strong></th>
<th><strong>Base the efficiency program off of more realistic testing procedures, look at different classes of rebates for water heating. Nobody offers adequate rebates.</strong></th>
<th><strong>PA8. Can you identify special applications or field situations that need attention from boiler efficiency programs?</strong></th>
<th><strong>maybe water source heat pump applications, and geothermal applications. They are the best in terms of condensing or design, but no separate attention is given to them as they are not as popular.</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One thing they need to do is to force the people to install HE boilers and to demonstrate that they are operating in the manner to get the HE fuel savings from the installations.</td>
<td>Focus has to be on the whole system efficiency. If you put in a new boiler but the building envelope isn’t good, ducts and piping have leaks, won’t see the savings and performance you should expect.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>increase the dollar value of incentives</td>
<td>perhaps boilers installed with an indirect fired tank, boilers in combination with solar panels, or heat pumps.</td>
<td>for hot water staying high. The gas networks have a lot of incentives but not a hot water supply boiler on there.</td>
</tr>
<tr>
<td></td>
<td>Focus on how the water is pumped, and what is the operating temp of water</td>
<td></td>
<td>level the playing field, better understand the testing procedures, and understand what you compromise when you just push efficiency</td>
</tr>
<tr>
<td></td>
<td>Increase the amount of public education, because most consumers aren’t aware of rebate options</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Used to be an added bonus when you replaced a 30+ year old system, one of the points he makes in training, base board heating here in MA. Based on 180 degree water going through those tubes. For new construction by dropping the water temp down to 160 degrees. An incentive for a fan coiler unit that ran at a lower temperature. Next steps towards efficiency are ancillary, return units, systemic gains not really combustion gains</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(1) Program bias mentioned above is a big problem, it should not happen. (2) minimize paperwork necessary for incentive/installation. (3) combination installation of boiler/indirect water heater.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>certify installers, more education program for installers, condensing boiler checklist should be made a part of the incentive. Or a “bonus” incentive would be given if all of the things in the checklist could be done such as outdoor temp setback, return less than 140 degrees, Qualify AFUE rating (not applicable to non-residential boilers)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>In terms of improving the market, organic growth of the market there is not any one facilitating force, from a replacement standpoint looking to get existing owners to proactively upgrade their equipment, more promotion and advertising. A key to that is real world marketing material that explains to building owners what they can expect to see in terms of savings, dollars.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>level the playing field, better understand the testing procedures, and understand what you compromise when you just push efficiency</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.1.6 Possible Manufacturer-Distributor-Installer Roundtable

The boiler manufacturing outreach found that many of the boiler manufacturers involved in the interview process were very supportive of helping the efficiency program. In fact, the few most active participants who are the most knowledgeable of both market and technical issues were strongly opinionated that it was mutually advantageous if all entities in the gas boiler industry worked cooperatively.

During the interview process a list of recommended referrals of distributors and installers were compiled that combined with the most informative manufacturers would empower an informative roundtable discussion of the current Massachusetts market to explore in more detail:

- Baseline assumptions
- The effects of new proposed efficiency standards
- Limitations of condensing and non-condensing boiler equipment in certain applications.

This concept can be further explored if desirable. The interviews served the secondary purpose of identifying the most technically knowledgeable and market savvy individuals who are also supportive of the efficiency program and would be willing to participate in a roundtable.

4.2 Massachusetts Customer Billing Data Analysis

This section presents the results of the Massachusetts customer billing analysis. Results include a summary by program administrator, boiler size and facility type as well as a sensitivity analysis to assess the inherent level of uncertainty.

4.2.1 Boiler Market Characterization by PA/Size/Facility Type

This section presents the results of the boiler market characterization through Massachusetts C&I Billing information. The resulting number of boilers replaced per year is summarized by Program Administrator (Table 13), Boiler Size (Table 14) and Facility Type (Table 15).

<table>
<thead>
<tr>
<th>Table 13: Number Boilers Replaced by Program Administrator</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PA</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>NGRID Gas</td>
</tr>
<tr>
<td>BayState Gas</td>
</tr>
<tr>
<td>NSTAR Gas</td>
</tr>
<tr>
<td>Berkshire Gas</td>
</tr>
<tr>
<td>Liberty Gas</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>
Table 14: Number of Boilers Replaced by Boiler Size

<table>
<thead>
<tr>
<th>Boiler sizes (MBH)</th>
<th>Boiler replaced (standard)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 - 300</td>
<td>1,209</td>
<td>48%</td>
</tr>
<tr>
<td>301-500</td>
<td>426</td>
<td>17%</td>
</tr>
<tr>
<td>501-1,000</td>
<td>358</td>
<td>14%</td>
</tr>
<tr>
<td>1,000-1,700</td>
<td>220</td>
<td>9%</td>
</tr>
<tr>
<td>1,700+</td>
<td>329</td>
<td>13%</td>
</tr>
<tr>
<td>Grand Total</td>
<td>2,543</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 15: Number Boilers Replaced by Facility Type

<table>
<thead>
<tr>
<th>Facility type</th>
<th>Boiler replaced (standard)</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Office</td>
<td>2,014</td>
<td>79%</td>
</tr>
<tr>
<td>Apt</td>
<td>199</td>
<td>8%</td>
</tr>
<tr>
<td>Restaurant</td>
<td>104</td>
<td>4%</td>
</tr>
<tr>
<td>College</td>
<td>71</td>
<td>3%</td>
</tr>
<tr>
<td>Retail</td>
<td>69</td>
<td>3%</td>
</tr>
<tr>
<td>Grocery</td>
<td>20</td>
<td>1%</td>
</tr>
<tr>
<td>Lodging</td>
<td>19</td>
<td>1%</td>
</tr>
<tr>
<td>Health</td>
<td>19</td>
<td>1%</td>
</tr>
<tr>
<td>N-Home</td>
<td>12</td>
<td>0%</td>
</tr>
<tr>
<td>2Shift</td>
<td>10</td>
<td>0%</td>
</tr>
<tr>
<td>Constant</td>
<td>7</td>
<td>0%</td>
</tr>
<tr>
<td>Total</td>
<td>2,543</td>
<td>100%</td>
</tr>
</tbody>
</table>

The last table in this series associated with the billing analysis; Table 16, presents the expected number of replacement boilers that are sold each year by Massachusetts program administrator service territory with further categorization by the size of the boiler. Since the data used for this analysis stems from the 2010 commercial and industrial billing data from the Massachusetts program administrators the results are based on the number of C&I accounts and are representative of replacement boilers. The growth rate of the number of C&I accounts of each program administrator would provide additional insight to the number of boilers added each year from C&I sector new construction. The billing data analysis used one year of billing data and therefore represents of replacement boilers rather than boilers added by new construction.
4.2.2 Sensitivity Analysis of Customer Billing Analysis

Each step of the billing analysis methodology described in Section 3.2.1 presented earlier has inherent uncertainty within the proposed assumptions. The sensitivity analysis below identifies the magnitude of that uncertainty by applying supposedly unrealistic low and high assumptions. A summary of these assumptions is shown in Table 17 and the resulting number of boilers replaced per year is shown in Figure 10.

Table 16: Number of Boiler Replaced by Size and Program Administrator

<table>
<thead>
<tr>
<th>Massachusetts Program Administrator</th>
<th>90–300</th>
<th>301–500</th>
<th>501–1000</th>
<th>1001–1700</th>
<th>1700+</th>
<th>Program Administrator Boiler Replacement Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbia Gas</td>
<td>300</td>
<td>102</td>
<td>82</td>
<td>48</td>
<td>78</td>
<td>610</td>
</tr>
<tr>
<td>Berkshire Gas</td>
<td>48</td>
<td>15</td>
<td>13</td>
<td>7</td>
<td>11</td>
<td>94</td>
</tr>
<tr>
<td>National Grid Gas</td>
<td>625</td>
<td>226</td>
<td>189</td>
<td>122</td>
<td>172</td>
<td>1,333</td>
</tr>
<tr>
<td>NSTAR Gas</td>
<td>228</td>
<td>82</td>
<td>71</td>
<td>41</td>
<td>67</td>
<td>489</td>
</tr>
<tr>
<td>Liberty Gas</td>
<td>9</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>18</td>
</tr>
<tr>
<td>Boiler size totals</td>
<td>1,209</td>
<td>427</td>
<td>358</td>
<td>220</td>
<td>329</td>
<td></td>
</tr>
</tbody>
</table>

Table 17: Billing Analysis Sensitivity Parameters

<table>
<thead>
<tr>
<th>Group</th>
<th>Life</th>
<th>Non-boiler reduction</th>
<th>Multiple boilers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>25</td>
<td>30%</td>
<td>28%</td>
</tr>
<tr>
<td>Low</td>
<td>30</td>
<td>40%</td>
<td>20%</td>
</tr>
<tr>
<td>High</td>
<td>20</td>
<td>20%</td>
<td>35%</td>
</tr>
</tbody>
</table>

Figure 10: Billing Analysis Sensitivity Results
4.3 Market Sizing & Characterization, Integration of Results

The results from the study’s three research areas:

- boiler manufacturer outreach,
- existing building database analysis,
- gas billing analysis

Table 18 summarizes results and assumptions from the boiler manufacturer outreach and the existing building database analysis and identifies the source of information.
**Table 18: Summary of Commercial Boiler Market Characterization**

<table>
<thead>
<tr>
<th>Market Sector - Characterization</th>
<th>Massachusetts Boiler Market Characterization</th>
<th>Source - Assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Utility Rate</td>
<td>Small C&amp;I</td>
<td></td>
</tr>
<tr>
<td>Typical Boiler Capacity</td>
<td>90 - 2,000 MBH</td>
<td>2012 Precriptive Program Data</td>
</tr>
<tr>
<td>Energy Efficiency Program</td>
<td>Small C&amp;I</td>
<td></td>
</tr>
<tr>
<td>Applicability</td>
<td>Prescriptive</td>
<td></td>
</tr>
<tr>
<td>Typical Installation Configuration</td>
<td>Wide variation of small single units to redundant and multiple modular units at a site</td>
<td>Manufacturer Interviews</td>
</tr>
<tr>
<td>2012 Total gas-only C&amp;I annual boiler sales (assumes: 50% of oil/gas) (condensing &amp; non-condensing)</td>
<td>1,500 - 3,000</td>
<td>Manufacturer Interviews</td>
</tr>
<tr>
<td>2012 Prescriptive Boilers (675) percent of 2012 total annual gas sales (includes gas only, eligible and non-eligible)</td>
<td>23 – 34% of annual Massachusetts boiler sales</td>
<td>Combination of 2012 Program Data &amp; Manufacturer Interviews</td>
</tr>
<tr>
<td>Estimated Massachusetts Statewide Boiler Inventory (2014)</td>
<td>94,563 boiler sites 121,040 boiler units</td>
<td>Existing Building Database (US Census &amp; Project 18)</td>
</tr>
<tr>
<td>&quot;Redundancy Factor&quot; (when boilers are placed into side-by-side configurations, ie: lead/lag and modular configurations)</td>
<td>28%</td>
<td>Manufacturer Interviews</td>
</tr>
<tr>
<td>Number of Gas Accounts providing service to Boilers</td>
<td>58,534</td>
<td>Gas Billing Analysis</td>
</tr>
<tr>
<td>Boilers Replaced (per year)</td>
<td>2,543 Annual Replacement Units</td>
<td>Gas Billing Analysis</td>
</tr>
<tr>
<td>Boiler Replacement Distribution by PA: by Size, Facility Type</td>
<td>Tables: 11-13</td>
<td>Gas Billing Analysis</td>
</tr>
<tr>
<td>Fuel Distribution</td>
<td>50% natural gas</td>
<td>MA DOER &quot;Expansion&quot; Docket, October Stakeholder Meetings, NGA, Sussex Economic Adviser’s Report</td>
</tr>
<tr>
<td>Condensing vs. non-condensing of current annual boiler sales (of gas fired units)</td>
<td>60-80% Condensing, 20-40% Non-condensing</td>
<td>Manufacturer Interviews</td>
</tr>
<tr>
<td>Estimation of condensing vs. non-condensing units in existing statewide boiler inventory</td>
<td>101,040 non-condensing 20,000 condensing</td>
<td>Manufacturer Interview plus existing building database (Manufacturers estimation of 20k units sold)</td>
</tr>
<tr>
<td>New Construction vs. Replacement</td>
<td>76% of annual sales are replacement of existing boilers/buildings 24% of annual sales are new construction of boiler/ buildings</td>
<td>Manufacturer Interviews</td>
</tr>
<tr>
<td>Average age of boiler in MA inventory</td>
<td>20 - 35 years</td>
<td>Manufacturer Interview plus existing building database</td>
</tr>
</tbody>
</table>
The confidentiality associated with each manufacturer’s sales quantities and the blurred distinction between the residential and commercial classification for some of the manufacturers responses resulted in annual sales quantities that are best represented as a range. Table 19 shows the 2012 boiler sales quantities starting with total boilers to program eligible for 2012. A list of the key assumptions used to develop the values in Table 19 columns from left to right are as follows:

- Total estimated all fuel types of C&I sized boilers (90 to 2,000 MBH size range) sold in the state (twice the gas-only estimation from the manufacturer interviews) this includes oil and gas commercial boiler sales.
- The assumption that half of the boiler sales are for gas boilers and the other half for oil and other fuel boilers is used to arrive at high and low values for gas-only commercial boiler sales.
- The manufacturers interview response value of condensing boilers sales vs. total gas-only boiler sales was used (80% for “high range” and 60% “low range” to arrive at the estimation of high and low values of condensing boilers sold.
- Then, using the known value of 675 program boilers that comes directly from the 2012 program data the calculation of high and low values of prescriptive boiler participation rate can occur.

In this context, prescriptive boiler participation rate is the number of program boilers in relation to the total number of program-eligible-condensing-boilers sold in 2012 in Massachusetts. More simply stated it represents the boiler that went through the program to the total number of condensing boilers sold in the state. Figure 11 illustrates the relationship of the known 675 program boilers to the high and low range estimations of non-program “eligible” condensing boilers sold in 2012. In this figure, red represents boilers in the prescriptive program and blue are the high and low values of boilers that were condensing (program eligible) and sold and were installed outside of the program.

**Table 19: Estimated Prescriptive Boiler Program Participation Level Ranges**

<table>
<thead>
<tr>
<th>Sales Range from Manufacturer Interviews</th>
<th>2012 Total oil and gas CI annual boilers sales</th>
<th>2012 Total gas-only CI annual boiler sales (assumes: 50% of oil/gas (condensing &amp; non-condensing))</th>
<th>2012 Total gas-only condensing annual boiler sales Assumes: 80% (high range) and 60% (low range) of gas-only boiler sales</th>
<th>2012 Total condensing non-program boilers</th>
<th>2012 Prescriptive Program Participation of Condensing Boiler Sales (675 prescriptive program boilers)</th>
<th>2012 Prescriptive Program Participation of Condensing Boiler Sales (675 prescriptive program boilers)/(2012 Total gas-only boiler sales)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Range</td>
<td>6,000</td>
<td>3,000</td>
<td>2400</td>
<td>1725</td>
<td>675</td>
<td>28%</td>
</tr>
<tr>
<td>Low Range</td>
<td>3,000</td>
<td>1,500</td>
<td>900</td>
<td>225</td>
<td>675</td>
<td>75%</td>
</tr>
</tbody>
</table>
Figure 11: Estimated Prescriptive Boiler Program Participation Level Ranges

Prescriptive Program Participation - High & Low Sales Levels From Interviews

- High Boiler Sales Range of 2400 Condensing gas only (1725 non-program + 675 program) 28% Program Participation
- Low Boiler Sales Range of 1500 Condensing gas only (225 non-program + 675 program) 75% Program Participation

- 2012 Prescriptive Program Condensing Boilers (675 prescriptive program boilers)
- 2012 Total condensing non-program boilers
5 RECOMMENDATIONS AND NEXT STEPS

**Summary:** Discussion of the findings resulted in consensus thought that program administrators would benefit from five next steps to provide more focus on boiler market characterization in the State:

- Seek input and any voluntary feedback on this final report from manufacturers who participated in the interview and expressed an interest in follow-up. This “sets the table” for prospective panel members of a proposed “Massachusetts Boiler Roundtable”. While confidentiality associated with the manufacturers interviews would be strictly preserved; going forward in an additional phase of investigation if a manufacturer or individual wanted to voluntarily provide feedback on the findings of this report it could be done on a voluntary and non-confidential basis. The objective would be targeted at “tightening the band” of Massachusetts prescriptive program participation in this study.

- Conduct more comparative research of gas program data targeting condensing boilers in the Northeast region. Starting with Massachusetts, 2013 first and then including the last four years of prescriptive program analysis. The assumption based on preliminary discussions with Northeast program administrators is that Connecticut, Rhode Island and New Hampshire would be interested in informal mutual information sharing on boiler programs or perhaps brief interviews or a working meeting on boiler programs. The objective would be the identification of comparative boiler program data to enable market lift analysis.

- Initiate “boiler product line mapping” that would create a simple matrix where every manufacturer of a 90–2,000 MBH boiler would be identified. All models; size, type, fuel, efficiency, etc. would be detailed with specific categorization of: standard (cast iron), mid-efficiency (firetube), high efficiency (condensing) types of boilers. This would be done using information available in the public domain and would not be confidential (all boiler manufacturer names would be included). The objective would be the clearer identification of market participants (boiler manufacturers), their types of product offerings with the purpose to better understand how long standard efficiency products will remain in the market and how fast high efficiency market transformation might occur.

- Provide an overview of DOE’s current NOPR for Commercial Boiler Standard’s (U.S. Department of Energy Notice of Proposed Rulemaking) which will determine if pre-packaged commercial boilers will have new federally mandated efficiency requirements. The overview will be focused on answering if the proposed standards will be adopted, when and what are implications. Preliminary conversations suggest that exploring possible teaming with ASAP (Appliance Standards Awareness Project) for this task may be mutually advantageous.

