Multifamily Boiler Effective Useful Life Study

prepared for

Con Edison

energy & resource solutions

Corporate Headquarters:
120 Water St., Suite 350
North Andover, Massachusetts 01845
(978) 521-2550
Fax: (978) 521-4588

July 28, 2017

Contents

1 EXECUTIVE SUMMARY

This section summarizes the main objectives of the study, including background information that prompted the study, research approaches used by the team, and the study findings and conclusions.

1.1 Program Background & Objectives

Effective useful life (EUL) is an estimate of the number of years a type of equipment is expected to be useful or operational. Con Edison suspected that boilers in NYC are run well beyond their deemed EUL due to a combination of high replacement costs and logistical challenges of retrofitting heating systems in a dense urban area. If that is true, then the old boiler population is also likely to be less efficient than current models and thus represents an opportunity for Con Edison's incentive programs. However, current technical reference manual (TRM) methods dictate that beyond-EUL measures can only claim savings against code (rather than the actual efficiency of the existing boiler, which is likely to be much lower). The incentives can also only cover the incremental costs of the boiler replacement, which is generally too small a rebate to convince a customer to replace the equipment if they plan to continue operating it. Con Edison was interested in gathering data to prove or disprove its suspicion and to assess how best to target the population.

There are three primary research objectives that this study set out to explore:

1. Investigate the actual age and characteristics of multifamily boilers in NYC.
2. Estimate the potential savings opportunity from beyond-EUL boilers.
3. Compare how current TRM methods and potential changes affect savings.

The Analysis Findings section covers each one of these objectives separately.

1.2 Research Approach

The team used a three-phased approach to address the objectives of this study.

- ❑ **Phase I: NYS TRM Review:** Phase I included a review of the existing NYS TRM and corresponding sections relevant to potential boiler projects to develop an understanding of how savings were calculated under different scenarios. The study team also reviewed other reports and proceedings from entities that were considering the same question of "indefinite life" measures.
- ❑ **Phase II: Primary Data Collection:** Phase II included surveys and interviews conducted with building superintendents or operators, boiler contractors, and boiler suppliers. These gathered data on age and other characteristics of boilers in service, motivations for replacement, and efficiency and cost of new boilers currently on the market.
- ❑ **Phase III: Data Analysis:** Phase III compiled the data received through the survey and interview work, supplemented by additional population-level data sets from Con Edison and the City of New York. There were three separate analyses, each corresponding with one of the three study objectives.

The findings were presented to Con Edison at the conclusion of Phase I and Phase III.

Due to difficulties gathering enough data during Phase II – involving poor survey response rates, an inability to obtain a City of New York data set, and little survey data on efficiency or boiler size – Con Edison and the study team reorganized their data collection efforts and analysis outcomes to present usable findings despite the data deficiencies. Estimates and assumptions were used where appropriate during the analyses and are documented in the report text. Further data collection, especially for large buildings and existing boiler efficiencies, would alleviate some of these challenges.

1.3 Analysis Findings

The study team organized the analysis and findings by the three study objectives, related to boiler age and other characteristics, savings potential, and TRM impacts on savings.

1.3.1 Boiler Age and Characteristics

This analysis aimed to study the age and characteristics of multifamily boilers and determine whether Con Edison's suspicion that boilers are being used beyond their EUL was correct. The primary activities were analysis and visualizations of the building operator/superintendent surveys and contractor interviews. There are five findings from this analysis:

1. The overall boiler population is young, possibly due to the recent increases in NYC's requirements for fuel oil and combustion efficiency that have spurred replacements.
2. Nearly a fifth of the boilers in the survey are older than 25 years old and past their EUL.
3. Manhattan has the overwhelming majority of beyond-EUL boilers, but the Bronx has the oldest on an absolute basis.
4. Contractors and building operators estimate a boiler's life to be between 20 and 29 years.
5. Reliability and efficiency/energy bills were the two most-cited reasons for replacing boilers from building operators; contractors thought that their customers were more motivated by cost to repair or replace the boiler.

1.3.2 Savings Potential Analysis

This analysis aimed to quantify the savings potential of replacing the population of natural gas-fired beyond-EUL boilers in Manhattan and the Bronx. A back-of-the-envelope calculation based on data gained from the surveys and interviews, population data from Con Edison and the City of New York, and research into needed parameters was used to develop an estimated potential. There are three findings from this analysis:

- Approximately 2 million therms could be saved in the first year by replacing all beyond-EUL boilers in the population, assuming a code baseline.
- The additional potential savings from using an existing baseline rather than code increases dramatically as baseline efficiency decreases. At minimum, there are 3 million therms of savings assuming a conservative 80% existing efficiency. At 70% efficiency the savings are around 10 million therms.

- Large buildings (≥7 floors) in Manhattan represent the largest potential savings segment, encompassing approximately 60% of the savings.

1.3.3 TRM Impacts

This analysis examined the NYS TRM savings calculation methodologies that may be applied to aging boiler projects and how they impact the savings that can be claimed. The study team built a simple model using an example multifamily building to compare the calculation methods, and also assessed how five TRM revision options would impact savings. There are two findings from this analysis:

1. The Special Circumstances provision has the most potential to aid in targeting this market. However, there may be real or perceived barriers to its use.
2. Out of five potential revisions to the TRM that could increase the savings claimed from this population, the best and most readily implementable one is to increase use of the Special Circumstances provision by revising its requirements.

1.4 Conclusion

The study confirmed Con Edison's suspicion that a portion of its population is continuing to run their boilers well beyond the 25-year EUL. It also estimated the savings opportunity from replacing these boilers and assessed TRM revision options to help target this population. There are three opportunities for additional study that Con Edison may wish to undertake:

- **Opportunity #1:** Assess the current use of the Special Circumstances appendix by the New York utilities and any barriers, real or perceived, to its use. Review the four criteria laid out by the Commission and develop a proposal to streamline and/or create more defined and easily proven requirements.
- **Opportunity #2**: Consider the best method(s) to collect boiler efficiency data, which is needed to accurately characterize the savings potential from the population. This could be done through site visits or by attempting again to partner with the City of New York to gain combustion efficiency data through Local Law 87 or through the Department of Environmental Protection.
- **Opportunity #3**: Work with program staff to include relevant data fields in the incentive application, including efficiency, age, and state (i.e., functioning/nonfunctioning when replaced). This data is useful for boilers but may also be of value for a variety of other measures.

These additional research studies serve both to further Con Edison's goal of reaching these old boilers and in gathering data to strengthen the programs' understanding of the population and its characteristics.

2 Introduction

This section provides a background of the study's motivations, objectives, and limitations.

2.1 Background

Effective useful life (EUL) is an estimate of the number of years a type of equipment is expected to be useful or operational. This is not just a measure of how long the equipment will operate before failing; it also takes into consideration measure persistence, which accounts for other factors such as building turnover or changes of use in that space.

Due to observations and anecdotal evidence from other studies, Con Edison suspects that boilers in New York City are frequently kept in operation beyond their New York Technical Resource Manual (TRM)-deemed EUL, which is 25 years.[1] Boilers that continue to operate beyond their EUL are likely to be less efficient and generate more emissions, which makes them excellent targets for Con Edison energy efficiency programs and the City of New York's programs for reducing greenhouse emissions.

However, because these boilers are beyond their EUL they are considered "normal replacement," and the utility can only claim savings against the code requirements for boilers rather than the existing efficiency. The assumption is that these boilers would likely fail soon or be replaced anyway with a new code-compliant model, and so the program cannot claim that it influenced the changeover. The incentives associated with normal replacement can also only cover incremental costs, or the premium a customer pays for purchasing a higher-efficiency unit. These incentives will therefore be small and not enough to motivate a customer to make such a large investment if their old unit is still running.

Con Edison initiated this study to explore whether the suspicion is true and assess the opportunity to promote the replacement of those old boilers with new, high efficiency units.

2.2 Study Objectives

There are three primary research objectives that this study set out to explore:

1. Investigate the actual age and characteristics of multifamily boilers in NYC.
2. Estimate the potential savings opportunity from beyond-EUL boilers.
3. Compare how current TRM methods and potential changes affect savings.

This study used a three-phased approach to gather and analyze a variety of data sources with the goal of answering these three main objectives. The three phases of the study include:

- ❑ **Phase I: TRM Review** – Document review of the NY TRM and other relevant reports and proceedings on the topic of claiming savings from exceptionally old equipment.

[1] The TRM section on boilers cites six different EULs from 24–35 years depending on the boiler type (pages 98–99). However, the Early Replacement section (Appendix M) collapses these to a single number, 25 (see Table M-1 on page 471). For simplicity's sake, this study uses 25 as the default EUL for boilers.

- **Phase II: Primary Data Collection** – Surveys and interviews with building operators, contractors, and suppliers.
- **Phase III: Analysis** – Calculations and visualizations with the gathered data to answer each of the three study objectives.

Section 3 discusses the methodologies of each phase in greater detail.

2.2.1 Target Segments

Con Edison was interested in studying hot water (HW) and steam boilers in its natural gas territory, which for this study was limited to Manhattan and the Bronx.[2] The target population was multifamily and commercial office buildings, broken into four segments.

1. Multifamily residential buildings ≤ three stories
2. Multifamily/mixed-use buildings ≤ six stories
3. Multifamily/mixed-use buildings ≥ seven stories
4. Commercial office buildings ≥ seven stories

The size cutoffs of these segments were chosen in part by Con Edison due to the impact of building height on distribution systems. For steam systems, buildings will typically have one-pipe systems if there are six or fewer floors, and two-pipe systems for buildings with seven or more floors.

During the project, the four segments were grouped into two larger ones (see Limitations, Section 2.2.3, below). The segments used throughout this report therefore are "small" (buildings six stories or fewer) and "large" (buildings seven stories or greater). Table 2-1 shows the study population broken out by segment and by borough.

Table 2-1. Study Target Population by Segment and Borough

	Manhattan	The Bronx	Total
Small (6 stories or fewer)	5,196	6,076	11,272
Large (7 stories or greater)	2,443	319	2,762
Total	**7,639**	**6,395**	**14,034**

In total, the target population for this study was just over 14,000 buildings.

2.2.2 Limitations

Throughout the course of the study, the team came across three obstacles in data collection that required study redirection and altered the format of the results and conclusions. Con Edison

[2] Con Edison's gas service territory also includes parts of Queens and all of Westchester. However, shapefiles would be needed to determine which buildings in Queens are truly in the service territory, and the publicly available data sets PLUTO and CATS are only available for NYC's five boroughs. There do not appear to be correlated data sets for Westchester. As a result, the study focused on Manhattan and the Bronx.

provided input and direction at each point to ensure that the study's results were valuable to the programs.

