Census of Massachusetts

MULTIFAMILY BUILDINGS

(RES 43)

Prepared for:
The Electric and Gas Program Administrators of Massachusetts
Part of the Residential Evaluation Program Area

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EXECUTIVE SUMMARY

The Census of Multifamily Buildings (RES 43) study (the study) focused on identifying the population of multifamily buildings in Massachusetts, as well as the subset of this population that are condominium (condo) buildings. Multifamily buildings, for the purposes of this study, are defined as having five residential units or more. The census also focused on characterizing interactions of these properties with Mass Save initiatives.

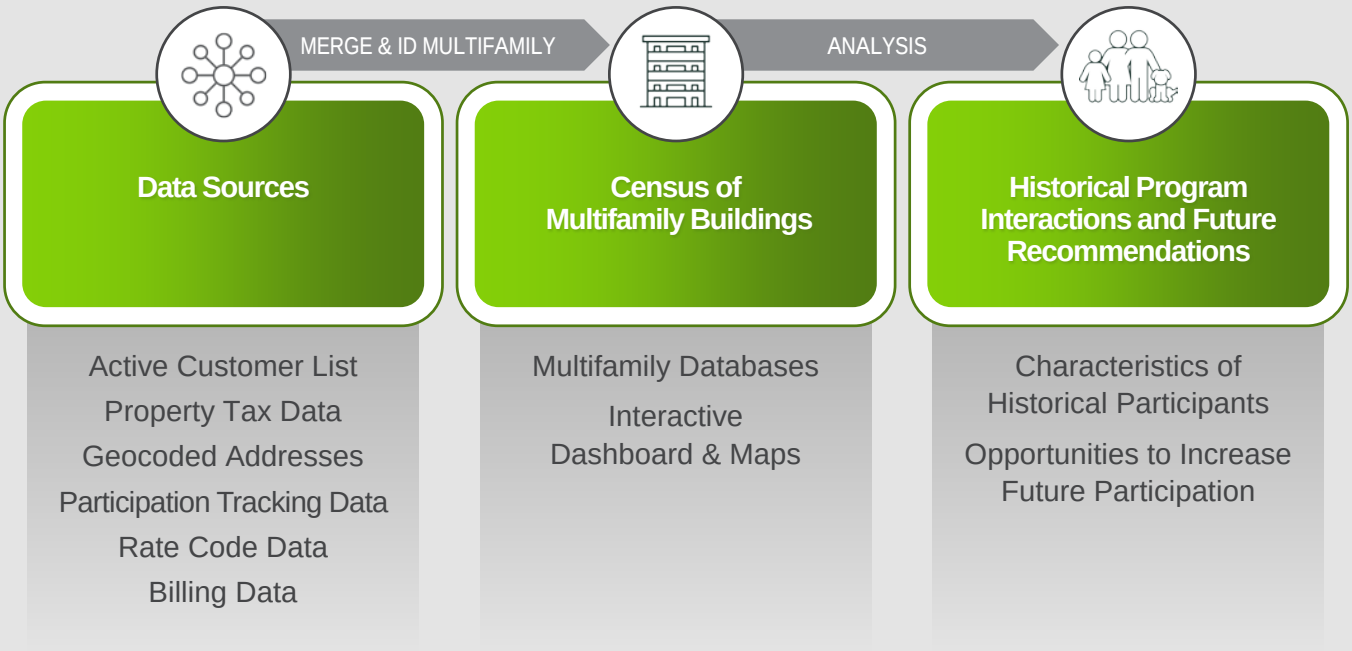
This study had two main objectives:

1. Identify multifamily properties in Massachusetts and characterize any past program interactions with this population.
2. Analyze this compiled building data to identify opportunities for customized multifamily program delivery strategies to maximize energy savings.

Figure ES-1 depicts the study's process. The study team first merged a compiled active customer lists (ACLs) for all program administrators (PAs) with various data sources, creating an augmented ACL. The study team then analyzed this ACL to identify multifamily addresses. This analysis produced a multifamily building database, which the team explored to understand trends in past participation and identify future opportunities.

Not every account in the multifamily database has complete information, which must be considered when interpreting this analysis. The current study shows that the multifamily database provides a useful tool for exploring the multifamily population across the state and can be updated in the future to further increase its accuracy and completeness.

FIGURE ES-1. ANALYSIS METHODOLOGY FOR RES 43



Source: Navigant Analysis

Data Sources and Health

For this study, DNV GL served as the data management team and compiled several sets data submitted by PAs for Navigant, including:

- Residential ACL (snapshots of customer accounts from Q4 2015 to Q4 2016)
- Commercial and Industrial (C&I) ACL (snapshot of active accounts in 2017)
- Property tax data (most recently updated in 2017)
- Geocoded address data (most recently updated in 2017)
- Participation tracking data (program years 2013 through 2016)
- Rate code data (most recently updated in 2017)
- Billing data (years 2013 through 2016)

The study team merged these data sources to produce an augmented ACL with characteristics for each customer. Each customer in the ACL was matched with one or more available data sources depending on data availability. For example, because there is no direct link between the ACL and property tax data, the data management team for the Residential sector, DNV GL, applied a methodology to match customers between these sources based on address match, address proximity, and/or customer name.

Table ES-1 summarizes the data health of the residential ACL after merging the data sources, specifically listing the number and percentage of records in the ACL that were successfully matched with records in each other data source. Twenty-six percent of records in the residential ACL were found in the participation tracking data; those customers who were not found in the tracking data were assumed to have not participated between 2013 and 2016. Fifty-six percent of all records matched with all data sources, excluding participation tracking data. Participation tracking data was excluded from this calculation as many records may not have participated and would not be present in the tracking data.

TABLE ES-1. SUMMARY OF DATA HEALTH FOR MERGED RESIDENTIAL ACL DATASET

Data Source	Years Represented	Residential ACL Records Matched
Entire Residential ACL	2015 – 2016	3,886,915
Property Tax Data	2017	2,891,176
Geocoded Address Data	2017	3,718,098
Rate Code Data	2017	3,670,724
Billing Data	2013 – 2016	2,921,904
Complete (Matched to all Sources Except Participation Tracking)	-	**2,160,170**
Participation Tracking Data	2013 – 2016	997,405

Source: Navigant Analysis

Table ES-2 summarizes the data health of the C&I ACL, listing the number and percentage of records in the ACL that were successfully matched with records in each other data source, including the residential ACL. Only forty-six percent of available C&I accounts were successfully matched with the residential ACL, which can be explained by these factors:

- C&I accounts were matched to the residential ACL by associating accounts from both databases that were successfully matched to the same property tax parcel. As a result, seventy-four percent of the residential ACL was successfully matched with property tax data and 26% of residential ACL accounts could not be matched with the C&I account database.
- The C&I account database was based on 2017 data, while the residential ACL represents accounts from 2015-2016. As a result, some of the accounts in the C&I account list could be matched to a more recent residential ACL but not the version used for the current study.

Forty percent of all records matched with both billing data and the residential ACL. Participation tracking data was excluded from this calculation as many records may not have participated and would not be present in the tracking data.

TABLE ES-2. SUMMARY OF DATA HEALTH FOR C&I ACL

Data Source	Years Represented	C&I ACL Records Matched
C&I ACL (associated with residential locations)	2017	120,501
Property Tax Data	2017	120,501
Billing Data	2013 – 2016	102,274
Residential ACL	2015 – 2016	55,426
Complete (Matched to all Sources Except Participation Tracking)		**48,178**
Participation Tracking Data	2013 – 2016	37,380

Source: Navigant Analysis

Census of Multifamily and Condo Properties

RES 43 focused on identifying properties that RES 43 focused on identifying multifamily buildings with five residential units or more. The study team used the following definitions:

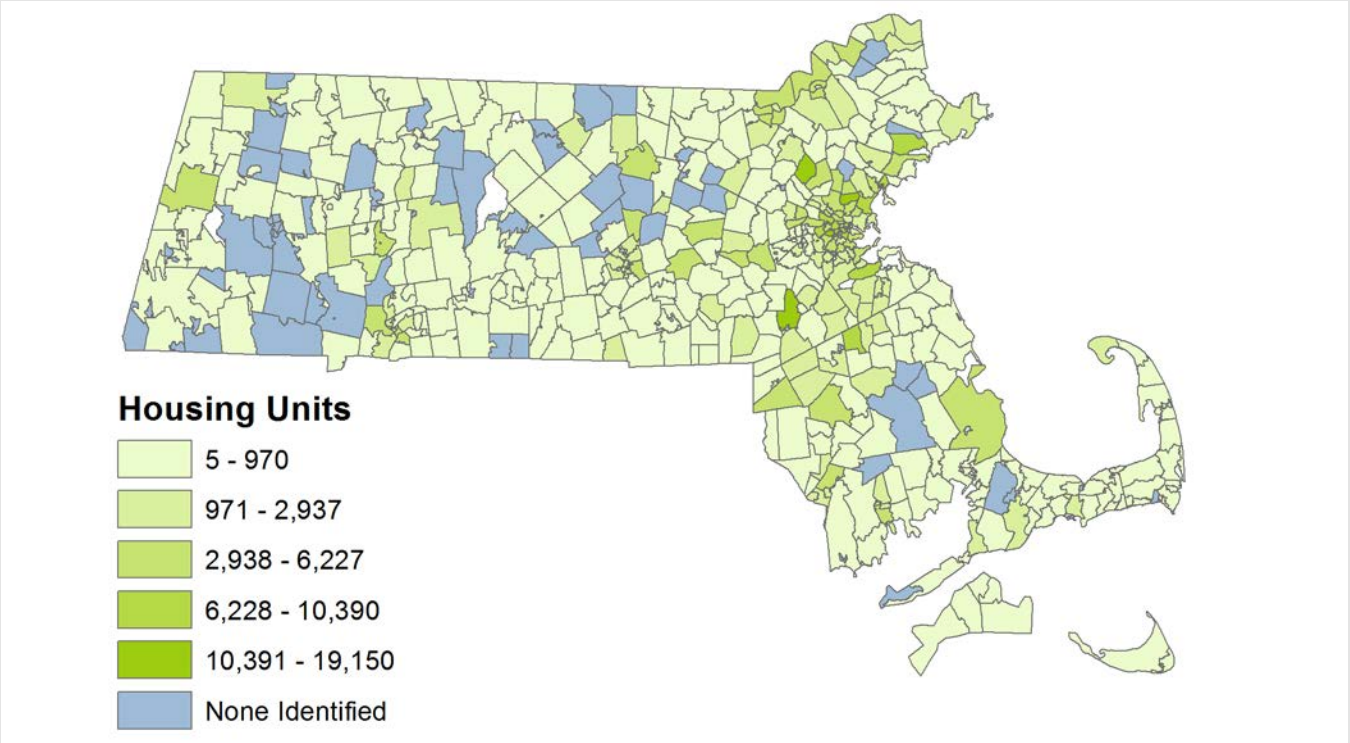
- Building – a single address that may have one or more electric or gas accounts
- Property – a group of buildings that are centrally managed that comprise multiple addresses and normally one tax parcel

The study team determined whether each address in the ACL was multifamily using several criteria:

- Has five or more housing units at the address
- Has a property tax use code indicating a multifamily building with five or more housing units
- Historically participated in a multifamily program
- Has one or more accounts under multifamily-specific rate codes

Using these criteria, the study team developed a multifamily building database and an interactive dashboard containing a series of maps that illustrate the geographic location of multifamily properties in Massachusetts. The study team identified 37,751 multifamily buildings statewide, representing 611,381 housing units. Of interest among all multifamily buildings are condo properties, where individual housing units may have multiple different owners. The team identified 6,713 condo buildings with five or more units, representing 111,005 housing units, or roughly 18% of the total. Figure ES-2 shows the distribution of multifamily housing units by ZIP code throughout the state.

FIGURE ES-2. DISTRIBUTION OF MULTIFAMILY HOUSING UNITS BY ZIP CODE

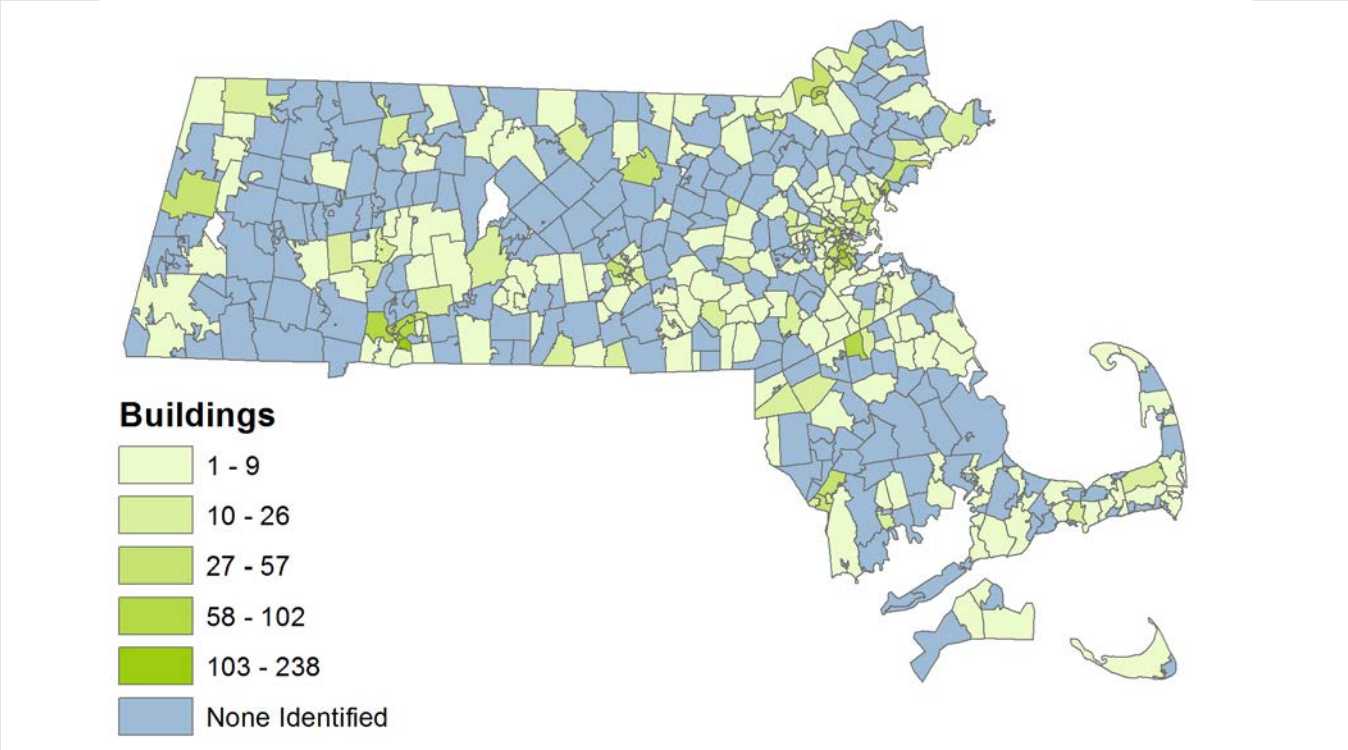


Source: Navigant Analysis

The multifamily databases also contain various characteristics for each property. The study team classified the number and location of buildings by the number of housing units, meter type, fuel type, income level, ownership (i.e., condo vs. apartment), and seasonality. Although the study team lacked account-level income data to fully identify all low-income properties, we were able to identify low-income addresses based on other criteria including low-income rate codes, previous participation in a low-income program, ownership by a housing authority, and subsidized housing tax use codes.