- Conduct a “Massachusetts Boiler Roundtable” (a small-group forum discussion) with a select Massachusetts market-savvy boiler panel that can efficiently provide information on the complex boiler market that is evolving. Panellists would share their thoughts on a short list of pre-established key questions that efficiency program administrators are concerned with. Since the responses from interviews already conducted have illustrated the wide variance of perspectives between the different types of manufacturers the objective will be to flush out predictions from both condensing high-efficiency and non-condensing standard efficiency perspectives.

More details and supporting information along with additional observations are provided on the five proposed recommendations:
**Engagement of Boiler Manufacturers:** It was found through the participation of certain manufacturers in the outreach effort that they are more invested in market transformation towards higher efficiency boilers than other manufacturers. “Smaller” manufacturers often produced the highest efficiency units and typically only produced gas-fired condensing units. It was common for this to be done at a central manufacturing location. The majority of the smaller high-efficiency boiler company’s interviewed were located in the Eastern United States and Canada. “Larger” manufacturers produced more diverse product lines featuring different types of boilers that were often a mix of high, mid and standard efficiency models. It was typical in this situation that the different model types were produced at different locations often the result of boiler company mergers and buy-outs in the industry. It is reasonable to conclude then that boiler manufacturers that specialize in the highest efficiency gas-fired condensing units are “leveraged” towards efficiency program funding as well as natural gas distribution system expansion since their business profitability hinges on competing for market share against less efficient product choices. PAs may consider leveraging and expand their existing relationships with boiler manufacturers in the establishment of an ‘expert panel’ that could be used to gain deeper understanding of the market and provide guidance and feedback on future program offerings.

**Detailed Boiler Manufacturer Product Line Mapping:** The boiler interviews revealed that there are two facets of the boiler business that exemplify its highly competitive nature. The strategy associated with distributors and product lines. The manufacturer’s distribution system links its boiler sales to a distribution network of local representatives and regional/local stocking distributors have varying levels of exclusivity which would allow or prohibit a distributor to carrying competitive product lines. In short the manufacturers are competing with each other to have the best regional distributors and conversely the distributors strive for the product lines that will generate the greatest revenues. The manufacturers are acutely aware of the models and sizes that their product line competes with. The expense of adding new product offerings is gauged upon the potential market growth and competition between models/sizes.

Interpreting the sales numbers of each manufacturer required filtering the type of boiler, the fuel types, the models offered and the sizes and what market sectors the manufacturer participated. A more accurate annual boiler sales value would require a more precise boiler manufacturer “product line mapping”. This “product line mapping” would be of value to understanding the full spectrum of gas and oil fired standard, mid and high-efficiency model types available. The competition between boiler manufacturers exists for what is believed by each to be the “expanding” product choices in the market place. This product line mapping would also provide information on the available options other than the current program eligible condensing boilers. A key to understanding the current boiler baseline is knowing the mix of non-eligible model types (standard efficiency cast iron and mid-efficiency fire tube boilers) and specifically for how long cast iron boilers will continue to be available.

**Natural Gas Distribution Availability Plays an Important Role in Boiler Selection:** Fundamental complexities exist in the boiler market. First is the profitability of continuing to make standard efficiency cast iron construction boilers, but since this is still the predominant oil fired boiler configuration it is closely related to the expansion of natural gas infrastructure in the Northeast Region where large areas without natural gas distributions system access exist. Currently, boiler manufacturers can be divided into gas-only and gas/oil fired with the design and manufacturing considerations between standard and high efficiency condensing units creating an evolving separation. Second, is the evolution of newer boilers being smaller, lighter and more on board-control-enabled which enables more modular design configurations where smaller duplicative boilers are installed for a given application at the same site. Most manufacturers’ responses indicate that they play the
role of gauging the speed that the HVAC design community is willing to incorporate changes in modular boiler design rather than influence the change.

**Manufacturers Supportive of Massachusetts Prescriptive Boiler Program:** The interview responses from manufacturers when queried about the Massachusetts prescriptive boiler program were almost unanimously positive. “Don’t try to fix it if it is not broken” was a common theme echoed by the respondents. The ease and simplicity of a prescriptive program was identified as a positive by the majority of manufacturers who were knowledgeable about custom tracts or who had experience with other programs. Another common negative that was cited for other programs outside of Massachusetts was the lack of consistency when programs would be paused or not available for periods of time due to funding or annual regulatory approval processes.

**A Larger Size Tier Can Be Incorporated into the Prescriptive Program to Accommodate New Larger Condensing Product Offerings:** New models of larger condensing boilers are entering the market place being produced by several manufacturers which could be offered in the prescriptive program if new deemed savings values are identified. The advantage of prescriptive program expansion would be ease of administration versus the more effort intensive custom program. In general, manufacturer's responses relayed that the ease of administration of the prescriptive program typically favoured higher participation rates and boiler sales rather than the custom program.

When asked about additional savings that could be realized Manufacturers identified that they believed more savings existed with commercial hot water equipment where market place choices for condensing equipment was less common. This was a common answer from manufacturers that produced by boiler and commercial hot water heating equipment which is worthy of more investigation. Product line mapping in this case is appropriate since hydronic boilers and commercial hot water heater converge as the applications and the sizes of equipment get larger.

**Additional Savings from Engineered Applications and Installer Training:** Manufacturers of the highest efficiency units also volunteered that additional savings can typically come from the system-side of an installation rather than the boiler unit itself. This partially highlights that fact that a unit that is not installed or maintained properly will not achieve the potential savings. Manufacturer responses all reiterate that they are aware of installations of their units that fell short of the energy savings potential because of lack of knowledge of the installers. A condensing unit that does not operate in condensing mode will mimic the efficiency levels of a mid-efficiency model.

**Comments and Future Engagement of Manufacturers/Distributors/Installers:** The interviews that were conducted served the secondary purpose of identifying the most technically knowledgeable and market savvy individuals who are also supportive of the efficiency program. The best information from the interviews came from the most knowledgeable individuals who had strong opinions on the value of the efficiency program. Almost all of these individuals were interested in reviewing this study if it were made available. It seems likely that these most knowledgeable individuals would be willing to participate in a roundtable. A small group of manufacturers, distributors and installers most knowledgeable of both market and technical issues would have the potential for providing valuable information to program administrators on the complex topics of small commercial boiler:
- Baseline assumptions, evolving mix of non-eligible standard and mid-efficiency boilers,
- The possible effects of new proposed efficiency standards for commercial boilers,
- Limitations of condensing and non-condensing boiler equipment in certain applications.
APPENDIX A: RFI LETTER

[Contact Name]
[Boiler Manufacturer Company Name]
[Boiler Company Address]
[Boiler Company City, State]

Dear [Contact Name]:

For over 30 years, Energy efficiency has played a critical role in the commercial and industrial sectors in Massachusetts, and the electric and gas Energy Efficiency Program Administrators (EEPAs) which are the utilities in the State have provided incentives to customers who installed high efficiency equipment in their buildings. In particular, each year the Massachusetts gas EEPAs provide approximately $20 million in incentives to commercial and industrial customers to invest in new energy efficiency natural gas boilers. The Massachusetts EEPAs are currently undertaking a study that will better guide the current incentives for gas boilers. The EEPAs are specifically seeking ways to improve the program offerings, incentives and the implementation of the program. The study will also provide a better understanding of the type and efficiency of all boilers in the current marketplace.

We are seeking your help in this Massachusetts Boiler Study. Your company’s experience and knowledge of the Massachusetts boiler market will help provide the EEPAs with a better understanding of energy efficiency opportunities and the needs of customers. Our consultant, DNV GL Energy, will be contacting your company to solicit your participation in this study. The EEPAs are asking for your assistance in sharing information and knowledge of the boiler market. The EEPAs are respectful of the fact that some information is proprietary and confidential in light of the competitive marketplace that exists and will treat all information that you are willing to share as confidential and commit to “sanitize” and make anonymous any information that is shared. By implementing this protocol, neither your name nor your products will be linked or associated with any information that you choose to share.

Please share your thoughts and willingness to participate with our consultant Mike Smalec, DNV GL - Energy, 200 Court Street, Middletown, CT 06457, (860) 510-8433, Michael.Smalec@dnvkema.com. It is our hope that you will be able to contribute to this effort, since your input is valuable for informing the incentive program. If you are inclined, please feel free to contact Mike Smalec directly by phone or email to participate in the study, or contact me if you have questions that you would like to ask before contacting DNV GL - Energy. Again, we will respect the confidentiality of any information you choose to share and understand the sensitivity and importance of your organization’s input.

