Segmenting Chicago Multifamily Housing to Improve Energy Efficiency Programs

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ELEVATE ENERGY
Smarter energy use for all

Acknowledgments

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Executive Summary

Efforts to mitigate climate change in the United States must focus on buildings, which use the most energy and produce the most carbon emissions of any sector, including transportation. In particular, multifamily buildings, defined in this report as residential buildings with two or more units, need attention. Approximately 25 percent of U.S. households reside in a multifamily building. Utility- and government-run efficiency programs have had limited success serving this sector. As a result, well over 16 million households pay more to heat and cool their homes than necessary.[i]

Improving the efficiency of multifamily housing requires policymakers to understand the characteristics of the market. Elevate Energy constructed a database of 143,000 Chicago multifamily buildings and segmented them based on age, size, and other traits in order to better understand the Chicago multifamily sector.

The segmentation analysis revealed that:

- **Three Out of Four Chicagoans Live in a Multifamily Building.** Chicago is home to an estimated 1.3 million housing units, of which 77 percent, or around 1 million units, are in multifamily buildings. Approximately one third of these multifamily units are condominiums, which are more likely to be owner-occupied than the remaining two-thirds, or 700,000 units, which are likely to be rental units.
- **Most of Chicago's Lower-Cost Multifamily Housing Is Unsubsidized.** Chicago has nearly 91,000 units of subsidized housing, defined as housing whose rents are subsidized by a government entity. These subsidized units are dwarfed by Chicago's 440,000 units of unsubsidized lower-cost multifamily housing, defined by the report authors as housing located in low-income neighborhoods and receiving no government subsidy. Neighborhoods are considered low-income if the majority of households earn less than $57,920 for a family of four.
- **Chicago's Multifamily Building Stock Is Old and Energy Intensive.** More than 75 percent of Chicago's multifamily housing was built before 1942 and predates modern building codes. Unless the buildings have been substantially rehabbed, they lack basic energy efficiency improvements such as proper insulation and air sealing, which can cut energy usage and costs by up to 30 percent.
- **Chicago's Top Three Multifamily Segments Account for 93% of the Building Stock.** Elevate Energy segmented the multifamily housing stock into 15 building types based on age, size, and construction material. The analysis revealed that 93 percent of Chicago's multifamily buildings fall within just three segments, all of which were constructed before 1942. Together, the three segments represent nearly 500,000 housing units and the potential to avoid 6.5 million metric tons of carbon dioxide emissions through off-the-shelf energy efficiency improvements.

The segmentation findings point to opportunities to improve Chicago's energy efficiency programs. First, given the size of the unsubsidized lower-cost multifamily market in Chicago, this building type requires a specific efficiency program tailored to its particular needs. The added benefits of improved health outcomes for low-income residents and greater investment in disadvantaged neighborhoods strengthens the case for prioritizing

multifamily market for energy efficiency. Second, the ownership and operational differences in the top three multifamily segments will require distinct approaches for each segment in order to ensure program uptake. Third, low-income definitions for efficiency programs must be sufficiently broad to include all unsubsidized lower-cost multifamily housing. Fourth, mapping the multifamily segments to low-income census tracts reveals that six Chicago neighborhoods are home to more than 18 percent of the buildings in the top three segments. Targeting the six Chicago community areas – Auburn-Gresham, Austin, Humboldt Park, Lower West Side, North Lawndale, and South Lawndale – has the potential to streamline program implementation while delivering energy saving improvements to nearly 80,000 lower-cost multifamily units.

I.   Introduction

Cities across the United States are implementing policies to combat climate change and prepare for the changes already underway. Dozens of mayors, county presidents, city councils, and others have committed to climate action plans and agendas that reduce carbon dioxide emissions and other pollutants. These commitments often seek to reduce the energy use in buildings, the largest source of carbon pollution in the United States, including transportation.

Multifamily residential buildings in particular are prime targets for more efficient use of energy. For the purposes of this report, multifamily buildings include all residential buildings with two or more units. Multifamily buildings are home to 20 million families in the United States[ii] and account for approximately 25 percent of all U.S. housing units.[iii] Despite its size, the multifamily housing market is underserved by utility- and government-funded energy efficiency programs.

One reason is that most cities lack data about their multifamily housing stock. Another is that multifamily buildings have complicated utility service. For example, common areas like lobbies, hallways, and storage areas can be subject to a commercial electricity or gas rate, while tenant spaces are considered residential. Additionally, tenant spaces can be individually metered for utilities or be subject to a master meter account for billing. Because multifamily buildings have qualities similar to commercial and residential properties, energy efficiency programs are rarely tailored to the multifamily sector's specific needs and are instead lumped into a program designed to serve a different type of building.

A third reason the multifamily market has not been well-served by energy efficiency programs is that ownership structures vary widely. Whereas single-family energy efficiency programs target individuals who own and occupy one property, multifamily programs must target decision makers who may be owner-occupants, investor-owners, or building managers with very different motivations and resources.

In order to unlock the energy savings potential within the multifamily market, policymakers will need to develop programs specifically designed for this building type. A multifamily housing segmentation is an important first step to understanding the market and designing effective programs.

The remainder of this report will describe the methodology Elevate Energy applied to Chicago's multifamily sector and implications for energy efficiency program design. The report is organized into three parts. The first part describes the datasets used to build a database of Chicago's multifamily buildings. The second reviews key findings from the analysis. The third section provides recommended improvements to efficiency programs based on the segmentation.

The effort to understand Chicago's multifamily buildings is aligned with similar efforts across the country. Building Energy Exchange used data from building energy assessments and New York City's energy baselining ordinance to segment the multifamily stock into 12 types, allowing Building Energy Exchange to identify the potential to save energy use by 10 percent through a variety of energy efficiency measures that would pay for themselves within 10 years.[iv] The Energy Efficiency for All (EEFA) initiative is currently constructing a database of Los Angeles multifamily housing and will complete a market segmentation analysis for publication

II. Segmentation Data

Elevate Energy drew upon 13 data sources to segment the Chicago multifamily market. The Cook County Assessor provided the primary dataset, containing more than 173,000 observations. The assessor data included variables for property age, units, stories, construction material,[1] and assessed value. Each observation was associated with a unique 10-digit property identification number.

Elevate Energy incorporated additional sources to augment the Cook County Assessor data. This included joining an older version of the Cook County Assessor data with the more current version, incorporating two datasets from the City of Chicago Department of Buildings, and adding information from the commercial real estate database CoStar.

Elevate Energy relied on additional sources for information on building ownership and financing. The National Housing Preservation Database provided property-level subsidy information for the Low-Income Housing Tax Credit (LIHTC), public housing authority affiliation, and other funding sources. The report authors estimated ownership structure using the most recent estimates from the American Community Survey (ACS) published by the U.S. Census Bureau.

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[1] Construction material was only complete for buildings with two-to-four units.

Figure 1: Data Sources Used to Conduct the Chicago Multifamily Market Segmentation
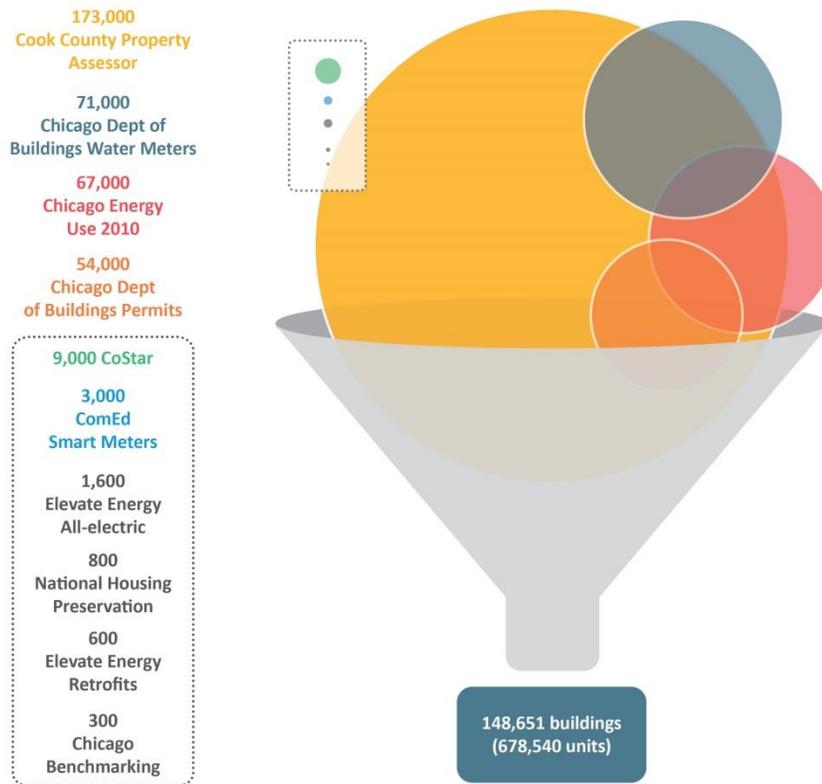
The report authors relied on several sources to obtain information on energy use. These included: program data from Elevate Energy's multifamily retrofit program, which covers roughly 600 buildings in Chicago; the Chicago City Data Portal, which published 2010 electricity and gas data at the census block level; the Residential Energy Consumption Survey (RECS), published by the Energy Information Agency; Bright Power, which shared energy baseline or "benchmarking" data for approximately 150 multifamily buildings in Chicago; and several published reports on multifamily energy use in Chicago and other cities.