1. **Low survey response rate** – After the initiation of the building owner survey in Phase II, it very quickly became clear that the survey would not reach the levels of participation needed to reach 90/10 confidence levels for all four segments. Connecting with the correct contact person was major hurdle, as the survey team often needed to go through multiple layers of gatekeepers. Even when the caller did reach the superintendent's number, they were rarely at their desks and the call went to voicemail instead.
2. **Inability to obtain Local Law 87 data from the Mayor's Office** – Local Law 87 requires all buildings larger than 50,000 square feet to conduct auditing and commissioning activities to help inform building owners of the energy usage. There is also a reporting requirement, which has created a wealth of data regarding the current equipment in large buildings. Con Edison attempted to reach an agreement with the Mayor's Office of Sustainability (MOS) to obtain an extract of this data set, but were ultimately unable to after over a month of effort.
3. **Poor-quality survey responses on efficiency and boiler size** – While most superintendents were able to provide the age of their boilers, few knew the unit's combustion efficiency and input rating off the top of their heads. Only about a quarter of respondents were able to estimate efficiency, and even fewer could provide a size number.

These obstacles impacted the study in several ways:

- **Grouped segments** – Segmenting the study population means that each segment must have enough completed surveys to be statistically representative on its own (i.e., meet 90/10 confidence levels). Due to the low response rates, the four segments were combined into two as described above, and the surveys were refocused on reaching only the small building segments. This was due to the assumption that the team would be able to acquire a richer data set from the MOS for large buildings, which unfortunately did not occur.
- **Large segment confidence level below 90/10** – The study team did not attempt to reach 90/10 confidence on large-building surveys after the scope revision, as the MOS data would have contained data for a census of all in-compliance buildings. When this data set did not materialize, the study team was forced to use the already-completed large-building surveys for the analysis. A sample of 67 would be needed to reach 90/10 confidence; a total of 34 surveys were completed with the large building segments. The results therefore have a 16% margin of error at a 90% confidence interval.
- **Efficiency of existing boilers was estimated** – The lack of data regarding the existing efficiency of the boiler population from the surveys and missing MOS data required the study team to estimate the average combustion efficiency using secondary data sources. The effects of this estimation are discussed more in Section 4.2.2.

These challenges and their impact on the analyses can be assuaged by gathering more data, which Con Edison has indicated it will continue to do. Areas for further research are described in Section 5.

3 EVALUATION METHODOLOGY

The study was intended to answer the three research questions presented in the objectives above and did so through three phases of research spanning document review, data collection, and analysis. Each phase is described in more detail below.

3.1 Phase I: TRM Review

Phase 1 of this study aimed to give the study team an understanding of how savings are currently claimed for measures based on their age, per the TRM, as well as how other entities are grappling with this issue. The main activities included a review of the existing NY TRM and other relevant studies and proceedings. In particular, the study team was investigating whether the TRM's requirements represented a barrier to targeting this population, and if so, what the appropriate changes would be. The relevant areas of the NY TRM that were reviewed included the following:

- **Appendix M: Guidelines for Early Replacement Condition –** This section explains the difference between early replacement and normal replacement as they relate to a piece of equipment's EUL. The dual baseline savings approach is presented for calculating an equipment's lifetime savings based on its age relative to its EUL.
- **Appendix N: Special Circumstances –** This section provides an exception to Appendix M to target older equipment that remains installed and operational. If the equipment is well beyond its EUL and meets other criteria, there is a dual baseline approach that can be used.
- **Appendix P: Effective Useful Life –** This section includes a table of EULs to be used for the different technologies addressed in the TRM.

These different appendices define how lifetime energy savings are calculated relative to different baseline conditions. These scenarios and calculation methodologies are addressed further in Section 4.3.

The study team also reviewed reports and proceedings from other entities who were exploring similar issues. These included:

- **Northeast Energy Efficiency Partnership (NEEP), "Early Replacement Measures Study" –** This study provided insight into how other programs in the Northeast are approaching early retirement versus normal retirement projects. [3]

[3] Evergreen Economics, Michaels Energy and Phil Willems, "Early Replacement Measures Study Phase I and II: A Report to the Regional Evaluation, Measurement and Verification Forum, facilitated by Northeast Energy Efficiency Partnerships," November 4, 2015.

- **California Public Utilities Commission (CPUC), "Early Retirement Using Preponderance of Evidence" –** The CPUC developed this set of guidelines and examples to help programs assess a given project's remaining useful life.[4]

The understanding the study team gained from reviewing the TRM sections and alternative methods for capturing savings associated with these measures was used heavily in assessing potential options for utilizing the TRM to better target the old boiler population.

3.2 Phase II: Primary Data Collection

The bulk of the work on the study occurred during Phase II, which used surveys and interviews with individuals who had firsthand knowledge and experience with boilers within the target population. The goal of the surveys and interviews was to gather data on the ages of existing boilers, their corresponding efficiencies, and the installed costs for new boiler projects.

- **Building operator/superintendent surveys** – Con Edison provided a data set of the target population. ERS drew a sample from this population that was intended to reach 90/10 confidence levels for each of the four building segments. As described above, the segments were later collapsed into the small and large building segments. The study team surveyed a total of 104 building owners and superintendents using computer-assisted telephone interviewing (CATI). Information was gathered on the age and condition of the boilers currently in use, as well as other characteristics of the building and motivations for replacement.
- **Contractor interviews** – ERS built a list of contractors that installed and serviced boilers in multifamily and commercial office buildings in Manhattan and the Bronx by filtering the Con Edison market partner database and conducting additional web research. The resulting list included 75 contractors, all of whom received at least one call from the study team. Twelve contractors completed the interview, which lasted about 20 minutes. They provided perspectives on the age and condition of the boilers they serviced and/or replaced, as well as information on costs to repair and replace boilers.
- **Supplier interviews** – ERS built a list of boiler suppliers or distributors operating in the New York City area by determining the most common boiler makes present in a Department of Environmental Protection (DEP) data set (see Section 3.3.2 below) and researching the distributors for each make. Out of the 20 major suppliers on the original list, 13 of them completed interviews with the study team. The interview questions focused on information about new boilers available on the market, including their efficiencies and costs, and which types were most popular.

Table 3-1 shows a breakdown of the surveys and interviews completed for the study.

[4] Southern California Edison, California Public Utilities Commission, "Early Retirement Using Preponderance of Evidence," Version 1.0, July 16, 2014.

Table 3-1. Surveys and Interviews Completed

Data Source	Quantity Completed
Building operator/superintendent surveys	104
Small buildings (6 stories or fewer)	70
Large buildings (7 stories or more)	34
Market actor interviews	24
Boiler contractor interviews	12
Boiler supplier interviews	13
Total	**129**

The data gathered from these efforts was analyzed in Phase III.

3.3 Phase III: Analysis

Phase III included a set of three analyses that reviewed the primary and secondary data collected in order to answer the three study objectives. Each of the three analyses is described in detail below. The results of each are presented in Section 4.

3.3.1 Survey/Interview Analysis

Once all of the responses were gathered for the building surveys and contractor/supplier interviews, the study team constructed frequency tables for each question to organize the data into a digestible format. The frequency tables were reviewed for initial findings, which guided further analysis. Objectives #1 (boiler age/characteristics) and #2 (savings potential analysis) were heavily informed by the data collected here. When it was appropriate, the study team compared responses regarding the same topic (e.g., age of boiler) across the three primary data collection sources to note similarities and differences in opinions.

The building survey resulted in a wealth of information regarding boiler age and type, but very few respondents were able to identify their boiler efficiency or capacity.

3.3.2 Savings Potential Analysis

The savings potential analysis used a variety of data sources to develop a back-of-the-envelope calculation estimating the savings that could be realized if all natural gas boilers beyond their EUL in Manhattan and the Bronx were replaced. This analysis highlights the importance of the baseline efficiency assumed in the savings calculation. There are four major steps in developing the estimated savings potential:

1. **Population segmentation** – Break down the population based on borough, building size, and boiler type to allow specific assumptions to be applied to more accurate subgroups.
2. **Boiler size regression** – Create a regression using publicly available data that allows boiler capacity to be estimated based on the square footage for each building in the population.
3. **Savings potential assumptions** – Research and define assumptions for equivalent full load heating hours and boiler efficiencies that are applied to each segment.

4. **Savings calculation** – Calculate the potential savings from replacing the population of beyond-EUL boilers using the NY TRM recommended equation.

Each of these four steps are described in greater detail below. Six different data sources were used in developing this analysis, shown in Table 3-2.

Table 3-2. Savings Potential Analysis Data Sources

Entity	Data Set Name	Data Type	Number	Description
ERS	Building survey	Primary	104	Survey of building owners/managers regarding boiler age, type, and efficiency; included strong boiler age data but lacked in regard to efficiency
ERS	Contractor interviews	Primary	12	Interview of boiler contractors servicing MN/BX territory regarding boiler age, type, efficiency, and maintenance
ERS	Supplier interviews	Primary	12	Interview of boiler supplies serving MN/BX territory regarding the boiler market
Con Edison	Con Edison population	Secondary	19,993	List of multifamily heating accounts in MN/BX territory including annual natural gas consumption
City of New York Department of City Planning	Bytes of the Big Apple, Property Land Use Tax Lot Output (PLUTO) data set	Secondary	15,082	Includes detailed information on every building (multifamily or otherwise) within NYC, such as building vintage, class, number of floors, and area
NYC Department of Environmental Protection	CATS data	Secondary	109,133	Building-level data set on the boiler installed – the make, model, size, fuel used, permit filing date – matched to Con Edison population via unique borough-block-lot (BBL) identifier

There are two publicly available data sets from the City of New York that went to this analysis. The first, Property Land Use Tax Lot Output (PLUTO), provides dozens of data fields on every single tax lot (which generally corresponds to a building) in the five boroughs. The second is from the NYC Department of Environmental Protection's (DEP's) Clean Air Tracking System (CATS) program. The DEP mandates that all boilers operating in NYC with an input rating of 350,000 Btu/h or higher need to be registered. The CATS program was set up in 2012 to streamline the boiler registration system by enabling online permit filing. Each row in the data set is a permit, which can be traced back to the buildings filing them.

The combination of primary and secondary data sources provided enough information to conduct an approximate calculation of the savings potential in the beyond-EUL population.

Population Segmentation

The study team segmented the population based on borough, building size, and boiler type to provide specific categories within the population that specific assumptions and factors could be applied to. This segmentation allows the calculation to properly account for specific strengths and weaknesses of different portions of the population. The Con Edison population data set was first matched to the PLUTO data set using the borough-block-lot (BBL) identifier to determine building class, vintage, and area. Buildings with multiple accounts included in the data set were combined to ensure a unique population with no overlaps. There were 15,082 unique BBLs in the population. Certain buildings classes, such as hotels, were filtered out to ensure that the population was accurately representing the targeted multifamily and commercial office sector. Table 3-3 details which PLUTO Building Classes were retained in the population, which represents 14,034 buildings encompassing 645 million square feet.