Respectfully yours

Mark Sevier, PE
Senior Analyst, Policy & Evaluation
Program Strategy, Massachusetts
Nationalgrid  40 Sylvan Rd | Waltham, MA | 02451 | USA
mark.sevier@nationalgrid.com | (781) 907-3098
(Month, Date, Year)

Dear [Contact Name]:

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Mark Sevier, PE
Senior Analyst, Policy & Evaluation
Program Strategy, Massachusetts
Nationalgrid 40 Sylvan Rd | Waltham, MA | 02451 | USA
mark.sevier@nationalgrid.com | (781) 907-3098
APPENDIX B: SURVEY INSTRUMENTS

Massachusetts Gas Boiler Market Characterization Study
Boiler Manufacturer Interview Guide
October 11, 2013

Purpose/Background of Interview

The purpose of this interview guide is to enable the study team to address the following research topics:

1. Characterize the current boiler market in Massachusetts:
   a. Quantify the size of the total boiler market and the penetration of high efficiency boilers in Massachusetts
   b. Identify the distribution of boiler sales by efficiency, size and type (e.g., condensing, hydronic, steam) for new units
   c. Identify the distribution of boiler sales by efficiency, size and type for replaced units

2. Compare the data collected in #1 to the PA’s tracking data bases to determine market share affected by the PA’s EE programs
   a. Determine if market share varies by size, efficiency or type
   b. Determine if market share varies by customer type
   c. Assess the level of market transformation attributable to the PA’s programs
   d. Identify remaining savings potential

3. Identify differences in market share between Massachusetts and other states in the northeast.
   a. Determine if market share varies by size, efficiency or type
   b. Determine if market share varies by customer type

Topics for this survey include:

1. General Company Information
2. Sales Data
3. Massachusetts Market Information
4. New Product Offerings
5. Baseline Assumptions
6. Energy Efficiency Program Implementation
7. Distributor Manufacturer Representative Referrals
# Interview Tracking Sheet

## Interview Tracking Information

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## Contact Information

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<table>
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## Call Tracking

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## Respondent Follow-Up Tracking

[Determined after interview: This information is useful for potential follow-up with respondents]

<table>
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<tr>
<th>Respondent Characteristic</th>
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<tbody>
<tr>
<td>Respondent has strong market knowledge</td>
<td></td>
</tr>
<tr>
<td>Respondent is knowledgeable about boiler equipment applications/how boilers used</td>
<td></td>
</tr>
<tr>
<td>Respondent has strong opinions regarding condensing vs. non-condensing boilers</td>
<td></td>
</tr>
<tr>
<td>Respondent has strong opinions about efficiency programs in general (e.g., administration, measure offerings, incentive levels, etc.)</td>
<td></td>
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</tbody>
</table>
Interview Guide

Introduction
May I please speak to <contact>? (If we can gain this info)

Hi, my name is __ and I am calling from DNV KEMA on behalf of the program administrators of the Massachusetts’s Joint Electric and Gas Energy Efficiency Plan.

The Massachusetts electric and gas utilities have commissioned a study to better understand the natural gas boiler market in Massachusetts with the goal of implementing better energy efficiency programs. In order to improve the program, there is a need to gain more insight to the current dynamics of the boiler market.

Your help in this Massachusetts’s Boiler Market Study is requested. We are requesting your assistance in sharing your market knowledge and information. We are respectful of the fact that your sales information is proprietary and will treat all information that you share as confidential and we’ll keep your identity anonymous.

In addition to any general information or sales data you might be able to provide, we would also appreciate your thoughts on the high efficiency boiler incentive program currently offered by the utilities.

I have questions to make sure I address, but am hoping this can be more of a conversation.

First, did you receive our “Request for Information” letter via email that explains about the Massachusetts Program and the Study?

[If “Request for Information” letter has not been sent: This is something that can be emailed quickly and provide additional background information that is desirable to the interview process.]

According to our records, your boiler equipment has been purchased and installed by C&I customers in Massachusetts who participated in energy efficiency programs. We understand your product line includes boilers eligible for these programs meaning that your business manufactures and/or distributes boilers that are rated at least 90% efficient Annual Fuel Utilization Efficiency or AFUE.
Interviewer FAQs Information Sheet

[IF ASKED ABOUT LENGTH OF SURVEY: These interviews have been lasting about 20 minutes. If now is a bad time, maybe we could schedule a call back?]

[IF ASKED ABOUT AUTHENTICITY OF STUDY: If possible, obtain contact name from utility. The “RFI Letter” (Request for Information Letter) is available for this purpose and will be forwarded electronically to all manufacturer interview participants.]

[IF ASKED ABOUT CONFIDENTIALITY SALES DATA: The PAs are respectful of the fact that some information is proprietary and confidential in light of the competitive marketplace that exists and will treat all information that you share as confidential and commit to “sanitize” and make anonymous any information that is shared. By implementing this protocol, neither your name nor your products will be linked or associated with any information that is shared. Again, we will respect the confidentiality of any information you choose to share and understand the sensitivity and importance of your business.]

[IF ASKED ABOUT GETTING A COPY OF THE REPORT: The PAs and EEAC have already agreed that the final report will be shared with any manufacturer who participates and shares information in the manufacturer interview process. This is done with the intent to encourage manufacturers to contribute to the overall goal of the study which is to better understand the Massachusetts boiler market. The finalization of the report includes a thorough review by the PAs and EEAC. It is expected that the report will be available to any manufacturers who participated after the report is finalized.]

[IF ASKED “WHAT IS THIS INFORMATION USED FOR?”: In general, high-efficiency boilers replacements represent the largest natural gas energy efficiency savings component when compared to other individual efficiency measures. The purpose of the study is to get a better understanding of the Massachusetts boiler market so that the State’s natural gas energy efficiency program can continue to maximize the achieved program savings. Information related to baseline assumptions which incorporate the details of boilers currently being replaced, growth of the market and changes in the market such as possible new product offerings are vital to continued good program administration.]
**General Company Information:**
I’d like to ask for some general information about your company’s operations.

GCI1. First, what is your job title?

1. ................................................................. Sales Manager

2. ................................................................. General Manager

3. ................................................................. President/CEO

4. ................................................................. Other [SPECIFY: __________________]  

   -97. [Don’t know]  
   -98. [Refused] 

GCI2. Which of the following commercial and industrial heating products does your business sell or install from this location?

[READ LIST OF UNBRACKETED OPTIONS; ACCEPT MULTIPLE RESPONSES]

1. ................................................................ Gas Furnaces

2. ................................................................ Gas Water Boilers

3. ................................................................ Gas Steam Boilers

4. ................................................................ Indirect Water Heating Systems

5. ................................................................ Boiler Resets

6. ................................................................ Programmable Thermostats

   -97. [Don’t know]  
   -98. [Refused] 

GCI3. Besides “eligible boilers,” does your business make “non-eligible” boilers?

1. ................................................................ Yes

2. ................................................................ No
GCI4. Which of the following best describes your business?
[READ LIST. CHECK ONLY ONE RESPONSE OPTION.]
[NOTE TO INTERVIEWER: We are interested in information directly from the manufacturer but will ask for referrals to distributors/manufacturer’s representatives later in the questions]

1. .................................................................................................................. Manufacturer
   __________

2. .................................................................................................................. Distributor
   __________

3. .................................................................................................................. Both manufacturer and distributor
   __________

4. .................................................................................................................. Other
   [SPECIFY: __________]  __________

Sales Data:
[NOTE TO INTERVIEWER: We are interested in any data available. Confirm with respondent 1) if data refers from MA, Northeast, nationwide or industry wide and 2) if information is from 2012 (or other time period) with respondent. If possible/appropriate, let respondent know we would be interested in multi-year data which can provide trending information.]

SD1. What is the total number of boilers your business sold in the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) commercial and industrial market in 2012?
[READ LIST. CHECK ONLY ONE RESPONSE OPTION.]

1. .................................................................................................................. 1 to 5
   __________

2. .................................................................................................................. 6 to 10
   __________

3. .................................................................................................................. 11 to 25
   __________

4. .................................................................................................................. 25 to 50
   __________

5. .................................................................................................................. 51 to 100
   __________

6. .................................................................................................................. 101 to 150
   __________

7. .................................................................................................................. 151 to 200
   __________

8. .................................................................................................................. Over 200
   __________

-97. [Don’t know] __________
-98. [Refused] __________
SD1A. [If SD1 = -97 or -98] According to our records, in 2012, approximately 650 incentives were given by the Massachusetts utilities to end-users for high efficiency boiler installations. Would you be able to offer any comparisons to your sales numbers in Massachusetts [or other states/regions]?

1. Yes __________

2. No __________

SD51B. [If SD5A=Yes] What comparisons can you make to your sales numbers in Massachusetts [or other states/regions] in regards to the 650 incentives that were given by the Massachusetts utilities to end-users for high efficiency boiler installations? [Probe: What percentage of the 650 incentives that were given are your boilers?]

SD51C. [If SD5A=Yes] Knowing that these incentives were given high efficiency boilers, can you share whether you sold more or less non-high efficiency units in Massachusetts?

[SKIP SD2 through SD4 if SD1=-97 or -98]

SD2. [If GCI=Yes] About what percentage of gas boilers that you sold in the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) commercial and industrial market in 2012 were condensing (energy efficient) vs. non-condensing (non-energy efficient)?

[Should total to 100%; Don’t know = -97; Refused= -98]

% Condensing/Energy Efficient: _____%

% Non-Condensing/Non-Energy Efficient: _____%

SD3. About what percentage of gas boilers that you sold in the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) commercial and industrial market in 2012 were the following sizes...

