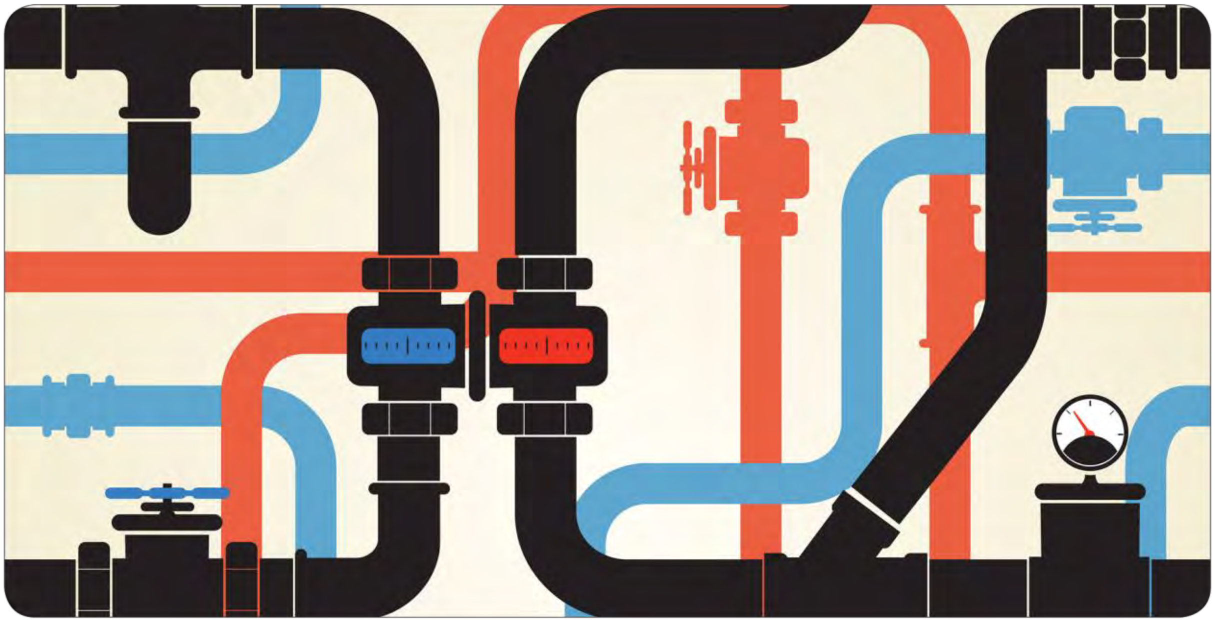
TORONTO
ATMOSPHERIC
FUND

FEBRUARY 2016

PUMPING ENERGY SAVINGS:

Ontario EMURB Market Characterization Study

Advancing the conservation opportunities of air and ground source heat pumps in the Ontario Electrically-heated Multi-unit Residential Building (EMURB) sector.



Acknowledgements

This project was made possible through the financial support of the Independent Electricity System Operator.

Further financial and in-kind support was provided by Horizon Utilities, Ontario Property Management Group (OPMG), and Toronto Hydro.

We thank our Advisory Group who gave their valuable time to contribute insight and feedback on many aspects of the project:

Frank Carnevale *(SustainCo)*; Keith Collins *(Energy Consultant)*; Rob Edwards *(IESO)*; Erik Janssen *(TRCA)*; Kirk Johnson *(EnerQuality)*; Jane Kearns*(MaRS)*; Sunil Kumar *(Kinross Gold)*; Mike Mulqueen *(Toronto Hydro)*; Peter Ormond *(Horizon Utilities)*; Kim Overbye *(OPMG)*; Bill Willis *(Thunder Bay Hydro)*; Suzanne Wiltshire *(Mitsubishi)*

We also thank the following who participated in our stakeholder engagement exercises and/or shared data for this study:

CAPREIT, City Housing Hamilton, Horizon Utilities, IESO, Mitsubishi, OPMG, Natural Resources Canada – Office of Energy Efficiency, Starlight Investments, Toronto Community Housing, and Toronto Hydro.

About Toronto Atmospheric Fund

Toronto Atmospheric Fund invests in urban solutions to reduce greenhouse gas emissions and air pollution. We achieve our mission by:

- Offering support through our community grants program;
- Collaborating with a broad range of stakeholders to realize common goals, understanding that clean air and greenhouse gas reductions benefit our health, our economy and the sustainability of our city; and
- Financing entrepreneurs whose product or service can significantly cut emissions in Toronto, and developers and property owners who are making their buildings more energy efficient.

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Table of Contents

Executive Summary i

1. Background Information and Project Rationale 1

1.1. PROBLEM 2

1.1.1. Why the Electrically-heated Multi-Unit Residential Building (EMURB) Sector? 2

1.1.2. Why Heat Pumps? 2

1.2. SOLUTION: Air and Ground Source Heat Pumps 2

1.2.1. Heat Pump Mechanics 3

1.2.2. Air Source Heat Pump (ASHP) 4

1.2.3. Ground Source Heat Pump (GSHP) 5

1.3. PROJECT OVERVIEW 6

2. Analysis of the Ontario Electrically-heated Multi-Unit Residential Building (EMURB) Sector 9

1.4. ANALYSIS SCOPE 10

1.5. THE DATA 11

1.6. ONTARIO EMURB MARKET ATTRIBUTES 14

1.6.1. Estimating the QUANTITY of EMURBs 14

1.6.2. Estimating the AGE of EMURBs 15

1.6.3. Estimating the OWNERSHIP TYPE of EMURBs 17

1.6.4. Estimating the SIZE of EMURBs 18

1.6.5. Estimating the HEATING SYSTEM present in EMURBs 22

1.6.6. Estimating the AIR CONDITIONING SYSTEM present in EMURBs 23

1.6.7. Estimating the METERING TYPE of EMURBs 24

1.6.8. Estimating the ENERGY USE of EMURBs 25

1.6.9. EMURB Market Attributes Comparison 28

1.7. ONTARIO EMURB SPATIAL DISTRIBUTION ANALYSIS 30

1.7.1. Comparing the Proportion of MURB Stock in Ontario by CSD 30

1.7.2. Estimating EMURB Quantity and Space Heating Electricity Use by CSD 31

1.7.3. Top 5 Ontario CSDs With Highest Estimated # of EMURBs 33

1.8. EMURB SECTOR STAKEHOLDERS 39

1.8.1. Engagement with Stakeholders 40

1.8.1.1. LOCAL DISTRIBUTION COMPANIES (LDCs) 40
1.8.1.2. EMURB PROPERTY MANAGERS (PM) 44
1.8.1.3. PRIVATE INVESTORS 50

3. Discussion and Conclusions 54

1.9. SUMMARY OF FINDINGS 55

1.10. EMURB MARKET SEGMENTS DEMONSTRATING HIGHEST POTENTIAL FOR FOCUSED HEAT PUMP RETROFIT PROGRAMMING 57

1.11. ANSWERING KEY PROJECT QUESTIONS 60

1.12. RECOMMENDATIONS 61

1.13. NEXT STEPS 63

4. APPENDIX A: Data Sample Used for MCS Analysis 64

5. APPENDIX B: Methodology for calculating Ontario EMURB estimate 66

List of Figures

Figure 1: Basic Heat Pump

Figure 2: Air Source Heat Pump Configuration

Figure 3: Ground Source Heat Pump Configuration

Figure 4: Construction Period of 75 Confirmed EMURB Properties in Ontario

Figure 5: Construction Period of EMURB Properties in Ontario

Figure 6: Ownership Type for Ontario EMURBs

Figure 7: Proportion of Total EMURB Properties of a Certain Size (% of EMURB Properties)

Figure 8: Proportion of Total EMURB Units in Buildings of a Certain Size (% of EMURB units)

Figure 9: Quantity of EMURB PROPERTIES of a Certain Size For 227 Confirmed Ontario EMURB Properties

Figure 10: Quantity of Units in EMURBs of a certain size for 227 confirmed Ontario EMURB Properties

Figure 11: EMURB Units by Structural Type for 154 confirmed Ontario EMURB properties

Figure 12: Comparison of Unit Quantity By Structural Type - 154 Confirmed Ontario EMURB Properties

Figure 13: Percentage of EMURB Units Found in Properties of a Certain Structural Type Based On 154 Confirmed Ontario EMURB Properties

Figure 14: In-Suite Electric Heating System Type For 167 Confirmed EMURBs in Ontario

Figure 15: Common Area Electric Heating System Type For 30 Confirmed EMURBs in Ontario

Figure 16: In-suite Air Conditioning Type For 76 Confirmed EMURBs in Ontario

Figure 17: Utility Metering Type for 111 Confirmed EMURBs in Ontario

Figure 18: Proportion of Electricity consumed for Space Heating For 25 Confirmed Ontario EMURB Properties

Figure 19: EUI for EMURB space heating for 85 Confirmed Ontario EMURBs (kWh/unit/year)

Figure 20: Top 20 CSD with the Highest Concentration of EMURB Units in Ontario

Figure 21: Toronto (CSD) Spatial Distribution of EMURB Units

Figure 22: Ottawa (CSD) Spatial Distribution of EMURB Units

Figure 23: Mississauga (CSD) Spatial Distribution of EMURB Units

Figure 24: Hamilton (CSD) Spatial Distribution of EMURB Units

Figure 25: London (CSD) Spatial Distribution of EMURB Units

Figure 26: EMURB Sector Stakeholder Map

Figure 27: EMURB Property Managers considering Electric heating system replacement

Figure 28: EMURB Property Manager Awareness of Heat Pumps (HP)

Figure 29: EMURB Property Manager Impression of Air Source Heat Pumps (ASHP)

Figure 30: EMURB Property Manager Impression of Ground Source Heat Pumps (GSHP)

List of Tables

TABLE 1: Estimate of Total EMURB Units in Ontario

TABLE 2: Comparing Ontario's Multi-Unit Residential Building (MURB) and Electrically-heated Multi-Unit Residential Building (EMURB) Sectors

TABLE 3: Ownership Type by Structural Type for Ontario EMURBs

TABLE 4: Proportion of Ontario EMURB Units by Ownership Type of a Particular Structural Type

TABLE 5: Estimates for Total Electricity Consumption for Space Heating in the Ontario EMURB Sector

TABLE 6: Estimated Savings Potential of Retrofitting EMURBs with Heat Pumps In Relation to the IESO's 2015 - 2020 Conservation Target of 7000 GWh

TABLE 7: Comparison of Varying Ontario EMURB Market Segment Characteristics by Ownership Type

TABLE 8: Top 20 Ontario Census Subdivisions (CSD) by Proportion of MURB Stock

TABLE 9: Estimated Total Electricity Use for EMURB Space Heating for Ontario Census Subdivisions (CSD)

TABLE 10: Four Key EMURB Market Segments In Ontario Demonstrating Highest Potential For Focused Heat Pump Retrofit Programming

TABLE 11: Ontario EMURB Market Segment Analysis - Packaged Terminal Air Conditioning (PTAC) Unit Market Penetration

Executive Summary

Toronto Atmospheric Fund (TAF) has embarked on an exploration of the potential to achieve energy savings and greenhouse gas (GHG) emission reductions by accelerating adoption of heat pump technology in Ontario's Electrically-heated Multi-Unit Residential Building (EMURB) sector. This Market Characterization Study (MCS) is intended to augment the understanding of the EMURB sector in Ontario. Currently, very little is known with confidence about the number, characteristics, or distribution of EMURBs in the Province of Ontario. Developing a better understanding of the EMURB sector is essential to assessing the energy and GHG reduction potential, and developing recommendations for realizing that potential.

The majority of the data presented in this Market Characterization Study are derived from estimates based on the best available information. A key lesson learned during the MCS investigation was that much of the available data related to the EMURB sector in Ontario is limited, fragmented, found in multiple formats, and sometimes contradictory. Due to the limitations with data availability and quality, estimates are used where no reliable data was available. Readers should therefore exercise appropriate caution in using the figures to support decision making. A scale of data quality is employed to assist readers in evaluating the reliability of specific data and estimates. The three levels are as follows:

- HIGH QUALITY: Acceptable to use
- MEDIUM QUALITY: Use with caution
- LOW QUALITY: Verify prior to use

KEY FINDINGS

<table>
<tr><th>FACTOR</th><th>FINDING</th><th>DATA QUALITY</th></tr>
<tr><td>SIZE</td><td>It is estimated that 23.8% (405,000 units) of all multi-unit residential households in Ontario are heated electrically. EMURB units are concentrated in larger buildings, with over 66% of units estimated to occur in buildings with over 150 units.
The EMURB sector is estimated to be compromised of the following structural types:
<table><tr><th>STRUCTURAL TYPE</th><th>SHARE OF EMURB MARKET</th></tr><tr><td>Row House</td><td>9%</td></tr><tr><td>Low Rise</td><td>22%</td></tr><tr><td>Mid Rise</td><td>23%</td></tr><tr><td>High Rise</td><td>46%</td></tr></table></td><td>MEDIUM QUALITY</td></tr>
<tr><td>AGE</td><td>The vast majority of Ontario's EMURBs are estimated to have been built between 1960 to mid-1990s, with the dominant periods of EMURB construction being the 1970s (52% of EMURBs) and 1980s (23% of EMURBs).</td><td>MEDIUM QUALITY</td></tr>
<tr><td>OWNERSHIP TYPE</td><td>Approximately 70% of Ontario EMURB units are rented and 30% are owned.
The identified ownership types for Ontario EMURB units are:
Co-operatives: 3%
Condominiums: 30%
Public Housing: 17%
Rental Apartments: 50%</td><td>LOW QUALITY</td></tr>
<tr><td>METERING TYPE</td><td>It is estimated that 45% of EMURB units are individually suite metered and 55% are bulk metered</td><td>MEDIUM QUALITY</td></tr>
<tr><td>HEATING EQUIPMENT PRESENT</td><td>A large majority of EMURB units are heated with electric baseboards (70%), with the next most common heating distribution system being PTAC units (17%).</td><td>MEDIUM QUALITY</td></tr>
<tr><td>ELECTRICITY CONSUMPTION FOR ELECTRIC SPACE HEATING</td><td>Approximately 42% of electricity consumption in EMURBs is for electric space heating. Total annual electricity use for electric space heating in the Ontario MURB sector is estimated to be 1,921 GWh. This equates to 13% of total annual MURB electricity consumption for Ontario.</td><td>LOW QUALITY</td></tr>
</table>

Stakeholder Characteristics

Common issues and potential solutions identified through stakeholder engagement exercises include:

Common Issues (Data Quality: HIGH QUALITY)

- Lack of EMURB heat pump retrofit examples undermines confidence in the viability of the technology.
- Uncertainty over technical/financial feasibility leads to perceived high level of risk and costs among LDCs/Lenders/Property Owners.
- Lack of benefit awareness reduces implementation priority for owners/boards/residents.

Commonly Cited Solutions (Data Quality: HIGH QUALITY)

- Direct financial incentives would be the most effective method for motivating property stakeholders to participate in an electric heating system retrofit.
- Detailed technical and financial documentation regarding implementation requirements, technology and financing options, performance metrics & life-cycle factors.
- Guidelines for stakeholders on how to implement a retrofit.
- Presentations from key organizations (e.g. TAF, engineers) to other stakeholders (e.g. property Board of Directors) to increase awareness of benefits.
- Provide clearer guidance to LDCs and property stakeholders on how to implement Measurement & Verification in compliance with the International Performance and Measurement Verification Protocol (IPMVP).

RECOMMENDATIONS

This assessment indicates that the total annual electricity consumption for heating in EMURBs is sufficiently large (1,921 GWh) to justify further exploration of the energy savings opportunity within the sector. However, it should also be noted that the prevalence of EMURBs varies significantly between different regions of the Province. For example the five census subdivisions with the highest concentration of EMURB units are estimated to have a combined 220,000 EMURB units and 1.05 TWh of electricity use for space heating. On the other hand, some Local Distribution Companies (LDCs) may not have a sufficient concentration of EMURBs within their service area to justify dedicated conservation programming or outreach.

Estimated Total Electricity Use for EMURB Space Heating for Top 5 Ontario Census Subdivisions (CSD)

RANK	CSD	TOTAL EMURB UNITS	ESTIMATED TOTAL ELECTRICITY USE FOR SPACE HEATING (GWh/year)**	MAXIMUM THEORETICAL CONSERVATION POTENTIAL Retrofitting all EMURB units with heat pumps & Achieving 60% energy savings (GWh/year)
1	Toronto	125,582	**595.9**	**357.5**
2	Ottawa	35,998	**170.8**	**102.5**
3	Mississauga	26,675	**126.6**	**76.0**
4	Hamilton	16,758	**79.5**	**47.7**
5	London	15,407	**73.1**	**43.9**

**Based on "Total EMURB Units" multiplied by estimated EMURB Space Heating EUI (4,745 kWh/unit/year)

Conservation programming or outreach to encourage EMURB heat pump retrofits should have a priority focus on large rental properties built between 1970 and 1989, equipped with electric resistance baseboards and bulk metering. Bulk metered rental apartments would be an ideal first target for heat pump retrofits as a single owner-operator pays the utility bills and controls in-suite capital improvements (avoiding split incentives), and they are the most common EMURB property type.

The following four key EMURB market segments demonstrate the highest potential for focused heat pump retrofit programming based on their high market share and feasibility issues (ranked in order of market share and feasibility):

FOUR KEY EMURB MARKET SEGMENTS DEMONSTRATING HIGHEST POTENTIAL FOR FOCUSED HEAT PUMP RETROFIT PROGRAMMING

RANK	OWNERSHIP TYPE	HEATING EQUIPMENT	METERING TYPE	STRUCTURAL TYPE	UNITS PER PROPERTY	AGE	EMURB MARKET SHARE
1	Rental Apartment	Electric Resistance Baseboards	Bulk	Row House Low Rise Mid Rise High Rise	Up to 350	1970s to 1990s	22%
2	Rental Apartment	Electric Resistance Baseboards	Individual	Mid Rise High Rise	100 to 300	1970s to 1990s	16%
3	Condominium	Electric Resistance Baseboards	Individual	Row House Mid Rise High Rise	Up to 500	1970s to 1990s	11%
4	Public Housing	Electric Resistance Baseboards	Bulk	Row House Low Rise Mid Rise High Rise	Up to 700	1960s to 1990s	8%

How were the top ranking EMURB market segments chosen?