Figure ES-3 shows the geographic distribution of low-income properties throughout the state. Identified low-income buildings make up 10% of all multifamily buildings. Due to incomplete data, the study team cannot estimate what portion of the remaining 90% of properties would qualify as low-income. To provide additional low-income context we added a field to the multifamily database that indicates the percentage of the population in the block group containing each address that has income less than 200% of the poverty line.

FIGURE ES-3. DISTRIBUTION OF LOW-INCOME MULTIFAMILY BUILDINGS BY ZIP CODE

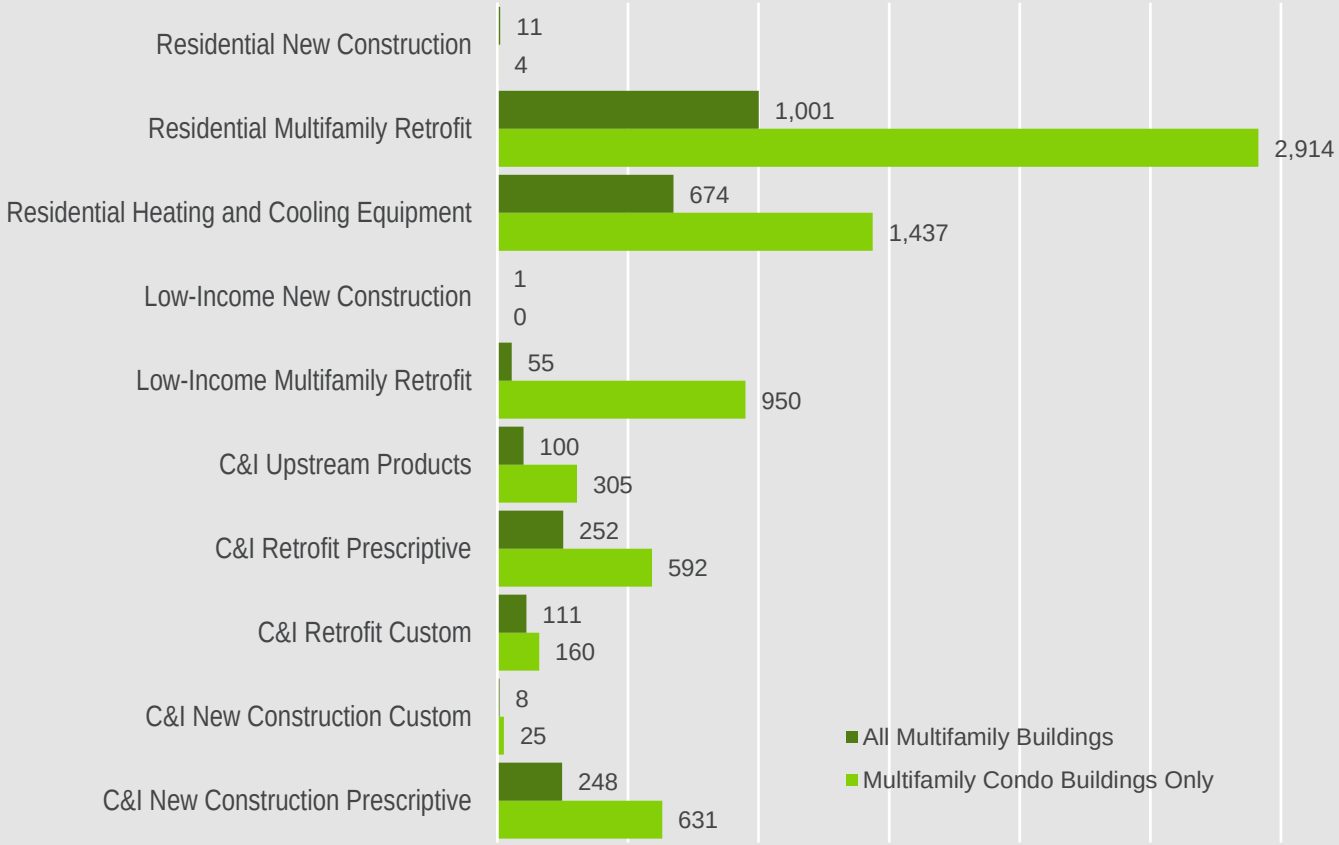


Source: Navigant Analysis

Historical Program Interactions

The study team analyzed the historical participation of low income and market rate multifamily buildings in relevant multifamily programs. The programs and years considered were based on data available at the time of the analysis, namely participant tracking data for 2013-2016. The number of buildings that participated in each program is shown in Figure ES-4.

FIGURE ES-4. MULTIFAMILY BUILDING PARTICIPATION BY PROGRAM



Note: The participant building in the Low-Income New Construction program is in the 'All Multifamily Buildings' group

Source: Navigant Analysis

Summary

The census of all multifamily properties and the analysis of historical program interactions identified geographic areas and customer segments that show opportunity for improving participation based on 2013-2016 participation data. As new questions emerge, and program needs evolve, the multifamily database can be used to explore characteristics of these properties and gain new insights. Based on its analysis, the study team identified potential strategies that PAs can consider :

1. **CONTINUOUS IMPROVEMENT OF THE MULTIFAMILY DATABASE AND DASHBOARD.** The current multifamily database could be regularly refreshed with updated and more complete data sources, such as active customer lists, property tax data, participation data, and billing data. The team has returned PA specific databases to each PA, who can incorporate this data into their systems to flag multifamily accounts. With the database itself can be further refined. Such refinements could include grouping unique addresses into multifamily properties by synthesizing geographic, tax, and PA account data. The PowerBI dashboard could be further developed into an online tool to provide quick access for the PAs to important metrics.

2. **MULTIFAMILY PROPERTIES COMPRISED OF MULTIPLE BUILDINGS.** The team identified many buildings that were not confirmed to have more than 5 units, but have participated in multifamily programs. These buildings may be part of properties that consist of multiple centrally managed buildings that are treated as multifamily by PAs; and/or the current process was not able to identify all of the units in the building. Future research could better identify this population.

3. **TARGET AREAS FOR NEW PARTICIPANTS.** The multifamily database can be used to explore and find smaller buildings and areas with multifamily buildings to target. There are also several geographic regions in Massachusetts that have a significant number of identified multifamily buildings that may not have participated. Such cities/regions offer a valuable opportunity to market multifamily programs. These areas could be further explored for new participants.

4. **FUEL TYPE.** The study team had limited information regarding fuel type, but identified that approximately 54% of buildings had both electric and gas service. Additionally, as much as 32% of multifamily buildings may use delivered fuels. Importantly, this percentage likely includes buildings that utilize electric resistance heat or heat pumps and should be considered as an upper bound. Further investigation into the types of heating systems that are installed in multifamily buildings could inform strategies to tailor incentives around fuel type and improve the success of engaging these customers.

5. **LOW-INCOME PROPERTIES.** While the study team was able to identify some low-income properties based on rate code and past participation, there are likely additional low-income properties that have not been identified in the database. This gap could be addressed by utilizing the low-income block group information in the multifamily database to identify areas with higher low-income populations that could be explored to find new participants. Further identifying such low-income properties would enhance the PAs' ability to serve these customers.

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1. INTRODUCTION

The Census of Massachusetts Multifamily and Condo Properties study (the RES 43 study or the study) focused on identifying the population of multifamily properties in Massachusetts, as well as the subset of this population that are condominium (condo) properties. For the purposes of this study, multifamily buildings were defined as having five residential units or more. The census also focused on characterizing interactions of these properties with Mass Save initiatives.

In the spring of 2016, Navigant conducted a collaborative workshop with Home Energy Services and multifamily stakeholders to determine how evaluation could assist the program administrators (PAs) in implementing the best possible program to serve the multifamily market. Through these discussions, it was clear that the PAs wanted to obtain a holistic understanding of the composition of multifamily and condo buildings in Massachusetts and the extent to which past program activities had served these markets. For example, the PAs wanted to know how many multifamily properties exist in Massachusetts, what percentage of multifamily properties are condos, what percentage of condo properties would qualify for the multifamily program, and what percentage of both the multifamily and condo properties have already been touched by program activities.

This study attempts to answer these questions and provide the PAs with a more comprehensive understanding of the opportunity that exists for multifamily programs in Massachusetts. More specifically, this study had two main objectives:

1. Identify multifamily properties in Massachusetts and characterize any past program interactions with this population
2. Analyze the compiled multifamily building data to identify opportunities for customized multifamily program delivery strategies to maximize energy savings and equitably serve the market

The study team first merged compiled active customer lists (ACLs) for all PAs with various data sources to add a variety of customer-specific details, creating an augmented ACL. The team then analyzed this ACL to identify multifamily addresses based on several criteria including the number of housing units, property tax use code, billing rate code, and past participation in multifamily programs. This analysis produced a multifamily building database, which the study team explored to understand trends in past participation and identify future opportunities to increase participation in energy efficiency programs.

Importantly, the multifamily database and this analysis must be contextualized in terms of the data that was available to the study team. The multifamily database was created using snapshots of data sources when each was extracted. Data sources such as participant tracking and billing data were only available for the years 2013 through 2016. As a result, not every account in the multifamily database has complete information, which must be considered when interpreting this analysis. Readers should be cautious not to draw strong conclusions regarding the population of multifamily buildings and trends in historical participation. Instead, the multifamily database is a useful tool for exploring the multifamily population across the state and can be updated to increase the databases accuracy and completeness.

2. AVAILABLE DATA SOURCES AND METHODS

This section describes the data sources and methods that the study team used to identify multifamily and condo properties for the RES 43 study. DNV GL served as the data management team and compiled several sets of PA-submitted data for the study team. The study team combined these data sources to create a detailed ACL where each customer is associated with information regarding the property the customer lives in, whether the customer participated in various Mass Save programs, and average monthly usage. The study team then used this information to identify multifamily and condo properties across Massachusetts.

2.1 Data Sources

The study team reviewed and merged the data sources described in this section including the ACL, geocoded address data, property tax data, participation tracking data, rate code data, and billing data.

Residential ACL: The residential ACL is a list of electric and gas customers collected by the data management team. This list contains residential accounts and some commercial and industrial (C&I) accounts (identified by rate code) that are associated with residential locations, such as those accounts associated with common areas of multifamily buildings. This customer list does not contain all C&I customers. The study team identified additional C&I accounts through the C&I account database described later in this section.

The list of customers for each utility represents a snapshot in time. The data management team assigned each customer a primary key (PK) unique over the entire ACL. The data management team also assigned surrogate foreign keys (FKs) to each account that mask the account, location, meter, and customer IDs provided by each PA. These FK values are unique within each PA and can be used to link customers between the ACL, participation, rate code, and billing datasets. Importantly, because each utility submitted this data individually, the customer lists for each utility and fuel represent snapshots that were taken on different dates. Consequently, the data management team generated multiple versions of the ACL to produce one that represented the most consistent snapshot in time. For this analysis, the study team used a version of the ACL transmitted on April 20, 2017. The accounts in this database represent dates ranging from Q4 2015 through Q4 2016. Additionally, accounts for customers located in territories with municipal utilities were included in this database, but any associated municipal account information was not included.

Geocoded addresses: Geocoding is the process of matching an address to a specific latitude and longitude on the earth. The study team initially received geocoded coordinates developed by the data management team using a SAS geocoding tool that leverages US Census Topologically Integrated Geographic Encoding and Referencing (TIGER/Line) shapefiles. Due to issues concerning the accuracy of these geocodes, the data management team and the study team produced two additional sets of geocodes using an E911 geocoding tool (based on the emergency responder database) and Google's geocoding tools (using the Google Maps application programming interface). Each of these tools have strengths and weaknesses. The teams compared these results and found that the E911 and Google geocoding tools produced similar results pinpointing exact building locations, while the SAS results tended to produce street-level locations. Ultimately, the teams were able to leverage all three datasets by using the E911 results as the base set of results. In cases where E911 did not produce a result, a result from Google was used when validated against SAS results (i.e., Google and SAS results are within 0.1

miles of each other). Using this methodology, 96% of addresses in the database were assigned a geocoded address, latitude, and longitude.

Property tax data: The study team received tax assessment data sourced from the Massachusetts and Boston governments. This data contains information such as the number of housing units, building area, and year the structure was built. It was updated by the data management team in 2018 to incorporate 2017 property tax data. For this study, the data management team employed a matching process involving geocoded location and fuzzy matching of owner names to match customers in the ACL with records in the tax data. A successful match for a customer was indicated in the ACL by the presence of LOC_ID and PROP_ID values that match with corresponding values for a record in either the Massachusetts or Boston tax data, as applicable.

C&I ACL: The data management team also compiled and transmitted to the study team a list of active customers sourced from the C&I database. This list represents active customers in 2017. These C&I accounts were matched to accounts in the residential ACL by matching through property tax data. Specifically, the residential and C&I ACLs were each matched individually with the tax data. To differentiate between C&I accounts at residential locations and those associated with a commercial establishment, the team excluded accounts that had a tax use code associated with a commercial or industrial use. In this way, we removed C&I accounts for dry cleaners or restaurants located within the MF building. Those accounts matched with the same LOC_ID and PROP_ID were then considered to be part of the same address. This list does not contain all C&I accounts, only those successfully matched with the property tax data. Additionally, the list does not contain any multifamily properties that would have only C&I accounts.[1] Finally, of the accounts available, not all are multifamily accounts. For example, some of the C&I accounts may belong to a commercial establishment at a mixed-use building that would not qualify as multifamily. This type of account was excluded from the analysis via tax use code (e.g., those beginning with 3 refer to a commercial establishment).

Participation tracking data: The study team received participation tracking data in the form of a list of accounts with columns that indicate participation in several Mass Save programs from 2013 to 2016, where available. This list was most recently updated in 2018. Customers in this data are linked to the ACL via surrogate FK values (at the account level) The following programs were included:

- Low-Income Multifamily Retrofit
- Residential Home Energy Services
- Residential Multifamily Retrofit
- Low-Income New Construction
- Residential New Construction
- Low-Income Single-Family Retrofit
- Residential Consumer Products
- Residential Heating and Cooling Equipment
- Residential Heating and Water Heating Equipment

[1] At the time of this study, the data management team could identify such properties in the future, but the timeline was uncertain. As a result, identification of C&I properties was left as a future opportunity, requiring another refresh of the multifamily C&I account list. Therefore, some multifamily buildings would not be included in the current database, such as: buildings with both electric and gas master-metered C&I accounts; and buildings in municipal electric territories with C&I gas master-metered accounts.

- Residential Lighting

The study team also received participant tracking data as a list of locations that participated in programs between 2013 and 2016. In addition to the residential programs listed above, this dataset also contained tracking information for the following programs:

- C&I Upstream Products
- C&I Retrofit Prescriptive and Custom
- C&I New Construction Prescriptive and Custom

Note that not all programs had data for the entire 2013-2016 period. Some only had data for a portion of this period. The location-level data was created by matching participating accounts and locations provided by PAs with locations in the tax data to link with the ACL. This matching process was developed to track participation at given locations even if specific accounts no longer existed in the ACL.

Rate code data: The study team received a list of rate codes for each PK in the ACL, along with descriptions for a portion of these rate codes received from PAs. These descriptions indicated characteristics such as commercial, seasonal, low-income, and multifamily.

Billing data: The study team received customer billing and usage data for 2013 to 2016 for both residential and C&I customers. Customers in this data are linked to the ACL via surrogate FK values or account numbers. Using this data, the study team calculated characteristics such as average monthly usage for accounts.

American Community Survey (ACS) data: The study team used 2016 ACS 5-year estimates[2] for the population of each block group in Massachusetts with income below 200% of the poverty line, a low-income indicator. This data was merged into the ACL using the geocoded address data to help identify accounts in areas with a higher low-income population. The ACS was also used to assess the accuracy of the total number of multifamily housing units identified in the multifamily database.