Figure 1 illustrates the number of data sources and size of observations comprising the Chicago multifamily database. Because the data were gathered from many different sources and for differing original purposes, the database required extensive cleaning before completing the segmentation. The report authors removed approximately 5,000 observations due to duplication, leaving 143,000 buildings for the segmentation analysis described in the next section. The criteria used to segment the multifamily market were number of units, year built, and number of stories. Construction material was an incomplete data field, and was used only for smaller buildings.

A detailed description of the data and methods used for the Chicago segmentation is available in Appendix A. A companion document, "Understanding Your Multifamily Building Stock: A Framework for Cities and

Municipalities," outlines a replicable approach and potential data sources researchers can use to complete a multifamily housing stock segmentation in other geographies.[2]

III. Findings

The Chicago multifamily market segmentation revealed four key findings with implications for energy efficiency program design.

Three Out of Four Chicagoans Live in a Multifamily Building

Chicago is home to approximately 1.3 million housing units. Roughly 1 million units, or 77 percent, are occupied by either a renter or condominium owner in a multifamily building. Single family homes account for approximately 300,000 housing units, or 23 percent, of the city's residential housing.

The perceived prevalence of a residential category can change whether one analyzes housing units or buildings (Figure 2). Single family homes account for 65 percent of Chicago's residential buildings, for example, but make up less than 25 percent of its housing units. By contrast, condominium buildings make up less than 3 percent of Chicago's residential buildings yet represent 25 percent of the city's housing units. The remaining multifamily categories (two-to-four units, five-to-49 units, 50-or-more units) account for nearly one-third of Chicago's residential building stock (32 percent) but more than half of the housing units (52 percent).

Figure 2: Chicago Residential Housing Composition by Units (left) and Buildings (right)

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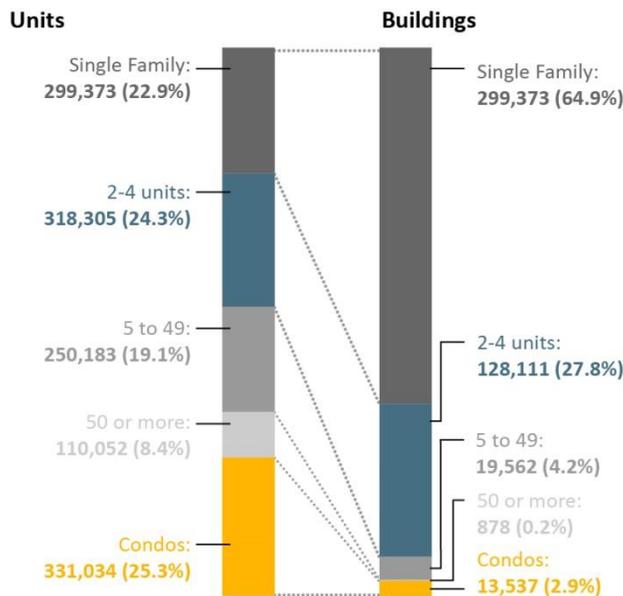
[2] The document is available at www.ElevateEnergy.org.

Condominium units receive their own category in the analysis because the ownership structure and decision-making for condominiums differ from typical renter-occupied apartment buildings. Elevate Energy separated two-to-four unit buildings from other buildings for reasons that are described in later sections of the analysis. The report authors separated buildings with five-to-49 and 50-or-more units, following the convention of the ACS.

Most Multifamily Housing Is Lower-Cost and Unsubsidized

Multifamily housing can be divided into two groups: government-subsidized units and market-rate units that attract rents based on what the local market will bear.

In Chicago, there are nearly 91,000 units of subsidized multifamily housing, as shown in Table 1. These units reflect several programs tracked by the National Housing Preservation Database, including HUD Section 8, Rental Assistance Payments, the Low-Income Housing Tax Credit (LIHTC) program, public housing, and several others.

Market rate housing is a broad term that refers to any unit not receiving government subsidy. A newly built penthouse suite on Chicago's Magnificent Mile and an older unit in a disinvested neighborhood can both be described as market rate as long as they do not receive a rental subsidy. Following a methodology put forth by the EEFA initiative,[v] the report authors divided the market rate building stock into "higher-cost housing" and "lower-cost housing" to create a more nuanced view of the housing options available to low-income households.

The report authors used census tracts to determine higher-cost housing and lower-cost housing. For this analysis, a census tract is deemed low-income if the majority of households earn less than $57,920 for a family of four. Based on this definition, 58 percent of Chicago census tracts are low-income. Figure 3 shows area median income by census tract.

Figure 3. Area Median Income by Census Tract in Chicago, 2014
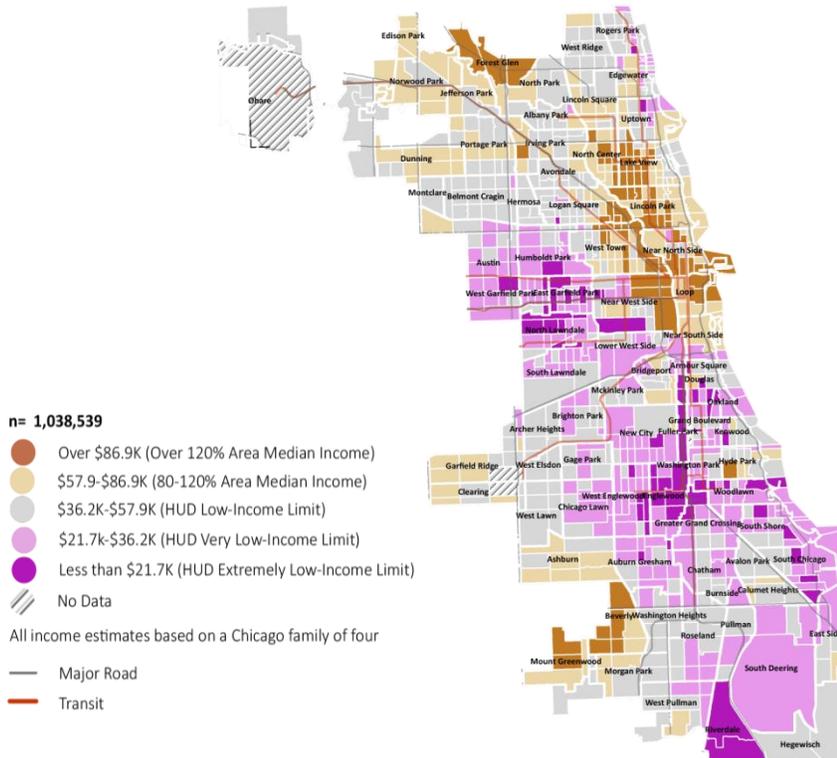
Low-income tracts are depicted in purple, pink, and gray. The report authors classified all units in an unsubsidized multifamily building as lower-cost housing when located in low-income census tracts. Similarly, if a market-rate multifamily building was located in a higher-income census tract, shown in brown and tan in Figure 3, the report authors classified all of the units in that building as higher-cost housing. The report authors exclude higher-cost housing units from the total of unsubsidized lower-cost units in Chicago.