The majority of EMURBs (70%) in Ontario are heated with electric resistance baseboards. Within that larger grouping rental apartments with electric resistance baseboards built during 1970s – 1990s represent the largest EMURB market segment in Ontario by volume of units and the largest opportunity for electricity conservation. With rental apartments the decision-making process for implementing a retrofit is much simpler compared to other ownership types, such as condominiums, due to the requirement to foster support from a single owner. For these reasons rental apartments are the top ranked market segment for focused heat pump retrofit programming. Condominiums (Individually metered) and Public Housing (Bulk metered) with electric resistance baseboards represented the other largest EMURB segments in Ontario by volume of units.

What about the split incentive issue for individually suite metered rental apartments?

Many of the EMURB rental apartments are individually suite metered. This can pose as a barrier for conservation efforts due to the issue of split incentives reducing interest from landlords to implement a retrofit. Still, the quantity of EMURB apartment units in Ontario that are individually metered equate to a significant conservation opportunity and warrants the consideration of dedicated heat pump retrofit programming. Furthermore, landlords may be keen to retrofit if shown the benefits of what a new heat pump heating system can do for their property and residents. One such benefit could be the reduction in resident turnover and apartment vacancies. Many rental apartments are occupied by low income groups that may be forced to seek alternative accommodations as heating costs rise. A heat pump retrofit may increase the appeal of suite metered rental apartments and improve resident retention rates, thus a shared incentive for residents and landlords. A heat pump retrofit may also increase property values, from the reduced resident turnover and improvement to building elements, which can certainly benefit a landlord.

Based on stakeholder feedback, demonstration projects and case studies would be helpful to build market confidence in the technical and financial feasibility of heat pump retrofits. Case studies would also be helpful to verify the energy-savings and GHG reduction potential.

Stakeholder engagement with EMURB property managers has revealed a need for assistance in assessing the financial and technical feasibility of heat pump retrofits, as well as generally raising awareness amongst management, owners, and residents. This indicates that any financial incentives for EMURB retrofits should be complemented by information, outreach and technical assistance targeted specifically at EMURB customers.

The development of an EMURB database developed in collaboration with strategic partners could help to reduce EMURB market data gaps and assist LDCs seeking to identify and quantify EMURBs in their service area.

Most EMURBs lack central cooling; heat pump retrofits can incorporate cost effective cooling options which may be a key selling point for some stakeholders. However, the impact on summer peak loads needs to be considered.

NEXT STEPS

TAF will be assessing the technical and financial feasibility of heat pump retrofits in EMURBs by conducting pre-feasibility studies in eight EMURB properties and investment grade feasibility studies in four EMURB properties. Findings from the MCS will help with the site selection process.

Further areas for investigation

Although this project is focused on EMURBs, it must be noted that the dominant source of heating in Ontario's residential sector is natural gas. The potential GHG reductions from converting gas-heated MURBs to heat pumps are likely much larger than for converting EMURBs. However, at current energy prices, the business case for such conversions is weak. Nonetheless, the Province's long-term GHG reduction targets may not be achievable without such conversions. Future research is recommended to identify the potential GHG reductions from such conversions, as well as the technical and financial feasibility.

1

Background Information and Project Rationale

PROBLEM

1.1.1. Why the Electrically-heated Multi-Unit Residential Building (EMURB) Sector?

Due to the combination of rising electricity rates and relatively low natural gas rates, buildings with electric resistance heating have the strongest business case for converting to heat pump technology. Ontario has a relatively large concentration of EMURBs, most of which are at an age (30+ years) where major building retrofits are likely to occur. These buildings house a disproportionate share of Ontario's lower income residents, who may be negatively impacted by rising electricity prices. Without dedicated effort to convert these buildings to heat pumps, increasing financial pressure may cause EMURB owners to convert instead to natural gas heating, which would undermine Ontario's ability to meet its long-term GHG reduction targets. Furthermore, the Ontario Government has tasked Local Distribution Companies (LDCs) with achieving a combined 7 TWh of conservation by December 2020. Retrofitting EMURBs across Ontario with energy efficient heat pumps could make a meaningful contribution to achieving that target.

1.1.2. Why Heat Pumps?

Heating is the dominant source of energy-use and GHG emissions within Ontario's homes and buildings. While conventional heating technologies range in efficiency from 70% to 100%, heat pumps alone can achieve efficiencies in the 200% to 400% range by using the renewable thermal energy found in outdoor air, soil, or water. Increasingly, heat pumps are being recognized as one of the key technologies for reducing energy-use and GHG emissions in the buildings sector. Ground and Air Source Heat Pumps are proven technologies that can provide space heating, domestic hot water heating, and space cooling with significantly less energy than conventional HVAC systems. Continued advances in heat pump technology have improved the cold climate performance of both ASHP and GSHP, making heat pumps an efficient and reliable low carbon heating solution for the Ontario context.

SOLUTION: Air & Ground Source Heat Pumps

The emergence and refinement of heat pump technology – using a reversible refrigeration cycle – offers the ability to significantly reduce the energy required to heat and cool buildings while maintaining (or improving) thermal comfort. Air source heat pumps (ASHP) harvest ambient air and ground-source heat pump systems (GSHP, often called geo-exchange) harvest the renewable heat/cool from below the ground's surface. The latter can (should) be structured to re-charge the ground with heat extracted from the building in the summer so that it can be extracted the following winter and not dumped into the atmosphere, which would add to urban "heat island" effect and cooling demand.

A heat pump is a mechanical device that extracts low temperature renewable heat, from sources such as the air or ground, and transfers concentrated heat at a higher temperature to a desired space. A heat pump can also be configured to reverse the heat transfer process and remove heat from a space and expel it into the environment, such as back into the air or ground, in order to provide space cooling. For the purposes of cooling, heat pumps are a commonly found technology, primarily in conventional air conditioners and refrigerators. However, in Canada heat pumps for space heating are less common, despite their ability to utilize a small amount of electricity compared to conventional electric heating systems while providing higher levels of thermal comfort.

1.1.3. Heat Pump Mechanics

A typical heat pump is comprised of five primary elements (Please see Figure 1):

1. **Refrigerant:** a chemical that circulates throughout the heat pump, absorbing and releasing thermal energy at various stages as it transfers from liquid to vapour.
2. **Evaporator:** A coil which the liquid refrigerant circulates through and absorbs low temperature heat from the surrounding environment (e.g. air or ground)
3. **Compressor:** An electronic mechanical device that increases the temperature of the liquid refrigerant by squeezing the refrigerant molecules closer together after the refrigerant passes through the evaporator. The compressor increases the pressure and temperature of the refrigerant to such a point that it converts to a high-temperature vapour.
4. **Condenser:** The Condenser is a coil that circulates the high-temperature refrigerant vapour. Heat from the refrigerant vapour is exchanged to the coil, and subsequently the heated coil releases the thermal energy to the surrounding environment (e.g. indoor space).
5. **Expansion Valve:** The expansion valve lowers the pressure of the refrigerant vapour and in so doing lowers the refrigerant temperature, allowing the refrigerant to return to a liquid, circulate back to the Evaporator coil and begin the thermal transfer process again.

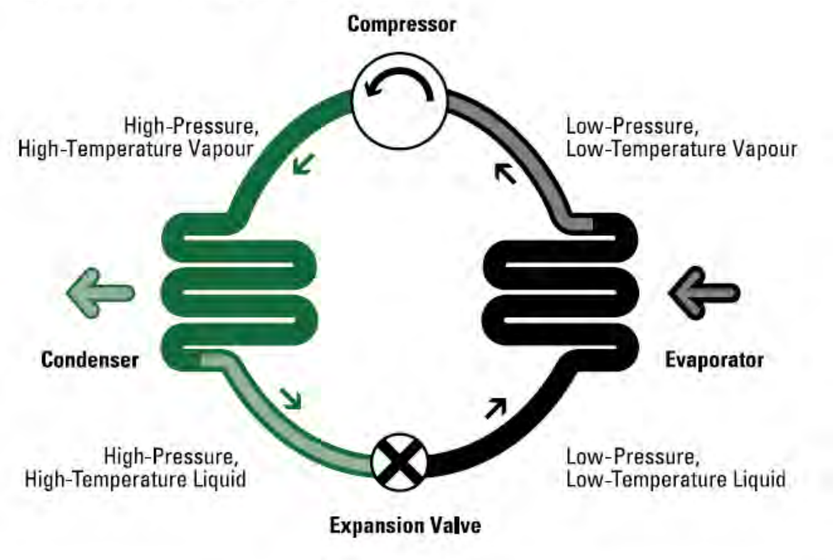

Figure 1: Basic Heat Pump

1.1.4. Air Source Heat Pump (ASHP)

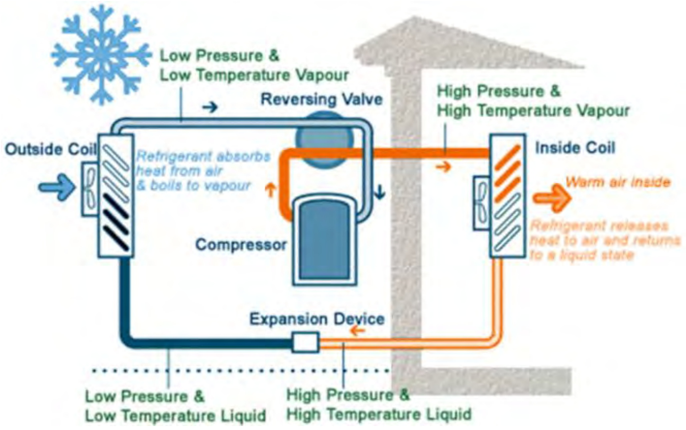

Figure 2: Air Source Heat Pump Configuration

ASHP extract low-temperature heat from outdoor air and transmit warmer air to an indoor space during cooler seasons, and can also collect and reject indoor heat to the outside air for space cooling.

Specifications

- The two primary types of ASHP are:
  - ***Air-to-air:*** Extracts or expels heat via outdoor air; used in conjunction with forced air heating distribution systems
  - ***Air-to-water:*** Extracts or expels heat via outdoor air; used in conjunction with hydronic heating distribution systems
- Advances in ASHP variable speed technology have improved cold climate operation capabilities, with some ASHP being able to operate efficiently in temperatures below -15°C and some as low as -35°C.
- ASHP have an average service life of 15 – 20 years.
- Energy costs for ASHP can be significantly lower than conventional electric heating systems but will be dependent on factors such as:
  - Type of system installed
  - Climate conditions
  - Efficiency of heating system to be replaced
  - System size
  - Fuel/electricity costs
- Among the various types of ASHP, the mini-split ASHP presents a viable option for retrofitting urban buildings with conventional electric baseboard or hydronic heating systems due to its limited façade and interior space requirements, as well as not needing ductwork. Mini-split ASHP are wall-mounted, and provide enhanced thermal comfort and control by allowing up to eight individual wall-mounted units to provide thermal energy via a single outdoor heat pump unit.

1.1.5. Ground Source Heat Pump (GSHP)

[Other common names: geoexchange, earth energy system, geothermal]

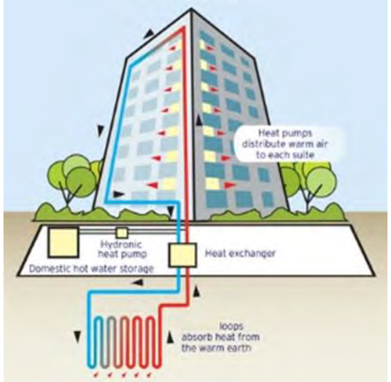

Figure 3: Ground Source Heat Pump Configuration

GSHP absorb heat found in soil and/or nearby water sources (e.g. ground water, ponds, lakes) and distribute the upgraded heat either by forced-air or hydronic heating systems for space heating. During the summer GSHP can be designed to expel unwanted heat into the ground for space cooling. The ground can act as seasonal storage during the summer, as the heat that was expelled for space cooling, can be utilized again during the winter for space heating.

Specifications

- GSHP are comprised of underground piping that circulates either a refrigerant or water to an indoor heat pump that will exchange heat from the liquid thermal medium to a distribution system.
- The two primary types of GSHP are:
    - ***Closed Loop:*** Closed-loop systems circulate a refrigerant through a continuous piping loop buried beneath the ground, with the refrigerant either absorbing or expelling heat as it circulates.
    - ***Open Loop:*** Utilizes a water source in close proximity as the thermal transfer medium (e.g. ground water, well, pond, lake). Water is pumped from the water source, circulated through the GSHP, and pumped back to the source. Open loop systems are easier to install and cost less than closed loop systems.
- GSHP configurations are generally categorized as:
    - ***Horizontal Loop:*** Land requirements for North American climates similar to Ontario range on average from 79 m^2/kW (One pipe) to 40 m^2/kW (Six pipes).[1]
    - ***Vertical Loop:*** Land requirements for North American climates similar to Ontario range on average from 5 to 10 m^2/kW based on an average borehole depth of 91 m and a spacing of 5 m.[2]
- Geothermal energy is a highly dependable thermal resource, with the average coefficient of performance (COP) observed between 2.5 and 3.8.

With EMURBs generally located in dense urban contexts and open space limited, land requirements can be prohibitive to the implementation of GSHP. However, suitable drilling technologies have become available that allow for borehole drilling in underground parking garages and narrow alleyways reducing the barrier that land requirements might pose.

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[1] Natural Resources Canada (2002). Commercial Earth Energy Systems: A Buyers Guide.

[2] Natural Resources Canada (2002). Commercial Earth Energy Systems: A Buyers Guide.

PROJECT OVERVIEW

This Market Characterization Study (MCS) is one component of the Pumping Energy Savings project which is intended to accelerate adoption of heat pump technology in Ontario's Electrically-heated Multi-Unit Residential Building (EMURB) stock.

This two year project consists of multiple phases that will generate information, resources, and tools for key stakeholders in order to:

- Identify opportunities for accelerating the adoption of heat pump technologies for the Ontario EMURB sector
- Quantify the potential GHG emission reduction and energy cost savings from implementing heat pumps in EMURBs
- Address concerns of financial risk from investing in heat pump retrofits through clearly communicated real world business case scenarios and technical reporting from a series of feasibility studies
- Qualify the need for dedicated programming to assist EMURB property owners to develop and implement heat pump retrofits; and provide programming design and implementation recommendations to Local Distribution Companies (LDC)
- Demonstrate the willingness and capacity for EMURB stakeholders to develop and implement heat pump retrofits
- Develop resources that provide EMURB property owners and managers guidance on how to assess their technical and financial capacity to implement heat pump retrofit projects

PHASE 1: MARKET CHARACTERIZATION STUDY (MCS)

This Market Characterization Study (MCS), is the starting point of the project and is intended to establish a quantitative and qualitative understanding of the EMURB sector in Ontario by beginning to answer the broader questions the project aims to address. The anticipated contribution of the MCS for helping to answer the broader project questions and to better understand the varying levels of implementation potential is outlined as follows:

BROADER PROJECT QUESTIONS	CONTRIBUTIONS TOWARDS A BETTER UNDERSTANDING OF POTENTIAL by POTENTIAL CATEGORY	ANTICIPATED KNOWLEDGE OBTAINED FROM MCS
What are the total measured potential GHG and Energy savings opportunities available from deploying heat pumps in EMURBs?	• Total Implementation Potential • Economic/Market Potential • Technical Potential	• How many EMURBs in Ontario • Sizes • Heating/DHW electric use & peak demand
What financial capacity is available in the EMURB sector?	• Total Implementation Potential • Economic/Market Potential	• Typical ownership structure • Typical financial capacity of buildings
What are technical constraints imposed building/site physical attributes?	• Total Implementation Potential • Technical Potential	• Age • Construction type • Lot size • Zoning/code issues
What is the Management capacity in the EMURB sector?	• Total Implementation Potential • Economic/Market Potential	• Size • Type of ownership • Property type
What are the Motivations/interests of key decision makers affecting heat pump retrofits in the EMURB sector?	• Total Implementation Potential • Economic/Market Potential	• Metering Type (Bulk vs. Individual) • Stakeholder Priorities • Identify bias against heat pumps

The MCS is intended to become a resource for stakeholders by providing the best available data on the state of the EMURB sector and how this affects the potential to accelerate EMURB heat pump retrofits. Our data collection approaches included a public data scan from various commercial and institutional sources, and data sharing agreements with our project partners in order to collect data on the quantity of EMURBs (# buildings and individual suites), their location, and physical characteristics of identified EMURBs (i.e. age, Gross Floor Area, stories), and energy consumption data. We also engaged in public outreach to key market informants by way of one-on-one interviews, focus groups, and surveys to gain more qualitative insights into the state of the EMURB sector by gaining a better understanding of the willingness and capacity of the EMURB stakeholders to implement retrofits.

The MCS is also intended to inform the development and implementation of the next phases of the project. In Phase 2 of the project, the MCS findings will be used to assist in the selection of eight representative EMURB sites to undergo technical and financial feasibility assessments. In later project phases, results from the site specific feasibility studies will be combined with the MCS findings to estimate the achievable energy savings potential in the EMURB sector and develop recommendations for future conservation programming to realize that potential.

Heat pumps can provide a multifaceted solution that addresses the social, economic, and environmental problems associated with conventional energy use for space heating and cooling by simultaneously reducing the need for centralized fossil-fuel dependent energy systems and increasing the utilization of local renewable energy. However, to achieve widespread adoption of heat pumps in the EMURB sector we must establish a baseline to help us chart the trajectory for getting to where we want to be. That is the purpose of the MCS.

2

Analysis of the Ontario Electrically-heated Multi-Unit Residential Building (EMURB) Sector

2.1 ANALYSIS SCOPE

Data mining and analysis was undertaken to contribute to a better understanding of the Ontario EMURB sector. This investigation has generated estimates that will contribute to an enhanced understanding of the Ontario EMURB sector. The findings were made possible through the rigorous analysis of data at several spatial granularities:

PROVINCIAL

- Utilized publicly available provincial estimates regarding the quantity of MURB units in Ontario that consume electricity as the primary fuel source for space heating.
- Correlated provincial level estimates of quantity of MURBs that are heated electrically to other estimates of MURB characteristics including tenure, construction dates, property types, and sizes (# suites, height).
- Utilized the "Individual Building" scale EMURB database to supplement and strengthen provincial estimates.
- TAF quantified the size of the Ontario EMURB market using a TAF derived Toronto EMURB estimate in conjunction with TAF's EMURB estimates for areas outside of Toronto.