Table 3-3. PLUTO Building Classes

Building Class	Description
C	Two-family dwellings
D	Elevator apartments
G	Garages & gasoline stations (>=7 stories)[5]
J	Theaters (>=7 stories)[5]
K	Store buildings (>=7 stories)
O	Office buildings (>= 7 stories)
R	Condominiums
S	Residence – multiple use

Once the population was filtered properly, it was segmented into the four segments listed in Table 3-4, which breaks down the buildings by number of floors and borough. The building survey results were segmented in the same manner to determine a unique percentage of buildings that have beyond-EUL boilers.

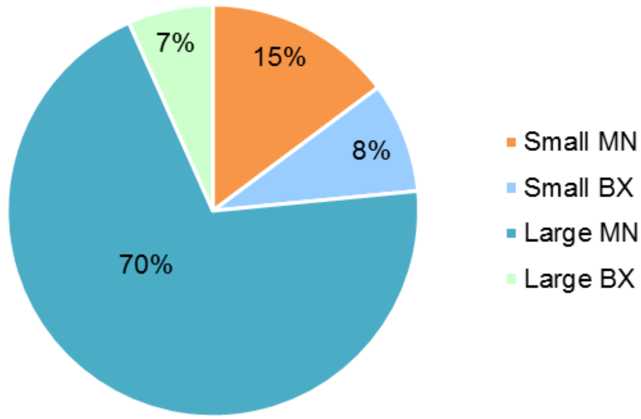
Table 3-4. Population Segmentation

Size	Borough	Sample Size	25+ Years Count	25+ Years %
Small	MN – Manhattan	37	8	21.6%
Small	BX – Bronx	33	4	12.1%
Large	MN – Manhattan	33	7	21.2%
Large	BX – Bronx	1	0	10.0%
Total		**104**	**19**	**18.3%**

The Bronx large building category had a very low representation in the survey results for two reasons: first, there are not many large buildings in the Bronx (this building segment represents only 7% of the square footage in the population, shown in Figure 3-1 below), and second, the survey was refocused on small buildings in anticipation that the study team would be able to use Local Law 87 data for large buildings (described in Section 2.2.2 above). As a result, only one survey was completed with a large building in the Bronx. For the purposes of the analysis, the study team assumed that 10% of the large Bronx buildings were beyond EUL to be in line with the small Bronx segment and represent a conservative estimate. Figure 3-1 depicts the share of each segment's total square footage within the total population.

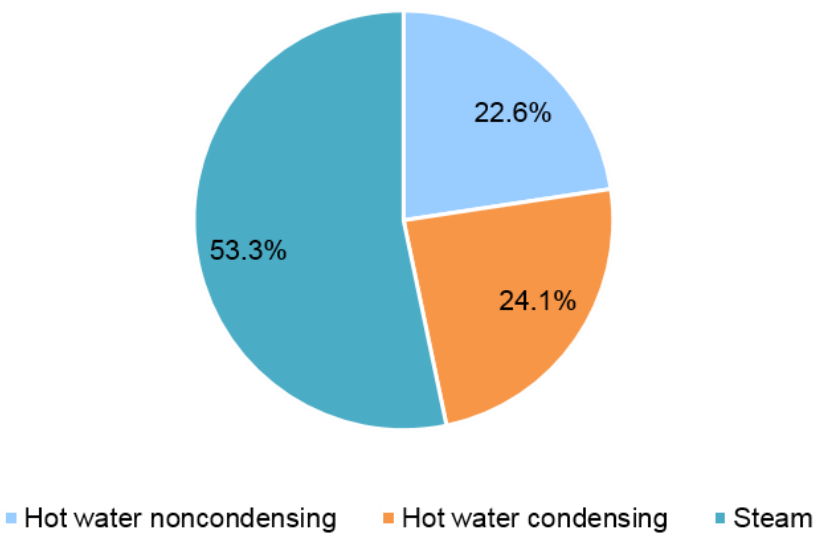
[5] The very few buildings included in this category are within a subcategory deemed by the study team to function as retail or office space.

Figure 3-1. Building Segments by Square Footage



The building survey results, along with input from the contractor and supplier interviews, were further broken down into boiler type segments, including steam, hot water condensing, and hot water noncondensing. These sub-segments were used because each boiler type has different code- and program-required efficiencies. Since condensing hot water boilers operate more efficiently than noncondensing hot water boilers, two segments were created to accurately represent the population in the analysis. The breakdown of the population is shown in Figure 3-2.

Figure 3-2. Boiler Segments by Share of Buildings

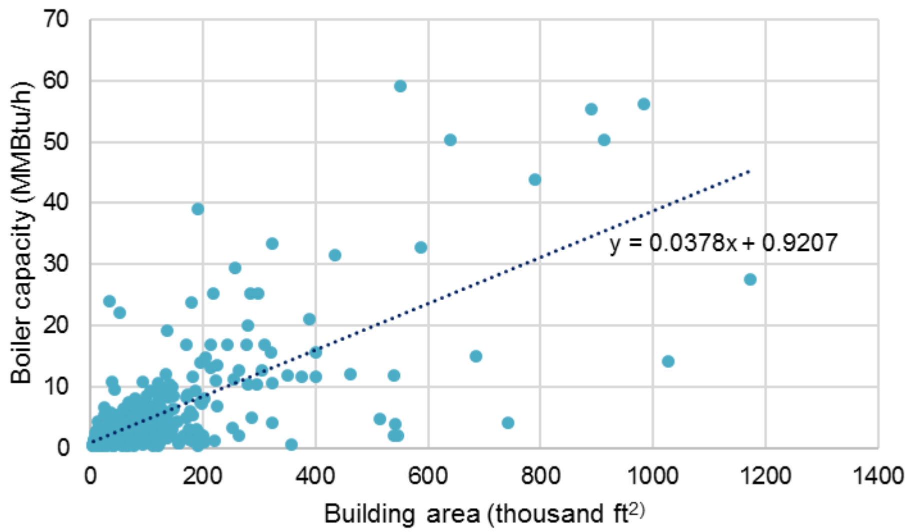


With the creation of separate building and boiler segments, the population was more accurately portrayed in the analysis.

Boiler Size Regression

The study team developed a regression to estimate the boiler capacity of each building in the population based on its area, since the Con Edison population data set did not include information about the boilers in each building. The regression was developed using the publicly available CATS data set, which includes building-level data regarding the boiler registered for that premise, along with the boiler make, model, fuel used, and date of registration. The data on the boilers' sizes was absent from this spreadsheet but could be found when searching for a building address directly through the CATS webpage. To collect the additional data, the study team used a macro to query the boiler's input rating from the CATS webpage and merge the value with the existing CATS data set. The data set was then filtered to include only the relevant building types as described in Section 3.3.2, and cleaned according to the list below. A final sample size of n=748 was used to create the regression of boiler sizes against the building area, shown in Figure 3-3.

Figure 3-3. Boiler Size Regression



In addition to removing data points with missing values, entries were removed from the data set based on several criteria to improve accuracy and ensure correct targeting of the population. The following list explains the methodology and assumptions involved in developing the regression:

- The CATS data set often had multiple entries for a single BBL. While some of the repeats were due to multiple boilers being installed within a given building, others occurred because there were separate entries for permit renewals or cancellations. In the regression, only the permits filed for new boiler installation were used. Because permits for some boilers were renewed multiple times and all boiler capacities within a site were aggregated for the regression, using the boiler permit renewals in addition to the new installations would lead to overestimating the total size. If there were multiple new-installation permits filed in the same BBL, it was assumed that they were all concurrently operational (i.e., the building had multiple boilers) and they were aggregated.

- Although boiler input ratings were supposed to be reported in MMBtu/h, most were up to six orders of magnitude off from an expected range of boiler sizes and were therefore assumed to be reported in Btu instead. The study team converted these values into MMBtu/h for consistency in calculation.
- Entries with gas consumption, boiler size, or building area values in the top and bottom 0.5 percent of the population were dropped from the calculation. This was done to prevent possible errors in DEP data entry from affecting the results.
- To maintain simplicity, a linear relationship was assumed to exist between building area and boiler size. Using a higher order regression did not significantly improve the fit of the regression model. While this is intuitively correct, it may not necessarily be the case, especially for buildings that are in the top 1% of building size.
- Although only boilers greater than > 350,000 Btu/h had to be registered with the NYC DEP, approximately 3% of the boilers in the CATS data set were in the sub-350,000 Btu/h capacity range. These boilers were included in the regression since the study also included buildings at or below three stories (segment #1) that may use smaller boilers.
- To align multiple data sets, the study team used BBL instead of the building's address as the formatting of addresses varied across the data sets. The BBL was used to merge the CATS, Pluto, and Con Edison population data sets to create a consolidated, building-level data set which was then used to regress the boiler size.
- The study team also investigated an alternative approach to conducting the size regression, which would use the annual gas consumption from the Con Edison population data set combined with the building-specific EFLH value to estimate the theoretical size of the boiler installed. This approach led to estimated boiler sizes that were three to four times larger than the capacity values in the CATS data set. The study team was not able to account for the significant difference in sizes, though one possible explanation could be that the consumption data might have included non-heating end uses, such as domestic hot water heating and cooking. Since the CATS data set included actual rather than estimated values, was readily usable, and led to a more conservative calculation of boiler sizing, the regression was built with the CATS data set rather than the Con Edison consumption data.

To ensure that the regression results were reasonably estimating boiler capacities, the study team calculated energy use intensity (EUI) values for each building segment and compared them to the Building Performance Database (BPD) from the Lawrence Berkeley National Laboratory, which has self-reported energy usage and building characteristic data for over 60,000 buildings across the United States.[6] The EFLH discussed in the following section were used to calculate the EUI. The EUIs for each building segment ranged from 20 to 74 kBtu/ft^2,

[6] The Building Performance Database can be accessed here: https://bpd.lbl.gov/

which fall within the expected range of the BPD's EUI distribution for multifamily buildings in NYC and more broadly in U.S. cold climates.

Savings Potential Assumptions

There are two additional data inputs needed to build the savings model: equivalent full-load hours (EFLH) and the combustion efficiency for existing boilers. This section describes the methodology for developing assumptions for each.

EFLH

EFLH values for heating are one of the factors used in the boiler savings potential estimation, which are available in tables in the NY TRM's Appendix G for the New York City metro area. The EFLH values were dependent on the building type, size, and year it was built. The PLUTO data set included the building type, the number of floors, and the vintage under the fields "*BldgClass*,, "*NumFloors*," and "*YearBuilt*," respectively.

Further, for commercial buildings, the EFLH value recommended by the NY TRM is dependent on the type of heating system used – constant air volume (CAV) with economizer, CAV without economizer, or VAV with economizer. Due to the lack of information on the heating system type, the average of EFLH for all three systems was used when necessary.

Once the Con Edison population data set was filtered to only the relevant buildings, the EFLH values were applied by using the logic in Table 3-5.