Table 1 categorizes multifamily housing units as subsidized, unsubsidized lower-cost, and market-rate higher-cost units by building type. In addition to more than 90,000 subsidized units in Chicago, the city has roughly 440,000 unsubsidized lower-cost units. The majority, or 59 percent, of Chicago's multifamily units are either subsidized or unsubsidized lower-cost housing.

Table 1. City of Chicago Affordable Multifamily Housing Units

	Multifamily Buildings with Two-to-Four Units		Multifamily Buildings with Five-or-More Units		Total Multifamily 2+ Units	
	# Units	Percent	# Units	Percent	# Units	Percent
Market-Rate Higher-Cost	111,632	30%	264,359	49%	375,991	41%
Unsubsidized Lower-Cost	261,502	70%	183,860	34%	445,362	49%
Subsidized	Data not available		90,747	17%	90,747	10%
Total Housing Units	373,134	100%	538,966	100%	912,100	100%

Source: NHPD, ACS

Figure 4 shows the geographic distribution of Chicago's subsidized affordable housing units in buildings with five-or-more units. Darker shades correspond to a greater number of subsidized multifamily housing units by Chicago community area. The percentages refer to the percentage of multifamily housing units in the community area that are subsidized. Figure 5 at right maps the number and percentage of unsubsidized lower-cost housing units by community area.

Figures 4 and 5. Subsidized (left) and Unsubsidized Lower-Cost (right) Multifamily Buildings with Five-or-More Units, by Chicago Community Area
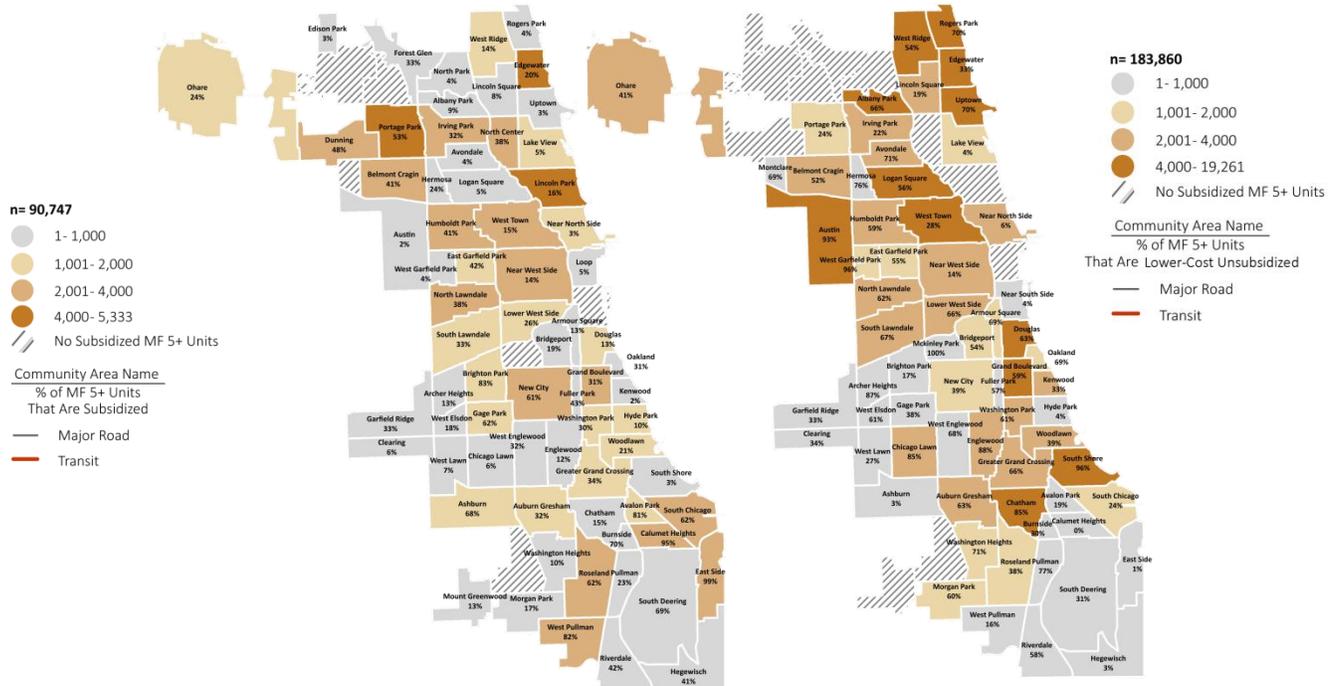
Chicago's Multifamily Building Stock Is Old and Energy Intensive

Of the 120,000 two-to-four unit buildings in Chicago, more than 90 percent were constructed before 1942 (Table 2). More than half were built of masonry construction, and another 30 percent were frame construction. Less than 3 percent of these smaller multifamily buildings were constructed after 1978, the year building codes began to require insulation.

Table 2. Percentage of Two-to-Four Unit Buildings by Year Built, Number of Units, and Construction Type

Year Built	Number of Units	Construction Type				
		Frame	Masonry	Frame/ Masonry	Stucco	All Construction Types
Pre - 1942	2	21.0%	31.0%	2.8%	0.3%	55.0%
	3	9.3%	17.3%	1.1%	0.1%	28.0%
	4	1.5%	6.2%	0.4%	-	8.0%
	Total	31.5%	54.1%	4.4%	0.4%	90.5%
1942-1978	2	0.5%	3.3%	0.2%	-	4.0%
	3	0.4%	1.9%	0.1%	-	2.4%
	4	-	0.7%	-	-	0.7%
	Total	0.9%	5.9%	0.3%	0.0%	7.1%
Post 1978	2	0.2%	0.6%	0.1%	-	0.9%
	3	0.1%	1.0%	-	-	1.2%
	4	-	0.3%	-	-	0.3%
	Total	0.3%	1.9%	0.1%	0.0%	2.4%
Grand Total		**33.0%**	**62.0%**	**4.8%**	**0.4%**	**100.0%**

For 0.2% of buildings, the construction type was unclassified.

Larger multifamily buildings are also old. More than 75 percent of multifamily buildings with five-or-more units were built before 1942 (Table 3). Regardless of construction year, few are skyscrapers – 96 percent of the buildings do not exceed four stories. Only 7 percent of five-or-more unit buildings were constructed after 1978, the year building codes began to require insulation.

Table 3. Percentage of Five-or-More Unit Buildings by Year Built and Number of Stories

Vintage	Low Rise - 1 to 4 Stories	Mid Rise - 5 to 9 Stories	High Rise - 10 Or More Stories	Grand Total
Pre - 1942	76%	1.4%	0.6%	78%
1942-1978	13%	0.8%	0.7%	15%
Post 1978	6%	0.5%	0.4%	7%
Grand Total	95.7%	2.7%	1.6%	

Figure 6 charts the number of multifamily buildings with five-or-more units constructed by year. Low-, mid-, and high-rise building construction increased from the 1800s into the 1920s, followed by a precipitous drop-off during the Great Depression. Construction remained low through World War II and never reached the volume experienced in the first decades of the 20th Century. Construction increased the 1960s and 1970s, particularly for high-rise buildings. Construction ebbed and flowed after 1978.