MUNICIPAL

- Compared the proportion of MURB stock in Ontario by Census Subdivision (CSD) for twenty CSDs with the most MURBs.
- Estimated the proportion and distribution of EMURB units by Census Tract for the top five identified CSDs with the most assumed EMURB.

TORONTO (CSD)

- Identified Toronto as the CSD with the highest concentration of MURBs of any other CSD and therefore warranting a priority analysis focus.
- The TAF research team utilized Toronto Hydro data, along with data from the TAF EMURB and Natural Gas Heated MURB database, and through rigorous analysis techniques established a Toronto specific EMURB estimate.

INDIVIDUAL BUILDINGS DATABASE (EMURBs and Natural Gas Heated MURBs)

- Acquired data under non-disclosure agreements from energy audits, apartment/condo/co-op/public housing property management firm portfolios, and local distribution companies.
- Consolidated data for confirmed EMURB properties and Natural Gas heated MURBs into two databases.
- Generated and strengthened EMURB sector estimates using the EMURB Nat. Gas MURB databases in conjunction with Provincial estimates.

For the purposes of this project the following dwelling classifications were used to connote the Multi-Unit Residential Building (MURB) sector.

- **High Rise:** A residential structure comprised of ten or more stories.
- **Mid Rise:** A residential structure comprised of five to nine stories.
- **Low Rise:** A residential structure with fewer than five stories.
- **Row houses:** A row of houses joined by common sidewalls and no additional residential units above or below.

2.2 THE DATA

Information was gathered from multiple sources revealing assumed archetypal EMURB features at the individual building, municipal, and provincial scales across Ontario. The data acquired for this study is summarized in the table below:

DATA TYPE	DATA AVAILABILITY			
	Public		Private/Third-Party	
	Provincial	Individual Property	Provincial	Individual Property
ANNUAL CONSUMPTION DATA FOR ELECTRIC SPACE HEATING (kWh)	●			●
MONTHLY CONSUMPTION DATA (kWh)				●
OWNERSHIP TYPE				●
IN-SUITE HEATING EQUIPMENT				●
COMMON AREA HEATING EQUIPMENT				●
AC EQUIPMENT				●
UNITS	●			●
FLOORS				●
YEAR BUILT				●
METERING TYPE				●
Electric heating as percentage of annual kWh consumption	●			●
Cooling as percentage of annual kWh consumption	●			●

A summary of the individual building scale data sample size, applicable location, and data type acquired for this study is available in Appendix A.

Publicly Available Data

Reliable publicly available EMURB data was limited to aggregated provincial level estimates from Natural Resources Canada and Statistics Canada. The data sources that were utilized are as follows:

Natural Resources Canada

a. **Survey of Household Energy Use, 2011 (SHEU2011)**
The SHEU2011 provides estimates for the number of dwellings by type in Ontario that are heated electrically. The dwelling type classifications important to this project are:
  - High Rise apartments (Five or more stories)
  - Low Rise apartments (Fewer than five stories)
  - Double/row house[3]

b. **Comprehensive Energy Use Database – Residential Sector - Ontario – Table 24: Apartments Heating System Stock by Heating System Type (CEUD)**
The CEUD provides estimates for the number of 'APARTMENTS'[4] in Ontario that are heated electrically to 2012.

Statistics Canada

c. **Focus on Geography Series, 2011 CENSUS - Table 13 Canada, Ontario – Distribution of private households by structural type of dwelling - (CENSUS2011)**
The Ontario 2011 Census data provides accurate counts for the various structural types of dwellings distributed across the entire province. The response rate for Ontario was 97.2%.

d. **National Household Survey, 2011(NHS2011)**
Part of the Ontario 2011 Census, the NHS2011, provides important information pertaining to 'Dwelling Type Construction by Period' and 'Dwelling Type by Tenure' for the Dwelling Type called 'Apartments'.

e. **Focus on Geography Series, 2011 Census – Structural Type data by Census Subdivision (CSD-CENSUS2011)**
Structural type of dwelling data is provided for all Census Subdivisions (CSD) in Ontario, with data for Row House, Apartment, building that has five or more stories, and Apartment, building that has fewer than five stories.

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[3] **Double/Row house:** A house connected to at least one other dwelling, which together form a building. For SHEU2011, duplexes (two dwellings one above the other, not attached to any other structure) are included in this category.

[4] **Apartments:** This type of dwelling includes dwelling units in apartment blocks or apartment hotels; flats in duplexes or triplexes (i.e. where the division between dwelling units is horizontal); suites in structurally converted houses; living quarters located above or in the rear of stores, restaurants, garages or other business premises; caretakers' quarters in schools, churches, warehouses, etc.; and private quarters for employees in hospitals or other types of institutions.

Private/Third-Party Data

Several organizations assisted the project by providing individual level disaggregated data for confirmed EMURB properties. The sources of information included energy audits of EMURBs from TAF's multi-unit residential building energy audit database, property management companies, non-profit public housing providers, and local distribution companies.

Measuring the Quality of EMURB Sector Estimates

FINDINGS

Pertinent data will be summarized at the beginning of an analysis sub-section with the heading "FINDING".

DATA QUALITY SCALE

A finding will be accompanied by a measure of its data quality, providing readers with a level of caution when using the information. The data validity metrics are as follows:

High Quality	ACCEPTABLE 1) Third-party data verified via statistically robust methods. 2) Survey/interview responses	Example Source: 1) National Census data 2) Raw data from Interviews/Surveys
Medium Quality	USE WITH CAUTION 1) Third party data 2) High quality data has been used to generate resonable estimates.	Example Source: 1) Government estimates 2) Combining quality data from multiple reputable sources to generate new data.
Low Quality	VERIFY DATA PRIOR TO USE Generated from the use of small or unevaluated datasets. No other data was readily available.	Example Source: Using a small dataset to make generalizations for the entire sector.

2.3 ONTARIO EMURB MARKET ATTRIBUTES

2.3.1. Estimating the QUANTITY of EMURBs

Medium Quality

FINDING:

Based on the best available data it is estimated that there are approximately **404,869 EMURB units in Ontario out of 1,703,365(CENSUS2011), or 23.8% of provincial MURB stock to be EMURBs.** This estimation was based on an aggregation of two estimated quantities: ***19.2%(125,582) for Toronto(CSD) and 26.6%(279,287) for the rest of Ontario.***

TABLE 1: Estimate of Total EMURB Units in Ontario

STRUCTURAL TYPE	# of EMURB units	% of EMURBs
Row House	36,438	9%
Low Rise (< 5 stories)	89,071	22%
Mid Rise (5 – 9 stories)	93,120	23%
High Rise (10+ stories)	186,240	46%
TOTAL	404,869	100%

TABLE 2: Comparing Ontario's Multi-Unit Residential Building (MURB) and Electrically-heated Multi-Unit Residential Building (EMURB) Sectors

MURB SECTOR		EMURB SECTOR			
Structural Type*	**Units[!]**	**Structural Type****	**Units**	**% of MURB Structural Type**	**% of Total MURB Stock**
Row House	415,230	Row House	36,438	8.8%	2.1%
Low Rise (< 5 stories)	498,160	Low Rise (< 5 stories)	89,071	17.9%	5.2%
High Rise (5+ stories)	789,975	Mid Rise (5 - 9 stories)	93,120	35.4%	16.4%
		High Rise (10+ stories)	186,240		
TOTAL	**1,703,365**		**404,869**	**23.8%**	**23.8%**

*MURB Sector Structural Type definitions aligned with definitions established by Natural Resources Canada and Statistics Canada
**EMURB Sector Structural Type definitions aligned with MURB definition established by TAF for this study
! Source of MURB Units data from Canada National Household Survey (2011)

More generally, the Ontario EMURB stock is estimated to be 20 – 30% of total MURB stock. Furthermore, Northern areas or areas with a history of limited natural gas heating access are anticipated to be more in the range of 30 – 40%. However Toronto is assumed to have a lower proportion of EMURBs to MURBs; this assumption based on TAF's own experience with the MURB sector, consultation with sector experts, rigorous data analysis, and knowledge of Toronto`s long legacy of access to natural gas heating. Moreover, determining a reliable EMURB estimate for Toronto was found to be important because Toronto (CSD) possesses a significant share of all MURBs within the province, 38.4%. Thus if Toronto was assumed to have a lower EMURB to MURB ratio compared to other areas of Ontario, this study's EMURB market size assessment needed to ensure that it captured the variance between Toronto and the rest of the province, as not doing so would likely skew the estimates.

A multistep approach was employed for estimating the quantity of EMURBs in Ontario using a variety of data sources and analysis techniques. For more details regarding the methodology used for arriving at the provincial EMURB estimate please see Appendix B.

2.3.2. Estimating the AGE of EMURBs:

Medium Quality

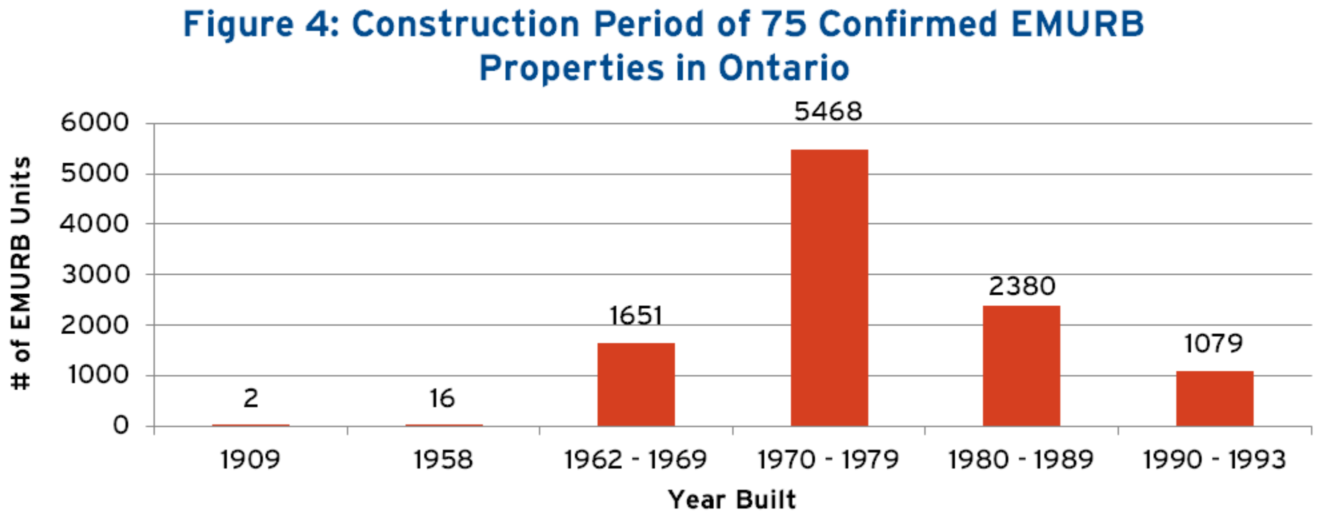
FINDING:

99.8% of all EMURBs in Ontario are built between 1962 and 1993.

The estimated percentage of total EMURBs by Period of Construction range is as follows:

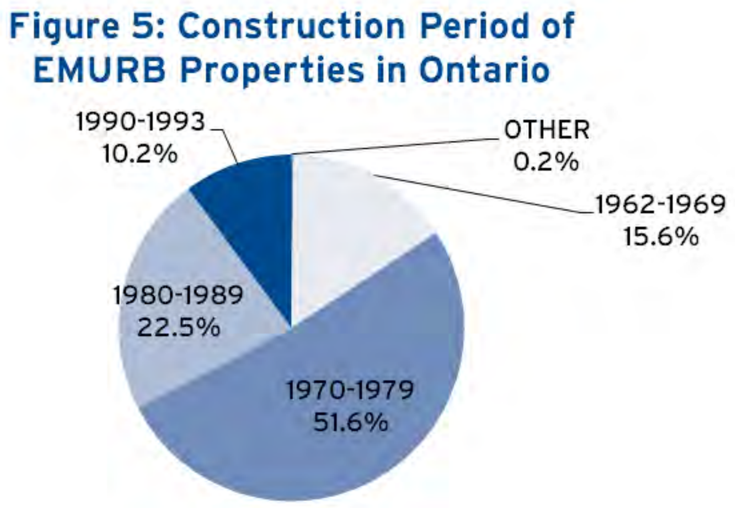
- **1960 – 1969: 15.6%**
- **1971 – 1980: 51.6%**
- **1981 – 1990: 22.5%**
- **1991 – 1993: 10.2%**

Data was collected from a sample of seventy-five electrically-heated multi-unit residential buildings (EMURBs) in Ontario. Based on this sample, it appeared that the largest two construction periods for EMURB units were the 1970s and 1980s. Out of the sample 52% of the EMURB units could be found in properties built during 1970 to 1979 and 22% during 1980 to 1989. See FIGURE 1 for a summary of the sampled EMURB properties by period of construction.



Using the sample data from the 75 confirmed EMURBs we find that 89.6% of the identified EMURB units were built between 1962 and 1989. Additionally, 84.2% of the sample was built post 1970.

There is little information readily available regarding the age of EMURBs in Ontario. However, our findings on the quantity and age of EMURBs are in line with other research findings such as an earlier report prepared for Toronto in 1992 indicating that 20% of the MURBs built post-1970s in the Greater Toronto Area were outfitted with electric baseboard heaters.[5] Another study prepared for CMHC indicated the popularity of electric space heating, albeit in Canada, from the "mid 1960s to the mid-1980s".[6]



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[5] Marbek Resource Consultants. 1992. Potential for Electricity Conservation. Prepared for City of Toronto. March.

[6] CMHC Publications. 2003. Research Highlights: Investigation of a Ground-Source Heat Pump Retrofit to an Electrically Heated Multi-Family Building.

2.3.3. Estimating the OWNERSHIP TYPE of EMURBs:

Low Quality

FINDING:

The ownership structure in the Ontario EMURB sector is estimated to be 30% OWNED and 70% RENTED.

Using tenure data by structural type from the National Housing Survey in conjunction with the EMURB quantity estimates by structural type, the ownership type of EMURBs in Ontario is estimated to be the following:

TABLE 3: Ownership Type by Structural Type for Ontario EMURBs

STRUCTURAL TYPE	TOTAL ONTARIO EMURB UNITS	OWNED		RENTED	
		EMURB UNITS	% OF EMURBs	EMURB UNITS	% OF EMURBs
Row House	36,438	25,106	6.2%	11,332	2.8%
Low Rise	89,071	18,081	4.5%	70,990	17.5%
Mid Rise	93,120	26,260	6.5%	66,860	16.5
High Rise	186,240	52,520	13.0%	133,720	33.0%
TOTAL	404,869	121,967	30%	282,902	70%

Figure 6: Ownership Type for Ontario EMURBs

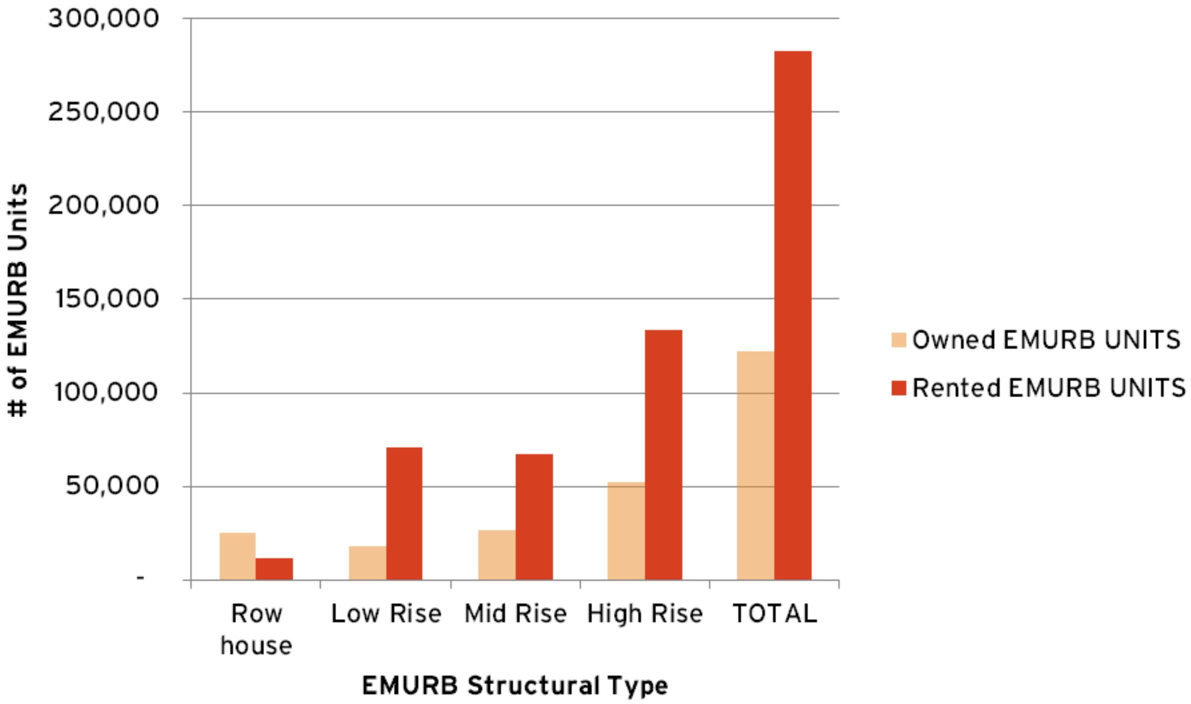


TABLE 4: Proportion of Ontario EMURB Units by Ownership Type of a Particular Structural Type

OWNERSHIP TYPE	MURB Units	EMURB Units	Percent of Total EMURBs	Percent of EMURB Ownership Type			
				Row House	Low Rise (<5)	Mid Rise (5 – 9)	High Rise (10+)
Co-operative	44,109	11,413	3%	16%	34%	33%	17%
Condominium	609,993	121,967	30%	21%	15%	22%	43%
Public Housing	260,000	67,273	17%	5%	36%	24%	35%
Rental Apartment	789,263	204,216	50%	3%	21%	23%	53%
TOTAL UNITS	1,703,365	404,869					

2.3.4. Estimating the SIZE of EMURBs:

Medium Quality

FINDING:

The EMURB sector is compromised of the following structural types: Row House (9%), Low Rise (22%), Mid Rise (23%), and High Rise (46%) (See TABLE 1).

68% of Ontario EMURB properties are comprised of 150 units or less. However, 53% of individual EMURB units are concentrated in properties ranging from 101 to 300 suites, and 66% of EMURB units are concentrated in properties with over 150 units.