2.2 Data Health

Each customer in the ACL was matched with one or more available data sources depending on data availability. For example, because there is no direct link between the ACL and property tax data, the data management team applied a methodology to match customers between these sources based on customer name and address. Table 2-1 summarizes the data health of the residential ACL after merging the data sources, specifically listing the number and percentage of records in the ACL that were successfully matched with records in each other data source.

Of records in the residential ACL, 26% were found in the participation tracking data; those customers not found in the tracking data were assumed to have not participated between 2013 and 2016. This assumption means that there may be buildings that have historically participated that were not identified as such. The percentage of ACL records successfully matched with at least 1 year of billing data was 75%. The study team applied a cleaning process to the billing data to remove missing or insufficient data. As a result, not all customers in the ACL have a complete set of billing data for all years. Of all records, 56% matched with all data sources, excluding participation tracking data. Participation tracking data was

[2] Available at: https://factfinder.census.gov

excluded from this calculation because many records may not have participated and would not be present in the tracking data.

Table 2-1. Summary of Data Health for Residential ACL

Data Source	Years Represented	Residential ACL Records Matched	Percentage of Residential ACL Records Matched
Entire Residential ACL	2015-2016	3,886,915	100%
Property Tax Data	2017	2,891,176	74%
Geocoded Address Data	2017	3,718,098	96%
Rate Code Data	2017	3,670,724	94%
Billing Data	2013-2016	2,921,904	75%
Complete (Matched to All Sources Except Participation Tracking)		**2,160,170**	**56%**
Participation Tracking Data	2013-2016	997,405	26%

Source: Navigant analysis

Table 2-2 summarizes the data health of the C&I ACL, listing the number and percentage of records in the ACL that were successfully matched with records in each other data source, including the residential ACL. Only 46% of available C&I accounts were successfully matched with the residential ACL, which can be explained by these factors:

- C&I accounts were matched to the residential ACL by associating accounts from both databases that were successfully matched to the same property tax parcel. As a result, 74% of the residential ACL were successfully matched with property tax data and 26% of residential ACL accounts could not be matched with the C&I account database.
- The C&I account database was based on 2017 data, while the residential ACL represents accounts from 2015 to 2016. As a result, some of the accounts in the C&I account list could be matched to a more recent residential ACL but not the version used for the current study.

Of all records, 40% matched with both billing data and the residential ACL. Participation tracking data was excluded from this calculation because many records may not have participated and would not be present in the tracking data.

Table 2-2. Summary of Data Health for C&I ACL

Data Source	Years Represented	C&I ACL Records Matched	Percentage of C&I ACL Records Matched
C&I ACL (Associated with Residential Locations)	2017	120,501	100%
Property Tax Data	2017	120,501	100%
Billing Data	2013-2016	102,274	85%
Residential ACL	2015-2016	55,426	46%
Complete (Matched to All Sources Except Participation Tracking)		**48,178**	**40%**
Participation Tracking Data	2013-2016	37,380	31%

Source: Navigant analysis

3. CENSUS OF MULTIFAMILY PROPERTIES

3.1 Definition of Multifamily and Condo Buildings

This study focused on identifying multifamily buildings with five residential units or more, the type of building eligible for the multifamily program when the study began. The study team used the following definitions:

- **Building:** A single address that may have one or more electric or gas account
- **Property:** A group of buildings that are centrally managed that consist of multiple addresses

The study team identified multifamily addresses using the geocoded match addresses returned by E911 or Google for each customer in the ACL. Each geocoded address groups all accounts located at that latitude and longitude. The team determined whether each address in the ACL was multifamily using several criteria. Specifically, an address was considered multifamily if it meets any of the following criteria:

- Has five or more housing units at the address
- Has a property tax use code indicating a multifamily building with five or more housing units
- Historically participated in a multifamily program[3]
- Have one or more accounts under multifamily-specific rate codes[4]

The study team estimated the number of housing units at a given address using three sources: the number of electric accounts at the address, excluding accounts identified as common meters via rate code information; the number of gas accounts at the address; and the number of housing units listed by tax data matched to accounts at the address. Importantly, these sources do not always produce the same estimate, which reflects that each source may underestimate the number of housing units at an address. For example, a multifamily building may be master-metered, with multiple housing units associated with a single electric or gas account. Additionally, tax data may be out of date and may list an address as a single-family house that has since been converted into apartments. The study team chose the highest estimate for each address, producing a high estimate of the total number of multifamily housing units.

To identify multifamily addresses using tax use codes, the study team reviewed property type classification codes listed by the Massachusetts[5] and Boston[6] governments. The team identified use codes associated with multifamily buildings with five or more units. These use codes include: 112, More than Eight Units; 113, APT 31-99 Units; and 114, APT 100+ units.[7] While there are other use codes that indicate an address may be multifamily, the team restricted this particular criterion to those use codes that were explicit in identifying a building with five or more units. Multifamily buildings with other use codes were identified using the estimated number of housing units at the building.

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[3] Participation in a multifamily program does not necessarily mean that a building has 5 or more units. All buildings that previously participated in a multifamily program were identified, but the number of housing units at the address was used to confirm that the building has 5 or more units.

[4] Some data submitted by PAs contained rate codes explicitly described as being for multifamily buildings.

[5] *Property Type Classification Codes.* Division of Local Services, MA Department of Revenue. http://www.mass.gov/dor/docs/dls/bla/classificationcodebook.pdf

[6] *Massachusetts Property Classification System Occupancy Codes.* Boston Assessing Department. https://www.cityofboston.gov/images_documents/MA_OCCcodes_tcm3-16189.pdf

[7] For Massachusetts tax data, Navigant identified property type using the first three digits of the use code.

The study team also identified multifamily addresses using participation tracking data and rate code data, which were each matched with the ACL. If any account at an address participated in the Multifamily Retrofit or Low-Income Multifamily Retrofit programs, the address was considered to be multifamily. However, past participation does not necessarily indicate that the building has 5 or more units. Therefore, the team distinguished between past participating buildings with 5 or more units and those that may have participated but had less than 5 units. The latter scenario suggests that the building may be part of a property that PAs have chosen to treat as multifamily. Similarly, some data submitted by PAs contained rate codes explicitly described as being for multifamily buildings. Therefore, if any account at an address had an explicitly multifamily rate code that address was considered multifamily.

Within the population of multifamily addresses, another important distinction is between apartment buildings and condos due to the difference in ownership structure. Condos will have multiple owners of different housing units, while an apartment building will typically be managed by a single entity. The team identified multifamily condo buildings using the property tax data, specifically those addresses that have the tax use code 102, Condominium.

3.2 Multifamily Databases and Interactive Dashboard

The study team implemented the criteria described in Section 3.1 on the augmented ACL to create the following:

- Account-level multifamily database(s)
- A building-level (or address-level) multifamily database
- An interactive building database dashboard

The study team produced separate account-level databases for each PA and fuel type (electric and gas). These databases provide information about individual customers at multifamily properties. Each database contains records from the augmented ACL identified as belonging to a multifamily address for that PA and fuel type. Importantly, due to data health issues, the team was not necessarily able to uniformly identify all accounts at a given address as multifamily. Consequently, for a given address, if at least one account was identified as multifamily, all accounts at that address were considered multifamily.

The team also aggregated records for all addresses in the augmented ACL identified as multifamily properties to create a single building-level multifamily database that summarizes their characteristics. This database includes all PAs and fuel types across Massachusetts. Each record in the database represents a single address. Consequently, if a single multifamily property consists of multiple buildings at separate addresses, these would be represented separately in the database. Moreover, the process of geocoding and merging all data sources led to situations where some characteristics may not have been consistent for all records at a given address. Therefore, in aggregating a given characteristic for each address, the team chose the value dictated by the majority of records. For example, at a given address, property tax data for records may list a different tax use code. In this situation, the study team would select the tax use code that appears most frequently among these records. For a complete list of fields contained in the building-level multifamily database, see the data dictionary contained in Table A-1 of Appendix A.

Finally, the study team developed an interactive dashboard in Power BI[8] to visualize and explore the building-level multifamily database. This dashboard contains a series of maps and charts that illustrate

[8] Power BI Desktop is available at: https://powerbi.microsoft.com/en-us/desktop/

the geographic location of multifamily properties in Massachusetts. Each map contains controls that allow a user to filter the database to explore specific subsets of customers by various characteristics. For more information about the interactive dashboard, see the documentation provided in Appendix B.

3.3 Identification of Multifamily and Condo Buildings

From the building-level multifamily database, the study team calculated the total number of identified multifamily and condo housing units and buildings (i.e., addresses), listed in Table 3-1. As described in Section 3.1, this analysis focuses on buildings with five or more housing units.

However, PAs also treat certain properties as multifamily, specifically those that are centrally managed groups of buildings, each of which may individually have less than five units. The study team identified a number of these based on past participation in multifamily programs, and the number of housing units and buildings associated with this type of property are also listed. The team did not estimate the total number of multifamily properties consisting of buildings with less than five units, as determining whether buildings were centrally managed was out of the scope of the current analysis. Identifying and characterizing these buildings remains an opportunity for future research. Therefore, in this analysis, references to multifamily buildings refer to those with five or more units unless otherwise specified.

Table 3-1. Identified Multifamily Housing Units and Buildings

Description	Number of Housing Units	Housing Units	Buildings
Multifamily buildings (including both apartments and condos)	5 or more units	611,381	37,751
	Less than 5 units[9]	32,893	26,446
	All	**644,274**	**64,197**
Multifamily condo buildings only	5 or more units	111,005	6,713
	Less than 5 units	13,591	11,961
	All	**124,596**	**18,674**

Source: Navigant analysis

The team evaluated the number of multifamily housing units and buildings identified from the ACL against existing estimates. In Massachusetts, the ACS estimates there were 586,956 housing units in buildings with five or more units in the 2012-2016 period.[10] Additionally, a previous market characterization study[11] estimated approximately 33,404 multifamily buildings in Massachusetts by dividing the total number of estimated housing units from the ACS by an assumed number of housing units per building. Based on this comparison, the study team believes the current methodology produces a reasonable estimate of multifamily buildings. The current estimate may still be overstated as the total due to, for example, the considerations made in estimating the number of housing units at each address, which produced a high estimate (described in Section 3.1).

[9] Buildings with less than 5 units were identified as multifamily based on past participation in a multifamily program.

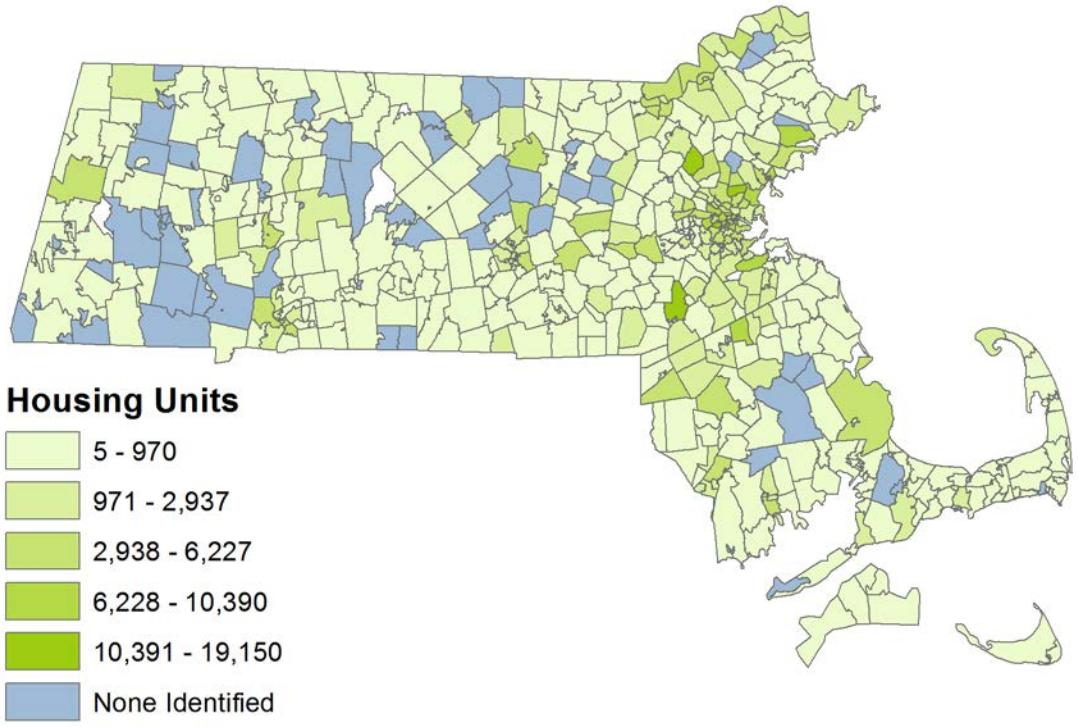
[10] "Selected Housing Characteristics, 2012-2016 American Community Survey 5-Year Estimates." https://factfinder.census.gov/bkmk/table/1.0/en/ACS/16_5YR/DP04/0400000US25

[11] *Massachusetts Multifamily Market Characterization and Potential Study Volume 1*. May 2012. p. 27. http://web.mit.edu/cron/project/EESP-Cambridge/Articles/MA%20RR_LI%20-%20Multifamily%20Potential%20Study_FINAL_Report%20and%20Appendix_17MAY2012.pdf

Regarding the estimated number of multifamily condos, the values listed in Table 3-1 represent the number of multifamily condo buildings for which both property tax data and an estimated number of housing units was available. As discussed in Section 2.2, 74% of records in the ACL were successfully matched to property tax data. This percentage represents the maximum portion of accounts that could be identified as part of a condo property via use code. As a result, a portion of all multifamily buildings identified as apartments are likely unidentified condos.

The study team further explored the geographic distribution of multifamily buildings with five or more units. Figure 3-1 shows this distribution for multifamily housing units by ZIP code, with the darker green regions representing greater numbers of housing units.

Figure 3-1. Distribution of Multifamily Housing Units by ZIP Code



Source: Navigant analysis

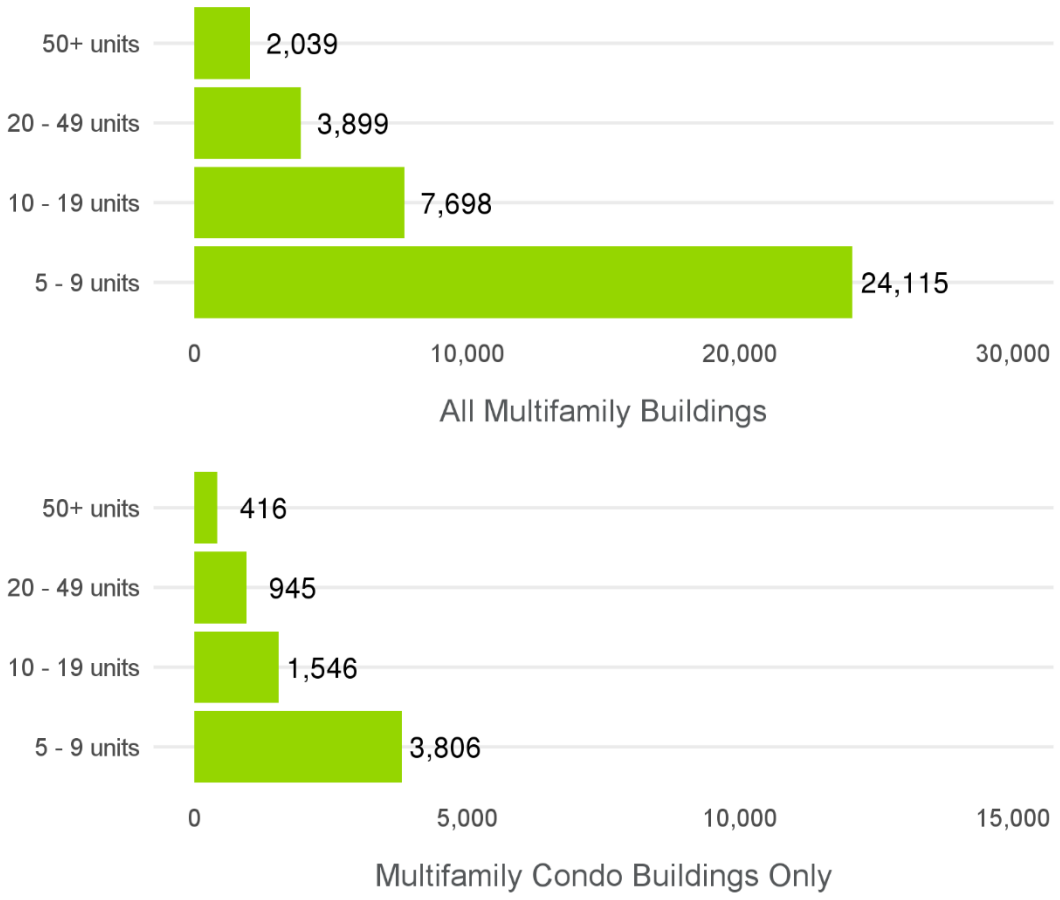
3.4 Classification of Multifamily and Condo Buildings

In the following discussion, multifamily buildings refer to those with five or more units unless otherwise specified. Historically, PAs have treated centrally managed groups of buildings that may individually have less than five units as multifamily properties. The study team identified a number of these based on past participation in multifamily programs and the number of housing units and buildings associated with this type of property are also listed. The team did not estimate the total number of multifamily properties consisting of buildings with less than five units, as determining whether buildings were centrally managed was out of the scope of the current analysis. Identifying and characterizing these buildings remains an opportunity for future research.