[Should total to 100%; Don’t know = -97; Refused= -98]

1. .......................................................................................... ≤300MBH_____ %

2. ............................................................................................................. 301-499
   MBH_______ %

3. ............................................................................................................. 500-999
   MBH_______ %

4. ............................................................................................................. 1000-1700
   MBH_______ %

5. ............................................................................................................. ≥1700
   MBH_______ %

SD4. About what percentage of gas boilers that you sold in the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) commercial and industrial market in 2012 had AFUE (or boiler rated thermal efficiency or nametag rated combustion efficiency for larger boilers) levels that...

[Should total to 100%; Don’t know = -97; Refused= -98]

1. Were under 90 AFUE: ________%
2. Were between 90 and 94 AFUE: ______% 
3. Were over 94 AFUE: ______% 

Massachusetts Market Information: 

MMI1. Which of the following best describes your company’s sales distribution network for the Massachusetts boiler market? [READ LIST.CHECK ONLY ONE RESPONSE OPTION.] 
   1. Multiple distributors/sales representatives
   ______
   2. Geographical region exclusive distributors/sales representatives ______
   3. No distributors (meaning all sales are handled by direct company employees only) ______
   4. Other [SPECIFY: ________________________________________________] ______

MMI2. Is the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) an expanding market for your high efficiency products? 
   1. Yes ______
   2. No ______

MMI2A. Why do you say that? 

MMI3. [IF GCI3 = Yes] Is the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) an expanding market for your products that are not high efficiency? 
   1. Yes ______
   2. No ______

MM3A. Why do you say that? 

MMI4. Is the market in Massachusetts for boilers expanding faster, slower or at the same rate as the Northeast or other regions (nationwide/industry wide)? 

MM4A. Why do you say that? 

MMI4. Do you think boiler sales at your business in Massachusetts (or alternatively, the Northeast/nationwide/industry wide) will increase, decrease or stay about the same over the next two years? [READ LIST.CHECK ONLY ONE RESPONSE OPTION.] 
   1. ..................................................................................................................... Increase ______
2. ............................................................................................................... Decrease______
   __

3. ............................................................................................................... Stay about the
   same______

-97. [Don’t know]__________
-98. [Refused]__________

**MMI4A.** [If MMI4 = 1 or 2] By what percentage do you think boiler sales at your business in
Massachusetts (or alternatively, the Northeast/nationwide/industry wide) will
[increase/decrease] over the next two years?
[READ LIST: CHECK ONLY ONE RESPONSE OPTION.]
1. ............................................................................................................... 1 to 2%
   __________

2. ............................................................................................................... 3 to 5%
   __________

3. ............................................................................................................... 6 to 10%
   __________

4. ............................................................................................................... Over 10%
   __________

-97. [Don’t know]__________
-98. [Refused]__________

**Possible New Product Offerings:**
**PO1.** Is your business planning any new boiler product offerings? [Probe: Will your business have new
boiler models with higher efficiency than present models?]

PO2. Are there any changes in the industry that you think will affect energy efficiency programs for boilers?

   PO2A. Why do you say that?

   PO2B. Based on where your company thinks most sales will be in the boiler market over the next
two years, where would you recommend that boiler efficiency program money be focused?

   PO2C. What part of your product line do you think the most sales will be in the boiler market over
the next two years?
**Operating Efficiency Assumptions: (Baseline being an 80% rated boiler)**

BA1. Do you think boilers, in general, operate at less than their rated efficiency?
   1. Yes __________
   2. No __________

BA1A. **[IF BA1=YES]** If a boiler that is being replaced has an efficiency rating of 80%, what do you estimate is the actual operating efficiency level?

BA1B. **[IF BA1=YES]** If a boiler has an efficiency rating of 90%, what do you estimate is the actual operating efficiency level?

BA2. Based on new regulations, if new minimum efficiency standards are imposed, of say 90% efficiency, is it correct to assume that 90% would be the new baseline?
   1. Yes __________
   2. No __________

BA2A. Why do you say that?
**Energy Efficiency Program Implementation:**
As a boiler [manufacturer/distributor], we are interested in your thoughts about high-efficiency boiler incentive programs? When considering natural gas funded energy efficiency programs, the installation of or replacement using high efficiency boilers often is considered the largest measure with regard to energy savings.

PA1. Please identify positive and/or negative aspects and that you encounter with the following components of energy efficiency programs and suggestions for changes that would improve the programs?

<table>
<thead>
<tr>
<th>Energy Efficiency Program Component</th>
<th>Positive Aspects</th>
<th>Negative Aspects</th>
<th>Suggestions on changes? (Better way of doing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incentives in Massachusetts compared to other states</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Differences in energy efficiency programs from one state to another</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allocation of boiler incentives by boiler size</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Allocation of boiler incentives by boiler efficiency</td>
<td></td>
<td></td>
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<tr>
<td>Customer awareness of efficiency programs</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Involvement of utilities in the energy efficiency programs</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
PA2. On a scale of 1 to 5, where 1 is “Very unimportant” and 5 is “Very important,” how important a factor do you think energy efficiency program incentives are to the sales of your company’s boilers?

[READ LIST. CHECK ONLY ONE RESPONSE OPTION.]

1. ................................................................. Very unimportant ________

2. ........................................................................................................ Somewhat unimportant ________

3. ........................................................................................................ Neither important nor unimportant ________

4. ........................................................................................................ Somewhat important ________

5. ........................................................................................................ Very important ________

-97. [Don’t know] ________

-98. [Refused] ________

PA2A. [If PA2 = 1 through 5] Why do you say that?

PA3. Can you offer any suggestions/recommendations to energy efficiency program administrators to improve the boiler market?

PA4. Can you identify any good ideas or “best practices” associated with energy efficiency program administration of the boiler market that stands out?

PA5. Do you feel that the Massachusetts program presents challenges to your boiler product offerings in any way?

PA6. In the United States, most energy efficiency programs provide incentives directly to end users that are based on the nameplate rating size and efficiency of the boilers being installed. Do you agree with incentives being based on the nameplate rating size and efficiency?

1. Yes ________

2. No ________

PA6A. Why do you say that?

PA7. Is there one particular energy efficiency program focusing on the boiler market that you are most familiar with?

1. Yes ________

2. No ________

PA7A. [If PA7=Yes] Which program is that?
PA8. Efficiency programs generally consider standard applications or the most common installation situations. Can you identify any situations as needing more attention by boiler efficiency programs? For example: An emergency boiler replacement where existing piping prevents the use of a high efficiency boiler?

1. Yes  __________

2. No  __________
Distributor/Manufacturer Representative Referrals:

RR1. Is there any distributor or a manufacturer’s representative that you can refer us to discuss their commercial and industrial boiler business in the Massachusetts area?
   3. Yes __________
   4. No __________

RR1A. [If RR1=Yes] [NOTE TO INTERVIEWER: Ask for any contact info able to be provided]

<table>
<thead>
<tr>
<th>Contact name:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of contact’s business:</td>
<td></td>
</tr>
<tr>
<td>Contact phone:</td>
<td></td>
</tr>
<tr>
<td>Contact email:</td>
<td></td>
</tr>
<tr>
<td>Any additional notes:</td>
<td></td>
</tr>
</tbody>
</table>

Thank you for your time. On occasion, we find it helpful to call back to clarify our notes. Would it be ok to call you back should we need further clarification?
# APPENDIX C: SANITIZED INTERVIEW RESULTS