Figure 7: Proportion of Total EMURB Properties of a Certain Size (% of EMURB Properties)

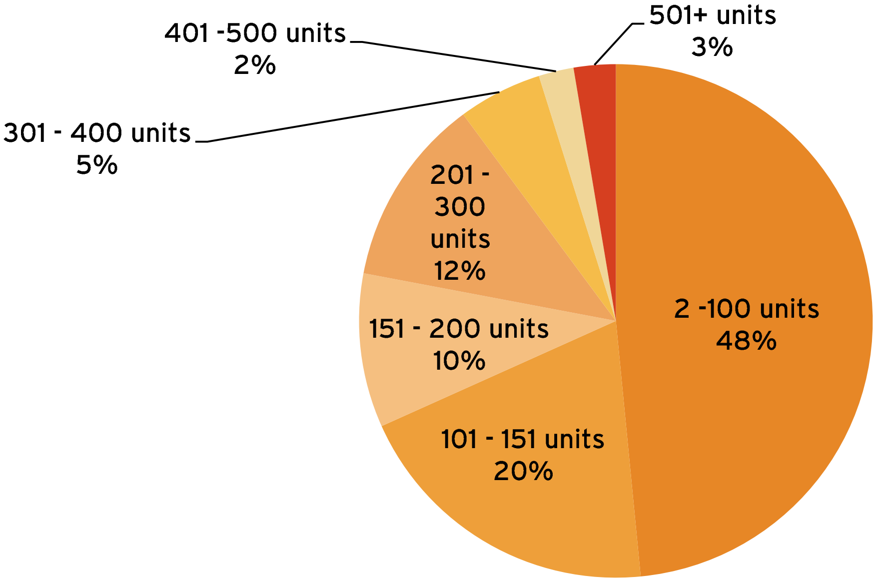
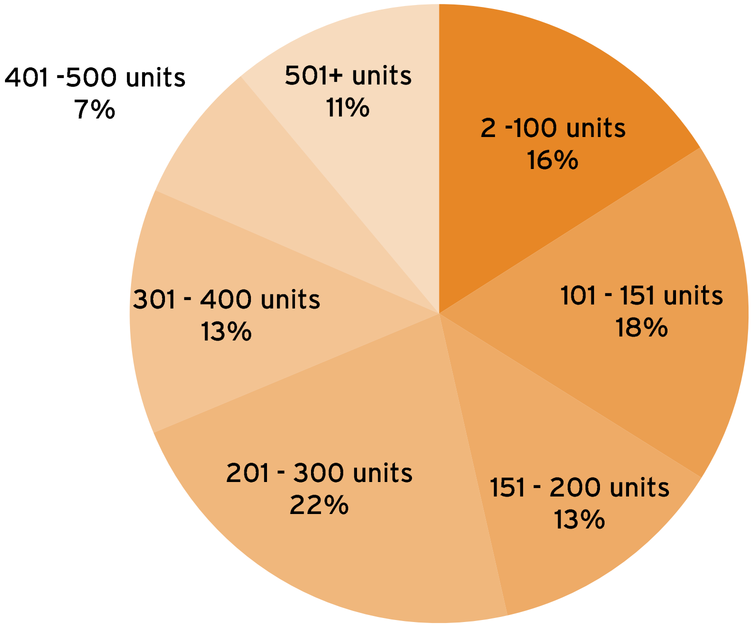


Figure 8: Proportion of Total EMURB Units in Buildings of a Certain Size (% of EMURB units)



Using available sample data for 227 confirmed EMURBs a comparative analysis of the number of EMURB units in each property was conducted to estimate the size of EMURB properties in Ontario. EMURB properties ranged in structural type from row house complexes to high rise apartments. In some cases a single EMURB property was comprised of a combination of structural types, such as with row houses and a neighbouring apartment building.

The analysis first looked at the quantity of EMURB properties of a particular size based on how many units a property was comprised of. The comparative analysis demonstrated that the majority of EMURB properties from the sample, approximately 68%, had 150 units or less.

A second assessment was subsequently conducted that compared the number of EMURB units in five EMURB property size categories: 2 – 100 units, 101 – 200 units, 201 – 300 units, 301 – 400 units, 401 – 500 units, and 501+ units. The findings were that although there were more EMURB properties with 150 units or less, there were more EMURB units in EMURB properties with 101 units or more.

Further investigation is required to validate these findings regarding EMURB size in Ontario.

Figure 9: Quantity of EMURB PROPERTIES of a Certain Size
For 227 Confirmed Ontario EMURB Properties

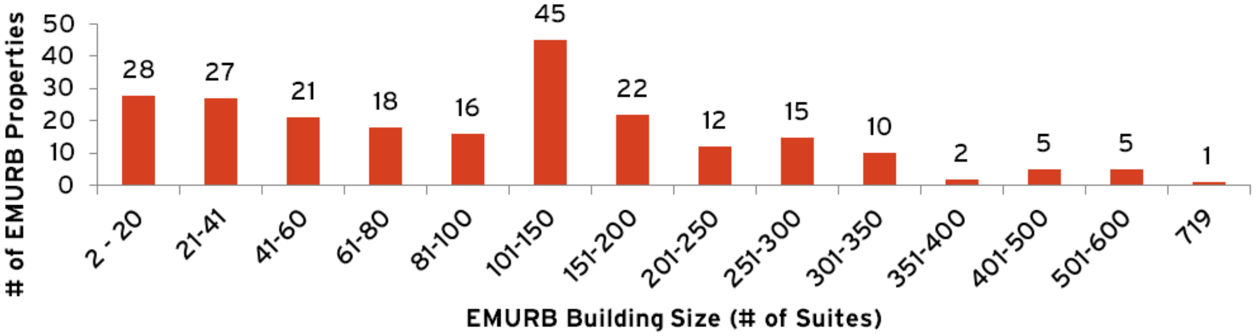


Figure 10: Quantity of Units in EMURBs of a certain size
For 227 confirmed Ontario EMURB Properties

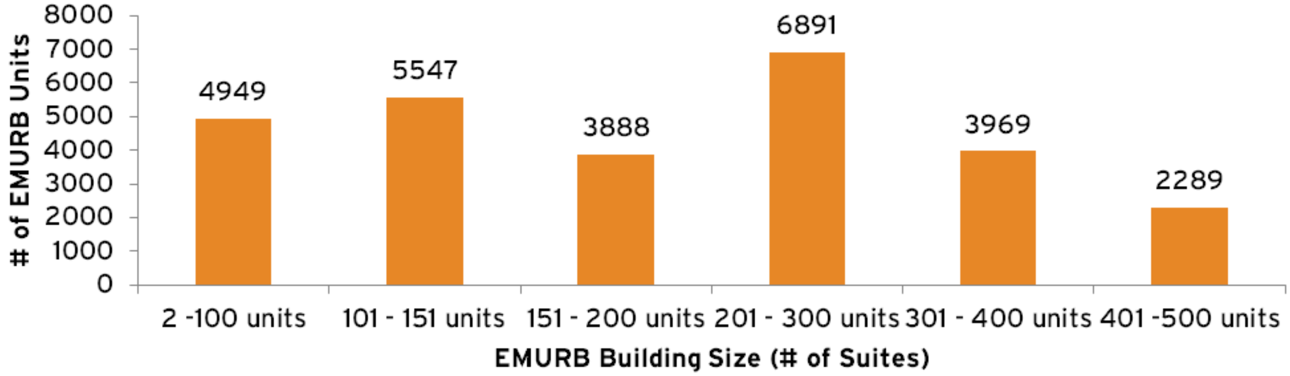


Figure 11: EMURB Units by Structural Type
For 154 Confirmed Ontario EMURB Properties

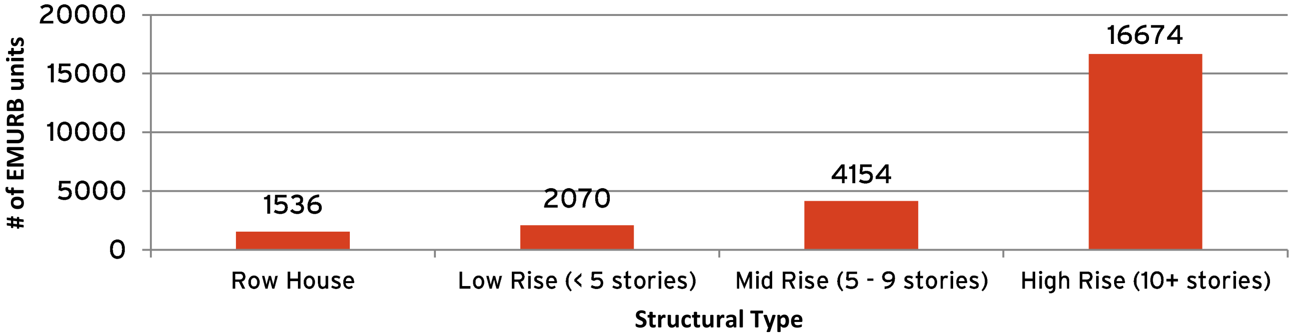


Figure 12: Comparison of Unit Quantity By Structural Type - 154 Confirmed Ontario EMURB Properties

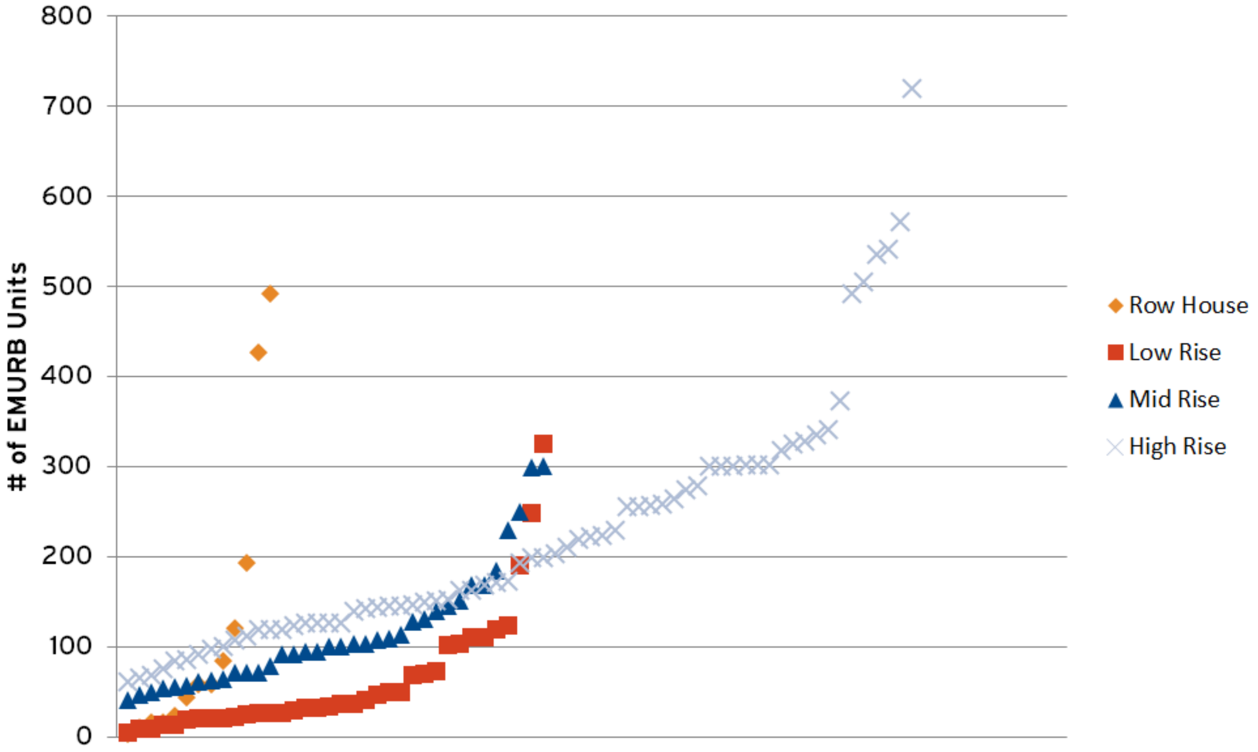
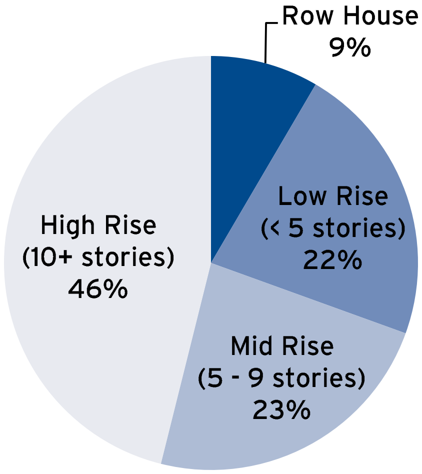


Figure 13: Percentage of EMURB Units Found in Properties of a Certain Structural Type Based On 154 Confirmed Ontario EMURB Properties



2.3.5. Estimating the HEATING SYSTEM present in EMURBs:

Medium Quality

FINDING:

Electric resistance baseboard heating is the dominant form of electric space heating, in either in-suite or common areas, in Ontario EMURB properties. The second most prevalent electric heating system in EMURBs are Packaged Terminal Air Conditioning (PTAC) units. However PTACs have a significantly reduced penetration in the EMURB sector compared to baseboard heaters.

Using available sample data for 167 confirmed EMURB properties allowed for a comparison of electric heating system type present in individual suites for each of the confirmed EMURB properties. The findings showed that in-suite electric heating is primarily electric resistance baseboard heating (70%), with Package Terminal Air Conditioners (PTAC) comprising the second dominant type (17%).

Of the confirmed EMURB data collected, there was only data on Common Area heating systems data for 30 confirmed EMURB properties. The majority again was electric resistance baseboard heating and PTACs in only one case.

Figure 14: In-Suite Electric Heating System Type For 167 Confirmed EMURBs in Ontario

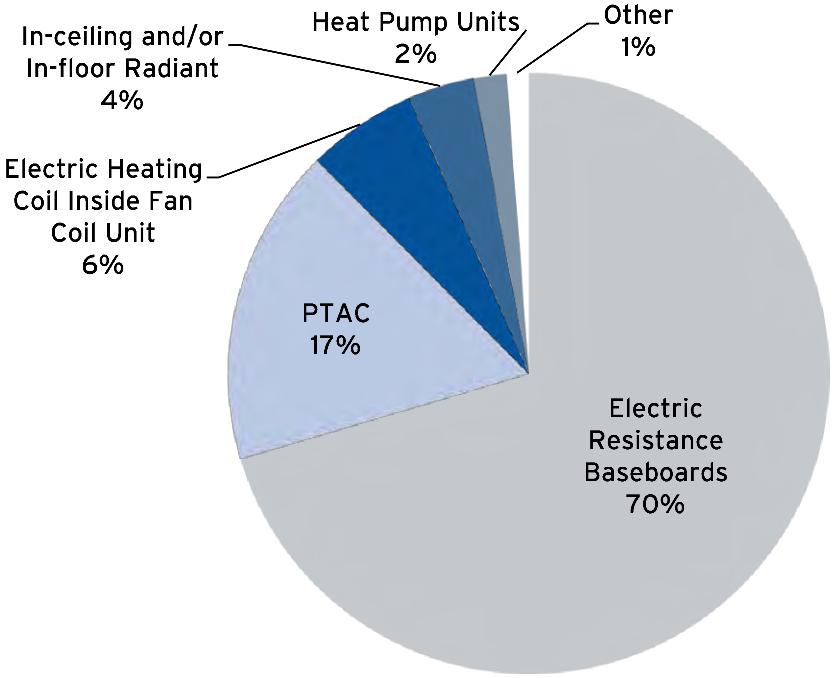
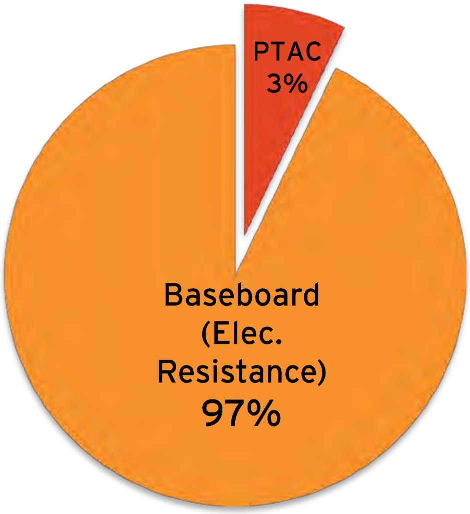


Figure 15: Common Area Electric Heating System Type
For 30 Confirmed EMURBs in Ontario



2.3.6. Estimating the AIR CONDITIONING SYSTEM present in EMURBs:

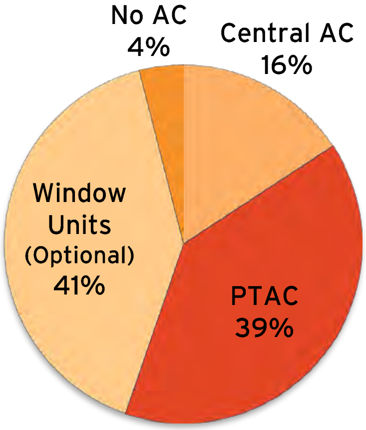
Medium Quality

FINDING:

The dominant forms of cooling in EMURBs will be provided by Window (41%) or PTAC (39%) units. For those EMURB suites that do have air-conditioning it will be provided primarily by Window units. Furthermore not all residents will have a window unit, with window AC penetration for MURBs typically being 40% - 60% of the suites.

Data was obtained regarding in-suite and common area air-conditioning (AC) equipment present for 76 EMURB properties. For In-suite AC: 41% of these EMURB properties had optional Window Units in 40 – 60% of the units, 39% had PTAC units, 16% had Central AC, and 4% had no AC.

Figure 16: In-suite Air Conditioning Type For 76 Confirmed EMURBs in Ontario



2.3.7. Estimating the METERING TYPE of EMURBs:

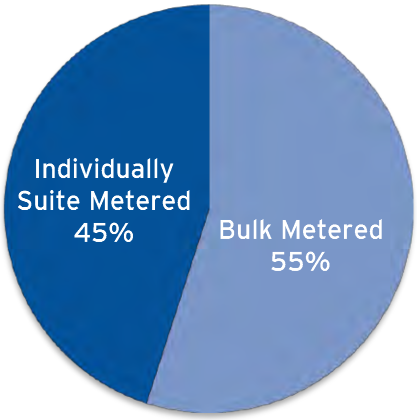
Medium Quality

FINDING:

The metering type of EMURBs in Ontario is divided almost evenly between Individual Suite metered (45%) and Bulk metered (55%).