Table 3-5. EFLH Logic

Pluto Building Class Tag	TRM Category Used	Vintage (Year built)	Number of Floors (Based on TRM definition)	EFLH
C, D, R, S	Multifamily	Pre-war (≤1945)	≤3	999
C, D, R, S	Multifamily	Pre-war (≤1945)	>3	1012
C, D, R, S	Multifamily	1945–1979	≤3	757
C, D, R, S	Multifamily	1945–1979	>3	526
C, D, R, S	Multifamily	1979–2006	≤3	723
C, D, R, S	Multifamily	1979–2006	>3	395
C, D, R, S	Multifamily	2007–present	≤3	503
C, D, R, S	Multifamily	2007–present	>3	219
G, J, K	Large retail	N/A	>3	1599
O	Large office	N/A	>3	1466

N/A: Not applicable

Boiler Efficiency

Regarding existing boiler combustion efficiency, this is a key input as it determines the potential savings from replacing the boiler with a code-compliant unit versus a high-efficiency unit. As described in Section 2.2.2, the study team was unable identify a reliable source of information to determine a current operating efficiency for the population of beyond-EUL boilers. The savings potential calculation therefore used an 80% existing baseline combustion efficiency. This assumption aligns with the NYC requirement that all gas-fired boilers must operate at a minimum of 80% efficiency. ERS recognizes that this is likely higher than the actual operation of the population based on data from the contractor interviews (see Section 4.1.1) and discussions with Con Edison, but it is a conservative estimate to base the calculations on.

To explore this, the team attempted to calculate an average existing building combustion efficiency using a degradation factor equation for boilers from NREL's "Building America Performance Analysis Procedures for Existing Homes" document. The equation is:

$$AFUE = (Base\ AFUE) \times (1 - M)^{Age}$$

where,

$Base\ AFUE$ = Typical efficiency of pre-retrofit equipment when new

M = Maintenance factor = 0.005 for annually professionally maintained gas boilers (0.015 for not-well-maintained boilers)

Age = Age of equipment in years

Assuming that annual professional maintenance is conducted, the team ran a back-of-the-envelope calculation that showed that the beyond-EUL boiler population's average operating efficiency is likely to be in the range of 71%–73% at age 25. Continued operation past that point would further decrease the efficiency unless part of the boiler is replaced or rebuilt. To recognize the potential for boilers operating well below the 80% assumed efficiency, the team ran the full savings potential model with differing levels of average combustion efficiencies. The effects of this assumption are discussed more in Section 4.2.2.

Con Edison's program requirements for boiler efficiency were used as the installed efficiency in the savings potential analysis. Some boilers will operate with higher efficiencies than what the program requires, but these requirements provide a conservative estimate. The program requires slightly higher efficiency standards for large boilers (greater than 2,500 kBtu/h), and thus the boiler type segments were broken down into size categories. Table 3-6 lists the code and program-required efficiencies used in the calculation.

Table 3-6. Code and Program-Required Efficiencies

Boiler Type	Boiler Size	Code Efficiency	Program Efficiency
Hot water (HW) noncondensing	Small	83%	85%
HW noncondensing	Large	85%	88%
HW condensing	Small	83%	90%
HW condensing	Large	85%	93%
Steam	All	80%	82%

Savings Calculation

First, the study team determined ways of creating building and boiler segments, a way of estimating the boiler input rating via a regression, the logic to assign EFLH values, and assumptions on combustion efficiency for boilers (existing, code, and high-efficiency). Then these determinations were used to build the full calculation.

The savings calculation was based on the NY TRM's recommended equation to calculate natural gas savings for a boiler replacement measure.

$$Savings\ (therms) = Units \times \left(\frac{kBtu/h_{in}}{unit}\right) \times \left(\frac{\eta_{EE}}{\eta_{BL}} - 1\right) \times \left(\frac{EFLH_{heat}}{100}\right)$$

The study team adjusted the equation to fit the characteristics of the data set.

- The boiler capacity of each building (kBtu/h_{in}) was estimated based on its area using the boiler regression.
- The first portion of the equation, boiler capacity multiplied by EFLH divided by 100, was calculated for each building and then summed for each building segment of the entire population.
- The EUL percentage and boiler segment percentage factors were then applied to each building segment.
- Finally, the baseline and installed efficiency assumptions were applied.

The adjusted equation used is thus:

$$Savings(therms) = \sum\left(\frac{kBtu}{h_{in}} \times \left(\frac{EFLH_{Heat}}{100}\right)\right) \times Building\ segment\ EUL\ \% \times Boiler\ segment\ \% \times \left(\frac{\eta_{EE}}{\eta_{BL}} - 1\right)$$

The results from the savings potential analysis are discussed in Section 4.2.

3.3.3 TRM Scenario Analysis

The study team created a simple model to determine the energy savings that could be claimed under the three different approaches as defined by the NY TRM. The goal of this exercise was to understand how the program currently claims savings for boiler projects under the existing TRM calculations, how that is impacted by the boiler's age, and what the effects would be if the calculation rules were modified.

A typical multifamily building was modeled, based on the survey and interview responses received as part of this project. The characteristics of the building and boiler types that were used in the model include the following:

- Six-floor multifamily building
- Steam boiler
- 1,055 kBtu input

- 80% existing boiler efficiency (conservative estimate based on NYC requirements – see discussion under Boiler Efficiency in Section 3.3.2)
- 80% code baseline efficiency (per NY TRM)
- 82% installed boiler efficiency (the minimum efficiency for a steam boiler to participate in the Con Edison multifamily program)

This boiler project was then evaluated assuming that all variables remained constant except for the boiler age. The model assessed differences in the TRM calculations used if the boiler was 20, 30, or 40 years old – both below and above the EUL. The study team also assessed the impact that different options for adjusting the TRM savings calculations or requirements would have on the savings. The results of this modeling are explained in further detail in Section 4.3.

4 Analysis Findings

This chapter describes the findings for each of the three analyses based on the three original research objectives:

1. Investigate the actual age and characteristics of multifamily boilers in NYC.
2. Estimate the potential savings opportunity from beyond-EUL boilers.
3. Compare how current TRM methods and potential changes affect savings.

Each is covered in detail below.

4.1 Boiler Age and Characteristics

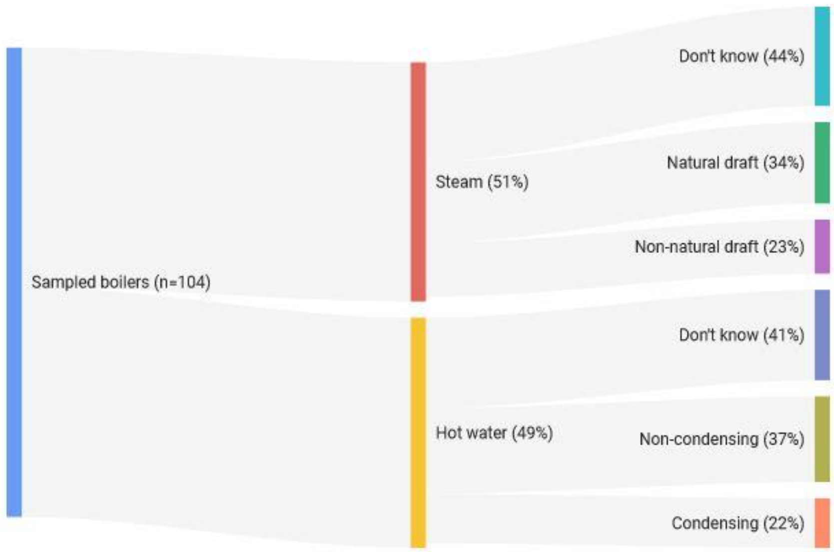
Objective One: Investigate the actual age and characteristics of multifamily boilers in NYC

A key goal of the study was to investigate the suspicion that boilers in NYC are being run beyond their EUL. The team gathered data about the ages of boilers in multifamily buildings in NYC by surveying 104 buildings in Manhattan and the Bronx and by analyzing age based on several other factors (location, size, etc.). The 12 contractor interviews also provided perspectives on age. In addition, the surveys and interviews also garnered perspectives on what the expected ages of boilers are and customers' motivations for replacing them early. Findings for each of these topics are covered in more detail below.

4.1.1 Boiler Characteristics

The surveys asked some general questions about the building's boilers, including their class and type. Figure 4-1 shows the survey population by distribution medium (steam vs. hot water) and class.

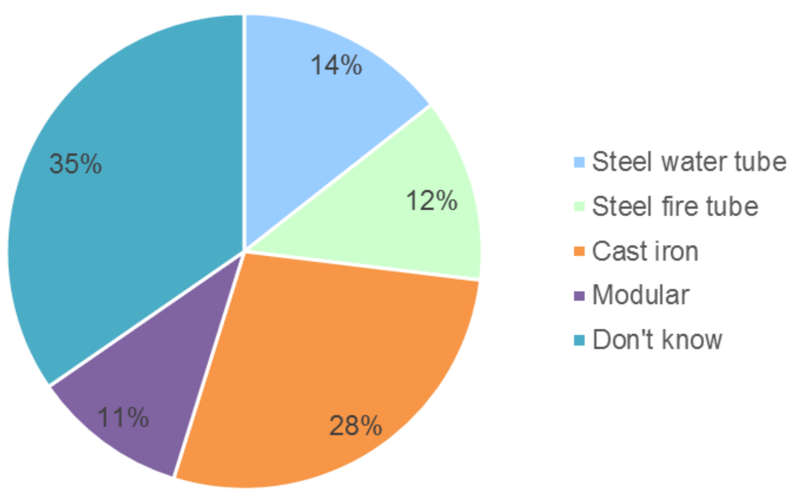
Figure 4-1. Boiler Classes



The buildings in the sample were split roughly evenly between steam and hot water for distribution. Large buildings tended a little more towards hot water (56%) and small buildings tended a little towards steam (54%).

The boiler structure is one of four main types – steel water tube, steel fire tube, cast iron, or modular. The distribution is shown in Figure 4-2.

Figure 4-2. Boiler Types



Cast iron boilers, which anecdotally have a reputation for being semi-indestructible if well-maintained, make up the largest percentage of boilers in the population. Steel water tube boilers were more likely to be seen in the large-building segment, but the other types do not show substantial differences. Small buildings were also less likely to know what their boiler type was.

Since the TRM breaks out different EULs by boiler type, this is also discussed further in Section 4.1.2 below.

In terms of servicing, 56% indicated that they had a contractor do regular maintenance on the boiler, while 41% indicated that the building's internal staff did the servicing. A slightly greater percentage of large buildings had contractors (59%).

Efficiency

The combustion efficiency of the boiler impacts how much energy the unit uses, and therefore how much the customer pays to operate it. Understanding the efficiency of the existing population is also necessary for estimating the savings from replacing the boiler with a new, more efficient one – the subject of the savings potential analysis in Section 4.2. However, building operators were unlikely to know the efficiency of the boiler off the top of their heads; only 29% of the 104 buildings surveyed could give a range. Due to the low response rate, the data is not included here. Contractors were able to give a better estimate of the percentage of boilers they serviced in each efficiency range, shown in Table 4-1.