## Table 20: Interview Question / Response Summary

<table>
<thead>
<tr>
<th>Question(s)</th>
<th>Response(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GCI1:</strong> First, what is your job title?</td>
<td>Executive Director, Technical Advisor, and distributor</td>
</tr>
<tr>
<td></td>
<td>Regional Sales Manager</td>
</tr>
<tr>
<td></td>
<td>Business Analyst</td>
</tr>
<tr>
<td></td>
<td>President</td>
</tr>
<tr>
<td></td>
<td>Regional Sales Manager</td>
</tr>
<tr>
<td></td>
<td>NE Regional Sales Manager</td>
</tr>
<tr>
<td></td>
<td>VP of company</td>
</tr>
<tr>
<td></td>
<td>VP of company</td>
</tr>
<tr>
<td></td>
<td>Eastern Regional Sales Manager</td>
</tr>
<tr>
<td></td>
<td>VP of eastern regional sales</td>
</tr>
<tr>
<td></td>
<td>Sales manager</td>
</tr>
<tr>
<td></td>
<td>National Sales Manager</td>
</tr>
<tr>
<td></td>
<td>Director of Sales and Marketing</td>
</tr>
<tr>
<td><strong>GCI2:</strong> Which of the following commercial and industrial heating products does your business manufacture, sell or install from this location?</td>
<td>Gas water boilers, indirect water heating systems, boiler resets</td>
</tr>
<tr>
<td></td>
<td>Water Heaters and hot water boilers</td>
</tr>
<tr>
<td></td>
<td>Gas water boilers, indirect water heating systems</td>
</tr>
<tr>
<td></td>
<td>Gas Water Boilers and Indirect Water Heating Systems</td>
</tr>
<tr>
<td></td>
<td>Gas water boilers, indirect water heating systems, internal boiler resets</td>
</tr>
<tr>
<td></td>
<td>Gas water boilers, indirect water heating systems, steam, hydronic, water heating, reset, control</td>
</tr>
<tr>
<td></td>
<td>steam, hydronic, water heating, reset, controls and several industrial process applications</td>
</tr>
<tr>
<td></td>
<td>hydronic boilers, indirect hot water heaters</td>
</tr>
<tr>
<td></td>
<td>furnaces, hydronic boilers</td>
</tr>
<tr>
<td></td>
<td>hydronic boilers, gas and oil fired boilers, onboard controls</td>
</tr>
<tr>
<td></td>
<td>Gas water boilers, indirect water heating systems, controls</td>
</tr>
<tr>
<td></td>
<td>Gas Water Boilers, Gas Stem boilers</td>
</tr>
<tr>
<td><strong>GCI3:</strong> Besides “eligible boilers,” Does your business make, sell or install “non-eligible” boilers? Please keep in mind that eligible boilers refer to high efficiency condensing boilers that operate at an efficiency range higher than 90% and that non-eligible boilers refer to lower efficiency non-condensing boilers that operate at an efficiency range of 80%.</td>
<td>No just eligible</td>
</tr>
<tr>
<td></td>
<td>Both types</td>
</tr>
<tr>
<td></td>
<td>Yes, ineligible for oil heating</td>
</tr>
<tr>
<td></td>
<td>Just eligible</td>
</tr>
<tr>
<td></td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>just eligible</td>
</tr>
<tr>
<td></td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Yes 87% is eligible... non high efficiency accounts for 13%</td>
</tr>
<tr>
<td></td>
<td>just eligible</td>
</tr>
<tr>
<td></td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>Both</td>
</tr>
<tr>
<td></td>
<td>9 (both), 4 only eligible</td>
</tr>
<tr>
<td>Question(s)</td>
<td>Response(s)</td>
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</tbody>
</table>
| GCI4: Which of the following best describes your business? | Manufacturer  
Both a manufacturer and a distributor  
Both a manufacturer and a distributor  
Both a manufacturer and a distributor  
Both a manufacturer and a distributor  
Both manufacturer and a distributor  
exclusive distributor for two manufacturers CB and F  
exclusive distributor for brand F in MA and CT  
manufacturer  
Manufacturer and a distributor  
Manufacturer and a distributor  
Manufacturer and a distributor |
| SD1: What is the total number of boilers your business sold in the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) commercial and industrial market in 2012? | 51-100 only C&I  
over 200  
over 200  
over 200 (combined C&I, Res)  
25-50  
over 200 (includes RES)  
over 200 (includes RES)  
around 2000 just C&I  
over 200 (just C&I), about a 50-50 split between condensing and non - Said their sales are 40% condensing/60% non-condensing |
| SD2: About what percentage of gas boilers that you sold in the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) commercial and industrial market in 2012 were condensing (energy efficient) vs. non-condensing (non-energy efficient)? | 100% Condensing  
less than 50% were condensing  
100% condensing  
100% condensing  
50-50  
100% condensing  
100% condensing  
90% condensing, 10% non-condensing  
100% condensing  
90% condensing, 10% non-condensing  
About 50-50  
40% condensing, 60% non-condensing |
| SD3: About what percentage of gas boilers that you sold in the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) commercial and industrial market in 2012 were the following sizes... | 500-999 MBH (10%), 1000-1700 MBH (45%), >1700 MBH (45%)  
DK about sizes  
<300 MBH (50%), 301-499 (30%), 500-999 (20%), 1000-1700 MBH (10%)  
301-499 (57%), 500-999 (35%), 1000-1700 (4%), over 1700 (4%)  
<300 (11%), 301-499 (41%), 500-999 (20%), 1000-1700 (6%), >1700 (22%)  
<300 MBH (91%), 301-499 MBH (9%)  
500-999=10%; 1000-1700=10%; 1700 higher=80%  
65% 399 MBH or below, 20% 400-1000 MBH, 10% 1000 - 1700 MBH and 5% >1700 MBH  
100% (less than 300 MBH)  
85% less than 300 MBH  
<300 (27%), 301-499 (45%), 500-999 (8%), 1000-1700 (12%), >1700 (8%)  
<300 (60%), 301-499 (20%), 500-999 (15%), 1000-1700 (5%) |
<table>
<thead>
<tr>
<th>Question(s)</th>
<th>Response(s)</th>
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<tbody>
<tr>
<td>SD4: About what percentage of gas boilers that you sold in the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) commercial and industrial market in 2012 had AFUE (or boiler rated thermal efficiency or nametag rated combustion efficiency for larger boilers) levels that...</td>
<td>90-94 (50%), 94+ (50%) 100% above 94% 90-94(5%), 94+ (95%) Under 90 (27%), 95+ (73%) 100% over 94% 5% under 90, 95% over 94 % efficiency 5% under 90, 95% over 94 % efficiency 10% under 90, 90% over 94% 100% over 94% 100% between 90 and 94% Under 90% (39%), 90-94% (56%), 94+ (5%) Under 90% (70%), 90-94%(20%), 95+ (10%)</td>
</tr>
<tr>
<td>MMI1: Which of the following best describes your company’s sales distribution network for the Massachusetts boiler market</td>
<td>Majority by regional representatives Geographical regional exclusive distributors/sales reps Multiple distributors/sales reps 4, one rep many distributors Multiple distributors/sales reps Multiple distributors/sales reps Multiple distributors/sales reps Multiple distributors/sales reps Multiple distributors/sales reps Multiple distributors/sales reps Multiple distributors/sales reps Geographical regions exclusive for cast iron, no distributors for commercial steel</td>
</tr>
<tr>
<td>MMI2: Is the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) market an expanding market for your high efficiency products?</td>
<td>Yes No overall market shrinking Yes YES YES Yes Yes Yes Yes Yes YES</td>
</tr>
<tr>
<td>MMI3: Is the Massachusetts (or alternatively, the Northeast/nationwide/industry wide) market an expanding market for your products that are not high efficiency?</td>
<td>Yes No pretty flat No DK, they don’t make them NO n/a (only sell eligible) No N/A no answer Yes Yes Yes YES</td>
</tr>
<tr>
<td><strong>Question(s)</strong></td>
<td><strong>Response(s)</strong></td>
</tr>
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<td>-------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
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</table>
| MMI4: Is the market in Massachusetts for boilers expanding faster, slower or at the same rate as the Northeast or other regions (nationwide/industry wide)? | About the same  
Don't know  
Slower at least the same if not greater  
Faster  
Same rate  
only knows sales numbers for MA and CT for this product line and cannot compare  
only knows sales numbers for MA and CT for this product line and cannot compare  
It is really a question of hydronic (boiler) vs. hot air (furnace) as the choice of equipment  
North East region is where boilers exist other parts of the country... not so much  
Yes  
Overall faster, though there is an aggressive program coming ot in CT  
NY their strongest market but MA in the upper tier |
| MMI5: Do you think boiler sales at your business in Massachusetts (or alternatively, the Northeast/nationwide/industry wide) will increase, decrease or stay about the same over the next three years? | Increase  
Stay the same  
Increase  
Increase  
Increase  
Increase  
Increase  
Increase  
Increase  
Increase  
Increase  
Increase  |
| MMI5A: By what percentage do you think boiler sales at your business in Massachusetts (or alternatively, the Northeast/nationwide/industry wide) will [increase/decrease] over the next three years? | 10%+  
0%  
6-10%  
10-12%  
10-12%  
6-10%  
3-5%  
2-5%  
10%+  
3-5%  
3-5%  
6-10%  
3-5% |
<table>
<thead>
<tr>
<th>Question(s)</th>
<th>Response(s)</th>
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<tbody>
<tr>
<td>PO1: New Product Offerings</td>
<td>They are the first to develop a turn down capability and the ability to have a high turn-down ratio. Raising the bar in the terms of technological benefits, optimizing your O2 in the whole range of your operations. Yes bigger and smaller in the non and condensing. There is a market for both, primarily in replacements for existing, also for piping and venting Yes Yes, more higher efficiency boilers, with more Btu's. Stainless Steel condensing types This December expanding their condensing boilers, mostly in the 2-5 million Btu range. This April will expand their wall hung boiler offerings, with multiple sizes None XX 350 HP &quot;Clarifier&quot; Model large condensing hydronic boiler which is a better solution to multiple small unitized units also check out the XX EX Model for firetube Steam XX is introducing a new high efficiency gas fired heat pump product EBC combination hot water -hydronic heating plant Yes Yes (condensing market and fire tube have their focus)</td>
</tr>
<tr>
<td>PO2: Changes in industry that will affect EE boiler programs</td>
<td>There should be. Suggested the move to an efficiency curve as opposed to efficiency values The programs affect the industry, they create the demand. A few between the new testing procedures, more interest in combination systems, especially boilers with cooling systems. Yes primarily the testing procedures and if the DOE will stick with them No Not really any Four other manufacturers (xx, xx, xx, xx) are all making condensing boilers over 3MM why not increase the Prescriptive program to include a larger tier. Four other manufacturers (xx, xx, xx, xx) are all making condensing boilers over 3MM why not increase Prescriptive program to include a larger tier. DOE Notice of Proposed Rulemaking... possible mandatory efficiency standard mandatory outdoor temperature sensor with setback possible mandatory efficiency standard or another words the DOE Notice of Proposed Rulemaking The numbers may not reflect it, it is tough to get a handle in the market numbers in total. His opinion is that there is some shift away from condensing, after 10 or so years of condensing products, the education of the heating contractor, the HE not always the best option for the consumer. The DOE is a constantly moving target, forcing the manufacturers to do some things as well. Not sure if the testing is accurate, forcing them to re-rate takes time away from R&amp;D</td>
</tr>
<tr>
<td>Question(s)</td>
<td>Response(s)</td>
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| **PO2B**: Recommendations for where boiler efficiency program money should be spent | In considering a higher range of rebate options, but also have a high turn down ratio to deal with seasonal efficiency changes  
If they are going to make rebates available, they ought to demand proof that they are saving energy.  
The commercial sector  
Directed at the property owner  
Money should be sent towards the 90% and higher efficiency boilers  
I think the direction has been very good, would like to see an incentive for replacing old equipment 30+ years, would like to see more of that.  
Direction fine, doesn't need to be changed  
Direction fine, doesn't need to be changed  
We see highest sales in high efficiency. Selling 2 MA units for every 1 CT unit  
Greatest gains in energy savings can be made where old steam systems exist. An entire system change (steam to hydronic) can be costly and a big project yet incentive programs still incent steam replacement, which limits the real energy savings.  
high efficiency direct Hot water and indirect hot water equipment  
Commercially  
Not really any, they have adapted to the market  
Gas fired water heater line, claim to be the only ones with an instantaneous version  
Non-condensing substantially more than condensing. New to the market, faster growth in condensing.  
red-done 100 line, 100-135 MBH  
in the million to 2 million Btu range residential condensing 95% efficient equipment  
small combination boiler market 100-150,000 BTU heating and hot water  
CB 350 HP "Clarifier" Model large condensing hydronic boiler  
Fulton Heat Pump high efficiency models combination HW/boiler  
high efficiency condensing hot water and indirect models of hot water equipment  
Residential condensing  
condensing stainless steel  
25% new, 75% replacement  
Less than 5% new, 95%+ replacements  
30% new, 70% replacement  
15% new, 85% replacement  
20% new, 80% replacement  
12% new, 88% replacement  
55% new construction, 45% replacement  
55% new construction, 45% replacement  
20% new construction and 80% replacement  
15% new construction and 85% replacement  
20% new construction and 80% replacement  
5% new, 95% replacement  
30% new/70% replacement |
<table>
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<tr>
<th>Question(s)</th>
<th>Response(s)</th>
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</table>
| PO4: What percentage of the boilers you sell are used in redundant or backup situations | 100%  
20-25  
30% in redundant  
10-15%  
20%  
Less than 1%  
98% placed in a semi-redundant configuration  
98% placed in a semi-redundant configuration  
0% is back-up anymore but for commercial 70% are used in modular (side by side) configuration  
4%  
10%  
Rarely see single boilers going in anymore, 100% only 45% |
| PO5: What percentage of the boilers that you sell are natural gas vs. oil fired | 90% NG, 10% propane  
90% NG, 10% LP  
95% NG, 5% Oil  
100% NG  
80% NG, 20% propane  
86% NG, 14% Propane  
90% NG, 10% oil  
90% NG, 10% oil  
100% NG  
55% NG, 45% propane  
85% NG, 15% liquid fuel  
60% NG, 40% oil  
70% NG, 30% oil |
| BA1: Do you think that boilers operate at less than their rated efficiency | Yes, absolutely  
absolutely about 100% of them do  
Yes  
Generally, they operate at the rated efficiency, the system is the challenge. Pumps and heat emitters, temperature they run at the higher the water temp the lower the efficiency  
Yes, misconception is based on water return temperature  
No  
yes rated efficiency is based on steady state operation not actual operating conditions  
yes rated efficiency is based on steady state operation not actual operating conditions  
Yes because nametag rating is based on a test procedure. Same efficiency cannot be reached with on/off cycling which is how units have to operate largely because of weather and the need for heat.  
yes because nametag rating is a steady state test procedure with real field conditions not being steady state  
Yes because nametag rating is based on a test procedure. Same efficiency cannot be reached with on/off cycling which is how units have to operate largely because of weather and the need for heat.  
I know that it is true for residential, for commercial it is probably similar.  
Yes |
<table>
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<tr>
<th>Question(s)</th>
<th>Response(s)</th>
</tr>
</thead>
</table>
| BA1A: Actual operating efficiency of an 80% boiler                        | 65 to 70%  
60%  
76%  
about 60%  
76%  
80%  
for fire tube 75 - 80%; for cast iron closer to 70 - 75%  
for fire tube 75 - 80%; for cast iron closer to 70 - 75%  
much less 65 -75%  
60 -70%much less than 80%  
60%  
74-76%                                                                 |
| BA1B: Actual operating efficiency of a 90% boiler                         | 80% at minimum  
60%  
85%  
85%  
87-89%  
90%  
88%  
88%  
depends on condensing/non-condensing mode of operation  
88%  
depends on condensing/non-condensing mode of operation  
also depends on system conditions  
85-90%  
84-86%                                                                 |
| BA2: If new regulations were imposed with an efficiency standard of 90%, would it be correct to assume the new baseline would be 90% | Yes  
No  
Yes, if legally required to be at 90, then they will be at 90.  
Yes  
Yes  
Yes  
yes assuming gas which brings in a question about gas availability and further questions about oil/gas when considering efficiency  
yes assuming gas which brings in a question about gas availability and further questions about oil/gas when considering efficiency  
Not sure  
Yes  
Not sure  
Yeah he would assume so, the range in looking at AHRI thermal efficiency 90-95 range. Given the fact that condensing equipment efficiencies driven more by the system, water temp, flow rates, it would be tough to set the level higher.  
Yes                                                                 |
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| PA1A. Thoughts on incentives in MA compared to other states               | Positive: National Grid has good rebated in terms of dollars/Btu<br>Positive: They tend to see higher dollar values for incentives in MA<br>Positive: MA generally higher<br>Positive: MA has better incentives than the rest of NE states<br>Positive: MA the only state in this region that has clear cut incentives. RI has limited budget, so money is not always available<br>Positive: RI and MA stand out. Suggestion: MA positive as compared to CT<br>Positive: RI and MA stand out. Suggestion: MA positive as compared to CT<br>"Positive: C&I sector in MA. Negative: because of one utility which has a bias for utility administered direct install where the customer is not allowed to choose the boiler of his choice. Only one brand is used which is not fair since rate payers fund are being used"<br>Positive: MA the best<br>"Positive: C&I sector - No utility bias (un fair treatment between boiler manufacturers). Negative: one utility, which has a bias for utility administered direct install where the customer is not allowed to choose the boiler of his choice. Only one brand is used which is not fair since rate payers fund are being used."
Positive: MA tends to have a more aggressive program<br>Negative: Mostly on the residential side need more explanation on the testing procedures, and why some manufacturers are excluded when others aren’t |
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| PA1B: Differences in EE programs from one state to another | Negative: Some don't offer money, or others only offer a small amount  
Negative: If one state pays more than another, business is going to move to that one state  
Negative: Difficult to track which states have incentives, and what dollar values those incentives contain.  
Negative: Need more consistency especially for marketing aspects  
Positive: Incentives are pretty consistent across the board since they all pretty much have the same tiers  
"Positive: MA evolved over the past few years but the general program has remained the same. MA has done a great job in keeping it consistent  
Negative: NH has none, RI very little"  
"Positive: In Massachusetts there is program consistency.  
Negative: budgetary start/stops that occur in other states are a very big problem when dealing with customers"  
"Positive: In Massachusetts there is program consistency.  
Negative: budgetary start/stops that occur in other states are a very big problem when dealing with customers"  
"Positive: C&I sector in MA. Negative: because of one utility which has a bias for utility administered direct install where the customer is not allowed to choose the boiler of his choice. Only one brand is used which is not fair since rate payers fund are being used"  
Negative: RI and CT because the program is not similar it causes less than desirable complexity.  
"Positive: C&I sector - No utility bias (un fair treatment between boiler manufacturers). Negative: one utility, which has a bias for utility administered direct install where the customer is not allowed to choose the boiler of his choice. Only one brand is used which is not fair since rate payers fund are being used."  
Negative: a lot of states don't have anything and those that do the programs vary widely  
Negative: Wants more consistency between states |
| PA1C: Allocation of boiler incentives by size | Positive: Higher dollars/Btu  
Positive: Buildings that require a large amount of heat, a larger rebate makes sense, because of the cost of installation. 30-40% cost difference for installing a non-condensing versus a condensing  
Positive: Likes how commercial boiler incentives are based on thermal efficiency rating, and residential on AFUE level  
Positive: Drives behavior, greater paybacks for bigger sizes  
Positive: MA does a really good job in the commercial 2+ million Btu range incentives  
Positive: Very pleased, the bulk of the replacement market has been in residential sizes  
Positive: acceptable way of doing it Positive: acceptable way of doing it  
Positive: acceptable way of doing it  
Positive: good way of doing it  
Positive: ok way of doing it  
Positive: fairly distributed  
Positive |
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| PA1D: Allocation of boiler incentives by efficiency | **Suggestion:** It would help to have different tiers, as most can reach the 92% thermal efficiency requirement  
**Negative:** The way programs have been run in the past  
**Positive:** Thinks it is positive, the more efficient the boiler the more expensive it is, so it should get higher incentives  
**Positive:** want the higher dollars for greater efficiencies  
**Positive:** MA gives out the most money to the more efficient boilers  
**Positive:** MA a good job, clear on efficiencies  
**Positive:** acceptable way of doing it. Suggestion: Don't fix it unless it is broken  
**Positive:** acceptable way of doing it. Suggestion: Don't fix it unless it is broken  
**Positive:** ok way of doing it  
**Positive:** good way of doing it  
**Positive:** ok way of doing it  
**Negative:** with the recent AHRI testing fiasco, caused many problems in terms of actual production as opposed to what the lab results stated was achievable. Suggestion: wants to see rebates based on condensing vs. non-condensing  
mostly positive |