3.4.1 Housing Units

Figure 3-2 shows the number of housing units identified for multifamily properties and for multifamily condo buildings only. Among all addresses, there is a relatively high number of buildings with five to nine units, which may reflect that many of these buildings most likely belong to a single property but are separate addresses. In this analysis, the study team did not cluster these addresses so they would be counted separately.

Figure 3-2. Distribution of Multifamily Buildings by Number of Housing Units



Source: Navigant analysis

3.4.2 Meter Type

The study team also analyzed the distribution of meter types among multifamily buildings. Meter type was identified either by rate code or the source of the account, the residential or C&I ACL. Importantly, as discussed in Section 2.1, the overall ACL does not contain all C&I accounts; rather, it only contains those known to be associated with residential locations. As a result, this analysis may be missing some C&I accounts, including those that have not been identified as associated with residential locations and any multifamily properties consisting of only C&I accounts.

Table 3-2 shows the distribution of multifamily buildings by energy meter type (i.e., commercial, residential, or a mixture of both, including all gas and electric accounts). Most buildings (75%) had only

residential meters, with the remainder being mostly buildings with both C&I and residential meters. Note this study did not include a full accounting of all multifamily properties with only C&I accounts, as described in Section 2.1.

Table 3-2. Distribution of Meter Types among Multifamily Buildings

C&I/Residential	Buildings	Percentage of All Buildings
C&I	56	0.1%
C&I and Residential	9,276	24.6%
Residential	28,419	75.3%

Source: Navigant analysis

The study team also identified buildings with mixed meter types, summarized in Table 3-3. The most common combination was residential electric, residential gas, and C&I electric (45.2% of buildings), followed by residential and C&I electric only (34.2%)

Table 3-3. Summary of Mixed Meter Types for Addresses with Residential and C&I Meters

Res Electric	Res Gas	C&I Electric	C&I Gas	Number	Percentage
Yes	Yes	Yes	No	4,195	45.2%
Yes	No	Yes	No	3,172	34.2%
Yes	Yes	Yes	Yes	1,132	12.2%
Yes	Yes	No	Yes	563	6.1%
Yes	No	No	Yes	141	1.5%
No	Yes	No	Yes	49	0.5%
Yes	No	Yes	Yes	19	0.2%
No	Yes	Yes	No	5	0.1%
			Total	**9,276**	**100%**

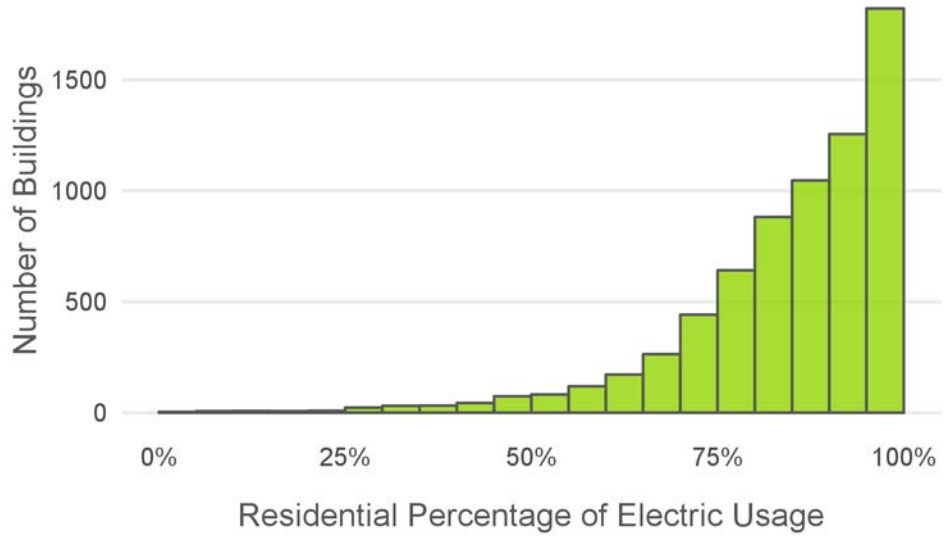
Source: Navigant analysis

Using monthly billing data, the study team investigated the breakdown of energy use from 2013 to 2016 between residential and C&I accounts for buildings with both types of meters (i.e., both residential and C&I electric or gas meters). Energy use for residential meters can be inferred to be associated with housing units, while commercial meter energy use can be inferred to be associated with common areas of residential buildings. For each building, the study team calculated the percentage of average monthly energy use for the building associated with residential meters relative to total consumption of a given fuel (residential plus commercial use). Since not all addresses had matched billing data for all 4 years, the team focused on comparing energy average monthly energy use over all four years, rather than by year. Over all 4 years, the average percentage of average monthly electric energy use was 90% and the average percentage of monthly gas use was 59%.

Figure 3-3 and Figure 3-4 show the distribution of these percentages across the state. Each bar shows the number of buildings with a given residential percentage of energy consumption in 5% increments. In general, residential usage drives electric energy consumption for these buildings. The breakdown of gas

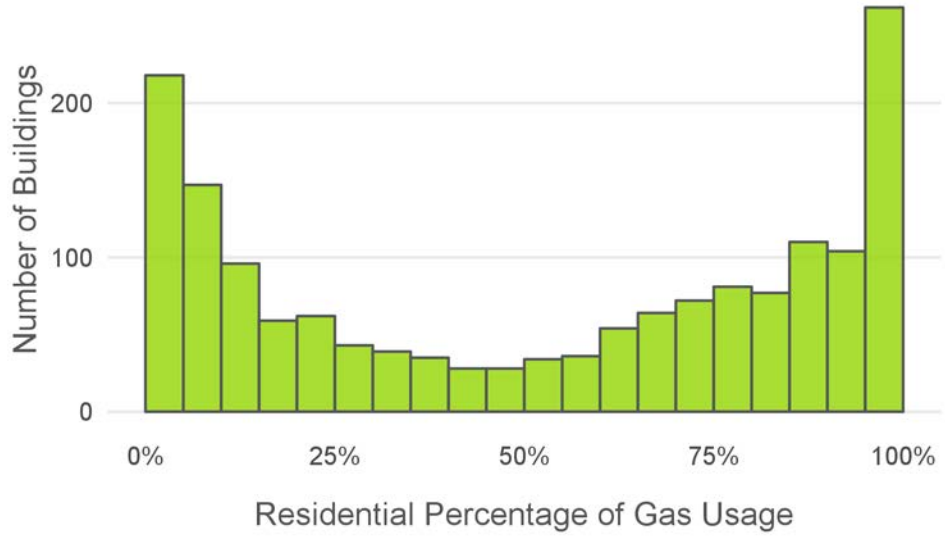
consumption by meter type is more varied, where Figure 3-4 suggests that either residential or C&I drives consumption for a given building.

Figure 3-3. Distribution of Residential Percentage of Average Monthly Electric Energy Use for Buildings with C&I and Residential Meters



Source: Navigant analysis

Figure 3-4. Distribution of Residential Percentage of Average Monthly Gas Energy Use for Buildings with C&I and Residential Meters



Source: Navigant analysis

Table 3-4 lists the breakdown of energy use for different building sizes in terms of number of housing units. The percentage of building energy use that is residential generally increases with the number of units. For all building sizes, residential usage drives electricity consumption. Residential and C&I use drive gas consumption more equally, except for buildings with 50 or more units. This result is consistent

with Figure 3-4, which suggests that either residential or C&I use tends to drive gas consumption for a given building. An important caveat is that the database does not contain multifamily buildings with C&I accounts only, as described in Section 2.1, which influences the calculated percentages. This caveat is important when interpreting the results for buildings with 50 or more units, as such buildings may be master-metered.

Table 3-4. Residential Percentage of Energy Use for Buildings with Both C&I and Residential Meters

Number of Housing Units	Residential Percentage of Average Monthly Electric Energy Use	Residential Percentage of Average Monthly Gas Usage
5-9 units	84%	50%
10-19 units	84%	46%
20-49 units	89%	53%
50+ units	96%	86%

Source: Navigant analysis

3.4.3 Fuel Type

Fuel or heating system type is another important characteristic that may influence participation. While heating system information was not directly available, the study team investigated heating system via the types of accounts at each address. The study team used the mixture of fuels at an address to estimate the number of buildings that may use delivered fuels. The team classified buildings into seven types based on the mixture of accounts at each address:

1. **Electric and gas:** Both electric and gas accounts
2. **Electric only, heating:** Only electric accounts and at least one account has a heating-specific rate code
3. **Electric only, non-heating:** Only electric accounts and no accounts have a heating-specific rate code
4. **Electric only, unknown:** Only electric accounts, but there is insufficient rate code information to determine heating or non-heating
5. **Electric only, gas municipal utility:** Only electric accounts, where the account has a ZIP code identified as being in the territory of a gas municipal utility
6. **Gas only, heating:** Only gas accounts and at least one account has a heating-specific rate code
7. **Gas only, non-heating:** Only gas accounts and no accounts have a heating-specific rate code
8. **Gas only, unknown:** Only gas accounts, but there is insufficient rate code information to determine heating or non-heating
9. **Gas only, electric municipal utility:** Only gas accounts, where the account has a ZIP code identified as being in the territory of an electric municipal utility

For a building, a lack of either gas accounts or electric heating accounts (i.e., electric only, non-heating, and unknown) suggests that the building may use delivered fuels. Table 3-5 describes the distribution of buildings by these account mixtures. Buildings classified as gas only indicate that no electric accounts were found at that address. This result could be ascribed to several factors, including geocoding

inconsistency between the addresses associated with electric and gas accounts, the area is served by a municipal electric utility, or the account lists for each PA and fuel represent slightly different periods of time. Nevertheless, the presence of a gas account suggests that the building would use gas heating rather than delivered fuels.

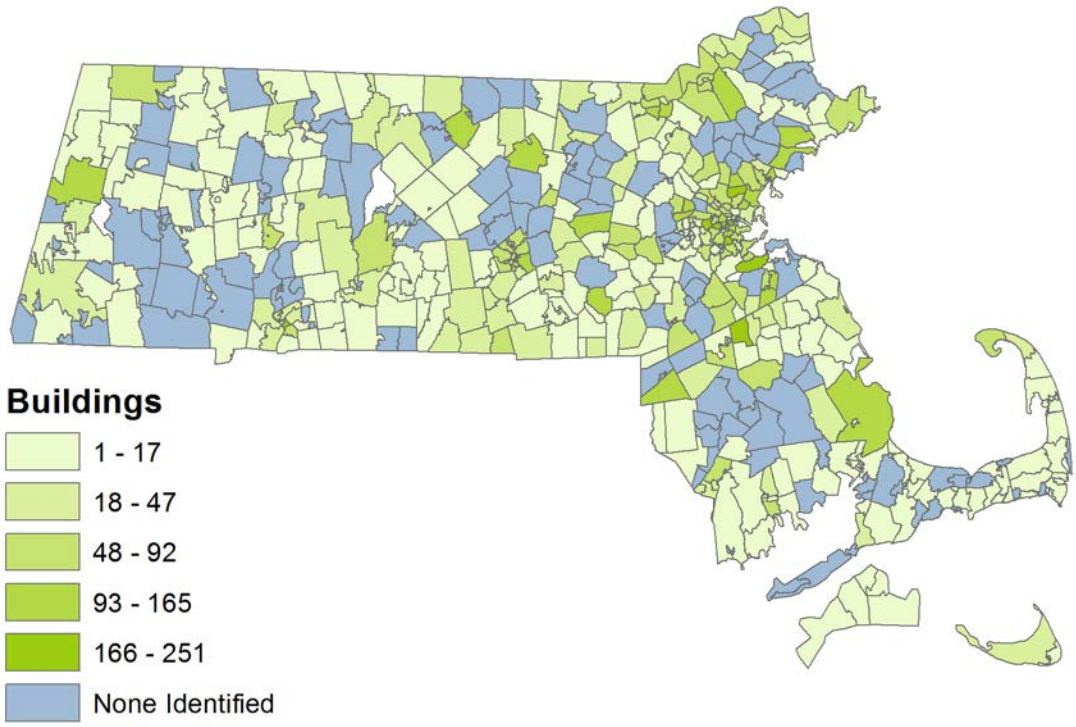
Table 3-5. Distribution of Buildings by Account Fuel Mixture

Fuel Type	Buildings	Percentage
Electric and gas	20,342	53.9%
Electric only, heating	2,840	7.5%
Electric only, non-heating	5,517	14.6%
Electric only, unknown	6,596	17.5%
Electric only, gas municipal utility	9	0.0%
Gas only, heating	289	0.8%
Gas only, non-heating	24	0.1%
Gas only, unknown	487	1.3%
Gas only, electric municipal utility	1,647	4.4%

Source: Navigant analysis

The number of buildings that may use delivered fuels represents 32.1% of multifamily buildings. This estimate would be an upper limit, as it likely also includes buildings that use electric resistance heat or heat pumps. Figure 3-5 shows the relative geographic distribution of multifamily buildings that may use delivered fuels.