Data was obtained regarding the electric utility metering type for 111 confirmed EMURB properties. The findings of this comparative analysis showed an almost even split between how many properties were Bulk and Individual Suite metered.

Figure 17: Utility Metering Type for 111 Confirmed EMURBs in Ontario



2.3.8. Estimating the ENERGY USE of EMURBs:

Low Quality

FINDING:

It is estimated that 42% of electricity use in EMURBs is dedicated to electric space heating. The average annual EUI for electric space heating in EMURB units is estimated to be 4,745 kWh/year. This approximation in conjunction with the estimated number of EMURB units in Ontario translates to an approximation of 1,921 GWh of annual electricity consumption for electric space heating in Ontario in the EMURB sector. The annual electricity consumption for electric space heating in EMURBs is estimated to be 13% of total annual electricity consumption in the Ontario Multi-Unit Residential Building Sector.

Data was acquired from energy audits conducted for 25 EMURBs to assist in determining what the estimated total energy use for EMURBs in Ontario is currently. The average proportion of total electricity use for EMURB space heating is estimated to be 42%.

Figure 18: Proportion of Electricity consumed for Space Heating For 25 Confirmed Ontario EMURB Properties

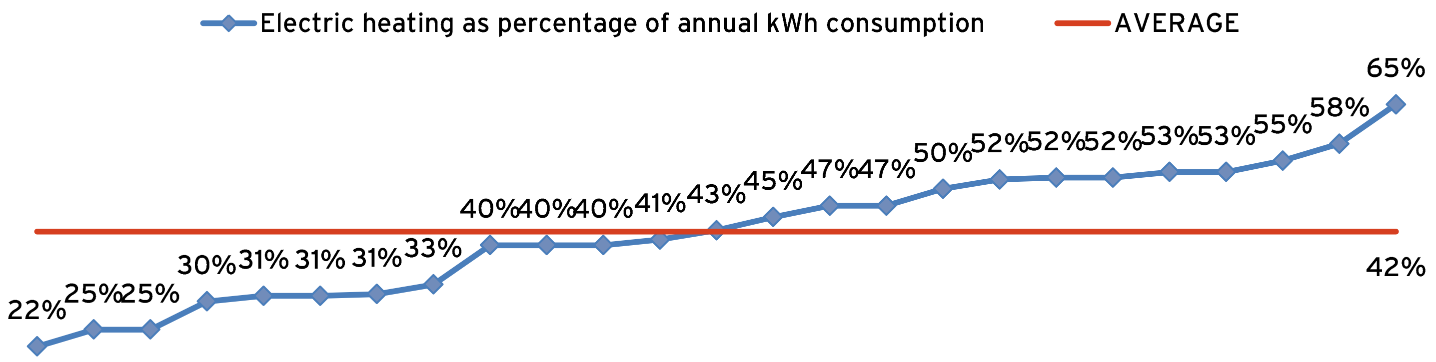
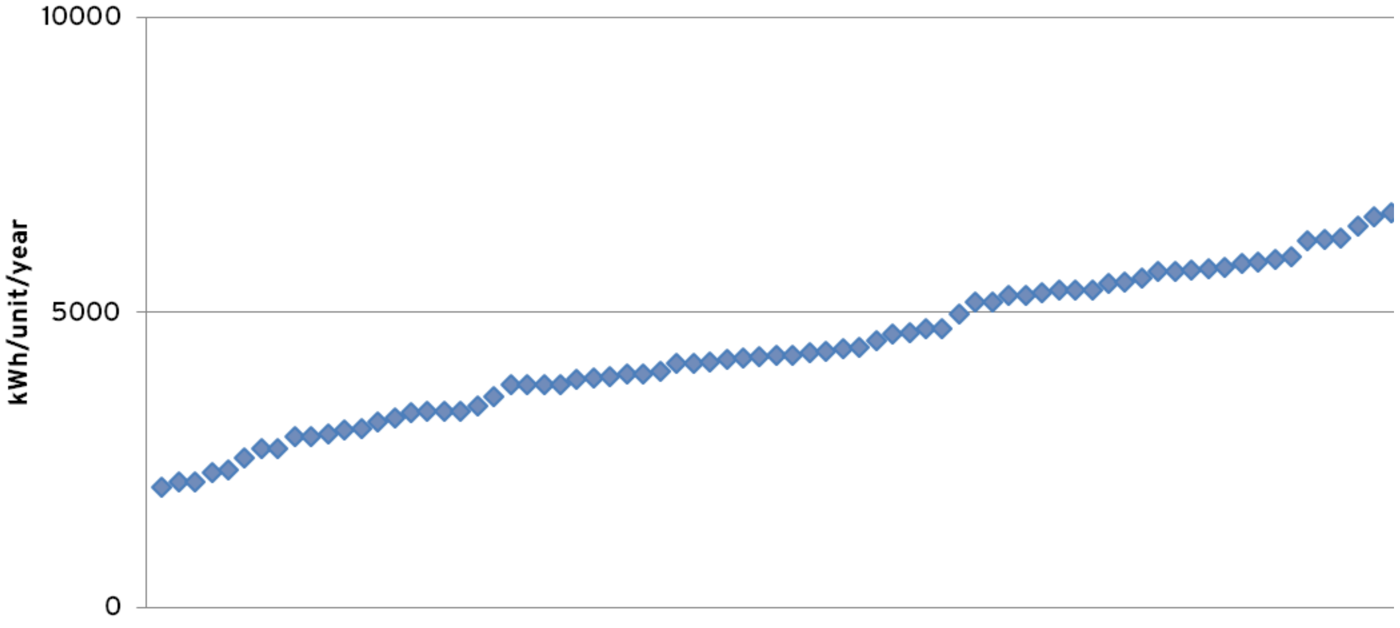


Figure 19: EUI for EMURB Space Heating
For 85 Confirmed Ontario EMURB Properties (kWh/unit/year)



The average annual Energy Use Intensity (EUI) figure for electric space heating in EMURBs is based on dividing the total annual electricity consumption for space heating by the number of units within a property for 85 confirmed EMURB properties in Ontario. Electricity use for space heating for each property was determined by either using a confirmed proportion identified via energy audit results or applying the estimated proportion of 42% to the total annual electricity use for a property. The annual EUI for electric space heating per EMURB unit is estimated to be 4,745 kWh/unit/year. It should be noted that the EMURB EUI for space heating for each of the 85 properties is based on total building electricity use, which includes common areas. By multiplying the average EUI with the estimated number of EMURBs in Ontario it is surmised that total energy consumption for electric space heating within the Ontario EMURB sector is 1,921 gigawatt hours per year.

An important observation revealed from the comparative analysis of EMURB space heating EUI is that electricity consumption for space heating in EMURBs is highly variable. As demonstrated by Figure 19, the marginal difference in consecutive data points in conjunction with the large data spread (approximately 2000 – 9000 kWh/unit/year) indicates a high degree of variability in space heating electricity use among EMURB properties. The variability may be due to a variety of factors including the thermal performance of a property's building envelope, air leakage, and resident behaviour. This finding is significant for conservation programming as the high concentration of EMURB properties with space heating EUI's above the identified average of 4,745 kWh/unit/year indicates a considerable conservation opportunity. Furthermore, total annual electricity use for EMURB space heating is estimated to be 13% of total annual electricity use in the Ontario multi-unit residential building sector (Please see Table 5). Table 6 also presents a conservation scenario demonstrating significant energy savings potential if all EMURBs were retrofitted with heat pumps. Based on these findings further consideration of EMURB targeted retrofit conservation programming is warranted.

TABLE 5: Estimates for Total Electricity Consumption for Space Heating in the Ontario EMURB Sector

STRUCTURAL TYPE	# EMURB Units	Total Space Heating Elec. Use (GWh/year)	% of Total Multi-Unit Residential Electricity Use in Ontario*
Row House	36,438	173	1%
Low Rise	89,071	423	3%
Mid Rise	93,120	442	3%
High Rise	186,240	884	6%
TOTAL	**404,869**	**1,921**	**13%**

* Estimates normalized against Ministry of Energy , Demand Forecast, 2013 LTEP and NRCan data

TABLE 6: Estimated Savings Potential of Retrofitting EMURBs with Heat Pumps
In Relation to the IESO's 2015 - 2020 Conservation Target of 7000 GWh

STRUCTURAL TYPE	TOTAL ELECTRICITY USE FOR SPACE HEATING (GWh)	Maximum Theoretical Conservation Potential: ALL ONTARIO EMURBs ARE RETROFITTED WITH HEAT PUMPS (SCENARIO CRITERIA: Achieve 60% energy savings)	
		Electricity Use Reduction (GWh)	Proportion of IESO Conservation Target (%)
Row House	173	104	1.5%
Low Rise	423	254	3.6%
Mid Rise	442	265	3.8%
High Rise	884	530	7.6%
TOTAL	**1,921**	**1,153**	**16.5%**

2.3.9. EMURB Market Attributes Comparison

This section consolidates the findings from the study into a comparison chart of the different key attributes that characterize EMURBs in Ontario.

Medium Quality

TABLE 7: Comparison of Varying Ontario EMURB Market Segment Characteristics by Ownership Type

OWNERSHIP TYPE	PERIOD OF CONSTRUCTION	PROPERTY SIZE (# Suites)	SIZE (Floors)	HEATING SYSTEM	METERING TYPE	ELECTRICITY USE FOR SPACE HEATING
Rental Apartment	• 1970s • 1980s • Early 1990s	48% - less than 100 units 55% - greater than 100 units 46% - between 100 to 300 units	53% High Rise (10+) 23% Mid Rise (5-9) 21% Low Rise(<5) 3% Row house	72% Electric Resistance Baseboard 10% PTAC 8% In-slab Radiant 8% Electric element in Fan Coil 2% Other	38% Bulk Metered 62% Individual Metered	44%
Co-operative	• 1970s • 1980s	71% - less than 100 units 29% - greater than 100 units 24% - between 100 to 300 units	17% High Rise (10+) 33% Mid Rise (5-9) 34% Low Rise(<5) 16% Row house	93% Electric Resistance Baseboard 7% PTAC	55% Bulk Metered 45% Individual Metered	39%

Public/Social Housing	• Early 1990s • 1980s • 1970s • 1960s • Before 1960	50% - less than 100 units 50% - greater than 100 units 42% - between 100 to 300 units	35% High Rise (10+) 24% Mid Rise (5-9) 36% Low Rise(<5) 5% Row house	75% Electric Resistance Baseboard 22% PTAC 1% In-slab Radiant 1% Electric element in Fan Coil 1% Other	61% Bulk Metered 39% Individual Metered	42%
Condominium	• 1970s • Early 1990s	22% - less than 100 units 78% - greater than 100 units 50% - between 100 to 300 units	43% High Rise (10+) 22% Mid Rise (5-9) 15% Low Rise(<5) 21% Row house	28% Electric Resistance Baseboard 22% PTAC 6% In-slab Radiant 28% Electric element in Fan Coil 17% Heat Pump	63% Bulk Metered 38% Individual Metered	30%

2.4 ONTARIO EMURB SPATIAL DISTRIBUTION ANALYSIS

2.4.1. Comparing the Proportion of MURB Stock in Ontario by Census Subdivision (CSD)

TABLE 8: Top 20 Ontario Census Subdivisions (CSD) by Proportion of MURB Stock

RANK	CSD	MURB UNITS by STRUCTURAL TYPE*				% of Provincial Total
		ROW HOUSE	LOW RISE (< 5 stories)	HIGH RISE (5+ stories)	TOTAL	
N/A	ONTARIO	415,230	498,160	789,975	1,703,365	100.0%
1	Toronto	60,295	163,895	429,225	653,415	38.4%
2	Ottawa	72,540	36,190	65,495	174,225	10.2%
3	Mississauga	33,100	16,600	58,825	108,525	6.4%
4	Hamilton	21,440	17,660	33,140	72,240	4.2%
5	London	19,085	15,620	30,935	65,640	3.9%
6	Brampton	17,215	6,805	17,005	41,025	2.4%
7	Kitchener	9,745	13,160	12,240	35,145	2.1%
8	Burlington	12,920	5,220	10,600	28,740	1.7%
9	Windsor	5,420	8,920	11,525	25,865	1.5%
+10	Markham	10,935	1,700	9,225	21,860	1.3%
11	Kingston	3,490	8,740	7,895	20,125	1.2%
12	Oakville	9,725	2,535	7,175	19,435	1.1%
13	Richmond Hill	8,465	1,350	8,100	17,915	1.1%
14	Greater Sudbury	2,860	10,435	4,460	17,755	1.0%
15	Oshawa	5,220	5,725	6,660	17,605	1.0%
16	Vaughan	9,305	1,330	6,940	17,575	1.0%
17	St. Catharines	4,400	7,345	5,795	17,540	1.0%
18	Guelph	5,975	5,760	5,155	16,890	1.0%
19	Barrie	5,015	4,930	3,650	13,595	0.8%
20	Cambridge	5,280	5,885	2,270	13,435	0.8%

= 43.7%

*MURB Structural Type definitions and data derived from CSD-CENSUS2011. See Section 2.2 ‘Publicly Available Data’.

2.4.2. Estimating EMURB Quantity and Space Heating Electricity Use by Census Subdivision (CSD):

Using Census Subdivision data (CSD-CENSUS2011), in conjunction with EMURB estimates, it was assessed which CSD's in Ontario have the highest concentration of EMURBs. TABLE 16 provides a summary of the estimated EMURB quantities in the TOP 20 identified Ontario EMURB CSD's. Figure 20 provides a visual depiction of the information summarized in TABLE 9.

TABLE 9: Estimated Total Electricity Use for EMURB Space Heating for Ontario Census Subdivisions (CSD)

RANK	CSD	EMURBs by STRUCTURAL TYPE*				ESTIMATED TOTAL ELECTRICITY USE FOR SPACE HEATING (GWh/year)**
		ROW HOUSE	LOW RISE	HIGH RISE	TOTAL UNITS	
1	Toronto	11,302	56,512	57,768	125,582	595.9
2	Ottawa	6,366	6,471	23,161	35,998	170.8
3	Mississauga	2,905	2,968	20,802	26,675	126.6
4	Hamilton	1,881	3,158	11,719	16,758	79.5
5	London	1,675	2,793	10,940	15,407	73.1
6	Brampton	1,511	1,217	6,014	8,741	41.5
7	Kitchener	855	2,353	4,328	7,537	35.8
8	Burlington	1,134	933	3,748	5,816	27.6
9	Windsor	476	1,595	4,076	6,146	29.2
10	Markham	960	304	3,262	4,526	21.5
11	Kingston	306	1,563	2,792	4,661	22.1
12	Oakville	853	453	2,537	3,844	18.2
13	Richmond Hill	743	241	2,864	3,849	18.3
14	Greater Sudbury	251	1,866	1,577	3,694	17.5
15	Oshawa	458	1,024	2,355	3,837	18.2
16	Vaughan	817	238	2,454	3,509	16.7
17	St. Catharines	386	1,313	2,049	3,749	17.8
18	Guelph	524	1,030	1,823	3,377	16.0
19	Barrie	440	881	1,291	2,612	12.4
20	Cambridge	463	1,052	803	2,318	11.0

*EMURB Structural Type definitions aligned with CENSUS2011. See Section 2.2 'Publicly Available Data'.

**Based on "Total Units" multiplied by estimated EMURB Space Heating EUI (4,745 kWh/unit/year)

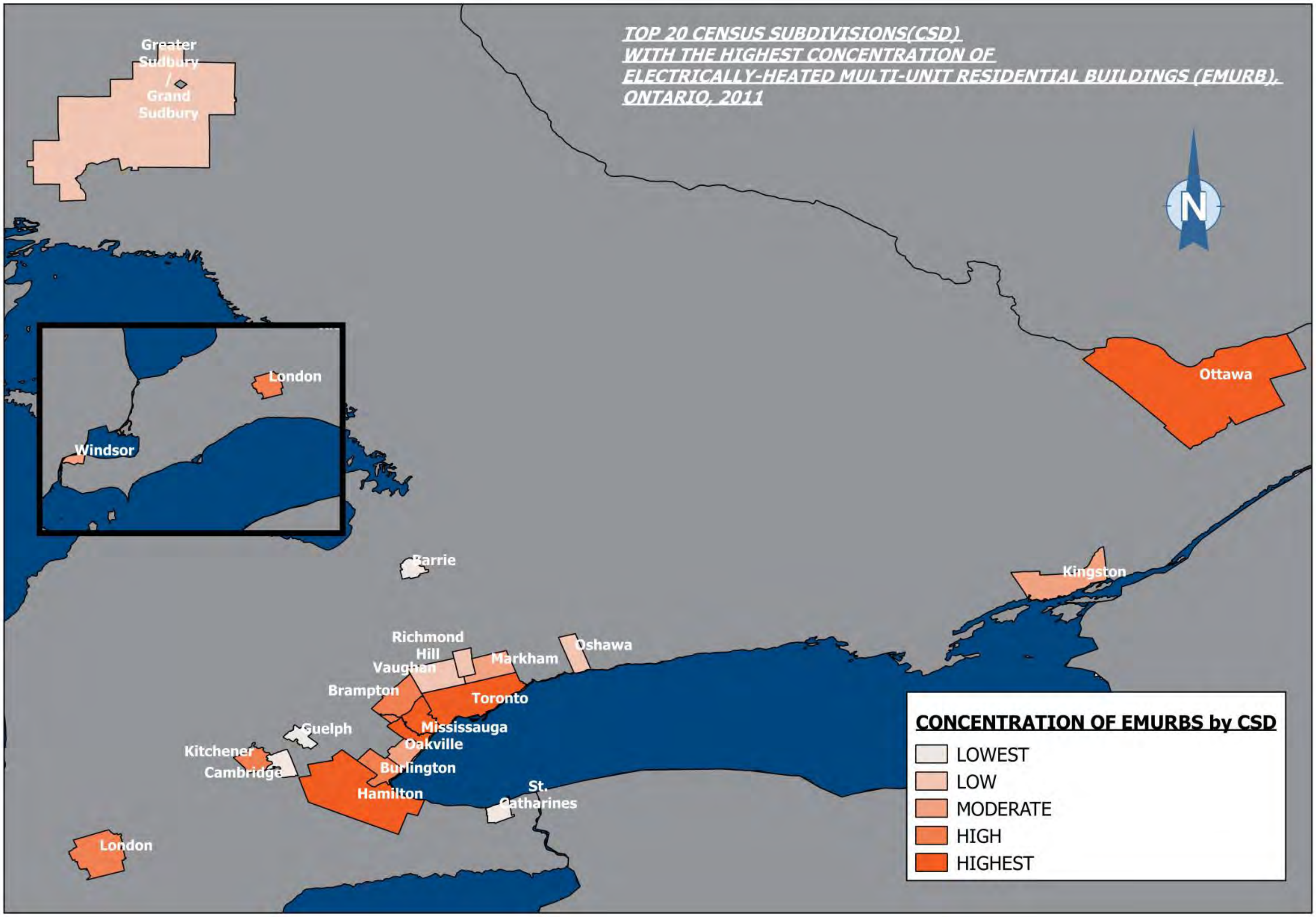


Figure 20: Top 20 CSD with the Highest Concentration of EMURB Units in Ontario

2.4.3. Top 5 Ontario CSDs With Highest Estimated # Of EMURBs:

Low Quality

FINDING:

By comparing the estimated distribution of EMURBs in Toronto, Ottawa, Mississauga, Hamilton, and London, it would appear that the Census Tracts with the 'HIGHEST' concentration of EMURBs are generally in close proximity to each other.