Table 4-1. Contractor Estimates of Boiler Efficiencies

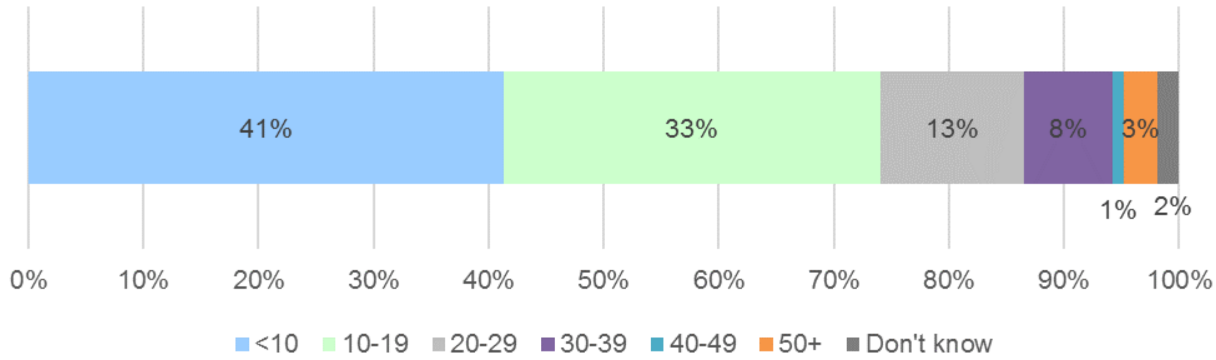
Multiple Choice	Percentage
<70% efficient	18%
71%–80% efficient	35%
81%–85% efficient	40%
86%–90% efficient	6%
>90% efficient	1%
Total	**100%**

The DEP's combustion efficiency rules require an 80% combustion efficiency, proof of which must be submitted every 3 years when the building reapplies for a permit. However, the data from the contractors seems to indicate that this is not well met or enforced; in aggregate, they estimated that 53% of boilers have an efficiency of 80% or lower, with 18% less than 70% efficient. This data is not statistically representative (and was not intended to be, since it was provided through interviews), but it anecdotally points to a large opportunity to replace inefficient boilers.

4.1.2 Age

Out of the 104 building operators surveyed, 102 provided data about the age of their boilers. The distribution, broken up into 10-year increments, is shown in Figure 4-3.

Figure 4-3. Age of Multifamily Boilers in NYC



The boiler population in the sample is overall fairly young, with 74% under 20 years old. The average age was 14.3, and the median is 11. There are two major NYC policy events within the last decade that could have impacted this population. First, in 2010 Local Law 43 required that all buildings burning No. 6 fuel oil for heating must convert to cleaner sources (natural gas or No. 4 or 2 fuel oil) by 2015. No. 4 fuel oil will also be phased out by 2030.[7] The City announced in 2016 that all 5,300 buildings previously burning No. 6 fuel oil had successfully converted.[8] Second, the NYC Department of Environmental Protection (DEP) set an 80% combustion efficiency requirement for natural gas boilers and mandated annual testing, submitted once every 3 years, in 2014.[9] Both of these policy changes may have spurred boiler retirements as buildings sought to comply with the new rules. The survey provided evidence of this: 23% of the operators who had replaced a still-functioning boiler in the last 10 years said that it was due to city laws or codes. This is discussed more in Section 4.1.4 below.

Although the boilers in the building sample overall are young, there are still clearly boilers being operated beyond their EUL; 18% of boilers in the survey are over 25 years old. 12% of them are older than 30 years. Of these beyond-EUL boilers, 79% of them are in Manhattan. Figure 4-4 shows a distribution of boiler age by building segment and borough. All three segments are roughly the same size (n= 33–37).

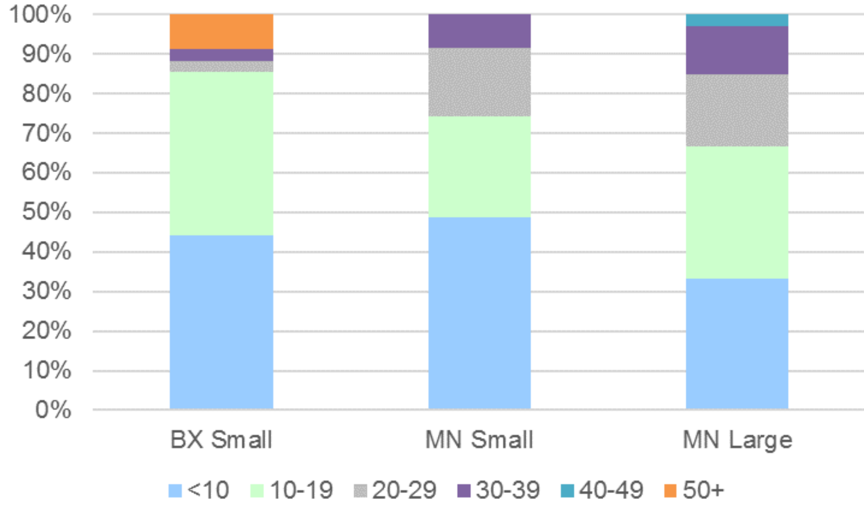
---

[7] Local Law 43, "To amend the administrative code of the city of New York, in relation to the use of clean heating oil in New York City," accessed at www.nyc.gov/html/dep/pdf/air/ll43.pdf.

[8] Office of the Mayor press release, "Mayor de Blasio and DEP Announce that All 5,300 Buildings Have Discontinued Use of Most Polluting Heating Oil, Leading to Significantly Cleaner Air," February 9, 2016. Accessed at http://www1.nyc.gov/office-of-the-mayor/news/152-16/mayor-de-blasio-dep-that-all-5-300-buildings-have-discontinued-use-most-polluting.

[9] Department of Environmental Protection, "Promulgation of Revised Chapter 2 of Title 15 of the Rules of the City of New York," accessed at www.nyc.gov/html/dep/pdf/air/engineering-criteria.pdf. The Urban Green Council (a chapter of the U.S. Green Building Council) has an explanation of the rule here: http://urbangreencouncil.org/content/proposals/expand-boiler-efficiency-testing-tuning.

Figure 4-4. Boiler Age by Building Segment and Borough

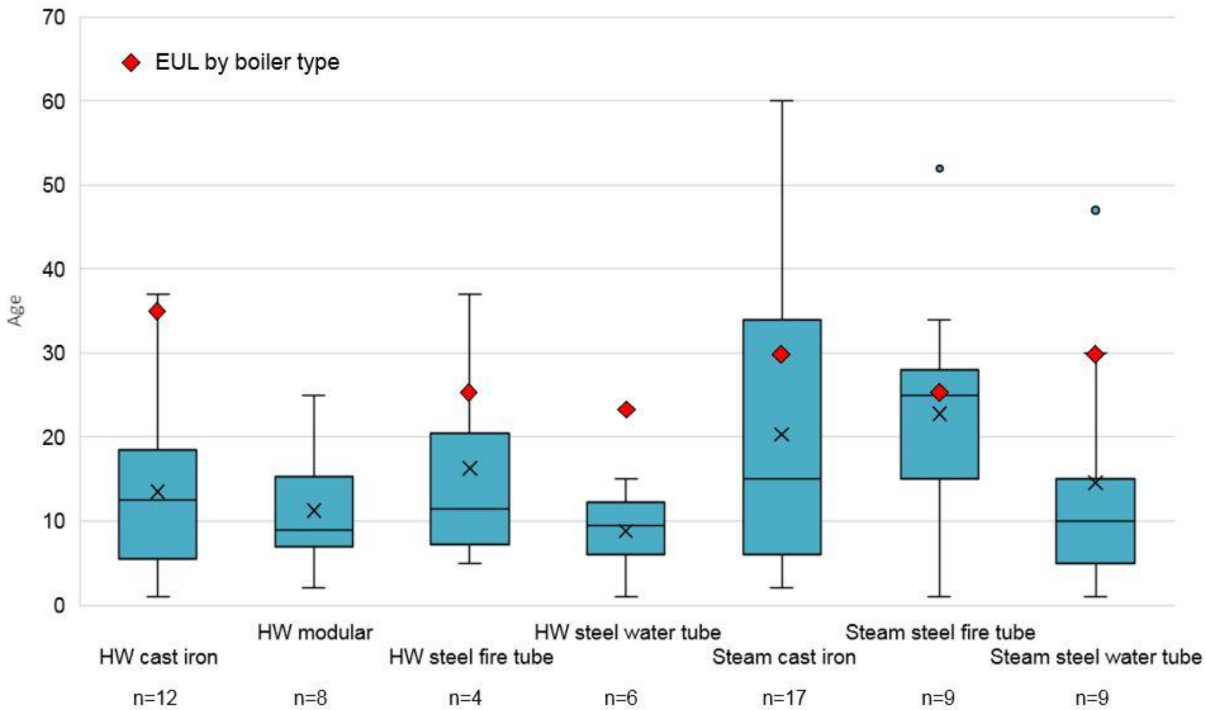


There is not a substantial difference in age between the building sizes in Manhattan; 22% of the small buildings (six or fewer stories) had boilers over 25 years old, compared to 21% in large (seven or more stories) buildings. However, the small building class had a much higher percentage of boilers younger than 10 years – 44% and 49% in the Bronx and Manhattan small segments, respectively, compared to 33% for the large Manhattan segment. The Bronx overall had a much smaller percentage of beyond-EUL boilers: 12%, compared to 21%–22% for Manhattan. However, the three absolute oldest in the surveys – which were 52, 56, and 60 years old – are all in the Bronx. The overall younger population in the Bronx could indicate that the logistical barriers of replacing a boiler in a dense urban area are major for Manhattan but less so for the Bronx. The oldest boilers there may instead be more affected by a lack of capital.

The study team also investigated age by boiler type, which is an important characteristic in the usage and expected life. The TRM provides six separate EULs by boiler type ranging from 24–35 years, which are collapsed to 25 for use with the early replacement and special circumstances calculations. Figure 4-5 below shows a comparison between the age distributions by boiler type and the TRM EUL values. The box-and-whisker plot shows the age quartiles from bottom-to-top for each boiler type, with the youngest 25% represented by the lower whisker and oldest 25% represented by the upper whisker. The box shows the middle 50% of the population by age; the bar across the middle represents the median age. The X represents the average. Two of the boiler types have outliers, or boilers that are much older than the rest of the population.[10] Finally, the red diamond shows the TRM-established EUL value for each boiler type. There is no TRM EUL value for hot water modular boilers.

[10] Statistically, an outlier is defined as a value that is greater than 1.5 times the interquartile range, which is the middle 50% of the population.