Figure 6. Number of Five-or-More Unit Buildings by Year Built and Number of Stories
n=20,440
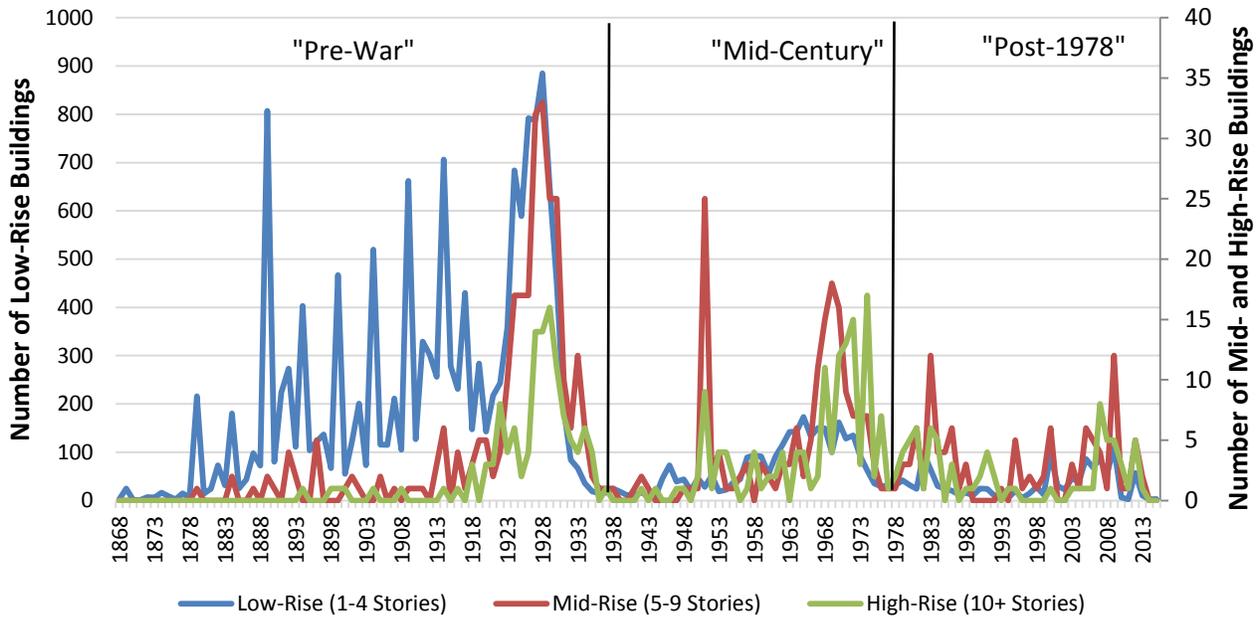
Building-level energy use data for all multifamily buildings in Chicago was not available. To compensate for the lack of large datasets, Elevate Energy consulted multiple energy data sources, including an aggregate analysis published by the City of Chicago, national surveys, and a dataset of several hundred buildings from Elevate Energy's multifamily efficiency program.

The City of Chicago dataset provided 2010 gas and electricity use information for all census block groups (Table 4). Although the breaks in data did not neatly align with this analysis, the information was illustrative. Assuming the "multifamily less than seven units" category was comparable to the energy use of two-to-four unit buildings and "multifamily seven units or more" was representative of buildings with five-or-more units, the City data revealed that larger multifamily buildings used less energy per square foot than single family homes and smaller multifamily buildings.

Table 4. Chicago Residential Building Energy Use, 2010

	Number of Electricity Accounts	Annual kWh per Account	Ft^2 per Account	Annual kWh/Ft^2/ Account	Number of Gas Accounts	Annual therms per Account	Ft^2 per Account	Annual therms / Ft^2/ Account
Single Family	279,639	8646	1207	7.2	281,167	1283	1223	1.05
Multifamily less than seven units	319,636	5740	1185	4.8	322,355	1052	1161	0.91
Multifamily seven units or more	129,784	7501	1710	4.4	69,932	1754	2964	0.59
All Residential	729,059	7168	1287	5.6	673,454	1222	1374	0.89

Source: City of Chicago Data Portal. Accessed September 2015.

Table 5 compares Chicago multifamily buildings' energy performance with other multifamily buildings across the United States. Energy use intensity (EUI) is a measure of how much energy is consumed per square foot over a one-year period. It is important to note whether an EUI is referring to source energy; the total amount of raw fuel required to operate a building; or site energy, the amount of fuel consumed at the building that is reflected on a building's utility bills. The most well-known national data sample is the Residential Energy Consumption Surveys (RECS), administered by the Energy Information Agency. According to RECS, the national EUI for multifamily buildings was 54.5. Some places, like Seattle, have significantly less energy intensive multifamily housing stock, whereas Chicago's multifamily buildings have a weather-normalized gas EUI of 111. Chicago's high median EUI is a function of building stock age, construction type, condition, Chicago climate, operations, maintenance, and occupant behavior.

Table 5. Multifamily Building Energy Use Intensity in the United States

	N	EUI	Energy Star Score	Notes
Building Performance Database[vi]	689	55 (median, site, national)	n/a	5+ units
Chicago Energy Benchmarking (2016)[vii]	952	N/A	55	≥50,000 square feet
Elevate Energy Chicago Data (2007-2015)	459	111 (gas only, median, site, pre-retrofit) 94 (gas only, median, site, post-retrofit)	n/a	5+ units; Master-metered gas heated buildings
Fannie Mae National Survey (2011)[viiiix]	536	127.9 (median, source) 78.8 (median, site)	n/a	
Los Angeles (2010)[x]	104400	46.5 (median, site)		N is parcels, not buildings
Minnesota[xi]	322	58 (owner-paid heat and hot water)	n/a	
New York City (2012)[xii]	8687	121 (median, source)	n/a	≥50,000 square feet
RECS (2009)	1924	54.5 (mean, site, national) 66 (mean, site, Midwest)	n/a	5+ units
Seattle (2013)[xiii]	1565	30.3 (low-rise, median, site) 34.3 (mid-rise, median, site) 49.0 (high-rise, median, site)	77 (low-rise, median) 85 (mid-rise, median) 47 (high-rise, median)	≥20,000 square feet Energy Star Scores are preliminary

Top Three Segments Account for 93% of Chicago Multifamily Buildings

Elevate Energy segmented the multifamily stock into 15 building types based on age, size, and construction material. These criteria were chosen because they were the most complete and high-quality variables in the dataset, and because they mirrored the segmentation approach used in a previous study of the single family housing market by Elevate Energy[xiv]. The analysis revealed that 93 percent of Chicago's multifamily buildings fall within just three categories (Table 6).

The largest segment – brick two-to-four unit buildings constructed before 1942 – represent more than half of all multifamily buildings in Chicago. Assuming an achievable 20 percent reduction in energy usage, this segment of

buildings has the potential to cut 3.6 million metric tons of carbon dioxide emissions, the equivalent of removing 760,000 cars from the road.[xv]

Pre-war low-rise buildings with five-or-more units make up the second largest segment, representing nearly 16,000 structures and 10 percent of the overall multifamily building stock. If efficiency programs targeting this building segment achieved a modest 20 percent energy savings, 1.1 million metric tons of carbon dioxide emissions would be avoided, the equivalent of planting more than 25 million trees.[xvi]

Wood frame two-to-four unit buildings constructed before 1942 have the third greatest potential for energy savings. A 20 percent reduction in energy use in this segment would save nearly 1.9 million metric tons of carbon dioxide emissions.

Table 6. Three Chicago Multifamily Building Segments with Greatest Energy Savings Potential

	Multifamily Building Segment	Units	Percentage of Chicago Multifamily Units	Buildings	Percentage of Chicago Multifamily Buildings	Estimated Median whole-building EUI[3]	Potential CO2 emissions avoided given 20% reduction
1	two-to-four unit building, pre-war, masonry	202,924	30%	79,903	54%	106	3,632,967
2	5+ building, low-rise, pre-war	199,294	29%	15,595	10%	173	1,160,168
3	two-to-four unit building, pre-war, frame	97,892	14%	41,159	28%	106	1,871,385

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[3] The estimated whole-building EUI is based on the 111 median gas EUI of the multifamily retrofit program run by Elevate Energy, and the typical fuel for larger multifamily and smaller multifamily buildings.

IV. Applying the Multifamily Segmentation

A primary motivation for conducting a market characterization is to identify opportunities to better align energy efficiency programs to buildings' and owners' needs. Segmentation of the multifamily building stock in Chicago revealed the following opportunities.

Unsubsidized Lower-Cost Multifamily Market Needs Its Own Efficiency Program

The analysis found that 59 percent of Chicago's multifamily housing units are found in lower-cost, low-income areas or are subsidized by a government entity. The number of unsubsidized lower-cost multifamily housing units (440,000) dwarfs the number of subsidized units (90,800). The sheer size of the unsubsidized lower-cost multifamily market in Chicago argues for a specific efficiency program tailored to its needs. The added benefits of improved health outcomes for low-income residents and greater investment in low-income neighborhoods strengthens the case for prioritizing the unsubsidized lower-cost multifamily market.