The following is a best attempt at analyzing the EMURB sector in detail at the municipal scale for the top five EMURB CSDs using the best available data. Data on EMURBs is not readily available at the CSD scale. For the top five CSDs that were assumed to have the highest concentration of EMURBs a more in depth spatial analysis showed the distribution of EMURBs within these CSDs by census tract. The purpose being to try to identify any patterns associated with EMURB distribution that might be prevalent throughout Ontario. If correlations between EMURB distribution and certain characteristics conducive to EMURBS could be drawn out from a spatial analysis, this may also provide valuable insights into how LDC programming could be developed. For instance if all EMURBs were concentrated in a few locations, then strategies could be devised to target those areas, and ensure resources were not wasted on areas with little or no EMURBs.

The most reliable spatial unit that could be analyzed across the five different CSDs based on available data was at the Census Tract (CT) level. The only data, relevant to this analysis, which was available for all the CSDs was 'quantity of dwellings by structural type' from each CT. Estimates summarized in TABLE 1 were used to estimate the number of total EMURB units by structural type for each CT.

Other additional information that would have been useful in this analysis would have included quantity of dwellings of a particular structural type by period of construction (e.g. Apt. Buildings that have less than 5 stories built during 1961 – 1970). By applying the assumption that the majority of all EMURBs were built within a certain period, we could estimate the number of MURBs within a CT that have a higher likelihood of being EMURBs. Again this would only be an estimate and would not provide confirmation of how many EMURBs were in a CT.

The top 5 EMURB CSDs were:

1. Toronto: *Figure 21*
2. Ottawa: *Figure 22*
3. Mississauga: *Figure 23*
4. Hamilton: *Figure 24*
5. London: *Figure 25*