| PA1E: Customer Awareness of EE Programs | **Negative:** Most customers not aware of these programs  
**Positive:** Customers very aware  
**Positive:** Customers are very aware  
"Negative: contractors-very little, engineers-somewhat, sales-most aware, building owners-not very"  
**Positive:** consumers are very aware  
**Positive:** Contractors very aware and do a good job of promoting to the customer  
**Positive:** MA program awareness is better than other States. Best comparison to other States is their Boiler Program is like MA's custom program... slower, more paperwork, tedious application, longer timeline. Suggestion: Outreach of MA Programs could be better - See Consumer ME Program which was a very positive event and provided contractors, vendors and customers with a lot of good information.  
**Positive:** MA program awareness is better than other States. Best comparison to other States is their Boiler Program is like MA's custom program... slower, more paperwork, tedious application, longer timeline.  
**Positive:** the majority of the knowledge is in the mid-sized commercial applications  
**Negative:** customers need to be more aware  
somewhat split, slight majority to positive |
### Question(s) | Response(s)
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**PA1F: Utility Involvement in EE Programs**
- Positive: reduce emissions and give rebates
- Positive: Utilities interested in selling more product so they encourage a change from one energy source to another.
- The gas company sees that people having split systems could erode their business. This way it is self serving them.
- Positive: Good that the utilities do these for the customer.
- Positive: This is critical since it drives sales and behavior towards condensing.
- Positive: allows the consumers to get rebates.
- Positive: At some meetings he attended, the gas company was involved strictly to promote their programs.