Figure 4-5. Age and EUL by Boiler Type

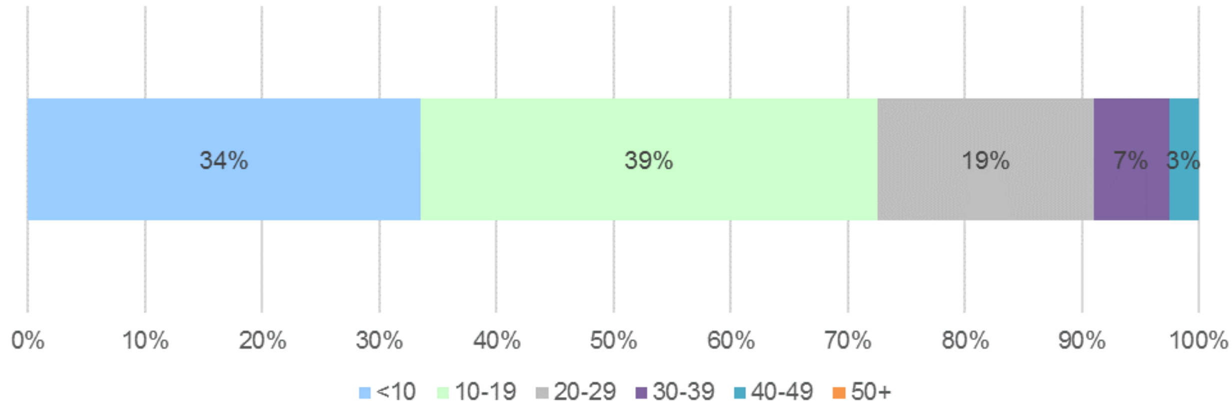


There is minimal correlation between the actual age of the boilers in the sample and their expected age as denoted by the EUL. One might expect that a boiler type with a higher EUL might have an older population than one with a lower EUL, but this is not true across the types.

Contractor Perspectives

The contractors were also asked to estimate the percentage of boilers they serviced in each decade age range. The result, shown below in Figure 4-6, is very similar to the distribution provided by the survey (Figure 4-3 above).

Figure 4-6. Contractor Estimate – Age of Multifamily Boilers in NYC



The contractors tended to estimate fewer buildings in the under-10 range than the survey sample, and more in the 10–19 and 20–29 ranges.

4.1.3 Expected Age

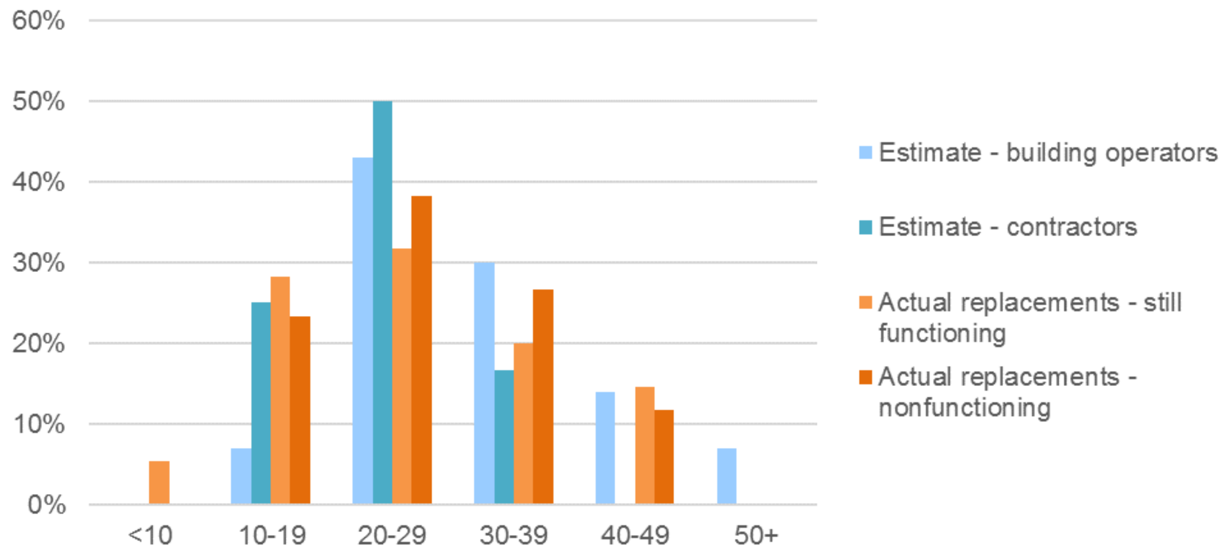
The study team asked several questions of building operators and contractors to assess how long they expected boilers to continue to operate. First, both building operators and contractors were asked to estimate the boiler's useful life:

- **Survey** – The respondent was asked to estimate how much longer they expected their boiler to run. The number was added to the age of their existing boiler to estimate the boiler's expected life.
- **Contractors** – Contractors were asked to estimate the average life of a boiler in NYC. Most gave a 5-year range, which was aggregated.

The contractors also provided estimates of the percentage of boilers that they had replaced for six age ranges, broken into still functioning and nonfunctioning (broken) when replaced. This provides another estimate into how long boilers actually operate in the field.

The distribution of responses is shown below in Figure 4-7. Estimations of expected life are shown in blue, and actual ages of replacements are shown in orange.

Figure 4-7. Estimations of Expected Life



The two estimated life distributions (shown in blue) are the most comparable; perhaps unsurprisingly based on economic motivations, building operators tended to think that their boilers would last longer than the contractors thought they would. The orange distributions, which shows the percentage of still-functioning broken boilers replaced at each age range, provides an actual comparison. Clearly, there are boilers being run beyond their EUL; an estimated 38% of the replaced-on-failure boilers were over 30 years old. For all four questions, though, the median and most common answer was between 20 and 29 years.

4.1.4 Customer Motivations

The building surveys included several questions to assess customers' motivations for replacing their boilers. The question differed slightly based on the boiler's age and state:

- Boilers less than 10 years old and not functioning at time of replacement (replace on failure, n=13): What were the most important factors in your decision to replace the old equipment rather than have it repaired?
- Boilers less than 10 years old and still functioning at time of replacement (early replacement, n=13): What were the most important factors in your decision to replace the old equipment when you did rather than wait until it broke down?
- Boilers greater than 10 years old (n=65): What are some of the factors that are most important in your decision to eventually replace your current boiler?

The five most common responses and the percentage of answers for each is shown in Table 4-2 below.

Table 4-2. Customer Motivations for Boiler Replacements

Replace on Failure (n=13)		Early Replacement (n=13)		Still Functioning (n=65)	
Broken/not worth fixing	38%	Reliability	23%	Efficiency/energy bills	31%
Reliability	31%	Fuel switching/city codes	23%	Reliability	17%
Efficiency/energy bills	15%	Repair/maintenance costs	23%	Broken/Not worth fixing	12%
Repair/maintenance costs	15%	Efficiency/energy bills	15%	Want current equipment	11%
		Want current equipment	15%	Cost of new unit	9%

The deciding factors for each customer's decision depends on the timing. A building with a boiler that breaks in the middle of the heating season does not have the luxury of time that a building looking to the future might, and the motivations change accordingly. Of the customers who had failed boilers, 38% indicated that they couldn't repair the equipment or it was essentially "totaled"; their decision was made for them as the boiler couldn't be repaired.

However, two factors were key for all three groups: reliability – or a concern that the boiler might break during the heating season – and efficiency/energy bills.

Contractors were asked a similar set of questions to assess why customers might choose to replace a failed boiler or replace it early. They saw repair/maintenance costs as the biggest deciding factor for their customers: how much would it cost to repair the boiler and continue to operate it, rather than replacing it. Reliability and energy efficiency were also mentioned, but costs came first.

4.1.5 Conclusions

This analysis aimed to study the age and characteristics of multifamily boilers and answer the motivating question of this study: are boilers being used beyond their EUL? There are five takeaways from this analysis:

1. The overall boiler population is young, possibly due to recent increases in NYC's requirements for fuel oil and combustion efficiency that spurred replacements.
2. Nearly a fifth of the boilers in the survey are older than 25 years old and over EUL.
3. Manhattan has the overwhelming majority of beyond-EUL boilers, but the Bronx has the oldest on an absolute basis.
4. Contractors and building operators estimate a boiler's life to be between 20 and 29 years.
5. Reliability and efficiency/energy bills were the two most-cited reasons for replacing boilers from building operators; contractors thought their customers were more motivated by cost to repair or replace the boiler.

4.2 Beyond-EUL Boiler Savings Potential

Objective Two:
Estimate the potential savings opportunity from beyond-EUL boilers

Using the methods and data sources described in Section 3.2, the study team conducted a back-of-the-envelope calculation to estimate the potential savings that could be realized by replacing all beyond-EUL boilers in the population. This calculation only represents the potential from replacing boilers 25 years or older, roughly 18% as determined by the building surveys. Table 4-3 compares the characteristics of the whole population to those of the portion of the population that is representing the beyond-EUL segment.

Table 4-3. Population Characteristics

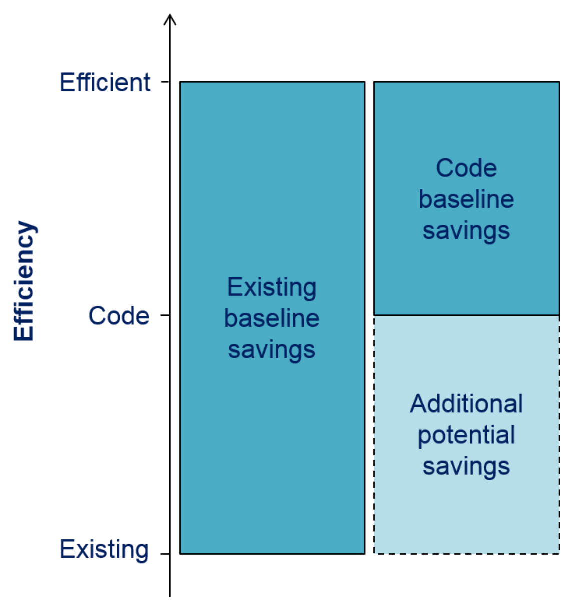
Characteristic	Total Population	Beyond-EUL Population
Number of buildings	14,034	2,410
Building area (ft^2)	644,912,986	120,297,638
Annual gas consumption (therms)	267,635,317	47,662,257
Total boiler capacity (kBtu/h)	37,293,338	6,765,178
EUI (kBtu/ft^2)	39	38

The savings potential for the beyond-EUL population is discussed below.

4.2.1 Savings Potential Results

There are two different levels of savings depending on which baseline is used, which the model calculated separately. These levels are illustrated in Figure 4-8.