Top Three Multifamily Market Segments Require Distinct Approaches

The analysis revealed 15 segments within the multifamily sector. It also showed that three segments dominate the market, representing 93 percent of all Chicago multifamily buildings and 73 percent of the multifamily units. All three segments were constructed in the first half of the 20th Century and have untapped potential for energy savings. Achieving 20 percent energy savings in these building segments alone would reduce the city's carbon footprint by 6.7 million metric tons of carbon dioxide emissions. To put that number in context, Chicago's infamous Fisk and Crawford coal-fired power plants annually emitted a combined 4.5 million metric tons of carbon dioxide before closing in 2012. [xvii]

Although old age is a shared characteristic of the three segments, differences in ownership structure and operational capacity require distinct approaches in energy efficiency program design. The market segmentation analysis underscored the prevalence of two-to-four unit buildings, which make up more than 80 percent of the multifamily market and are the largest source of unsubsidized lower-cost rental housing in Chicago.

Owners of two-to-four unit buildings may have more difficulty accessing energy efficiency upgrades than owners of other multifamily buildings. Cost is one hurdle. Owners of these smaller buildings have few options to finance improvements, and typically manage their properties on a tighter budget than owners of larger buildings. As a result, the owners may have difficulty paying for the upfront costs of energy efficiency improvements even though they save money in the long run. Deferred maintenance of the buildings, also due to cost and lack of financing, may create substantial health and safety issues that must be addressed before program implementers can safely make efficiency upgrades. Time and capacity may also be an issue. In many cases, owners live in one unit with tenants occupying the other unit or units, and the owner manages the building on a part-time basis while working full-time in another field. As a result, owners may focus on immediate operations and maintenance needs rather than long-term improvements such as energy efficiency. Given these realities,

efficiency program stakeholders, including utilities, City staff, and third-party program implementers have an opportunity to design energy efficiency programs that address these barriers and increase efficiency in this ubiquitous Chicago building type.

Larger multifamily buildings, in contrast, typically have dedicated maintenance personnel, access to low-cost financing, and administrative support. For nearly a decade, Elevate Energy has run a successful energy efficiency program aimed at this building type. In 2007, Chicago's public, non-profit and for-profit sectors launched the Preservation Compact to address the loss of affordable rental housing in the Chicago area. Market characterization and segmentation research conducted by the Institute for Housing Studies at DePaul University at the time revealed that the multifamily buildings were the backbone of Chicago's lower-cost rental housing. Project partners quantified the size of this market, conducted geographic analyses, and used the data to craft a comprehensive energy efficiency program that met their goals to both preserve the availability of lower-cost housing and reduce energy costs. As of December 2016, the program has served more than 26,000 units in 632 buildings, reducing the typical multifamily building's energy use by nearly 30 percent. Most of the upgraded buildings are old, low-rise, and brick – one of the top three segments identified in this segmentation analysis. Figure 7 maps the buildings retrofitted by Elevate Energy in concert with its lending partner, Community Investment Corporation. Elevate Energy's multifamily program is nationally recognized as a model program, yet it has reached just 4 percent of the nearly 16,000 buildings of this type in Chicago.
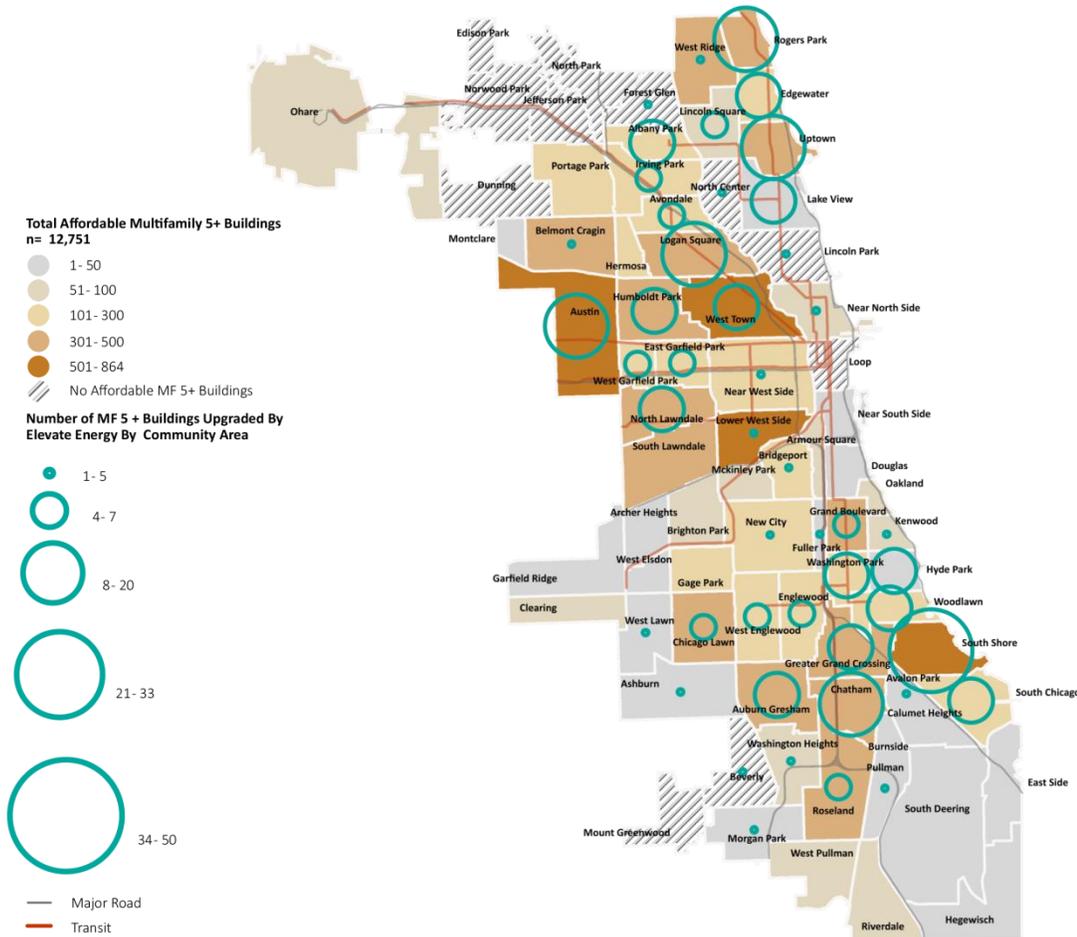
# Target Program Outreach to Low-Income Areas with a High Concentration of Key segments

This report has demonstrated how a market segmentation can help stakeholders better understand a community's multifamily building stock and identify priority segments for energy savings. GIS analysis of the segments can help identify priority geographies as well.

Figures 8 and 9 show the geographic distribution of Chicago's two-to-four unit multifamily buildings. For both maps, the color of the community area refers to the number of multifamily buildings. Darker shades correspond to a greater number of multifamily buildings. In addition to mapping all of the two-to-four unit buildings, Figure 8 at left shows the percentage of the residential stock that is multifamily. The Austin community area, for instance, has more than 4,000 two-to-four unit buildings, which represents 40 percent of the housing stock.

Figure 9 at right shows the distribution of unsubsidized lower-cost two-to-four unit buildings. The percentage on this map refers to the proportion of multifamily buildings located in low-income census tracts. Austin's percentage on this map is 98 percent, indicating that nearly all of its two-to-four unit multifamily buildings are in low-income census tracts.

Austin is not alone. In many Chicago neighborhoods, unsubsidized lower-cost two-to-four unit buildings make up more than half of the total housing stock. In Humboldt Park, for example, approximately 54 percent of the total housing stock is comprised of two-to-four unit buildings and 100 percent of them are located in low-income census tracts. In more affluent and adjacent Logan Square, 57 percent of the housing stock is comprised of two-to-four unit buildings, but only 50 percent of them are located in low-income census tracts.