Figure 3-5. Distribution of Multifamily Buildings that May Use Delivered Fuels by ZIP Code



Source: Navigant analysis

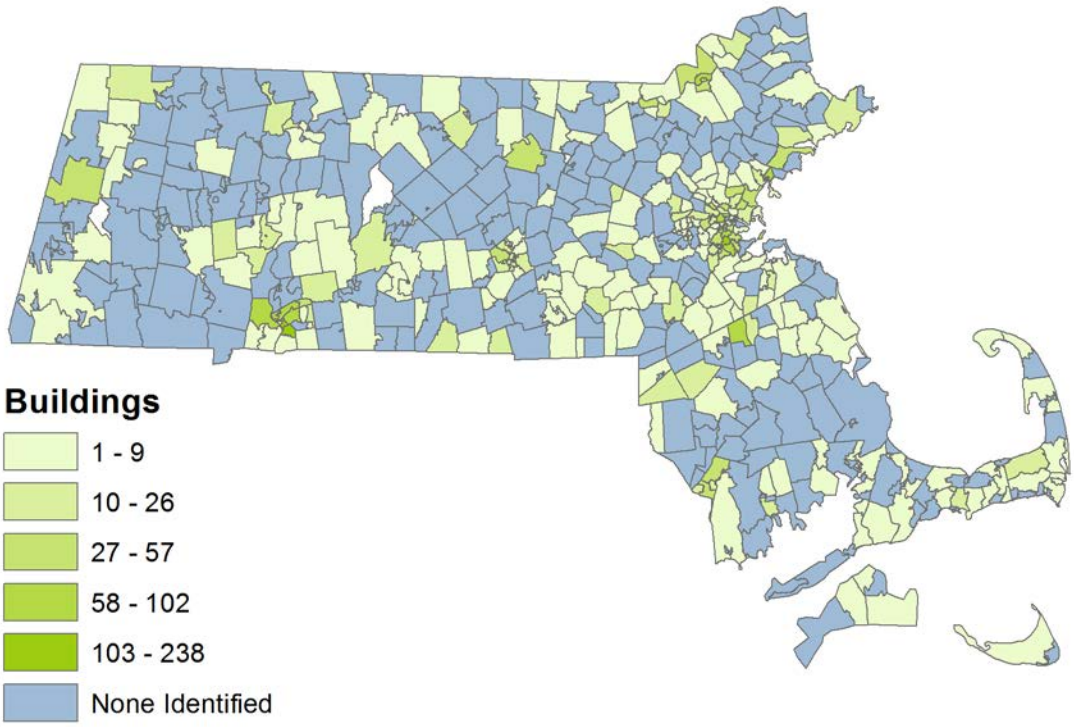
3.4.4 Income Level

Low-income properties are defined as those where at least 50% of households have an annual household income less than or equal to 60% of the area median income. However, the data sources available did not have income information available. As a result, buildings were classified as low-income based on each building's accounts. An account was considered to be low-income if it met any of the following criteria:

- Had a low-income rate code
- The building previously participated in a low-income program
- The owner of the building, as indicated by tax data, is described as a housing authority

Note that participation data was only available for 2013-2016, so there may be some buildings not identified in the current database that have previously participated in the low-income program. A given building was considered low-income if at least 50% of the electric accounts were identified as low-income. In total, 3,611 multifamily buildings (10% of all multifamily buildings) and 148 multifamily condo buildings (2% of all condo buildings) were classified as low-income buildings. Figure 3-6 shows the geographic distribution by ZIP code of the low-income multifamily buildings the study team identified in Massachusetts. Low-income buildings are not strictly concentrated to a few ZIP codes and are spread across several regions of the state.

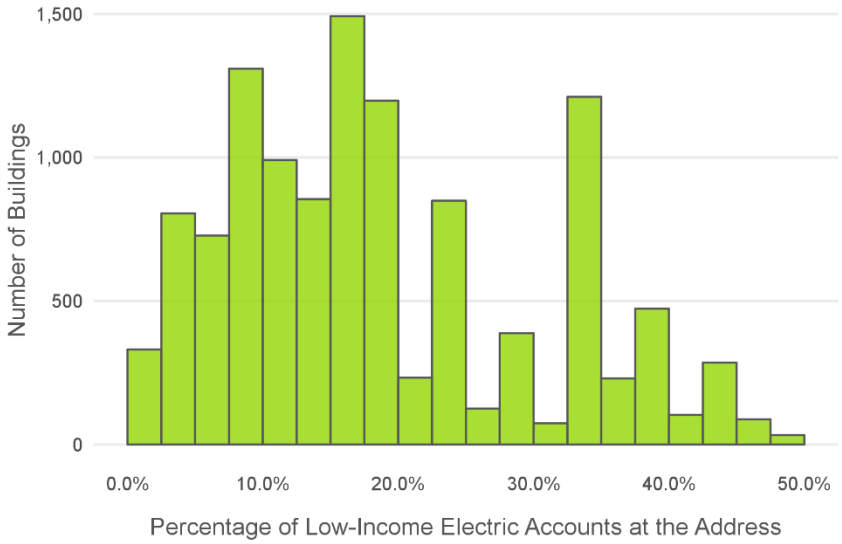
Figure 3-6. Distribution of Low-Income Multifamily Buildings by ZIP Code



Source: Navigant analysis

In addition to those buildings that were identified as low-income, there are also addresses that have low-income customers that may not meet the 50% threshold. The team identified 11,801 addresses with at least one low-income electric account but for which the number of low-income electric accounts was less than 50% of the total number at the address. Figure 3-7 shows the distribution of buildings with non-zero low-income percentage less than 50%. The prevalence of these buildings suggests additional buildings within the database may be low-income-eligible but were not identified due to a lack of income information or past participation information. For example, some customers from a given building may have not registered for a low-income electric rate despite being eligible.

Figure 3-7. Histogram of Number of Multifamily Buildings with a Non-Zero Low-Income Percentage



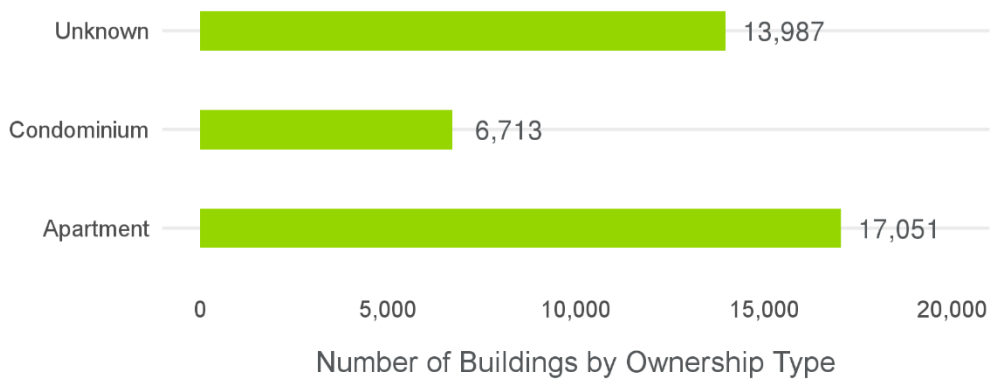
Source: Navigant analysis

As described in Section 2.2, the study team used ACS data to help identify buildings in areas with higher low-income populations. Specifically, for each address in the multifamily database, the team first found the block group in Massachusetts in which the address is located. The study team then included the proportion of the population with income less than 200% of the poverty line within that block group for each address. Block groups with a higher proportion of people in this income category are more likely to contain low-income multifamily properties. This information is included in the full multifamily building database, which can similarly be used to find additional areas with higher low-income populations.

3.4.5 Ownership

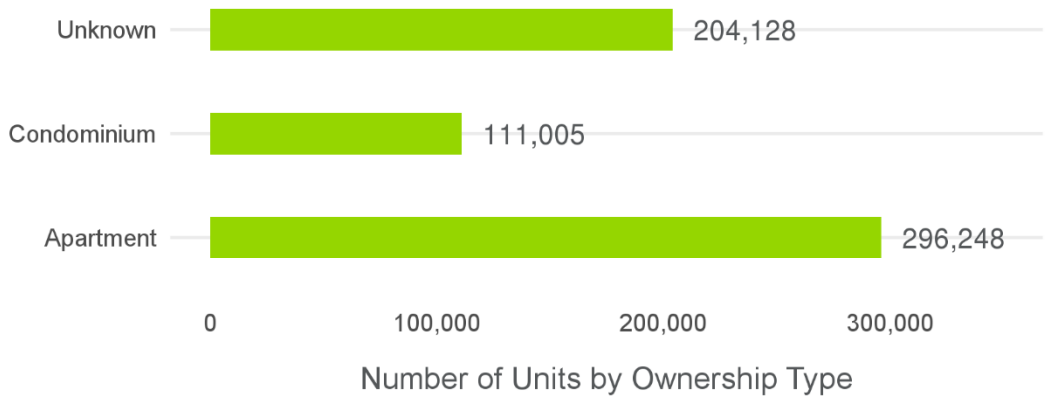
Figure 3-8 shows the number of multifamily buildings by ownership type. Figure 3-9 shows the number of multifamily units by ownership type. Ownership type was derived based on property tax use codes in the tax data. Specifically, the study team distinguished between buildings identified as condos and those identified as apartments. The unknown category represents buildings for which use code information was missing or invalid. This classification compares condo properties that are a mixture of individually owned (and either owner-occupied or rented) units and those properties that most likely consist of apartments only. The study team did not have sufficient data to determine owner occupancy for condo buildings.

Figure 3-8. Number of Multifamily Buildings by Ownership Type



Source: Navigant analysis

Figure 3-9. Number of Multifamily Units by Ownership Type

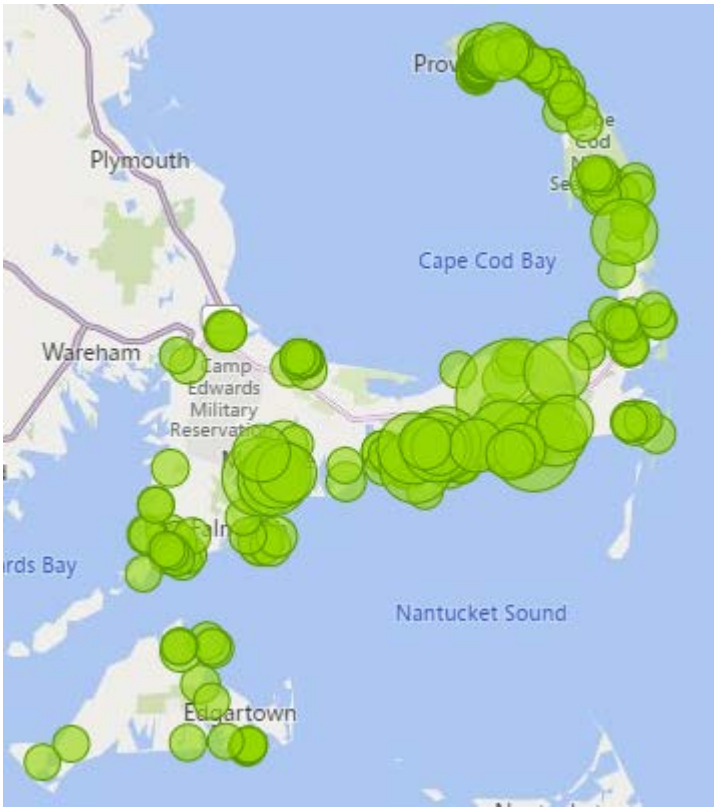


Source: Navigant analysis

3.4.6 Seasonal Buildings

Seasonal properties are another customer segment of interest due to reduced occupancy. In this analysis, the study team identified seasonal buildings using available rate code data. Specifically, the team identified accounts with rate codes classified as seasonal in the available rate code data (described in Section 2.1). Addresses with at least one account having a seasonal rate code were classified as seasonal buildings. In total, 311 multifamily buildings were identified as seasonal using this methodology. As Figure 3-10 shows, these buildings are primarily located in in the Cape Cod area. This analysis did not attempt to identify short-term rentals such as Airbnbs, which would also be reduced occupancy. Also note that seasonal rate information was not available for all accounts. As a result, there are other seasonal buildings that the team was not able to identify in this study.

Figure 3-10. Seasonal Multifamily Buildings



Note: Each circle represents an address and larger circles indicate a larger number of housing units. The smallest circle represents one unit and the largest circle represents 279 units.
Source: Navigant analysis

4. HISTORICAL PROGRAM INTERACTIONS

The study team analyzed the historical participation of both multifamily and condo buildings in relevant multifamily programs. Of the programs with available data described in Section 2.1, the study team focused on the following programs of interest for multifamily buildings:

- Low-Income Multifamily Retrofit
- Low-Income New Construction
- Residential New Construction
- Residential Multifamily Retrofit
- Residential Heating and Cooling Equipment
- C&I New Construction Custom
- C&I New Construction Prescriptive
- C&I Retrofit Custom
- C&I Retrofit Prescriptive
- C&I Upstream Products

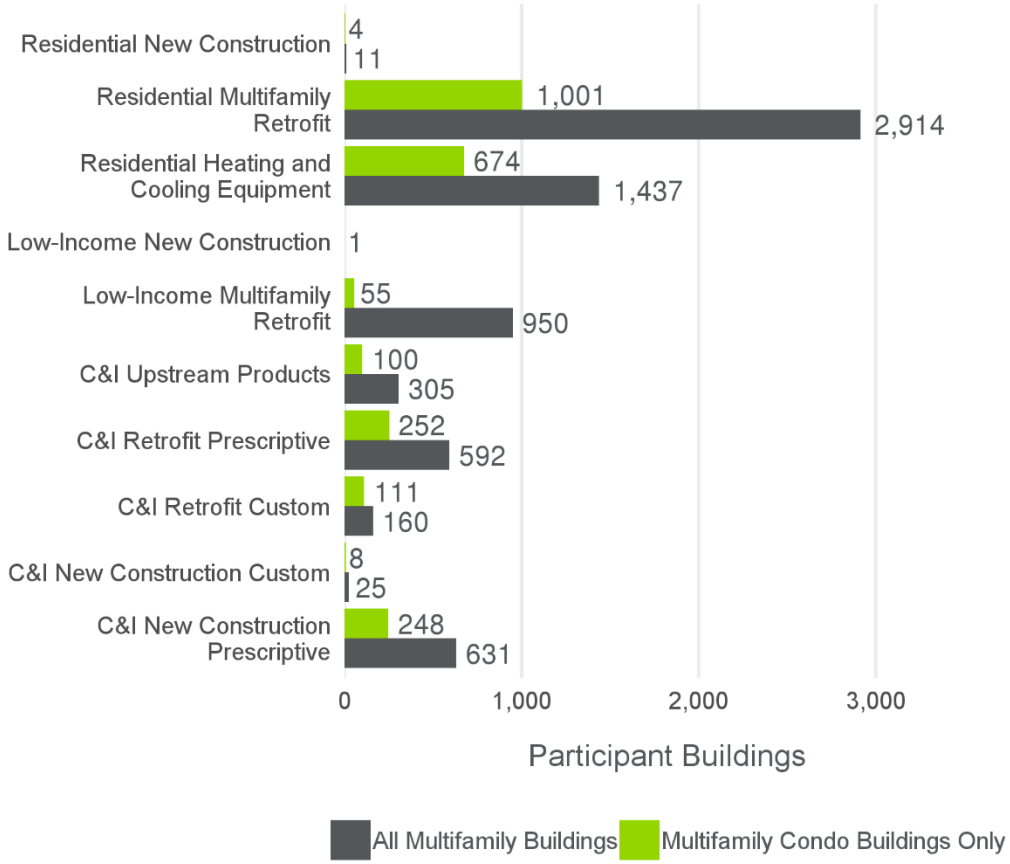
The team used the participation tracking data from these programs to link each account in the ACL with its corresponding set of participating programs. Each building was classified as a program participant or nonparticipant. For a given program, the team considered a building to have participated if at least one account was found to have participated from 2013 to 2016. In this discussion, multifamily buildings refer to those with five or more housing units unless otherwise specified. As will be discussed in this section, PAs often treat buildings with less than five units as multifamily—for example, if they are part of a property that is centrally managed. As a result, readers should be cautious to not draw strong conclusions regarding the population of multifamily buildings and trends of historical participation based on this discussion. Instead, this section shows the value of the database in providing PAs an exploratory tool to improve program delivery.

4.1 Participation by Program

Figure 4-1 shows the number of multifamily buildings that participated in each program between 2013 and 2016.[12] The Residential Multifamily Retrofit program had the highest number of participants of all programs, likely because many multifamily addresses were identified as participants in the Multifamily Retrofit program.