Figure 4-8. Additional Savings Potential



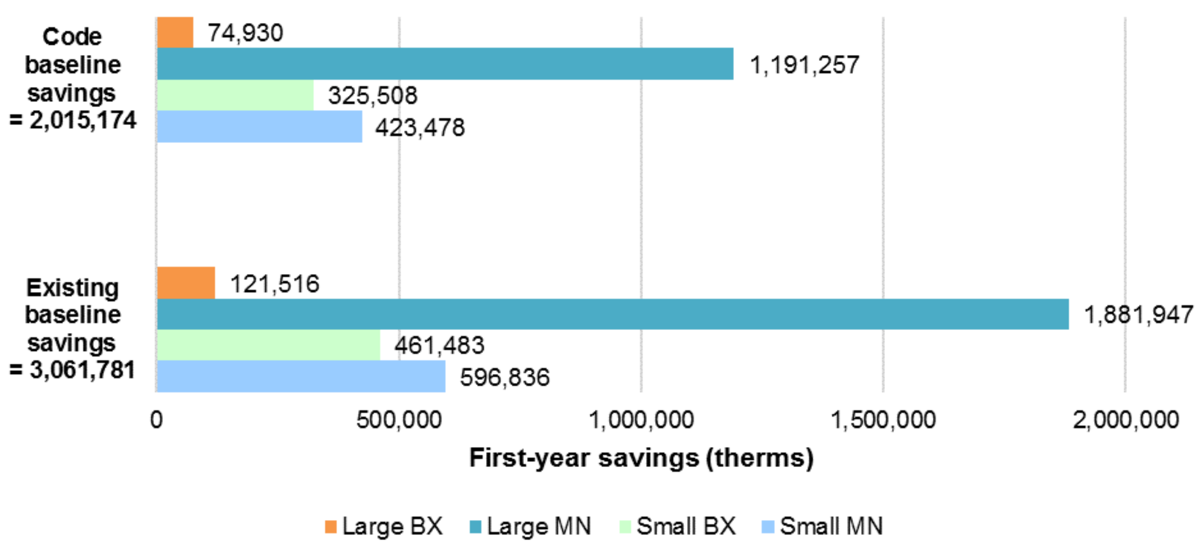
The potential savings depends on which baseline is being used. A code baseline allows the utility to claim savings for a new high-efficiency unit over the minimum code-compliant efficiency; an existing baseline allows the utility to claim savings from the existing efficiency, which is generally lower than code and therefore yields greater savings. The circumstances under which each efficiency is used are based on the TRM and are discussed in much greater detail in Section 4.3.

The first-year savings potential, in therms, are shown in Table 4-4 and presented graphically in Figure 4-9. This analysis assumes an existing boiler efficiency of 80%.

Table 4-4. Potential Savings from Beyond-EUL Boilers

Building Size	Borough	Code Baseline	Existing Baseline	Difference (Additional Savings)
Small	Manhattan	423,478	596,836	173,357
	Bronx	325,508	461,483	135,975
Large	Manhattan	1,191,257	1,881,947	690,690
	Bronx	74,930	121,516	46,585
Total		**2,015,174**	**3,061,781**	**1,046,607**

Figure 4-9. Savings Potential Results



There is a minimum of just over 2 million therms in savings from replacing all beyond-EUL boilers in Manhattan and the Bronx with new high-efficiency boilers using a code baseline (the TRM's default method). This is equivalent to approximately 4.2% of the beyond-EUL boiler population's gas consumption or about $2 million in gas savings for those customers on aggregate annually. Using an existing baseline adds another 1 million therms of savings and another 2.2% of the annual gas consumption. The largest potential by far is in the Large Manhattan segment, which represents 70% of the population's square footage and 59%–61% of the savings (depending on code or existing baseline).

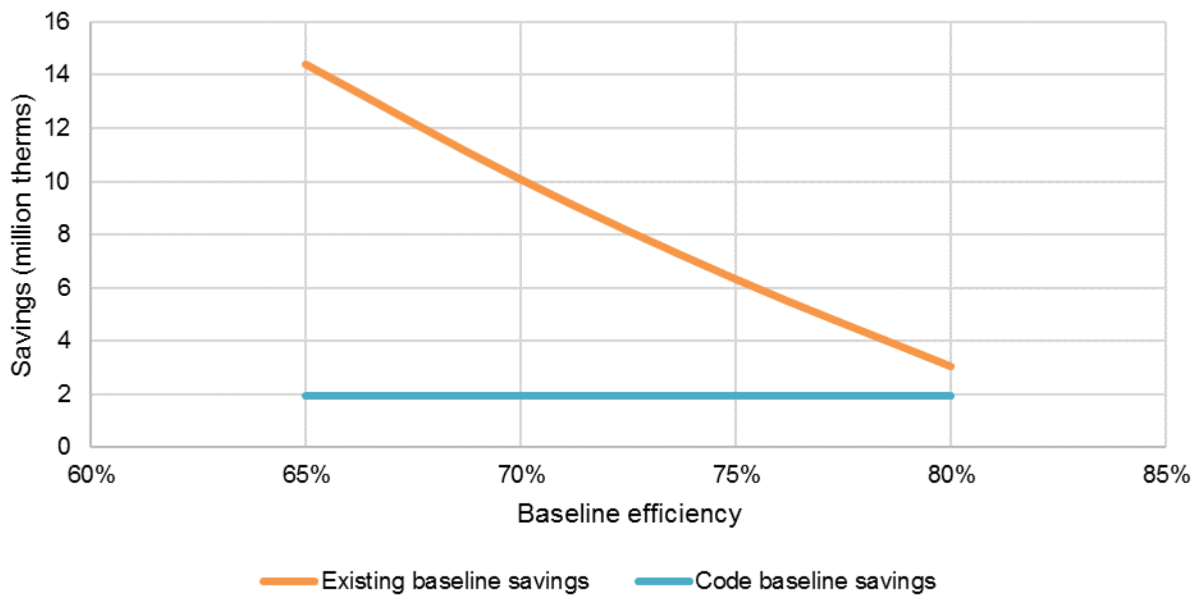
4.2.2 Existing Efficiency Impact on Savings

The results presented in Section 4.2.1 are calculated assuming an 80% existing efficiency. This was a conservative estimate to base the calculations on due to the study team's inability to gather statistically representative efficiency data from the building surveys, Local Law 87, or other sources. It also corresponds with the DEP requirement that all natural gas boilers in the city operate at least at 80% efficiency. However, several pieces of data from interviews and industry research point to the potential that the average existing efficiency of boilers in NYC may be well below that point.

- As discussed in Section 4.1.1, the contractors noted that 53% of boilers they serviced and 63% of the boilers they replaced are at or less than 80% efficient.
- A back-of-the-envelope calculation using an NREL degradation factor for boilers estimated the average combustion efficiency of a 25-year-old boiler to be between 71%–73% (see Section 3.3.2 for the analysis methodology).

Figure 4-10 depicts how the potential savings increase as the assumed existing efficiency decreases, which covers a range of nearly 12 million therms.

Figure 4-10. Potential Savings vs. Baseline Efficiency



Note that the savings claimed under a code baseline are independent of the existing combustion efficiency – it will be a steady 2 million therms. However, additional savings from using an existing baseline range from 1 million to 12 million additional therms, depending on the average efficiency. Based on the trend depicted in Figure 4-10, if the existing efficiency of the population is more properly represented by a value near 70%, then an existing baseline will yield about 10 million therms in savings. If a code baseline is used, there will be no difference – the savings potential will remain at 2 million therms.

4.2.3 Conclusions

This analysis aimed to quantify the savings potential of replacing the population of natural gas-fired beyond-EUL boilers in Manhattan and the Bronx.

There are three takeaways from this analysis:

1. Approximately 2 million therms could be saved in the first year by replacing all beyond-EUL boilers in the population, assuming a code baseline.
2. The additional potential savings from using an existing baseline rather than code increases dramatically as baseline efficiency decreases. At minimum, there are 3 million therms of savings assuming a conservative 80% existing efficiency. At 70% efficiency, savings are around 10 million therms.
3. Large buildings (≥7 floors) in Manhattan represent the largest potential savings segment, encompassing approximately 60% of the savings.

Given the importance of having a good estimate of baseline efficiency to more accurately predict the savings potential, Con Edison should consider conducting additional research to gather this data. This is discussed further in Section 5.1.

4.3 TRM Impacts

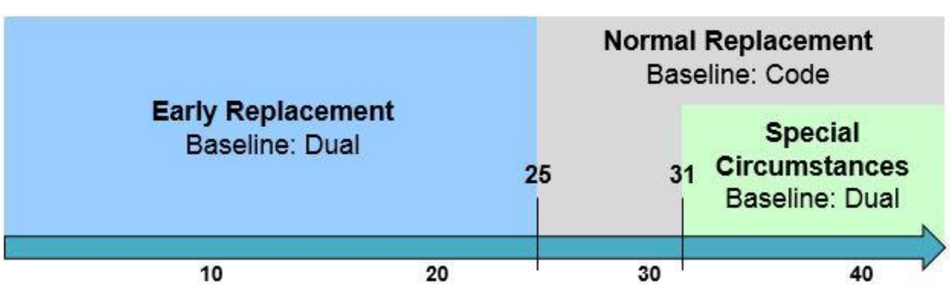
Objective Three: Compare how current TRM methods and potential changes affect savings

This analysis was built on the understanding of the TRM algorithms developed during the Phase I activities, as well as some of the other entities that are grappling with similar questions on "indefinite life" measures. The team then built a simple model to assess savings under current TRM algorithms and to show how adjusting those calculations would impact savings.

4.3.1 Calculation Scenarios

Under the current TRM, there are three different scenarios for calculating savings. The scenarios differ mostly in their definition of a baseline, or what savings can be claimed against. Which scenario a measure must use is dependent on its age relative to the EUL. The three scenarios and the age ranges are illustrated in Figure 4-11.

Figure 4-11. Scenarios for Calculating Boiler Savings



The list below presents some further details on how these three scenarios are used.

- **Early replacement** (Appendix M, page 466) – Per the NY TRM, early replacement is "the replacement of equipment before it reaches its EUL." This includes the replacement of boilers that are still operational, where first-year savings can be calculated relative to the existing baseline conditions. Lifetime savings are calculated with a "dual" baseline: savings can be claimed against the existing baseline for the number of years left in the old boiler's useful life (the remaining useful life, or RUL), and then against code for the remainder. Eighty-two percent of the boilers in the building sample were younger than EUL and could qualify as early replacement if they are still functioning.
- **Normal replacement** (Appendix M, page 466): Normal replacement includes projects where the boiler has reached the end of its EUL and savings are calculated relative to a code baseline. The rationale is that the boiler would be replaced soon with a new code-compliant boiler anyway irrespective of the programs; as a result, the utility can only claim incremental savings, or the difference between the code boiler and the program-influenced efficient boiler. Savings are claimed against code for first-year savings and lifetime savings. Eighteen percent of boilers in the building sample were older than EUL and would be considered normal replacement.
- **Special circumstances** (Appendix N, page 516): The "special circumstances" approach was developed by the Commission for measures similar to the ones targeted in this study: equipment that is well beyond its EUL but would continue to operate indefinitely. The customer would most likely choose to continue to repair the boiler rather than replace it. The equipment must be at least 125% of the EUL (31 years for a boiler) and meet three other criteria regarding energy usage, a history of patching and repairing, and a provision that the next repair would likely cost less than replacing it.[11] If these criteria are met, the program can capture savings against an existing baseline for 25% of the boiler's EUL (called the default functional period, or DFP), and savings against code for the remainder of the new boiler's EUL. Twelve percent of the boilers in the building sample were older than the special circumstances age requirement and could qualify if they meet the additional requirements.