Figures 8 and 9. Number of Two-to-Four Unit Multifamily Buildings by Chicago Community Area (left) and Percentage of Two-to-Four Unit Buildings in Low-Income Census Tracts (right)
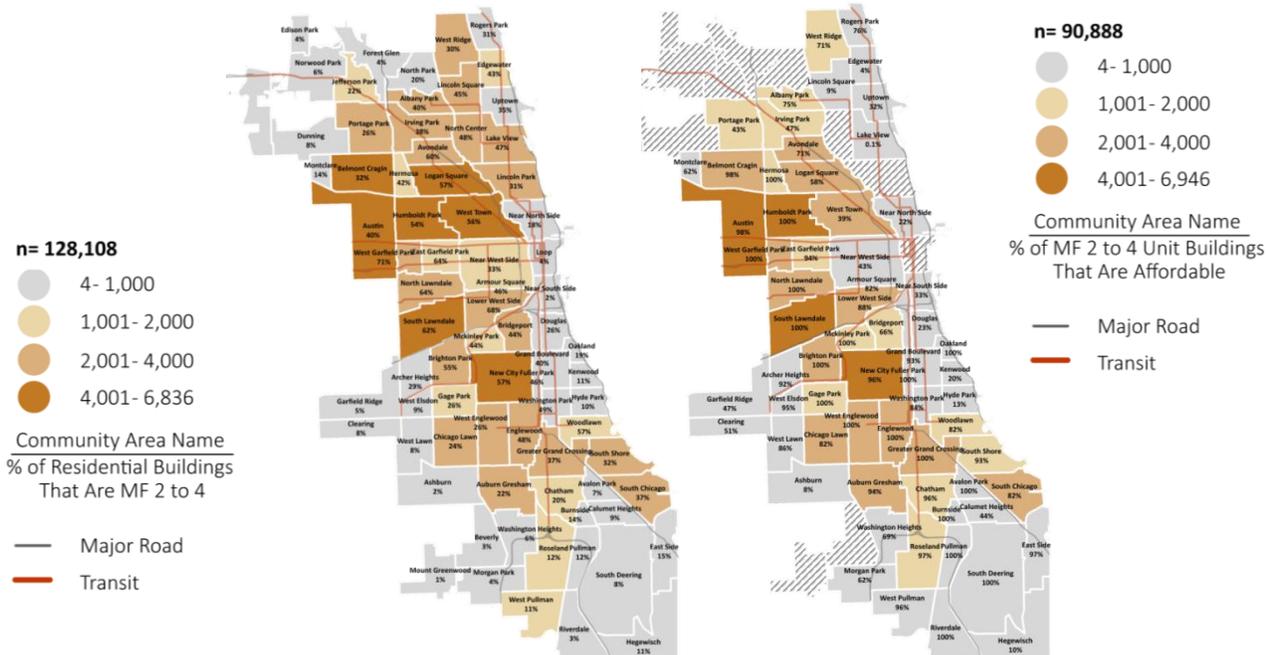
Figures 10 and 11 provide the same information for multifamily buildings with five-or-more units. Consider the South Shore community area at left. South Shore has more than 500 larger multifamily buildings that make up 14 percent of the total housing stock. The map at right shows that 95 percent of those buildings are located in low-income census tracts. Meanwhile, Lake View has a comparable number (501-1,410) and percentage (11 percent) of buildings with five-or-more units as South Shore, only 2 percent of the neighborhood's larger multifamily buildings are located in low-income census tracts.

Figures 10 and 11. Concentration of Five-or-More Unit Multifamily Buildings by Chicago Community Area (left) and Percentage of Five-or-More Unit Buildings in Low-Income Census Tracts (right)
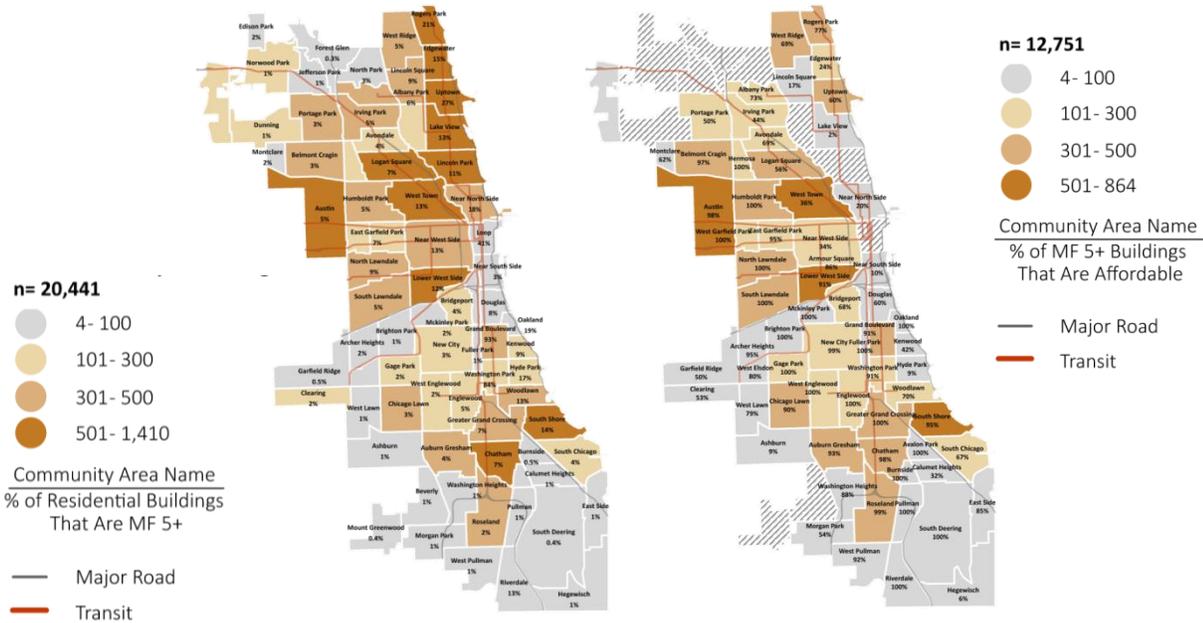
Drilling down even further, tables 7 and 8 list the 10 Chicago community areas with the most unsubsidized lower-cost multifamily buildings. Six community areas have the largest number of both two-to-four unit buildings and five-or-more unit buildings. By concentrating outreach in these six neighborhoods alone, efficiency programs have the opportunity to reach 80,000 units and 25,000 buildings. Segmentation analysis paired with GIS analysis can help those designing and implementing energy efficiency programs maximize scarce time and resources to the type of building with the greatest energy savings potential and the neighborhoods where those building types are located.

Tables 7 and 8. Neighborhoods with Lower-Cost Pre-war Two-to-Four Unit Buildings (left), and Lower-Cost Pre-war Buildings with Five-or-More Units (right). Bolding indicates neighborhoods common to both.

2-4 Buildings: Lower-Cost, Pre-War			5+ Buildings: Lower-Cost, Pre-War, Low-Rise		
Community	Units	Buildings	Community	Units	Buildings
Austin	13,006	5,659	**Austin**	7,989	585
South Lawndale	11,677	4,918	South Shore	7,429	543
Humboldt Park	10,366	4,290	**Lower West Side**	4,096	516
New City	8,396	3,435	**South Lawndale**	2,993	408
North Lawndale	7,549	3,108	**North Lawndale**	3,517	380
Englewood	6,555	2,716	**Humboldt Park**	2,987	343
Brighton Park	5,936	2,625	Woodlawn	3,622	312
Lower West Side	6,912	2,608	**Auburn Gresham**	4,060	308
West Englewood	5,068	2,182	Grand Boulevard	2,699	270
Auburn Gresham	4,929	2,090	Chicago Lawn	3,443	256

Use Low-Income Guidelines that Serve the Most People

In Chicago and all of Illinois, like many other states and municipalities, the amount of funding a program receives and who qualifies for it depends on which federal guidelines are used to set the criteria. In the case of energy efficiency, the guidelines for funding and eligibility are determined by two different agencies, creating a supply and demand mismatch that needs correcting.