[12] The PAs offered multifamily programs prior to 2013 (the Multifamily Retrofit Working Group was formed in 2008-2009), which means this analysis will not capture all past participants.

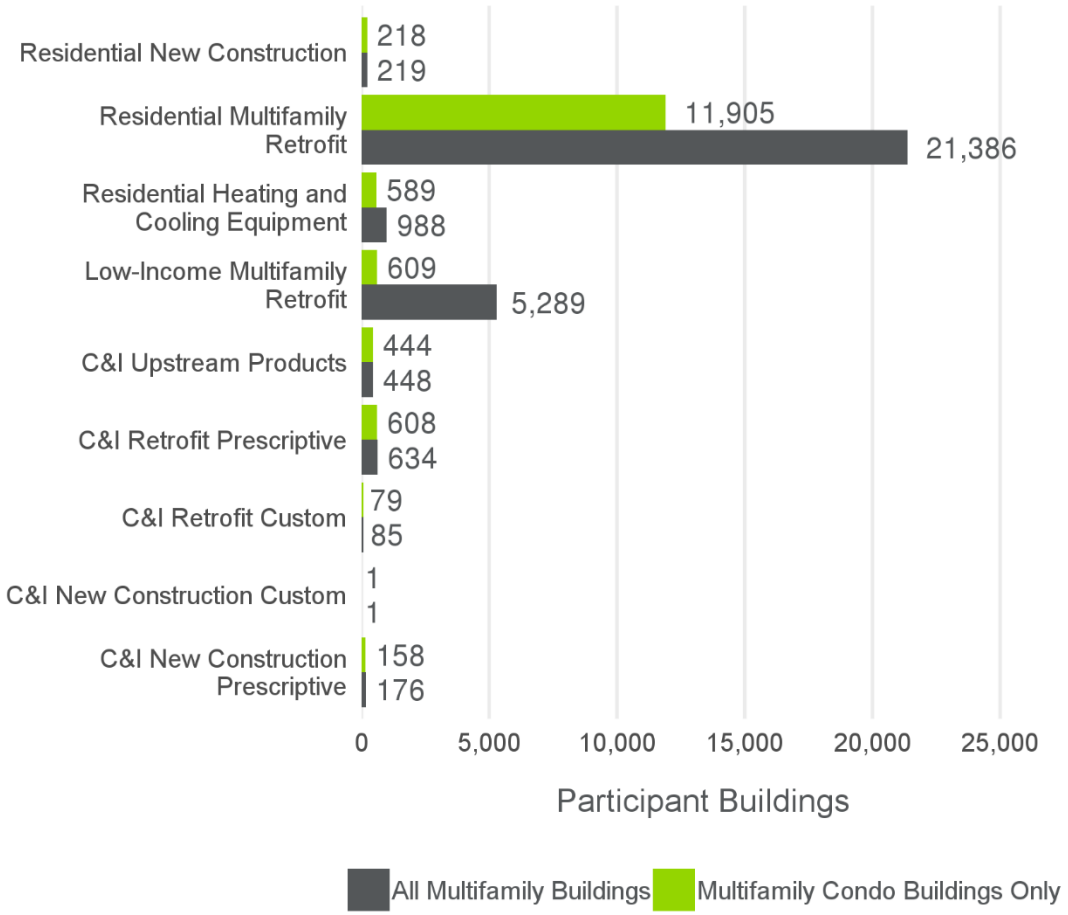
Figure 4-1. Multifamily Buildings Participating in Programs: 2013-2016



Note: The participant building in the Low-Income New Construction program is in the All Multifamily Buildings group.
Source: Navigant analysis

As noted in Section 3.3, PAs also treat some buildings with less than five units as multifamily, including collections of buildings that are centrally managed. The team identified some of this population via past participation in multifamily programs. Figure 4-2 shows how many of these buildings participated in programs between 2013 and 2016. Participation in multifamily programs was highest, as this was the criteria used to identify these particular buildings as multifamily. Since the team has not fully identified the population of these buildings, conclusions should not be necessarily be drawn from this result. Nevertheless, the team included this result as an example of opportunity for further exploration of this population.

Figure 4-2. Multifamily Buildings with Less than Five Units Participating in Programs: 2013-2016



Source: Navigant analysis

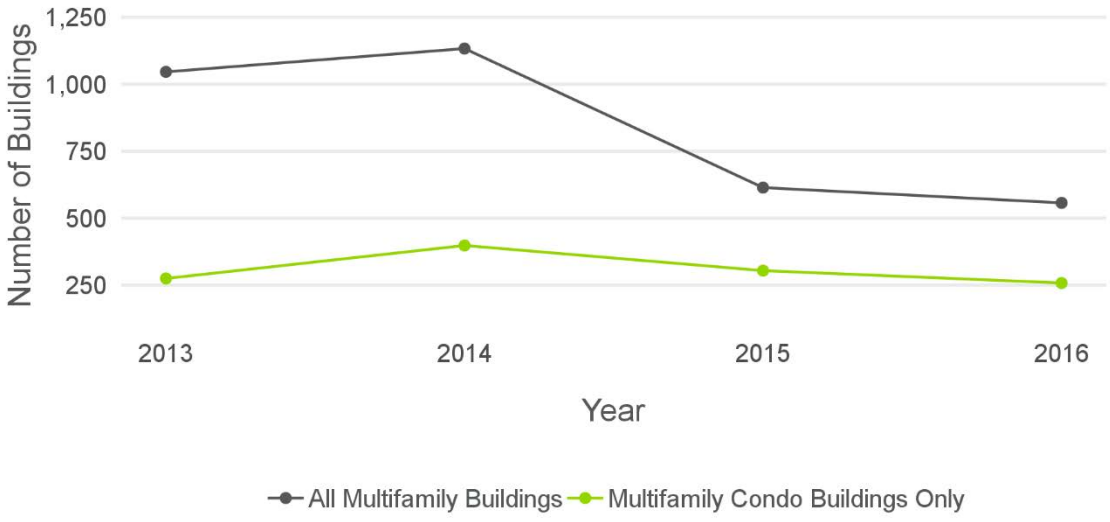
The study team also looked at how participation evolved from 2013 to 2016 for selected programs with the most participating buildings with five or more housing units. Figure 4-3 to Figure 4-7 show the number of buildings that participated in the following programs in each year from 2013 to 2016:

- Residential Multifamily Retrofit
- Residential Heating and Cooling Equipment
- Low-Income Multifamily Retrofit
- C&I Retrofit Prescriptive
- C&I New Construction

Figure 4-3 shows the number of participating buildings in the Residential Multifamily Retrofit each year, with between approximately 500 and 1,110 multifamily buildings participating each year. The number of condo buildings participating each year represents a large portion of these buildings— between approximately 250 and 400 each year. Similarly, the number of multifamily buildings participating in the Low-Income Multifamily Retrofit has been relatively stable between 2013 and 2016, with just 2014 showing a decrease in participation.

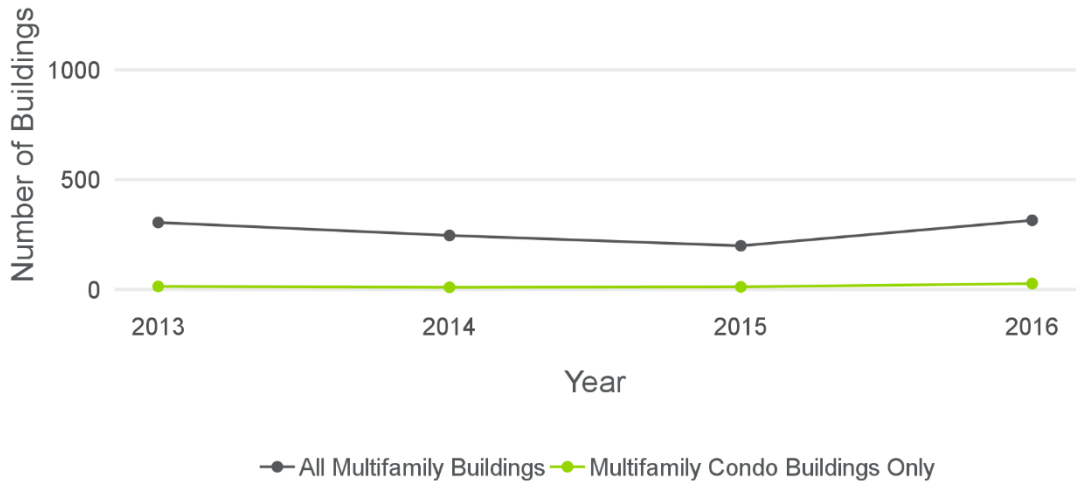
As shown in Figure 4-5 to Figure 4-7, participation in the Residential Heating and Cooling Equipment, C&I Retrofit Prescriptive, and C&I New Construction Prescriptive programs was more variable. The Residential Heating and Cooling Equipment program showed a sharp increase in participation in 2016. Participation in the C&I Retrofit Prescriptive program was highest in 2016. Participation in the C&I New Construction Prescriptive program increased between 2013 and 2015 but approached zero in 2016. Note that this result may also reflect an underlying data issue, as locations that participated in the program may not have been matched to the current residential ACL.

Figure 4-3. Participation by Year for Residential Multifamily Retrofit Program



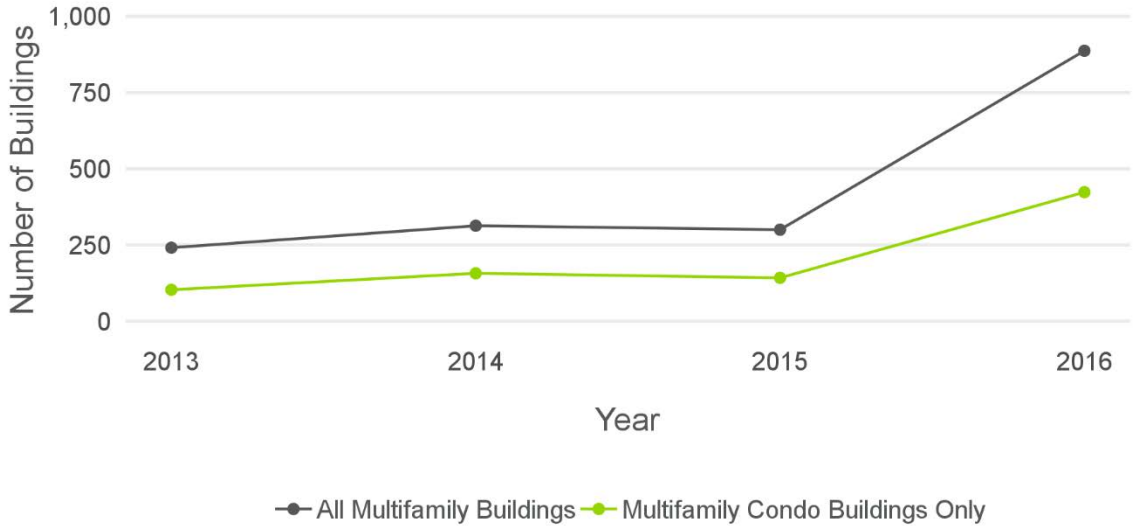
Source: Navigant analysis

Figure 4-4. Participation by Year for Low-Income Multifamily Retrofit Program



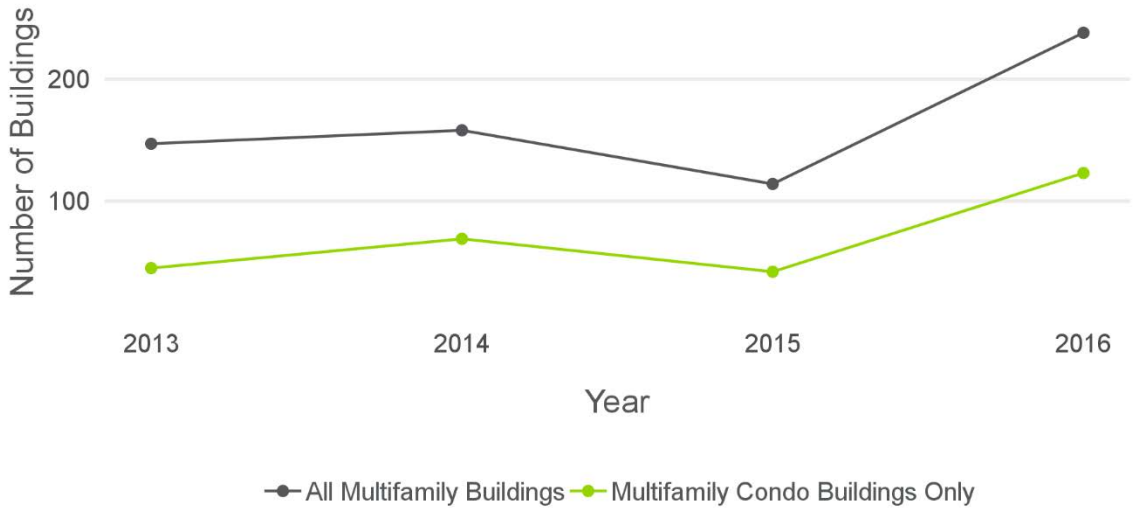
Source: Navigant analysis

Figure 4-5. Participation by Year for Residential Heating and Cooling Equipment Program



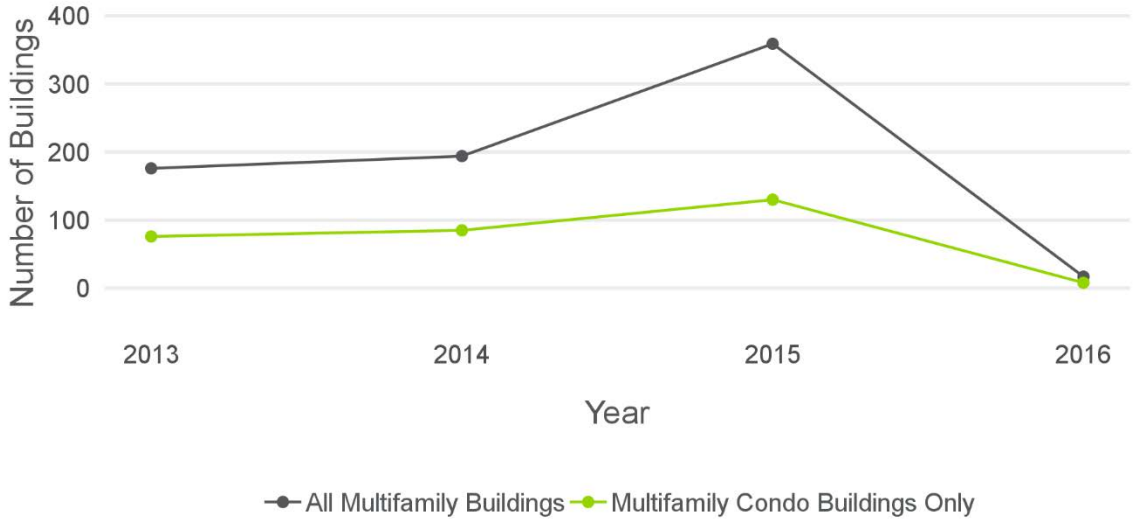
Source: Navigant analysis

Figure 4-6. Participation by Year for C&I Retrofit Prescriptive Program



Source: Navigant analysis

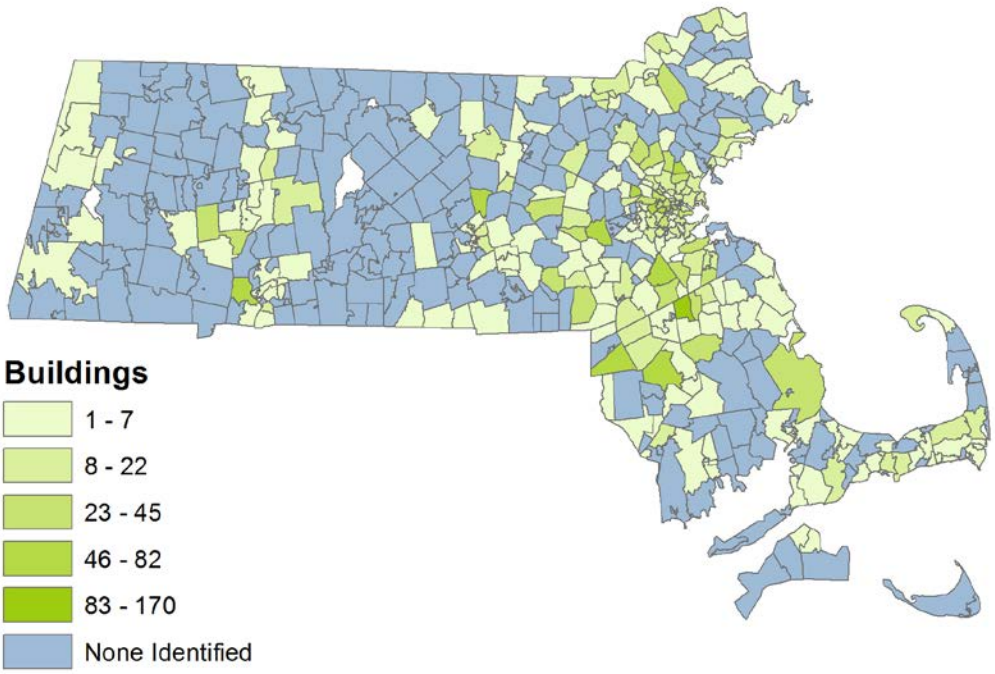
Figure 4-7. Participation by Year for C&I New Construction Prescriptive Program