Low Quality

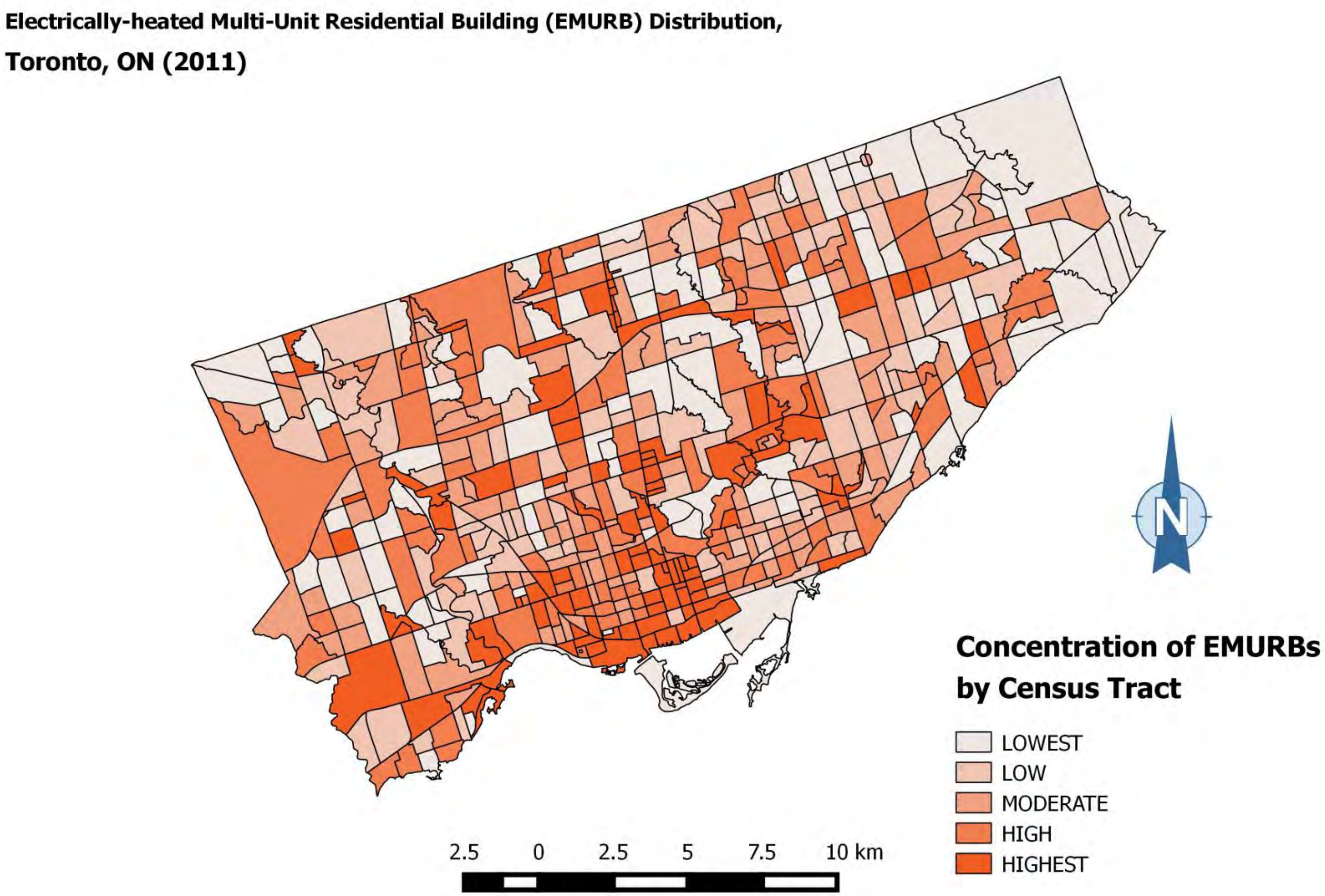


Figure 21: Toronto (CSD) Spatial Distribution of EMURB Units

Low Quality

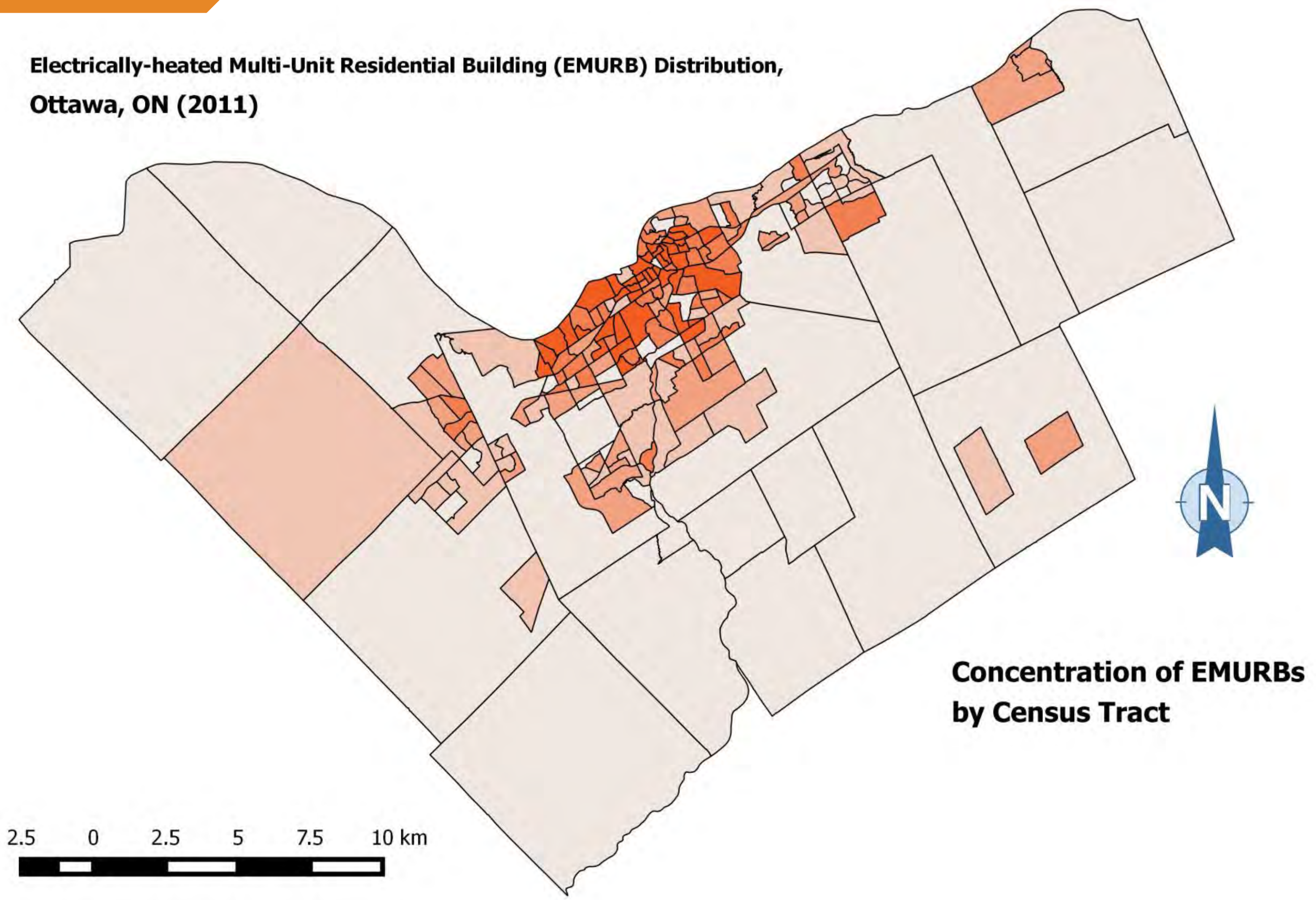


Figure 22: Ottawa (CSD) Spatial Distribution of EMURB Units

Low Quality

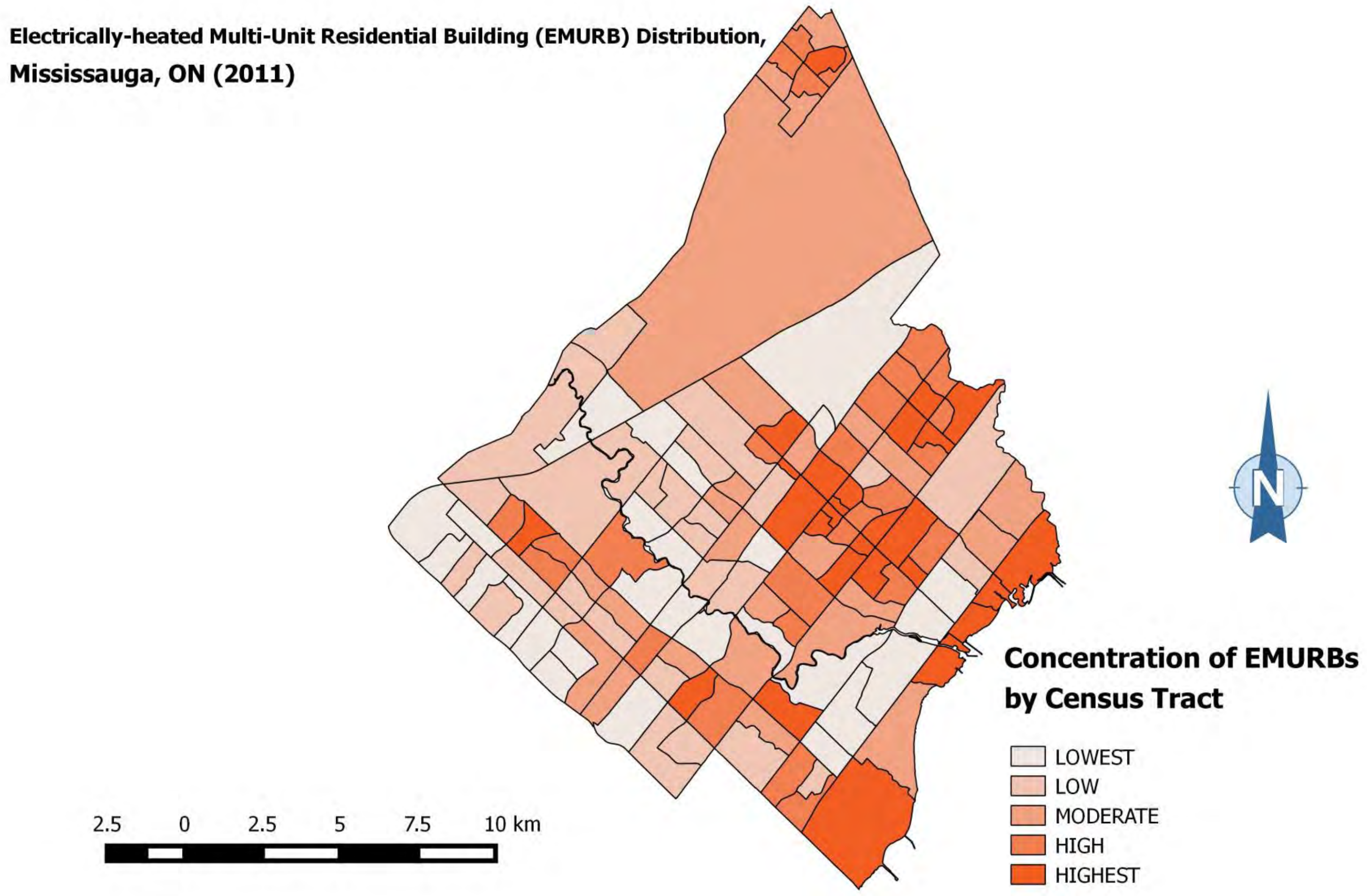


Figure 23: Mississauga (CSD) Spatial Distribution of EMURB Units

Low Quality

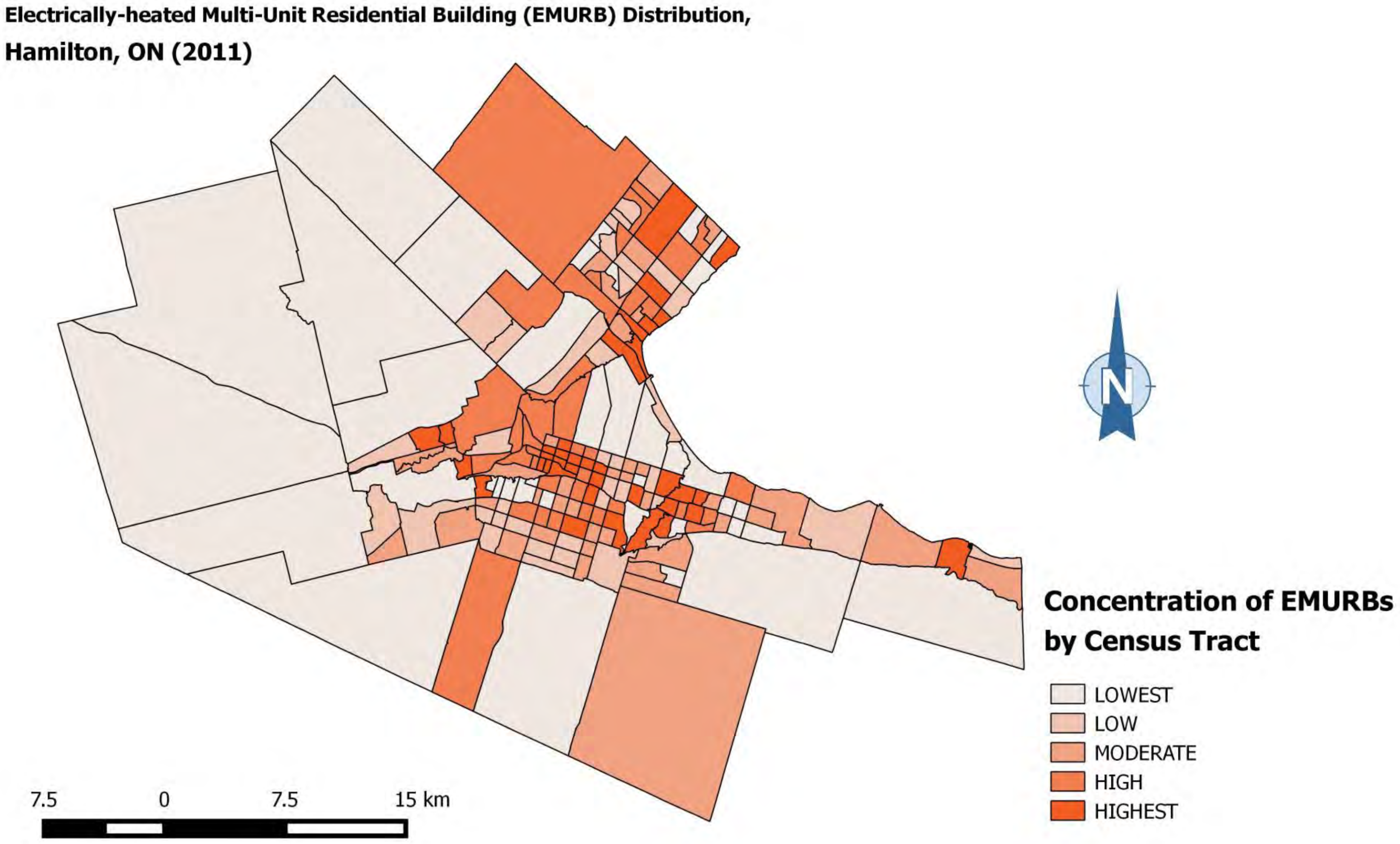


Figure 24: Hamilton (CSD) Spatial Distribution of EMURB Units

Low Quality

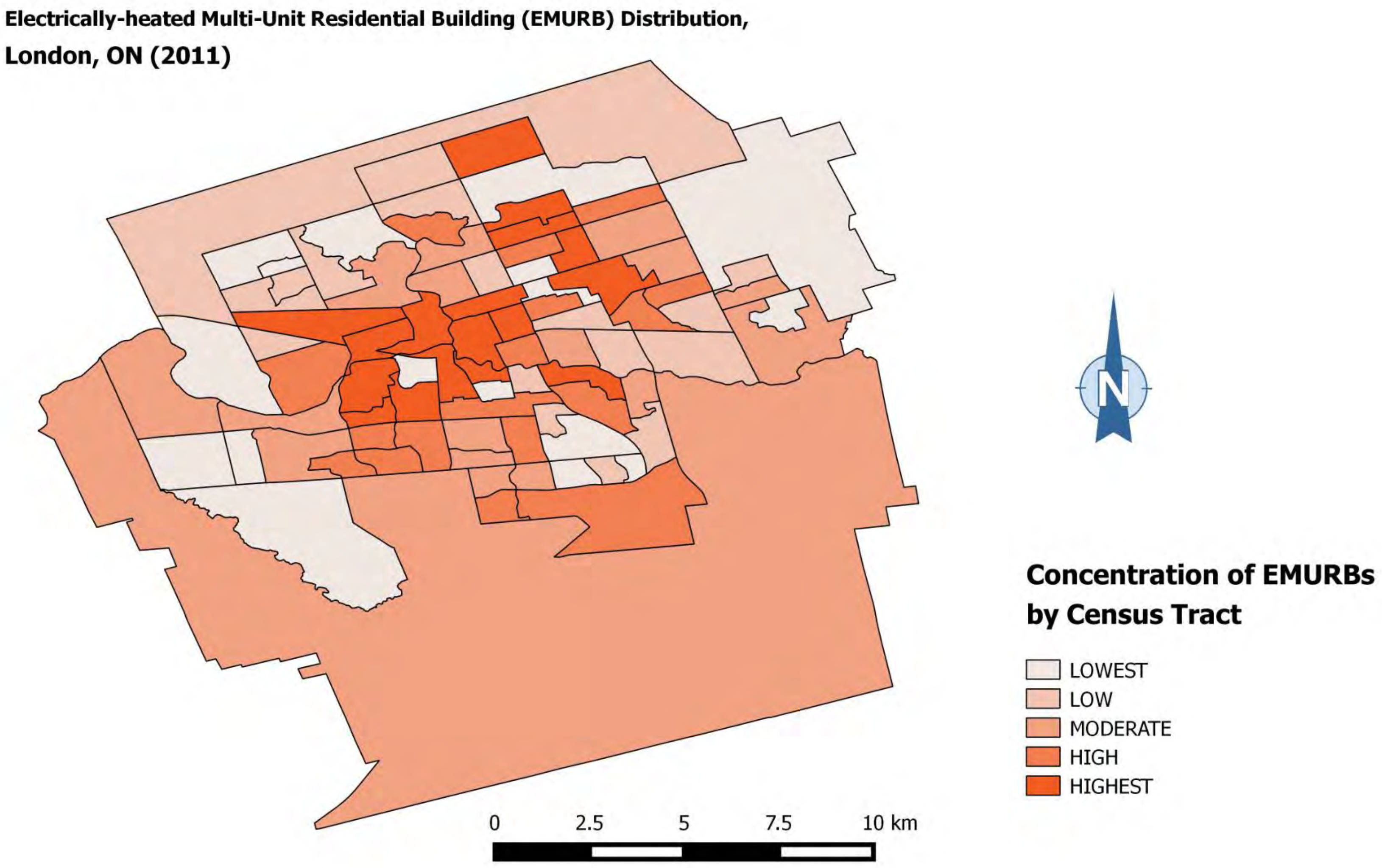
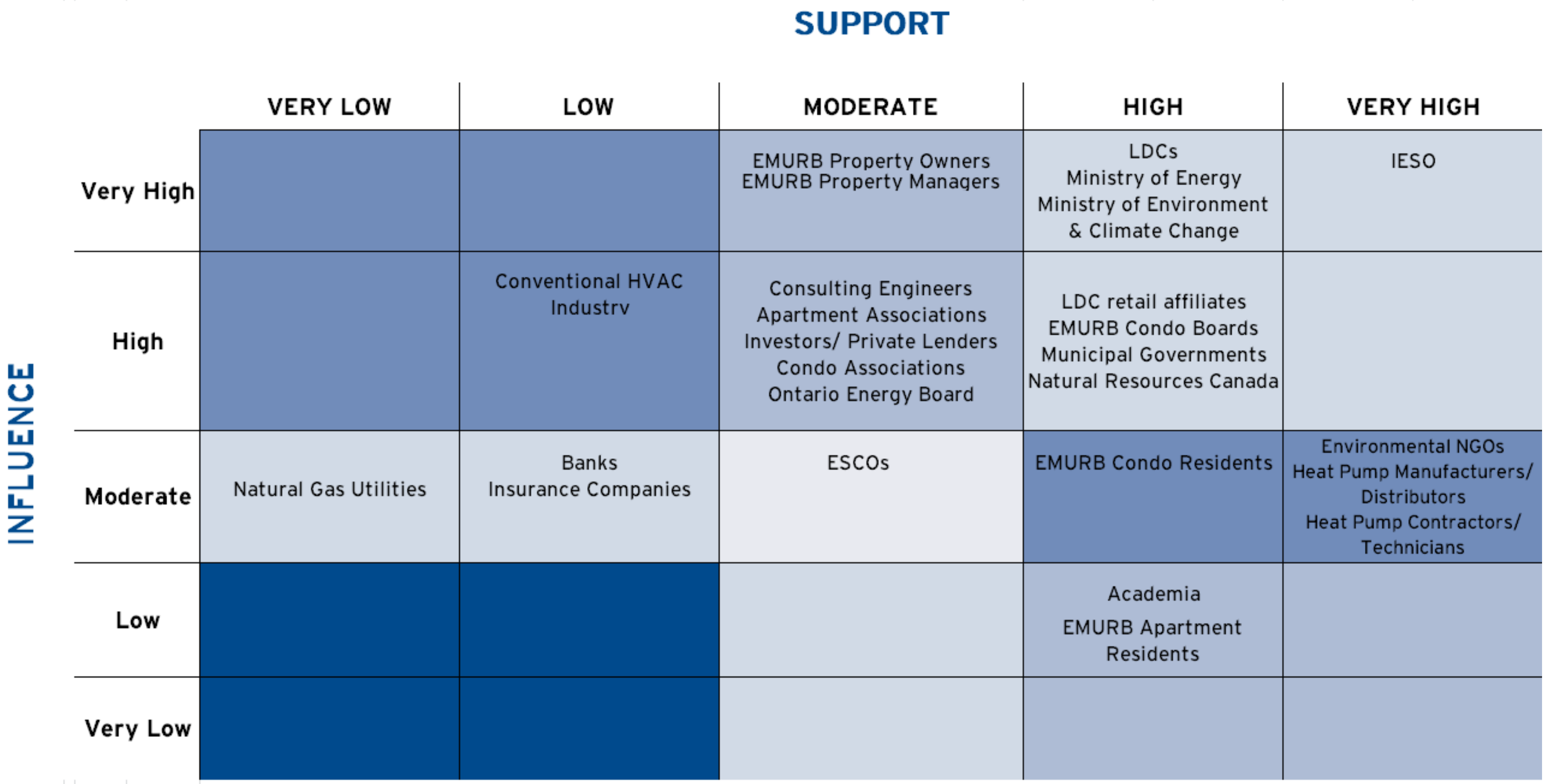


Figure 25: London (CSD) Spatial Distribution of EMURB Units

2.5 EMURB SECTOR STAKEHOLDERS:

Figure 26 compares EMURB sector stakeholders based on their level of support and influence with relation to retrofitting EMURBs with air or ground source heat pumps.



	VERY LOW	LOW	MODERATE	HIGH	VERY HIGH
Very High			EMURB Property Owners EMURB Property Managers	LDCs Ministry of Energy Ministry of Environment & Climate Change	IESO
High		Conventional HVAC Industry	Consulting Engineers Apartment Associations Investors/ Private Lenders Condo Associations Ontario Energy Board	LDC retail affiliates EMURB Condo Boards Municipal Governments Natural Resources Canada	
Moderate	Natural Gas Utilities	Banks Insurance Companies	ESCOs	EMURB Condo Residents	Environmental NGOs Heat Pump Manufacturers/ Distributors Heat Pump Contractors/ Technicians
Low				Academia EMURB Apartment Residents	
Very Low					

Figure 26: EMURB Sector Stakeholder Map

2.5.1. Engagement with Stakeholders:

TAF had the opportunity to gain valuable insight from several of the identified EMURB stakeholder groups through interviews, questionnaires, and focus group discussions. Respondents were chosen based on their strong level of knowledge and expertise. The responses from those interactions are summarized by stakeholder category in the subsequent sections. *Despite the astute responses from all participants it should be noted that the sample size of this stakeholder engagement exercise was relatively small and thus the following information should be used with caution when attempting to make generalizations for the entire stakeholder group.*

2.5.1.1. LOCAL DISTRIBUTION COMPANIES (LDCs)

High Quality

LDC perceptions of Heat Pump retrofits in EMURBs

Heat pump retrofits in EMURBs is a potential growth area. LDCs see the application of heat pumps in electrically heated buildings as a potential growth market. However, LDCs also see multiple barriers to overcome. This is partly due to a lack of real cases where EMURBs have replaced their heating system with heat pumps. Therefore LDCs do not see heat pump retrofits in EMURBs as a financially feasible solution at this time. Yet LDCs believe that the market is slowly adjusting to this opportunity and would be keen to participate should good case study data emerge that demonstrated the technical and financial benefits of implementing the technology in the EMURB market.

Key barriers preventing LDCs from supporting heat pump EMURB retrofits:

A lack of technical and financial data remains a major barrier for LDCs. Without customers implementing heat pump retrofits the issue is a lack of viable data from real world cases for LDCs to gain a better understanding of the technical and financial ramifications of such an endeavour; what heat pump options are best for various retrofit circumstances.

Rigorous Measurement and Verification (M&V) is not being conducted. LDCs and customers will avoid implementing a rigorous M&V approach to measuring the benefits of a project because it is complicated due to the multiple variables that need to be considered when retrofitting a MURB. The deficit in proper M&V in the sector means a lack of meaningful data. Therefore clear guidelines on how to establish a baseline with a high level of confidence for the base case and post retrofit are needed.

Largely the costs of EMURB heat pump retrofits are considered a barrier for LDCs. A lack of data coupled with resource constraints will affect LDC business decisions, particularly around implementation of CDM initiatives whereby LDCs will tend to choose solutions they consider will provide the best results (i.e. energy savings) for the least cost; "biggest bang for their buck". Without more examples of where and how a heat pump EMURB retrofit works LDCs will continue to choose the CDM options they have more experience with. This translates into business decision models that show heat pump retrofits as being too risky. “No one wants to be first”. In the absence of technical and financial information, heat pumps are viewed as an unproven technology and financially unfeasible. LDCs cannot afford to approve projects in there pipeline and then find out the expected savings were not achieved after the M&V is complete.

CDM programming constraints. The Conservation First Framework governing conservation programming for the 2015-2020 time frame, places greater responsibility on LDCs to manage budget for the local delivery of CDM programs. This can limit an LDC's willingness to explore the potential for heat pump retrofit uptake in their service territory. LDCs can apply to the IESO for pilot program funding, as has been done successfully for heat pump retrofit program pilots targeting single-family residential buildings. Additionally LDCs might also have an internal technology innovating budget, however; there is often a high level of competition for this funding when it comes available as there are generally multiple promising CDM solutions being considered at any point in time.

Providing incentives for social housing EMURB heat pump retrofits could be expensive. With social housing projects, the social housing adder requires LDCs to pay double the incentives versus non-social housing customers. Therefore, those EMURB heat pump retrofits for social housing will become very expensive projects for LDCs. LDCs know that many low-income families live in social housing apartments. Thus, there will be LDCs that will want to push forward retrofits for social housing, considering the positive implications it would have on an economically vulnerable segment of our society, and their customer base, by lowering a property’s energy costs. However, there will be LDCs that will find it difficult to do so as they have limited budgets, and so will not promote incentives for social housing as strongly, despite the positive impacts both socially and economically.

Given LDC’s human resource pressures it would be unlikely intense technical assistance would be provided. Aside from reviewing applications, providing high level technical consultation to customers, and directing customers to retrofit tools and resources it is unlikely LDCs will be able to devote staff to provide more intense technical assistance. LDCs will not be sending staff to help supervise heat pump retrofit implementation in EMURBs.

Key success factors for LDCs to support heat pump retrofits in EMURBs

Key success factors are going to be customer testimonials and case studies. For LDCs to effectively support heat pump retrofits in EMURBs they will require good technical information on different heat pump options. With the right type and quality of information the retrofit solution data can be utilized to help develop LDC tools, resources, and approaches to market. In part it will depend on the type of buildings the LDCs will be working with as well. Therefore, LDCs require guidance on determining whether there are unique characteristics about a building that would inform the technical solution. Identification of those particular set of characteristics and the appropriate better technical options would be useful to inform an LDC’s technical sales approach. By having this information an LDC’s team can better understand the technical issues that should be considered in each case. LDCs also require assistance with designing their approach to market; tailoring their messaging and technical approach for the EMURB sector. This would include help with the design of worksheets and templates that would support feasibility calculations and inform customers of the steps they should follow to carry out a retrofit. To develop such tools requires baseline assumptions for both the base case and retrofit solutions.

Clearer guidance for LDCs and property stakeholders on how to implement Measurement & Verification (M&V) in compliance with the International Performance and Measurement Verification Protocol (IPMVP). Developing guidelines on how to implement M&V in compliance with IPMVP would help foster greater participation and bridge data gaps with regards to EMURB heat pump retrofit performance. The guidelines would need to provide enough specificity to address ambiguity or challenges faced by stakeholders when implementing the required RETROFIT PROGRAM M&V procedures (IPMVP). The recommended M&V approach would be to adopt IPMVP Option C to garner widespread adoption. Option C applies a whole building approach to M&V and is best suited to measuring a building's entire energy performance, assuming the savings from a retrofit are significant enough to be identified when comparing post retrofit data against base case information, and no significant changes are expected to occur during the energy savings monitoring period. Therefore any guidelines should assist stakeholders with implementing the IPMVP Option C approach.

Governance structure of the buildings under consideration for a retrofit will affect the success of heat pump adoption. In part it depends on the nature of the building in terms of governance. For example there might be condominiums with very active boards, an engaged property manager, and a real buy in and/or willingness to accept a longer payback period. Therefore that customer might have more tolerance for a more expensive project that will yield savings past a 5 year threshold. In a building where you don't have that level of engagement or the residents are more transient in nature, or haven't resided there as long, it might be a more difficult to convince them of the merits of a heat pump retrofit. Another example would be on the non-profit side, with small co-operatives dealing with reserve fund challenges and weighing their level of financial preparedness for an expensive capital project like a heat pump retrofit, but might make the decision to adjustment their planning to save that money for the longer term. Additionally there may be sophisticated property managers with large apartment portfolios who are willing to implement a retrofit because they are in it for the longer haul so they might be willing to bear a greater investment horizon as well.

The *Conservation First* LDC CDM targets for 2020 will also encourage LDCs to participate. With each Ontario LDC tasked with achieving set energy savings in their service area by 2020, LDCs are prepared to explore any option deemed feasible. Multi-unit residential buildings (MURBs) are large customers for LDCs, with EMURBs suspected to be among the highest. LDCs know there is an opportunity to gain some savings, they just don't know how much and what the technical solution is yet.

Being able to bring technical solutions to customers in need is another fundamental reason for LDCs to participate in EMURB heat pump retrofits. For instance low-income customers living in electrically heated apartments and EMURB social housing providers are being negatively impacted by rising electricity rates. To date LDCs have offered very little to this market. The onus should be on LDCs to help mitigate that pressure. Therefore LDCs should move as aggressively as possible toward finding solutions that can be brought to market that can help our vulnerable customer base.

Ongoing maintenance requirements are a large determinant in overall energy savings. Perhaps there is an opportunity for the IESO to establish a capability building initiative where the IESO or large LDCs offer training on proper heat pump maintenance for building superintendents. This may be a partnership opportunity with an organization like Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI).

Other considerations

One of the challenges LDCs often have is that there is a retroactivity issue with the retrofit approval and work completed. A lot of housing providers approved for the retrofit program will retain a consultant to do detailed frontend engineering work before they submit their application. When a customer gets to the stage where they submit the application to the LDC, the supporting documentation ends up predating their data submission. This can be a potential issue for LDCs. LDCs often have to treat such situations with a waiver that explains the engineering design work was needed in order to provide a proper application and so by necessity the customer had to hire the engineer. The need for LDCs to prepare a formal waiver is on account of such a situation technically conflicting with the program rules and invoices predating the application.

Some costs may be deemed ineligible under the existing incentives programs. During the detailed project review there may be some costs that are deemed ineligible. For example if the structural integrity of a roof or underground garage structure needed to be upgraded to support an ASHP or GSHP upgrade it is possible those costs would be considered ancillary to the project. However until a specific example is provided it would be difficult to make a clear delineation. There are a number of costs that would result in an artificially large incentive if they were not deemed ineligible. LDC's technical team/engineers would need to determine what is required and what is ancillary. As part of the pre-approval process the applicant provides a quote for the work and so it is at that point that LDC engineers would look at that quote and deem what is ineligible for the incentives.