Historically, low-income efficiency funding levels were determined by the portion of the population that earned 150 percent of the Federal Poverty Guideline (FPG) or $35,775 for a family of four in 2014. Based on this measure, 381,000 Chicago households were low-income in 2014. Low-income efficiency program eligibility, by contrast, was determined by area median income (AMI), which is set by the U.S. Department of Housing and Urban Development (HUD). Low-income utility-run efficiency programs in Illinois use 80 percent AMI to determine eligibility. This was slightly less than $58,000 for a family of four living in Chicago in 2014. By the HUD definition, 602,000 Chicago households qualified for low-income efficiency programs. The difference between the two definitions meant that more than 220,000 families who can least afford high utility costs were left in the middle between the two income standards.

Improve Collaboration with Other Disciplines and Utilities

Segmentation can be an opportunity to identify cross-discipline partnerships. In Chicago, the authors engaged with local experts in the housing industry, and consulted recent neighborhood-level analysis of gentrification and disinvestment to provide a non-energy context. Stakeholders at the City of Chicago expressed an interest in the findings beyond the energy field, including community development and affordable housing.

In Chicago, preliminary data and conclusions of this analysis were shared with energy efficiency stakeholders from utilities, the City of Chicago, and other implementers. These early conversations about the prevalence and location of lower-cost housing in Chicago and the opportunity to implement energy efficiency helped inform a pilot program between Elevate Energy, ComEd, and Peoples Gas. This program targets deep energy efficiency upgrades in lower-cost multifamily buildings. The launch of this program underscores that rich local data is a valuable tool for stakeholders to design energy efficiency programs, target resources, and meet goals.

V. Conclusion

A segmentation analysis is an important first step for anyone seeking to improve energy efficiency in residential buildings, whether motivated by a need to halt climate change, preserve the availability of lower-cost housing, improve health outcomes in vulnerable populations, or achieve another policy objective. Elevate Energy applied a replicable segmentation methodology that revealed Chicago's multifamily buildings as ubiquitous, old, energy intensive, and the primary source of Chicago's lower-cost housing. The analysis also revealed stark differences between the two most prevalent building types and the need for specific program approaches that account for differences in financing options, capacity, and expertise.

As more cities and municipalities commit to energy reduction goals and pass legislation like energy benchmarking and reporting, local data and analysis of housing segments can provide insights and identify new areas of opportunity for energy efficiency gains. Through local datasets and partnerships between policymakers, utilities, and program implementers, cities can continue to lead the way in making urban areas more livable, sustainable, and economically viable.

Appendix A: Data Sources and Methods

Elevate Energy drew upon 13 data sources to create the database for the multifamily market characterization. Importantly, each data source was originally developed and maintained for a purpose other than market research, and thus the authors wrestled with issues of data availability, consistency, and linkages across disparate sources. Table A1 includes the primary data sources in order of the number of observations in each dataset. The primary data source used was from the Cook County Assessor, which provided a data source with more than 173,000 observations. Although incomplete for some properties, the data source included variables for property age, units, stories, construction material, and assessed value. Each observation was associated with a unique 10-digit number called a property identification number, or "pin10". The most commonly available data fields were year of construction, number of units, and number of stories.

Table A1. Selected Data Sources used in the Chicago Multifamily Market Characterization

Dataset Name	Brief Summary	Approximate Number of Buildings / Properties	Public, Fee-Based, or Private
Cook County Property Assessor Data	Residential properties that include the vintage, number of units, and other building characteristics	173,000	Public
Chicago Department of Buildings	Water meters in commercial, residential, and industrial buildings	71,000	Private
Chicago Energy Use 2010	Aggregate electricity and gas use, at the census block level, for particular building types	67,000	Public
Chicago Department of Buildings permit	Building permits for commercial, residential, and industrial buildings	54,000	Public
CoStar	Commercial real estate database with multifamily module	9,000	Fee-Based
ComEd 2013 Smart Meter data	Electricity usage data for ComEd customers with smart meters on the multifamily rate	3,000	Private
Elevate Energy All-Electric Database	Multifamily all-electric buildings in Chicago	1,600	Private
National Housing Preservation Database	Aggregated database of federally subsidized properties	800	Public
Elevate Energy Retrofit Program	Energy use and characteristics for buildings that have applied for or completed retrofits	600	Private
City of Chicago Benchmarking	Reported energy data for multifamily buildings over 250,000 square feet	300	Private

American Community Survey (ACS)	Ongoing survey that provides demographic data	N/A	Public
Residential Energy Consumption Survey (RECS)	National survey of 12,000 households on energy consumption	N/A	Public
Energy Score Cards / Bright Power	Energy reporting data for owners of multifamily housing in Chicago	166	Private

Data Cleaning and Joining

Elevate Energy conducted extensive data cleaning of the Cook County Assessor data for multifamily buildings. First, duplicates with the same unique property identification number (PIN10) were removed and any associated data fields were appended to the remaining observation. A single building, however, could be divided into multiple parcels according to the Assessor data. An example of this is shown in the image below.

Figure A1. Assessor Parcels versus Building Footprints

Red outlines of assessor parcels are overlaid onto footprints of existing buildings shown in pink.

Parcels that appeared distinct but actually belonged to a single building were condensed into one observation for a given building footprint, and the associated data were aggregated for that observation. The authors found that often these duplications reflected improvements undertaken over time, such as parking lots or garages that merited subsequent assessments, but that were not relevant for the purposes of this study. Vacant or demolished buildings were removed from the dataset. Condominium units were identified using their class code and the fact that the final four digits of their PIN10 were the same for condo units in the same building. Thus, condo units were aggregated to the building level and the number of units included as a field.

Whenever possible, the Assessor data, which served as the primary data source, was joined to other sources via the PIN10. For example, CoStar was joined in this way, and the roughly 1,200 observations in the CoStar multifamily database that did not have matching PIN10's in the Assessor file were appended to the master data file. The slight mismatch between the Assessor and CoStar files is attributed to a lack of standard methodology for classifying large apartment buildings as either residential multifamily, commercial, or both.

Finally, each observation was geocoded using ArcGIS, using the address to assign a unique geospatial location to each building. Using this information, each building was linked to a census tract,[4] which could be used to join the data from NHPD, ACS, and other census-based survey data.

The energy data sources were similarly geocoded where relevant, but not joined to the master data file due to differing levels of granularity.

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[4] A census tract is a geographical subdivision that ideally contains around 4,000 households, but can hold as few as 1,200 or as many as 8,000. They are intended to be relatively stable over time to allow comparisons across surveys, and have unique identifiers to allow for linkages across other geographic areas like counties or metropolitan statistical areas.

Appendix B: Multifamily Market Segmentation Resource Guide

The authors found the following sources particularly helpful in gaining background knowledge and context for the market characterization of the Chicago multifamily building stock. Where a resource included both a multifamily market characterization and an evaluation of a public program, or an energy efficiency potential study, the focus is on the aspects relevant to a multifamily market characterization. The summaries below focus on the datasets employed and the high-level findings of these analyses.

Cadmus Group, Inc. (2012, May). *Massachusetts Multifamily Market Characterization and Potential Study Volume 1.* **Prepared for The Electric and Gas Program Administrators of Massachusetts by The Cadmus Group, Inc.**

> The authors conduct a characterization of the multifamily market in Massachusetts, including the size of the market, tenant and building shell characteristics, and property manager and owner decision-making processes. The market characterization, published in 2012, relies on the following data sources: 2005 Census projections; Residential Energy Consumption Survey (RECS); Energy Information Administration (EIA); utility billing data; 2010 American Community Survey (ACS); and the 2009 Residential Appliance Saturation Survey (RASS), a survey of household appliances in Massachusetts. They estimate that Massachusetts has over 524,000 units of multifamily housing, which is based on ACS estimates of occupied units. They authors obtain the midpoints for number of units for a range of building sizes in order to interpolate the number of multifamily buildings in the state at approximately 33,404. The authors also conducted on-site visits, tenant survey, and property manager survey.

Carliner, M. (2013, December). *Reducing Energy Costs in Rental Housing: the Need and the Potential.* **Cambridge, MA: Joint Center for Housing Studies of Harvard University, Research Brief 13-2.**

> The research brief analyzes data from RECS and the American Housing Survey (AHS) to extrapolate energy burden figures for every state. For renters with the lowest incomes, energy costs make up 15 percent of their income. He concludes that rental housing consumes more energy per square foot of living area than owner-occupied housing and cites building age as a correlate of energy use intensity. Further, energy intensity is lower in owner-occupied housing than in rental housing of the same vintage. The research brief includes a discussion of the split incentive and in observable differences in behavior for owner- versus tenant-paid utilities.