Source: Navigant analysis

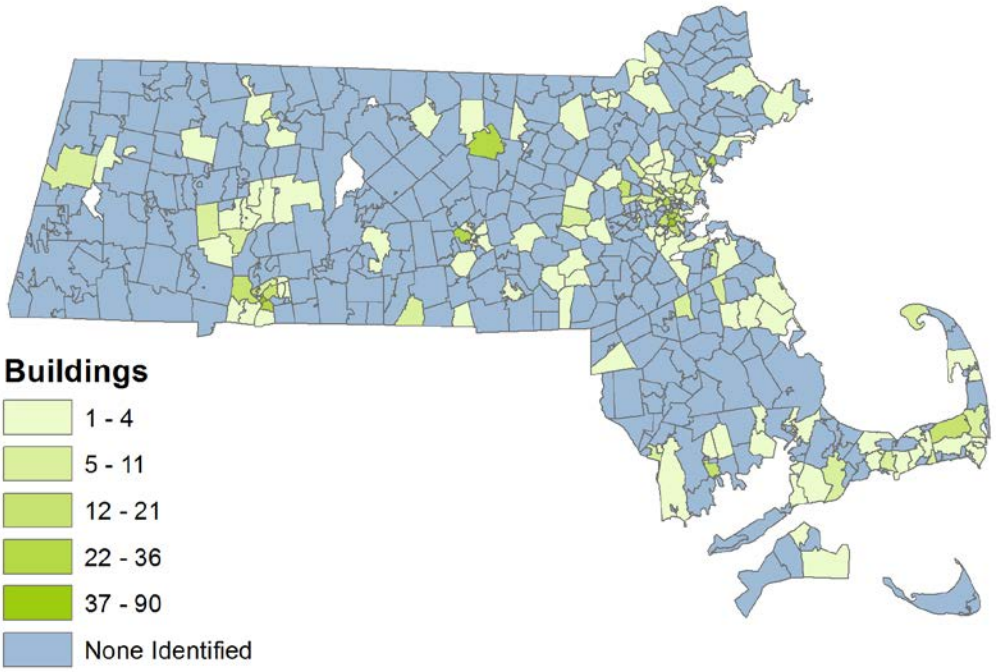
Figure 4-8 displays the geographic distribution of participant buildings in the Residential Multifamily Retrofit program by ZIP code. The ZIP codes with darker hues of green contained a larger number of multifamily buildings that participated in a program. Similarly, Figure 4-9 displays the geographic distribution of participant buildings in the Low-Income Multifamily Retrofit program by ZIP code.

Figure 4-8. Distribution of Participant Buildings in the Residential Multifamily Retrofit Program by ZIP Code



Source: Navigant analysis

Figure 4-9. Distribution of Participant Buildings in the Low-Income Multifamily Retrofit Program by ZIP Code



Due to issues incorporating some historical participation data into the database, in some areas this map does not reflect known participation of low-income multifamily buildings.
Source: Navigant analysis

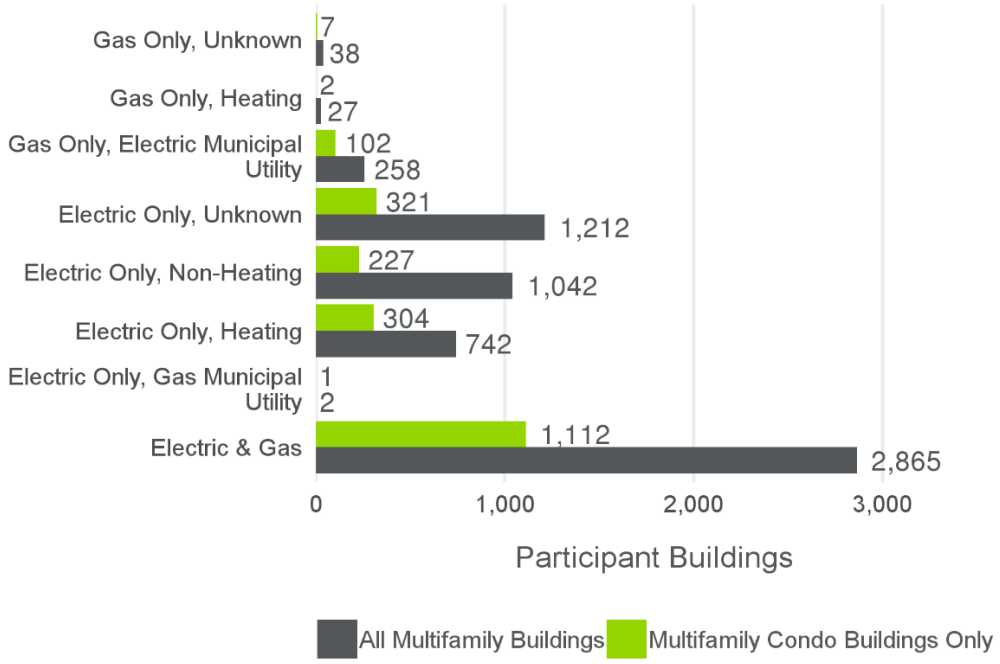
4.2 Participation by Customer Segment

The study team further compared the overall participation of all buildings in residential Mass Save initiatives between different customer segments. In these comparisons, a participant building refers to one that has participated from 2013 to 2016 in any of the programs discussed in Section 4.1.

4.2.1 Fuel Type

Figure 4-10 shows the number of multifamily buildings and multifamily condos that participated in any program split by fuel type. As discussed in Section 3.4.3, addresses with only gas accounts suggest instances where account information for the address is incomplete. However, because these addresses have gas accounts, it may be reasonable to infer they would not use delivered fuels. The majority of participants were those with electric and gas accounts, followed by those with only electric accounts with no heating rate codes.

Figure 4-10. Program Participation by Fuel Type

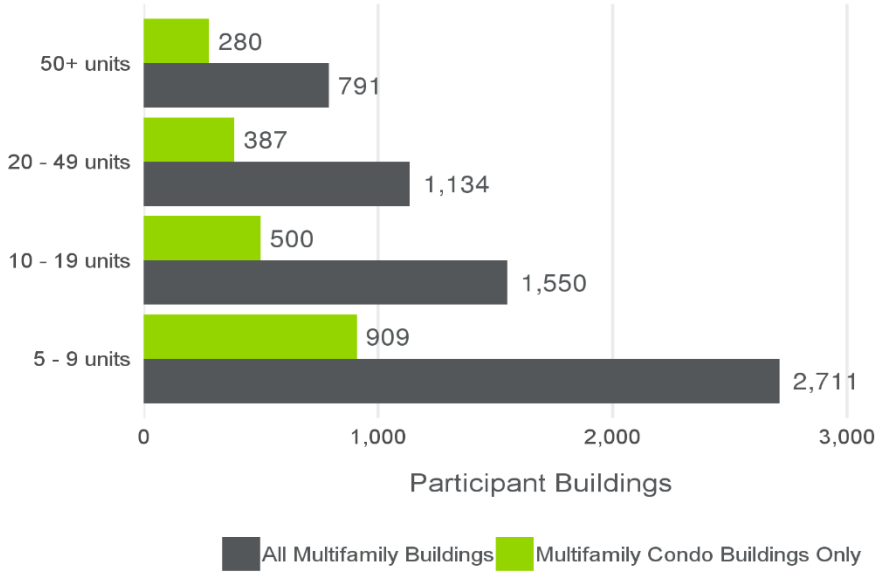


Source: Navigant analysis

4.2.2 Housing Units

Figure 4-11 shows the participation of residential programs by the number of housing units in the building. From 2013 to 2016, multifamily buildings showed participation across all building sizes.

Figure 4-11. Program Participation by Number of Housing Units

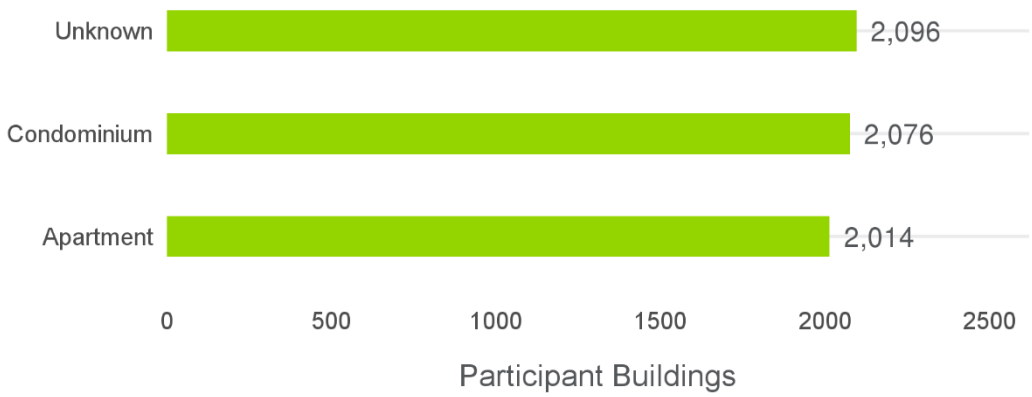


Source: Navigant analysis

4.2.3 Ownership

Figure 4-12 shows participation among condos, apartments, and unknown ownership (i.e., the remainder of properties without available property tax information). Further identification of these unknown properties would lead to a better comparison of the relative participation of apartments versus condos.

Figure 4-12. Program Participation for All Savings Programs by Ownership Type



Source: Navigant analysis

5. SUMMARY

The census of all multifamily properties and the analysis of historical program interactions identified geographic areas and customer segments that show opportunity for improving participation based on 2013-2016 participation data. As new questions emerge, and program needs evolve, the multifamily database can be used to explore characteristics of these properties and gain new insights. Based on its analysis, the study team identified potential strategies that PAs can consider:

1. **Continuous improvement of the multifamily database and dashboard**

   The multifamily database could be regularly refreshed with updated and more complete data sources, such as ACLs, property tax data, participation data, and billing data. The study team has returned PA-specific databases to each PA, who can incorporate this information into their customer information systems flag multifamily accounts. With the PAs' feedback, the database itself can be further refined. Such refinements could include grouping unique addresses into multifamily properties by synthesizing geographic, tax, and PA account data. The Power BI dashboard could be further developed into an online tool to provide quick access to important metrics for the PAs.

2. **Multifamily properties consisting of multiple buildings**

   The study team identified numerous buildings that did were not confirmed to have more than five units but have historically participated in multifamily programs. These properties may be centrally managed and consist of multiple buildings, which are treated as multifamily by PAs; and/or these may be buildings that have more than five units, but current process was not able to positively identify all of the units in the building. Future research could be conducted to better identify this population.

3. **Target areas for new participants**

   The multifamily database can be used to explore and find smaller buildings and areas with multifamily buildings to target to increase participation. This census has identified many smaller buildings that can now be targeted. There are also several geographic regions in Massachusetts that have a significant number of identified multifamily buildings that may not have participated in MassSave programs. Such cities/regions offer a valuable opportunity to market multifamily programs and could be explored for new participants.

4. **Fuel type**

   The study team had limited information regarding fuel type but identified that approximately 54% of buildings had both electric and gas service. Additionally, as much as 32% of multifamily buildings may use delivered fuels. Importantly, this percentage likely includes buildings that use electric resistance heat or heat pumps and should be considered as an upper bound. Further investigation into the types of heating systems that are installed in multifamily buildings could inform strategies to tailor incentives around fuel type and improve the success of engaging these customers.

5. **Low-income properties**

   While the study team was able to identify some low-income properties based on rate code and past participation, there are likely additional low-income properties that have not been identified in the database. This gap could be addressed by using the low-income block group information in the multifamily database to identify areas with higher low-income populations to find new participants. Further identifying such low-income properties would enhance the PAs' ability to serve these customers.

APPENDIX A. MULTIFAMILY DATABASE DICTIONARY

Table A-1 describes the columns available for the building-level multifamily database.

Table A-1. Data Dictionary for Available Data in the Building-Level Database

Column	Description
mf_prop_id	Multifamily property ID assigned by Navigant
match_addr	Building address—i.e., the E911 or Google geocoding result
ownership	Indicates whether the address is a condo (by tax use code), apartment (i.e., a multifamily address that is not a condo), or unknown (no tax information available)
multifamily	Indicates whether the address has been identified as multifamily (for this database, this value should always be 1)
fuel_bldg	Indicates whether the address has electric only accounts, electric and gas accounts, or gas only accounts; for addresses with gas only accounts, this scenario may indicate electric accounts were not available in the ACL for these addresses
n_units_est_addr	Estimated number of housing units at the address
lat	Latitude
long	Longitude
electric_pa	Name of the electric PA associated with the address; missing values indicate no account at the address
gas_pa	Name of the gas PA associated with the address; missing values indicate no account at the address
zip	ZIP code
city	City
tax_use_code	Use code, as indicated by tax data
tax_owner	Owner of the property, as indicated by tax data
tax_data_year	Year in which tax assessment data was entered for the address
tax_n_units	Number of housing units at the address, as indicated by tax data
tax_bldg_val	Current assessed value for the main building(s) on the property
tax_land_val	Current assessed value for land
tax_total_val	Current total assessed value for land and structures; because some databases include other categories of valuation not included above, this may not represent the total of the fields above
tax_bldg_area	Total building area (i.e., including common areas), as indicated by tax data
tax_res_area	Total living area at the address (i.e., excluding common areas, decks, garages)

Column	Description
tax_num_floors	Number of floors in the structure, as indicated by tax data
tax_year_built	Year in which the structure was built, as indicated by tax data
tax_num_rooms	Number of rooms in the structure, as indicated by tax data
n_units_cat	Category of number of housing units—i.e., 5-9, 10-19, 20-50, or 50+ units
tax_year_built_cat	Category of year built—i.e., 1998-2018, 1978-1997, 1958-1977, 1938-1957, 1918-1937, or before 1918
zcta	ZIP code tabulation area of the building
acs_bg_geoid	GEOID of the Block Group containing the address; used to link with ACS data
acs_bg_pop_under_200pl	Estimate of the population in the block group containing the address with income less than 200% of the poverty line as indicated by the ACS 2016 5-year estimates
acs_bg_total_pop	Estimate of the total population in the block group containing the address as indicated by the ACS 2016 5-year estimates
acs_bg_prop_under_200pl	Estimate of the proportion of the population in the block group containing the address with income less than 200% of the poverty line as indicated by the ACS 2016 5-year estimates

Source: Navigant analysis

APPENDIX B. DASHBOARD MANUAL

B.1 Software

The study team developed a dashboard for multifamily properties in Massachusetts using Microsoft's Power BI. The dashboard (a .pbix file) can be opened by using the Power BI Desktop, which is available as a free download here: https://powerbi.microsoft.com/en-us/desktop/.