"Positive: everyone needs to be involved for a successful program... manufacturer/distributor, contractor, utility, program administrator, customer. Negative: who is the right person to talk to on a project”

"Positive: everyone needs to be involved for a successful program... manufacturer/distributor, contractor, utility, program administrator, customer. Negative: who is the right person to talk to on a project”

Suggestion: Installer training is very important especially when dealing with high efficiency models... it becomes more critical than compared to conventional equipment.

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"Positive: They are a source of information and an easy way for customers to get rebates. Negative: one utility has aligned themselves with only one or two manufacturers which has created an unequal playing field.

"Negative: utilities have minimal involvement whereas they should have more mostly positive.

**PA2: On 1-5 how important are boiler incentives to your sales**

4 or 5

1, says the could sell more without the rebates

3

5

5

5

5

5

5

4

3

3

average 4
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<td>PA3:  Suggestions to improve the boiler market</td>
<td>Base the efficiency program off of more realistic testing procedures, look at different classes of rebates for water heating. Nobody offers adequate rebates. One thing they need to do is to force the people to install HE boilers and to demonstrate that they are operating in the manner to get the HE fuel savings from the installations increase the dollar value of incentives Focus on how the water is pumped, and what is the operating temp of water Increase the amount of public education, because most consumers aren't aware of rebate options Used to be an added bonus when you replaced a 30+ year old system, one of the points he makes in training, base board heating here in MA. Based on 180 degree water going through those tubes. For new construction by dropping the water temp down to 160 degrees. An incentive for a fan coil unit that ran at a lower temperature. Next steps towards efficiency are ancillary, return units, systemic gains not really combustion gains (1) Program bias mentioned above is a big problem, it should not happen. (2) Minimize paperwork necessary for incentive/installation. (3) combination installation of boiler/indirect water heater Certify installers, more education program for installers, condensing boiler checklist should be made a part of the incentive. Or a “bonus” incentive would be given if all of the things in the checklist could be done such as outdoor temp setback, return less than 140 degrees, Qualify AFUE rating (not applicable to non-residential boilers) (1) Program bias mentioned above is a big problem, it should not happen. Also combination installation of boiler/indirect water heater In terms of improving the market, organic growth of the market there is not any one facilitating force, from a replacement standpoint looking to get existing owners to proactively upgrade their equipment, more promotion and advertising. A key to that is real world marketing material that explains to building owners what they can expect to see in terms of savings, dollars. level the playing field, better understand the testing procedures, and understand what you compromise when you just push efficiency</td>
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<td>PA4: Can you identify any good ideas or best practices associated with energy efficiency program administration that stands out</td>
<td>a lot of the replacement market, the energy efficiency savings comes down to the controls, most customers and consulting engineers say originally designed from 180 degrees, even in the older systems a lot of oversizing with boilers. Can still reduce system supply temperature, should be varying based on outside temperature. Design around lower supply temperatures. Higher delta T's for replacements. None</td>
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<td>Folks in Wisconsin do, they will look at individual projects and qualify it and say if it is eligible for the rebates. Very low level if not significant dollars in the incentive. Want to compare AFUE levels and specify that the heat exchangers are ASME heat exchangers. Foreign boilers do not. Best practice is when all market participants perform like a team... everyone gets involved to inform and work with the customer to push high efficiency installation rather than &quot;standard&quot; cheapest replacement. Certify installers, more education program for installers, condensing boiler checklist should be made a part of the incentive. Or a &quot;bonus&quot; incentive would be given if all of the things in the checklist could be done such as outdoor temp setback, return less than 140 degrees, Qualify AFUE rating (not applicable to non-residential boilers) Best practice is when all market participants perform like a team... everyone gets involved to inform and work with the customer to push high efficiency installation rather than &quot;standard&quot; cheapest replacement. I think for guys that don't have experience with dealing with a gas utility in terms of rebates. They have personnel available to walk them through the process. Greater communication and easier access to the information, in other states</td>
<td></td>
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<td>PA5: Does the MA program present challenges to your business</td>
<td>No more of an assistance Causes them to work harder to develop products that meet the requirements on paper. Yes, It is not exactly the programs fault, just the new testing procedures are forcing them to have to redesign their boilers which is difficult to do No No No Yes. This applies specifically to the residential program where xx is not allowed to participate. No, program good Yes. This applies specifically to the residential program where Utica is not allowed to participate. No Yes Mostly no</td>
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| PA6: Do you agree with incentives being based on the nameplate rating size and efficiency | No, same issue with the AHRI testing procedure  
No, program should be based on actual energy savings.  
Yes  
Yes  
Yes  
Yes  
In terms of being able to administer it, Realistically a lot of condensing equipment in applications where there is no payback to the end user, consistently low natural gas pricing. We want HE, and there is benefit to the environment, I don't know that consumers have a good picture to a lot of their applications. Need to look at the applications more  
Yes |
| PA7: Is there one particular energy efficiency program focusing on the boiler market that you are most familiar with | National Grid  
National Grid program down in NYC  
Do a lot with National Grid Probably the gas networks one.  
National Grid  
yes equally CT- MA - RI- NY  
National Grid program, also the UIL program in CT that is more of a free market program  
No  
Most common is National Grid |
| PA8: Situations that are in more need from boiler efficiency programs     | Maybe water source heat pump applications, and geothermal applications. They are the best in terms of condensing or design, but no separate attention is given to them as they are not as popular.  
Focus has to be on the whole system efficiency. If you put in a new boiler but the building envelope isn’t good, ducts and piping have leaks, won't see the savings and performance you should expect  
Perhaps boilers installed with an indirect fired tank, boilers in combination with solar panels, or heat pumps.  
Commercial Hot Water. The heat loss is dropping, but the demand for hot water staying high. The gas networks have a lot of incentives but not a hot water supply boiler on there.  
Couldn’t think of any  
Not really any. Here in MA the program very well run, as well as being advertised, contractors knowledgeable. Other states had vagueness, using MA as a model seems to fit. Keeping it consistent. The program hasn’t made any major alterations. Very pleased with the policing and monitoring what money was spent, and if it was spent properly.  
Conservations services group, does a good job with that.  
None that he could think of.  
Level the playing field, better understand the testing procedures, and understand what you compromise when you just push efficiency. |
9 BIBLIOGRAPHY


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