The differences among these three scenarios are illustrated below.

4.3.2 Boiler Modeling – Impact of Boiler Age on Savings

To understand the impacts of the different savings calculation methodologies, a typical multifamily boiler project was modeled where only the age of the existing boiler varied. Other variables, such as existing boiler input, efficiency, and EFLH, remained constant (these variables

[11] The exact criteria listed in the TRM are: "1) Equipment age significantly exceeds its effective-useful-life; 2) Energy consumption significantly exceeds that of current high efficiency models; 3) There is a history of significant repair or replacement with used equipment; and 4) The prospective next repair or replacement is likely to be much less expensive than replacement with new higher efficiency machinery." See Appendix N, page 516 for more detail.

are listed in the methodology section, 3.3.3). This allowed the team to determine the impact that boiler age has on how much first-year and lifetime savings the program can capture. Table 4-5 shows the potential claimed savings for the boiler at different ages.

Table 4-5. Boiler Age & Corresponding Savings

	Example #1	Example #2	Example #3	Example #4
Boiler age	20 years	30 years	40 years	40 years
TRM scenario used	Early replacement	Normal replacement	Normal replacement	Special circumstances
Years of existing baseline	5	0	0	6.25
Years of code baseline	20	25	25	18.75
First-year savings (therms)	547	267	267	547
Lifetime savings (therms)	8,075	6,673	6,673	8,426

The differences in savings for these examples are due to which baseline is used: an existing baseline will allow the program to claim 547 therms per year of savings, compared to 267 for a code baseline. Note that the existing baseline assumes a conservative 80% existing boiler efficiency, and therefore savings will be greater if the efficiency is lower. The 20-year-old boiler in example #1 is under its EUL, and so as long as it is still functioning it can be considered early replacement. It receives an existing baseline for first-year savings and for its RUL (5 years) for lifetime savings. The 30- and 40-year old boilers are treated identically by the TRM's traditional methods: both are beyond EUL and thus are considered normal replacement. They take a code baseline for first-year savings and for all 25 years for lifetime savings. However, the 40-year-old boiler could be eligible for special circumstances if it meets the other three criteria listed in Appendix N. If it does, then the boiler receives savings against an existing baseline for the DFP (25% of the EUL, or 6.25 years) and a code baseline for the RUL. Special circumstances can therefore be a powerful tool for claiming savings for boilers that are 31 years or older and meet the other criteria. However, it is unclear if utilities are currently using the special circumstances method or have tried in the past.

4.3.3 TRM Revision Options

The team also explored five potential TRM revisions and how they might impact savings, shown in Table 4-6.

Table 4-6. TRM Revision Options

Revision	Population Affected	Impact	Notes
1. Increased EUL	All	Increases period that boiler could qualify for ER; increases lifetime savings for all	The study data did not support such a drastic change at this time.
2. Decreased SC age criteria[1]	Boilers aged 25-31	Allows boilers between 25 and 31 years old to qualify for SC	The current SC criteria are for "very old" measures that have proven they can continue to operate, but they do leave an arbitrary gap between 25 and 31 years where all measures are considered normal replacement.
3. Increased SC default functional period (DFP)	SC boilers (31+)	Increases lifetime savings for SC boilers	Currently 25% of EUL in NY; may be 33% in CA. To change, need to understand where 25% came from and the data needed to change it
4. Decreased SC requirement burden	SC boilers (31+)	Decreases barrier to using SC/increases participation	Three of the four criteria for eligibility are not clearly defined; the uncertainty may preclude utilities from using SC.
5. Site-specific EUL	All	Allows customer to claim ER by demonstrating that they would have continued to use the boiler	Recommended by the NEEP Early Replacement study and the method for CA's Early Replacement Using Preponderance of Evidence guidelines. However, this method is cumbersome, as it essentially turns each project into a custom one.

[1]SC = Special circumstances; ER = Early replacement

The five options studied by the study team are not equally attractive. First of all, programs claim only first-year savings, and so methods that allow boilers to claim first-year savings against an existing baseline are of most interest. Table 4-7 shows which scenarios would allow boilers to claim an existing baseline for first-year savings, provided that the boiler is still functioning.

Table 4-7. Eligible for First-Year Existing Baseline

Scenario	<25	25–31	>31
Current TRM			
Early replacement	Yes	No	No
Special circumstances (SC)	N/A	No	Yes
Potential TRM revisions			
1. Increased EUL	Yes	Yes	No
2. Decreased SC age criteria	N/A	Yes	Yes
3. Increased SC default functional period (DFP)	N/A	No change	No change
4. Decreased SC requirement burden	N/A	No change	No change
5. Site-specific EUL	Yes	Yes	Yes

N/A= Not applicable

Option #1, increasing the EUL for boilers by creating a metro NYC-specific EUL, is the broadest and bluntest instrument. It increases the period wherein a boiler would be eligible for early replacement and increases lifetime savings for all boilers, as savings would be claimed for 30 years, for example, instead of 25. The data gathered in this study does not support such a change; the median age of the population, which is one method of calculating EUL, is well below the current EUL. Market actors and building operators also believed their boilers to last between 20 and 29 years, which is in line with the current EUL.

The next three options all consider the special circumstances methodology.

- Option #2 would decrease the age criteria, currently set at 125% of EUL. This would only apply to boilers between 100 and 125% of EUL, or 6% of the buildings surveyed in this study. This is a lower priority option.
- Option #3 would increase the DFP, or the period that a special circumstances boiler can claim savings against an existing baseline. This is currently set at 25% of EUL, although it is unclear how that number was set and if it is the right one. California uses a 33% DFP, and others may be considered. This only impacts the lifetime savings, however, and since programs claim first-year savings, this is also lower priority.
- Option #4 does not change the amount of savings claimed, but it would aim to make use of the special circumstances method easier. Out of the four criteria listed in Appendix N, only one – the age requirement – is clearly defined with a measurable cutoff. The remaining three criteria are somewhat ambiguous, and this may represent a barrier to using special circumstances because utility companies are not sure what the Department of Public Service Staff will accept as evidence. The utilities could therefore develop guidance for the remaining criteria and/or explore whether some of the criteria can be removed. This is most likely the best option, especially in the short term.

Option #5, creating a site-specific EUL, is one way of reaching this beyond-EUL population. California uses this method in its "Early Retirement Using Preponderance of Evidence" guidance, and the NEEP Early Replacement study also recommends this method. However, it is burdensome: each site must prove that the boiler would continue to operate for a certain number of years, and this essentially turns the project into a custom project. The utilities are unlikely to choose this route.

4.3.4 Conclusions

This analysis examined the NYS TRM savings calculation methodologies that may be applied to aging boiler projects and how they impact the savings that can be claimed. There are two findings from this analysis:

1. The special circumstances provision has the most potential to aid in targeting this market. However, there may be real or perceived barriers to its use.
2. Out of five potential revisions to the TRM that could increase the savings claimed from this population, the best and most readily implementable one is to increase use of the special circumstances provision by revising its requirements.

These findings lend themselves to further research and action, with the following recommendations:

- Assess how frequently special circumstances is used in New York, what the use cases are, and what barriers exist.
- Review the four special circumstances requirements and propose ways to define, streamline, or reduce the criteria.

This is discussed further under “Areas for Further Study” in Section 5.1 below.

5 CONCLUSION

This study set out to investigate the age of multifamily boilers in New York City compared to the TRM's EUL value, estimate the potential savings from the replacement of beyond-EUL boilers, and assess the ability to claim savings from this population given the TRM's calculation methods. There are three major conclusions from this effort:

1. The NYC boiler population is fairly young, possibly because of recent regulations on fuel oil and combustion efficiency. However, roughly one-fifth of the boilers are greater than 25 years old. The vast majority of these boilers are in Manhattan.
2. There is at least 2 million therms in savings potential should every beyond-EUL boiler be replaced with a new high efficiency boiler, assuming that savings are only claimed above code. However, the actual potential may be much higher using an existing rather than a code baseline, which also increases as the existing efficiency assumed decreases.
3. The Special Circumstances section in the TRM was designed for old measure populations such as this one, and it has the potential to allow utilities to better target these older boilers. It may require additional guidance or streamlining to be fully usable.

As it gathers additional data, Con Edison will be able to revisit these findings.

5.1 Areas for Further Study

The collected data and analysis for this study can be considered a "phase one" for the broader goal of targeting the old boiler population. There are three areas of additional study that Con Edison could undertake in furthering this goal:

- ❑ **Special Circumstances –** The TRM's Special Circumstances appendix offers a way to claim additional savings for old measures and could be the key to targeting this population. However, it is unclear if it is used at all, and what data would be needed to support applications given its somewhat ambiguous requirements.
  - ➢ **Opportunity #1 –** Assess the current use of the Special Circumstances appendix by the New York utilities and any barriers, real or perceived, to its use. Review the four criteria laid out by the Commission and develop a proposal to streamline and/or create more defined and easily provable requirements.
- ❑ **Efficiency data –** This study was unable to gather data on existing boiler combustion efficiency due to reasons presented in Section 2.2.2. However, to accurately characterize the savings potential from the population, efficiency data is needed.
  - ➢ **Opportunity #2 –** Consider the best method(s) to collect boiler efficiency data. Site visits to directly measure boiler combustion efficiency or collect copies of the building's efficiency test records would yield accurate data for a sample of the population but could be expensive. The City of New York collects data on combustion efficiency in two places: first, the DEP requires that combustion efficiency data be included when the building reapplies for its boiler permit every three years. Second, compliance reports for Local Law 87, gathered by the Mayor's

Office of Sustainability, likely contain this data for buildings over 50,000 square feet. The City shares Con Edison's goal of moving the old boilers out of the market as they are likely to be the most emitting, and the City may be willing to partner in the long run.

- **Program data –** Boilers can receive funding through prescriptive or custom programs for Multifamily and C&I. It does not appear that data about the existing boiler to be replaced is currently being captured by the programs, but this represents a great opportunity to gather information about existing boilers.
    - **Opportunity #3 –** Work with program staff to include relevant data fields in the incentive application, including efficiency, age, and state (i.e., functioning/non-functioning when replaced). This data is useful for boilers but may also be of value for a variety of other measures.

There is one other program design option that the Con Edison multifamily program might consider in the meantime. Similar to how residential recycling programs offer "ugliest fridge" contests, the multifamily program could run an "oldest boiler" contest. Buildings could submit information about the age and efficiency of their boilers and win bonus incentive funding to help them replace the boiler. This would serve to gather some data about the old boilers in NYC, and it could also help generate customer interest. Although this study did not investigate the socioeconomic status of residents in the buildings that contain old boilers, it is not difficult to imagine that low-to-moderate income buildings may be disproportionately represented in the old boiler population. Access to capital could represent a major issue for these buildings, leading them to continually patch the boilers instead.

These additional efforts will help Con Edison in developing a strong case for the Commission on how to use the TRM to best target the old, inefficient boiler population and in starting to design offerings geared towards them.