B.2 Layout

The Power BI dashboard for multifamily properties in Massachusetts (referred to as dashboard through the rest of the appendix) has four tabs:

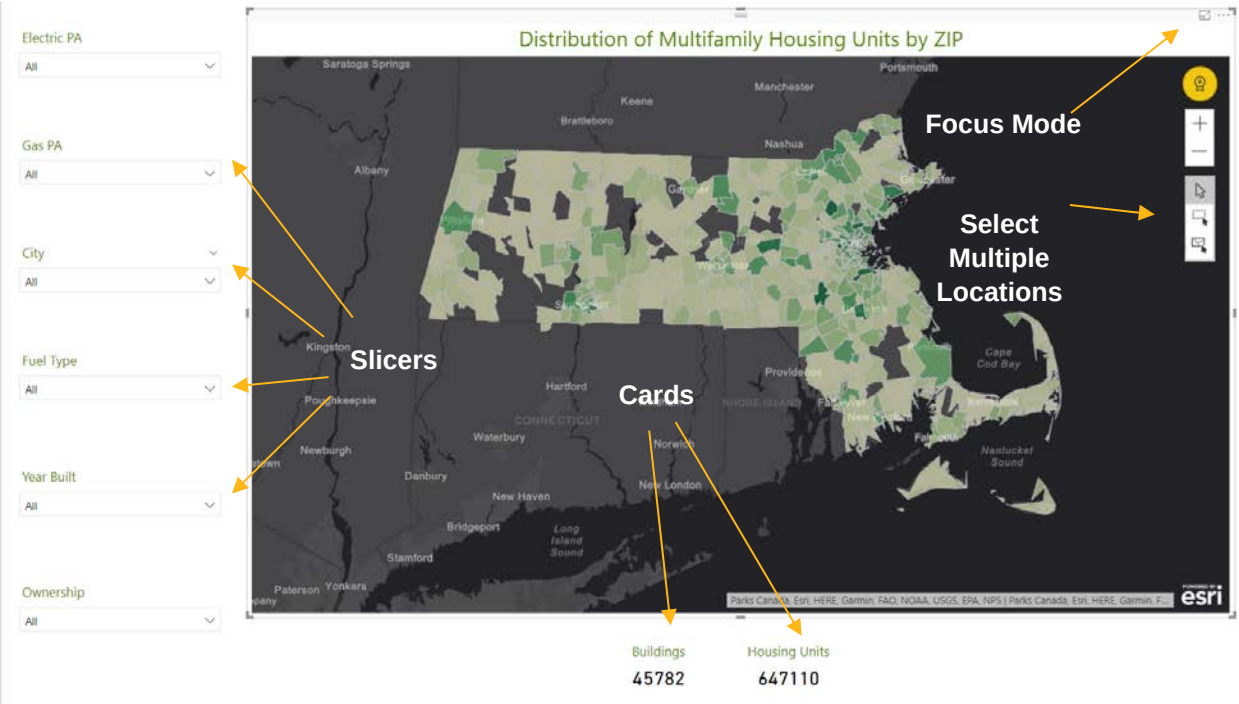
1. Distribution of Housing Units by ZIP
2. Distribution of Fuel Type
3. Distribution of Building Size (Housing Units)
4. Tables and Charts

Tabs 1 through 3 have similar formats, each consisting of a map, slicers, and cards. The map displays an overlay of relevant multifamily building locations and attributes on a reference map of the US. The slicers provide options to filter the data displayed by multiple criteria, and the cards display textual indicators to summarize the filtered data.

The final tab, Tables and Charts, demonstrates a few alternative methods of visualizing the underlying multifamily building database.

B.3 Maps

Figure B-1. Dashboard – Distribution of Multifamily Housing Units by ZIP



Source: Navigant analysis

Figure B-1 displays the Distribution of Multifamily Housing Units by ZIP tab in the dashboard. Below are a few ways to interact with the corresponding map (most of these steps apply to maps on the other tabs as well):

1. **Pan and zoom**

   Similar to other mapping interfaces, the map can be panned in any direction by clicking and dragging the map. To change the zoom level, either click on the + or - buttons on the top right of the map, scroll using the mouse scroll wheel, or double-click on a location in the map to zoom in.

2. **Click on Focus Mode**
   Focus Mode (highlighted in Figure B-1) stretches the map display to the whole page, allowing for an uncluttered and larger display of the map.

3. **Select Multiple Locations**

   The Select Multiple Locations tool (highlighted in Figure B-1) allows the user to select multiple locations on the map by drawing a rectangle to select the desired locations. If multiple locations are selected, the cards below the map will reflect updated metrics for the selected locations.

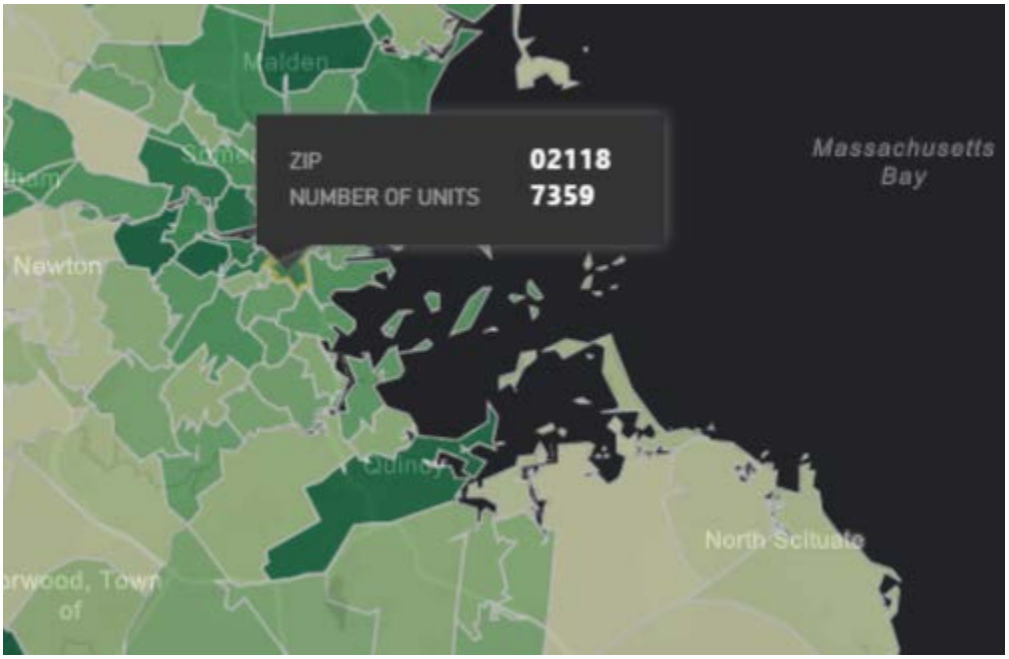
4. **Click on a feature**

   A feature can be selected and highlighted on the map by clicking on it. This will result in the cards below the map reflecting metrics specific to the selected feature. For example, by selecting one of the ZIP code polygons in the Distribution of Housing Units by ZIP map, that ZIP code would get highlighted and the cards below would display numbers corresponding to that ZIP code.

5. **Hover over feature**

   Hover over a feature in the map to display information particular to that feature. For example, as shown in Figure B-2, the number of units in ZIP code 02118 is displayed when the mouse pointer is placed over that ZIP code.

Figure B-2. Feature-Specific Information Displayed on Map



Source: Navigant analysis

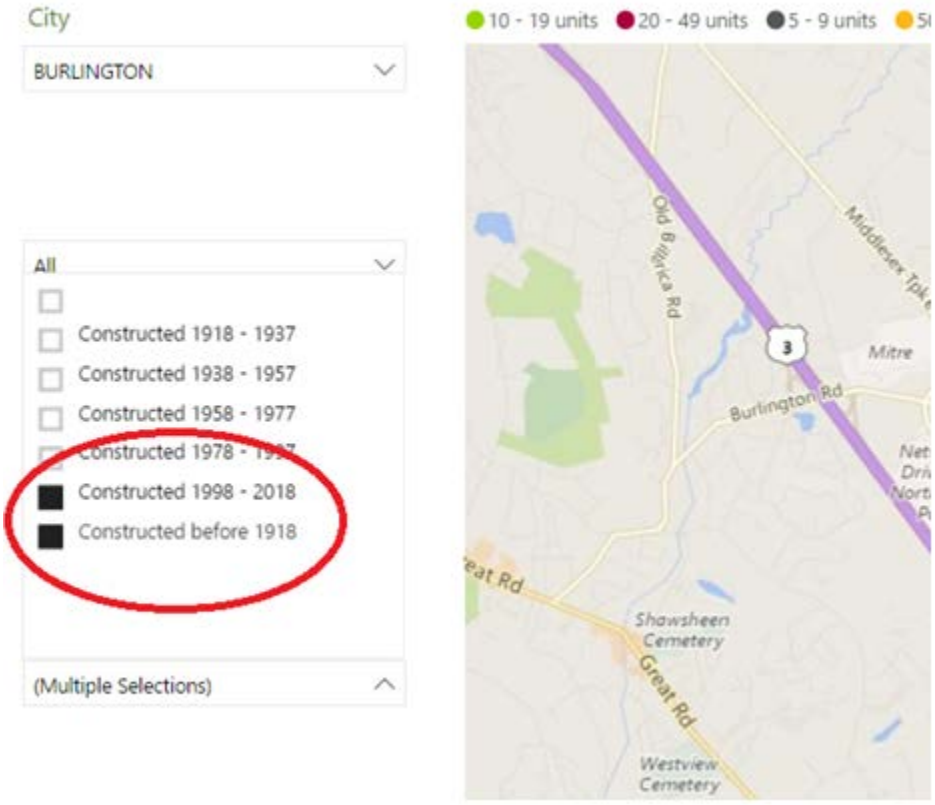
B.4 Slicers

The slicers allow for the data being displayed to be filtered by a field present in the underlying database. The Distribution of Fuel Type and Distribution of Building Size (Housing Units) tabs have slicers for the following:

1. **City**
2. **Fuel Type:** Indicates if a building had electric, gas, or both electric and gas accounts
3. **Year Built**
4. **Ownership:** Indicates if building is a condominium, apartment, or unknown

Click on a slicer's drop-down menu to choose the value of the field to filter by. Select All in the drop-down menu allows for all values to be selected. Multiple fields can be selected from the drop-down menu by holding Ctrl on the keyboard and clicking on the fields. Figure B-3 shows multiple Year Built fields selected from the drop-down menu.

Figure B-3. Multiple Selections in Slicer



Source: Navigant analysis

B.5 Tables and Charts

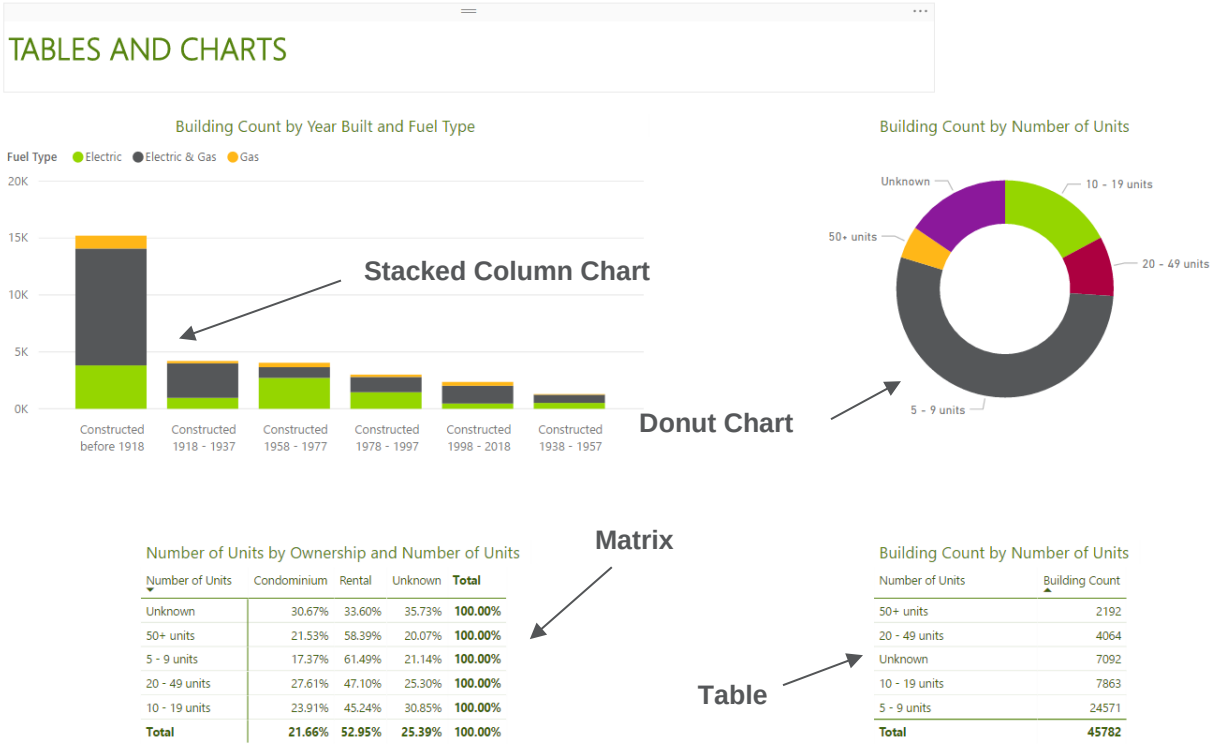
The last tab in the dashboard is Tables and Charts. As mentioned earlier, this tab's purpose is to demonstrate other methods available in Power BI to explore and visualize the multifamily buildings database.

Figure B-4 displays the Tables and Charts tab, which contains the following:

1. **Stacked Column Chart:** Displays count by multiple fields
2. **Donut Chart:** Displays a split of the data based on one field
3. **Matrix:** Useful to create a table from multiple fields and calculate totals, a percentage of the grand total, a percentage of column totals, or a percentage of row totals
4. **Table:** Useful to create a table from multiple fields and calculate totals or a percentage of the grand total

These tables and charts are interactive. By selecting a row, column, or bar of a chart, all the data visualized on this tab will be filtered by the selection. For example, selecting the bar corresponding to Constructed before 1918 would result in the donut chart, matrix, and table reflecting data filtered to only include buildings that were constructed before 1918.

Figure B-4. Tables and Charts



Source: Navigant analysis

B.6 Additional Power BI Support

Microsoft provides a few resources to learn more about features in Power BI. The following page provides easy to digest guides on working with data and visualizations: https://docs.microsoft.com/en-us/power-bi/guided-learning/.

Here are a few sections that may be the most useful:

1. Getting started
2. Introduction to visuals in Power BI
3. Create and customize simple visualizations
4. Slicers
5. Combination charts
6. Matrixes and tables