Fannie Mae. (2014, September). Transforming Multifamily Housing: Fannie Mae's Green Initiative and Energy Star ® for Multifamily.

> Fannie Mae oversees several initiatives to encourage energy efficiency in affordable multifamily properties: a Green Initiative, which seeks to "enhance the quality, affordability, and environmental sustainability of multifamily housing in the United states"; Green Mortgage Backed Securities (Green MBS), a securitization standard that provides financing to owners of affordable housing to implement energy efficiency, water, and general improvements; and in partnership with the U.S. Environmental Protection Agency (EPA), an ENERGY STAR ® score for multifamily properties. In conjunction with the

launch of the new ENERGY STAR® score, Fannie Mae also released results from a survey of over 1,100 multifamily properties. The survey's findings include that affordable units have a higher density of units per square foot than market rate units, and a smaller energy use per unit, but therefore higher energy use per square foot. They also find that the least efficient multifamily property may spend $165,000 more in energy costs than a similar property that is the most efficient.

Gonzales, P., Peters, J., Messer, B., & Wirtshafter, R. (2014, June). *Multifamily Performance Program Process Evaluation and Market Characterization: Final Report.* **Prepared for New York State Energy Research and Development Authority by Research into Action and Wirtshafter Associates, Inc.**

> The authors conduct market characterization of multifamily buildings in New York, and a process evaluation of the Multifamily Performance Program (MPP), which provides incentives and technical support for multifamily buildings that achieve 15 percent or more energy savings. The data used includes tax and finance records and ACS to estimate that there are over 162,000 multifamily buildings with over 2.5 million units in New York. Between 2005 and 2013, the MPP has reached less than 1% of all multifamily properties and 6.6% of units.

Johnson, K. and Mackres, E. (2013, March). *Scaling up Multifamily Energy Efficiency Programs: A Metropolitan Area Assessment.* **Washington, DC: American Council for an Energy-Efficient Economy.**

> The report estimates the size of the multifamily market in 50 metropolitan areas, assesses utility energy efficiency programs that serve the market, and discusses the funding and policy landscapes for energy efficiency in each state. To size each multifamily market, the authors rely on both the ACS and AHS. They find that 18.7 percent of all U.S. households live in multifamily buildings with 5 or more units. In particular, Chicago has just fewer than 1 million multifamily units, 72 percent of which are occupied by renters, and 67 percent of buildings were built before 1980. The report also includes data on whether renters or owners pay utilities; the primary heating fuel source; building age, and assisted and affordable housing units.

Mosenthal, P. and Socks, M. (2015, May). *Potential for Energy Savings in Affordable Multifamily Housing.* **Prepared for Natural Resources Defense Council by Optimal Energy.**

> This study estimates the potential for energy savings in affordable multifamily housing (defined as housing with 5 or more units occupied by households earning at or below 80 percent of the area median income) in nine states: Georgia, Illinois, Maryland, Michigan, Missouri, New York, North Carolina, Pennsylvania, and Virginia. The study finds that statewide economic potential for electricity ranges from 23 percent to 37 percent of the forecasted load by 2034. Natural gas potential is slightly lower, ranging from 18 to 36 percent depending on the state. For Illinois, the economic potential estimated is 32 percent for electric and 26 percent for gas. The authors estimate that Illinois has approximately 80,000 affordable buildings with 5-49 units and 294,000 buildings with 50 or more units, or 374,000 affordable multifamily buildings overall.

Petit, Kathryn, Hendey, Leah, Losoya, Brianna, Kingsley, G. Thomas. (2014, June). *Putting Open Data to Work for Communities.*

> This paper emphasizes the importance of open data practices and some of the challenges and opportunities associated with sharing data. The National Neighborhood Indicator Partnership (NNIP) and

its partners are committed to three primary functions: "the assembly, transformation, and dissemination of data; the application of data to achieve impact, particularly to address the opportunities and needs of distressed neighborhoods; and the use of data to strengthen civic capacity and governance". Partners of NNIP have access to both confidential and private administrative data, and run help desks for using the data. The authors discuss the lack of funding for efforts to leverage data to address the needs of distressed communities.

Pigg, S, LeZaks, J., Koski, K., Bensch, I., and Kihm, S. (2013, June). *Minnesota Multifamily Rental Characterization Study.* **Prepared for Minnesota Department of Commerce, Division of Energy Resources by Energy Center of Wisconsin and Franklin Energy LLC.**

The authors characterize the approximately 370,000 multifamily housing units in buildings with 5 or more units in Minnesota. Further, they sample 120 buildings for exterior construction, equipment, and utilities; measure indoor air and water temperature; and, survey tenants about energy use. The authors segment the multifamily buildings by size and vintage, and find that half of all multifamily properties will built before 1980, with a sizable minority built prior to the Great Depression; most are in two- or three-story structures; and, on average each housing unit is about 1,000 ft^2. The authors include photographs of typical multifamily properties, a discussion of heating, cooling, and hot water equipment, and discuss opportunities for further energy efficiency improvements to the multifamily building stock.

Pratt Center for Community Development. (2014) Retrofit Standardization Interim Report: a promising new approach to expanding residential energy efficiency.

The Pratt Center at New York University has demonstrated the importance of segmentation of the building stock to drive energy efficiency. Recognizing that small multifamily buildings were two thirds of New York City's building stock and accounted for 17 percent of carbon emissions, the Pratt researchers developed a standard retrofit package for specific building typologies that is low cost ($3,312) and has a Savings to Investment ratio of 1.74. In 2015, the New York City Council approved funding for a pilot program to implement the standardized retrofits in two-flat buildings.

Rambo, E, and Dethman, L. (2013, April). *2010-2012 MFEER Process Evaluation.* **Prepared for Pacific Gas & Electric Company and Southern California Edison by The Cadmus Group, Inc.**

The multifamily market characterization is part of a larger process evaluation of the Multifamily Energy Efficiency Rebate (MFEER) program in California. The authors find that 1.3 million households (or 26 percent) live in multifamily buildings in the PG&E and SCE service territories. The authors cite ACS Public Use Microdata and the 2009 Residential Appliance Saturation Study, which was conducted in 2009 and is used in the study to estimate annual energy consumption. The authors examine the number of multifamily units by vintage, building size, and utility area. Among their findings are that between 60 and 65 percent of multifamily buildings were constructed before 1980. They discuss the lighting, heating, cooling, and water heating characteristics of buildings using RASS. The study ends with survey findings including landlord preferences and opinions, and building operation structure.

West, A., et al. (2013 December). *ESA Program Multifamily Segment Study Volume 1: Report.* **Prepared for PG&E and the ESA Program Multifamily Segment Study Team by Cadmus Group, Inc and Research into Action.**

The authors characterize the low-income multifamily housing market in California as one part of a larger evaluation of the Energy Savings Assistance (ESA) Program, which is a ratepayer funded energy

efficiency program that provides energy-efficiency services to low-income households. To estimate the number of low-income multifamily households in California, the authors use ACS and AHS data. They apportion households by utility service territory, county, and census tract via geocoding of customer data provided by the utilities. They find that the low-income multifamily sector represents 9 percent of total households in California, and 32 percent of all low-income households, and that size and vintage of multifamily buildings varies by metropolitan area.

Yancy, R., Abramowitz, E., Hinge, A., Perlman, J., Laver, C., and Frank, Y. (2015 June). *Retrofitting Affordability: Evaluating New York City's Multifamily Building Energy Data for Savings Opportunities*. **Building Energy Exchange.**

The authors analyze the multifamily building stock in New York City using building characteristic and energy data resulting from the City's Benchmarking & Disclosure law. Subsequent energy audit data was released for a statistically representative sample of buildings that complied. The authors segment the multifamily market into twelve groups based on size (low- mid- or high-rise); vintage (pre- or post-war); and heating fuel source (electric, gas, oil, or steam). The authors assess affordability in the multifamily market using the ACS median income for census tracts, and counts of subsided housing from the Furman Center at New York University. They estimate over 18 trillion BTUs of source energy savings in the multifamily market.

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