Heat pump retrofits in low-income EMURBs would have high non-energy benefits. Even if it could be demonstrated that there is a significant market potential for savings with the low-income housing sector, LDCs do not have adequate budgets to meet that demand. However with strong evidence LDCs can bring attention to there being a broken market effectively and engage the problem at a high level to request additional funding. Part of the argument is that it moves beyond just being an energy issue, ultimately it is a poverty reduction strategy, and by framing the problem in that way that is how other funding can be utilized. If a retrofit project results in significant savings and a huge contribution to poverty reduction perhaps the burden of financing the retrofit should not be entirely on electricity utility rate payers. One of the challenges in this industry is capturing those societal benefits when measuring how cost effective a solution is. So on the low income side this could be something that really changes that equation. *The Ontario government is beginning to acknowledge the complimentary of addressing social, economic, and environmental issues simultaneously with the recent investment of $92 million from the Green Investment Fund to retrofit social housing with energy efficiency measures.*

2.5.1.2. EMURB PROPERTY MANAGERS (PM)

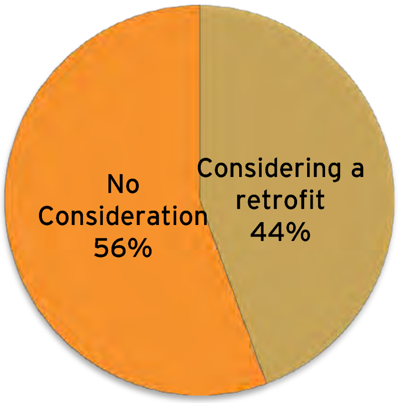
High Quality

Feedback from 9 EMURB property managers from the Greater Toronto Area and Hamilton regarding their willingness and capacity to support the implementation of heat retrofits is summarized below:

1. **Energy savings are the highest priority for EMURB Property Mangers in considering a retrofit.** In considering a potential retrofit to their building's electric heating system, EMURB PMs identify energy savings to be the most important potential impact to consider. The next factors tied for importance are maintenance costs and resident comfort. The least important factor was considered to be the potential GHG emission reductions and/or environmental impacts that would be derived from implementing a heating system retrofit.

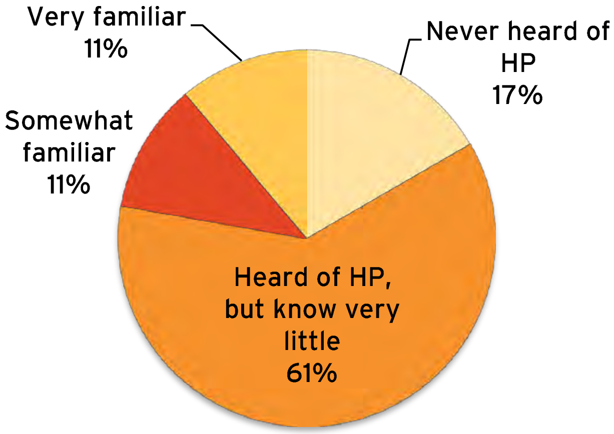
2. **Almost 50% of EMURB PMs have given consideration to replacing their property's electric heating system.**

Figure 27: EMURB Property Managers Considering Electric Heating System Replacement



3. **The majority of EMURB Property managers have heard of heat pumps but know very little about the technology.**

Figure 28: EMURB Property Manager Awareness of Heat Pumps (HP)



4. **Property Managers have a stronger positive impression of Air Source Heat Pumps over Ground Source Heat Pumps.**

Figure 29: EMURB Property Manager Impression of Air Source Heat Pumps (ASHP)

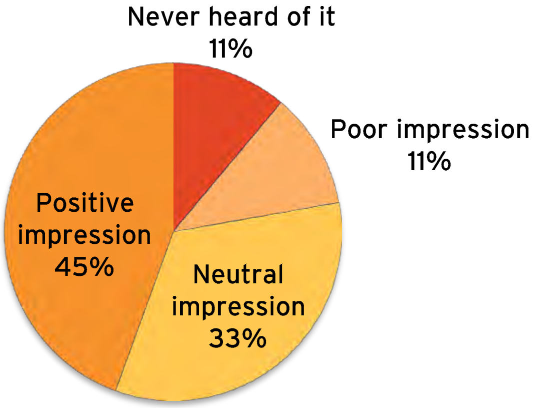
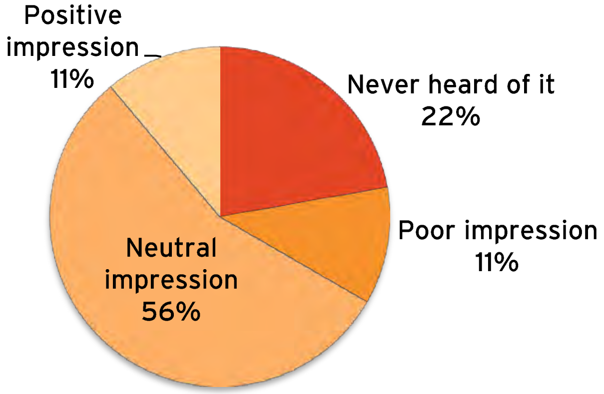


Figure 30: EMURB Property Manager Impression of Ground Source Heat Pumps (GSHP)



5. **Board of Directors determines if an electric heating system retrofit would be conducted.** PMs all agreed that Board of Directors will make the decisions regarding implementing a heat pump retrofit. The Property Managers unanimously agreed that if a property is governed by a Board of Directors, the Board would make the final decision on whether or not to implement a heat pump retrofit.

6. **PMs described their role in implementing a heat pump retrofit as a Project Manager, Liaison, and/or Advisor.** Boards make the final decision, but PMs would be the starting point. If PMs found there to be enough interest, or considered a beneficial opportunity existed, PMs would generate recommendations to the Board of Directors regarding how the building could execute such a project. Additionally, PMs indicated they would likely call on the assistance of experts to present pertinent information to the Board in the event of the Board's interest being piqued. If the Board decided to proceed the PM would liaise between the Board and whoever is implementing the heating system retrofit.

7. **The decision to implement a heat pump retrofit can occur within 12 months or less.** The majority of PM believed that the potential decision-making timeframe, from initial tabling of the idea by the Board of Directors to the final Board decision to begin a heat pump retrofit, would be 12 months or less.

8. **The majority of EMURB Property Managers are interested in exploring the potential for retrofitting their electric heating system with heat pumps.** Despite having given little thought previously to retrofitting their electric heating system with heat pumps, EMURB Property Managers are interested in exploring what the technical and financial feasibility of conducting such a retrofit would be for their properties.

9. **PMs can support heat pump retrofits through engineer/contractor selection, and ongoing maintenance & operations.** With regards to their capacity to assist with the implementation of a heat pump retrofit PMs felt they would have moderate to high capacity to:

- Select and manage engineering consultants for feasibility study, review findings
- Select and manage contractors to install heating system
- Assist with ongoing maintenance & operations (e.g. ensure new system working as designed, arranging for routine maintenance of new system)

10. **PMs have limited capacity to budget and arrange financing for a heat pump retrofit.** The majority of PMs felt that due to a lack of knowledge about heat pump systems they would have a low to very low capacity for assisting with **budgeting and financing a heat pump retrofit (e.g. incorporate costs into capital plan, identify financing options if needed)**

11. **Grants/financial incentives and information tools thought to be useful for implementing a heat pump retrofit.** EMURB PMs rated the following types of tools and resources for a heat pump retrofit:
    - Grants/incentives to offset implementation costs: ***Most Useful***
    - Information tools/resources to assist in assessing feasibility and designing retrofit: ***Very Useful***
    - Information tools/resources to assist in implementing a heat pump retrofit: ***Very Useful***
    - Information tools/resources to assist with commissioning and/or operating new system: ***Useful***
    - Dedicated financing tools (e.g. loans, leases, ESPAs): ***Somewhat Useful***

Key success factors identified by EMURB Property Managers that would aide in the implementation of heat pump retrofits in EMURB properties

EMURB PMs identified factors that would contribute to successfully implementing a heat pump retrofit in their properties would include:

- **Demonstrating significant energy savings.** If it could be proven to PMs and the Board that significant energy savings were possible by replacing the electric heating system with heat pumps for their property than there would be potential for the Board to implement a heat pump retrofit.

- **Residents experience immediate benefits.** Short term gains for residents would be crucial to ensure support for a retrofit. This could be in the form of increased thermal comfort or financial benefits.

- **Improved maintenance requirements.** A new system would have to make sense for PMs service-wise, particularly when comparing a new system to something like PTAC units, which can be difficult and costly to service and maintain,. For example to maintain the longevity of the PTAC units requires regular maintenance and to find a qualified service technician can be difficult. In addition to the high level of maintenance and special technical skillset required, there is also an issue of disposing of the condensation from the condensing pumps. Drainage issues from PTACs can cause both external and internal damage to buildings, increasing the maintenance costs associated with keeping such units in operation.

- **Improving the ability to control energy costs.** PMs can have difficulty controlling rising energy costs when the majority of heating system control is with residents. For example residents like PTAC units and electric resistance baseboards with in-suite thermostats due to the level of control they have with their heating and cooling. However, this provides PMs with little to no control with maintaining the costs of heating and cooling. PMs cannot qualify during the year how much energy each unit will use for heating and cooling from season to season. With regards to controlling costs in-suite control of electric heating does not work for most PMs.

- **Full Lifecycle cost Analysis.** PMs and the Board will want to know how much a heat pump system will cost to implement, operate, maintain, and repair throughout its entire expected service life.

- **Ease of use for residents.** If residents are to adopt a new heat pump space heating system it will have to be easy to use.

- **Interoperability with other current and potential technologies.** The more existing equipment within the building that can be integrated with a new heat pump system increases the attractiveness of the retrofit by potentially bringing the overall retrofit costs down. Ease of access to market proven tools, materials, and technicians that have crossover compatibility from other HVAC systems to heat pump service and installation will make implementing a heat pump system easier for PMs and Boards to accept.

- **Low susceptibility to vandalism and misuse.** Demonstrating the feasibility of heat pump solutions for EMURBs that are less susceptible to damage from vandalism and misuse through will increase the appeal and reduce perceived risk by showcasing less of a chance for high maintenance costs.

- **Aesthetics.** PMs, members of the Board of Directors, and residents will all want a heat pump solution that is aesthetically pleasing.

Key barriers identified by EMURB Property Managers that would hinder implementation of heat pump retrofits

Barriers EMURB PMs face for successfully implementing a heat pump retrofit in their properties included the following:

- **Capital cost to install the new system perceived as too high.** EMURB Property Managers consider the potential high capital cost to retrofit their property's existing electric heating system with a heat pump would be the dominant deterrent for implementation.

- **Lack of interest from the Board of Directors and Residents.** The second most cited barrier for implementing an EMURB heat pump retrofit would be trying to gain Board of Director and resident support for a project. Convincing Boards and residents of the urgency to replace the existing electric heating system can be difficult for several reasons. Firstly, if residents do not pay their electricity bills then the issue for residents becomes how I benefit from this retrofit directly. Another issue may be with the level of awareness among Board members and residents about the benefits of heat pumps, or energy conservation benefits in general. Additionally, there may be a lack of buy-in if residents have not lived within an EMURB property for long or Board members change frequently.

- **Capital project budget cycles and competing priorities.** Many of the EMURB properties the PMs oversee have multiple issues they are concerned about and electric heating is just one. After a building undergoes a Building Condition Assessment (BCA) it is the duty of the PM to make professional recommendations to the Board of Directors regarding which issues should receive immediate attention. However, it still comes down to the Board to make the final decision. After deliberating over information provided by the PM regarding the BCA and any other building related issues, the Board will implement a Capital Project plan. If a retrofit of the electric heating system was not considered a priority at the time of capital project plan implementation it may be difficult to gain Board support to go forward. Alternatively, in some cases it may require opening up the discussion to the entire resident community to decide. In which case the concern becomes convincing everyone how beneficial a heat pump retrofit would be and why it should take precedence over other elements, such as upgrading flooring, windows, landscaping, etc. This is especially difficult if residents do not pay their own electricity bills.

2.5.1.3. PRIVATE INVESTORS

High Quality

TAF interviewed a knowledgeable sector professional to gain insights into the perceptions held among the Private Investor community regarding heat pump retrofits.

- The current perception of heat pumps in the investor community falls into two lender scenarios:

  Construction financing. Lenders are very aware and have no issue with Heat Pumps in new construction projects of any type. A heat pump would be a routine HVAC line item on a new construction project budget.

  Third party Own & Operate financing. Investors are aware of heat pumps. However, at present there are no third party financing arrangements available for geothermal systems that include central HVAC equipment.

- The investment community is not yet actively pursuing investor opportunities in retrofit projects.

- There are many barriers that currently exist for investors/private lenders to finance heat pump retrofits in EMURBs. Investment is about risk. If risk is considered to be too high and cannot be mitigated then that is a barrier for investors. Multiple factors and considerations that impact the level of perceived risk and ability to mitigate include:
  - Information availability, completeness & reliability;
  - Technical assessment and alternative solutions;

  - Ability to manage project & risk legally, technically, financially;
  - Type & level of risk acceptable to the lender
  - A lender possibly requiring their own engineering advisor;
  - Assurance of equipment performance initially and over time;
  - Maintenances and Operational expenses;
  - Warranties;
  - Technical service availability and cost;
  - Counterparty considerations and agreement terms:
    - Credit worthiness;
    - Ability to provide down payment;
    - Payment amortization, term and interest rate;
    - Security;
    - Buyout/termination.

- If the risk is considered acceptable by investors/lenders then they will participate in a heat pump EMURB retrofit project.

- Investors would avoid participating in an EMURB heat pump retrofit project because of competing opportunities. There are many other investment opportunities available that are simple, quick, and easy to understand and manage, with varying levels of return. There are even publically traded stocks and bonds that offer up to 10%+ annual return, in return for a certain amount of volatility and capital risk that can be partially offset with a simple stop-loss.

- Interest for heat pump retrofits in EMURBs could be bolstered within the investor community by:

  - Breakdown and fully describe each component and its characteristics, in terms of asset investment/risk/management/return.

  - Investigate & document each component's risk mitigation (i.e. warranty, service options, maintenance logs, life, interest rate/currency, legal security, termination, etc.)

  - Identify, work with and produce a list of Investors who are willing to invest in heat pump retrofit projects; negotiate practical and suitable terms and conditions, rates, etc.

  - Identify and work with consultants who are educated, informed, experienced and cooperative, to form a list of "qualified" engineers. This should reduce the "search" and proceed directly to the "trained rescue", reducing frustration, learning curve, adversity, loyalty for reward, first mover risk, technical and design risk, and promote quality assurance and lower costs with little down-side "surprise" factor.

  - Identify and work with technology and equipment manufacturers who understand this market; have superior technical solutions including integrated design, equipment & controls, track record

    & performance data; service capabilities; terms & conditions suitable for the retrofit market & for third party metering/billing/financing participation; competitive pricing that produces attractive financial returns on investment; flexibility to adapt to variations in scale, scope, location; customer service support channel; etc.

  - Produce guidelines for both investors and project owners on how to structure deals and what items each will need to consider, negotiate and agree on.

  - Work with selected Investors to develop a financial model that is attractive to both counter parties, and assist by providing professional and legal information that is consistent and qualified by TAF research and experience, to foster investor participation in this market.

- The types of financing options that could be made available for heat pump retrofits in EMURBs may include:
  - Energy Service Provider;
  - Energy Provider;
  - Equipment rental;
  - Equipment service contract;
  - Equipment loan;
  - Energy Savings Contract;
  - Government Subsidies, Subsidized Loans, and Incentives;
  - Security; Performance Guarantees;
  - Variations of all of the above;
  - Others.

- Financing could be modeled to suit any type of EMURB heat pump retrofit. Financing can be designed by investors any way they want with as many variables as they care to build in. Investors need to identify their business model, being their scope and scale of acceptable technology and the level of customer service available which will define their application process, level of individual client interaction and whether or not they have access to their own dedicated technical advisors.

- Investors could develop financing models to fund all steps of a heat pump retrofit. Currently it does not exist. However there is no reason why Investors could not develop financial models that account for all steps in the process, developing an asset/risk profile for each and then aggregating them into a financing package. Still there are much simpler investment opportunities available and few are willing to invest in the development process, or have confidence in the acceptability of the outcome. Also, securitization is a huge barrier, whereby there is often a hierarchy of interests on title and access to security is limited by the unrealistic ability to recover the assets in the case of default or the existing equity in the project is not enough to cover an acceptable period of debt maturity.

3

Discussions and Conclusions

3.1 SUMMARY OF FINDINGS

The EMURB market in Ontario is estimated to be comprised of the following attributes:

Size

23.8% of all Multi-Unit Residential Building units in Ontario are heated electrically.

Approximately 84% of the EMURB units in Ontario will be found in buildings with over 100 units. However, 78% of EMURB properties/buildings will be comprised of 200 units or less.

Age

The construction period range for EMURBs in Ontario is estimated to be 1960 to mid-1990s, with the dominant period of EMURB construction between the 1970s (52% of EMURB units) and 1980s (23% of EMURB units).

Ownership Type

The majority of EMURB units are occupied by renters. When comparing renter versus owner occupied status of the EMURB sector, it is estimated that 70% of Ontario EMURB units are rented, and 30% are owned.

The identified ownership types for Ontario EMURB units are:

OWNERSHIP TYPE	MARKET SHARE
Co-operatives	3%
Condominiums	30%
Public Housing	17%
Rental Apartments	50%

Metering Type

It is estimated that 45% of EMURB units are individually suite metered and 55% are bulk metered.

Heating Equipment

Electric resistance baseboard heating was identified to be the dominant type of electric heating system present in EMURBs, both in private suites and common areas. PTAC units were the second most common electric heating system found in EMURBs. However, the proportion of baseboard to PTAC is highly divergent with data demonstrating 70% of EMURB units outfitted with electric baseboards versus only 17% of EMURB suites with PTAC units. Other identified heating system equipment included in-slab radiant heating systems, electric heating element in fan coil units, and heat pumps. Additionally, for those EMURBs with electric heating in their common areas 97% had electric baseboards and only 3% were equipped with PTAC units.

Electricity Consumption for Electric Space Heating

Using the best available data it is estimated that 42% of electricity consumption in EMURBs is for electric space heating. Furthermore the estimated average Energy Use Intensity of space heating for an EMURB unit in Ontario is 4,745 kWh/year. Using the estimate of 23.8% for the total number of EMURB units in Ontario in conjunction with the estimated EUI for electric space heating in EMURBs, the annual electricity use for electric space heating is presumed to be 1,921 GWh, which equates to 13% of total annual multi-unit residential electricity demand for Ontario.

Stakeholder Characteristics

A large group of stakeholders within the EMURB sector were identified with a wide range of influence and support for heat pump retrofits in EMURBs.

The three stakeholder groups that were engaged for this project (Investors, LDCs, and EMURB Property Managers) provided valuable insight into their own unique realms of influence and how the prospect of implementing heat pump retrofits in the EMURB sector affected them and how they too could affect implementation.

Each group identified its own unique perceptions regarding the barriers and success factors for implementing heat pumps and their stakeholder group's willingness and capacity to participate.

After reviewing the information that came out of the engagement with the different stakeholder groups commonalities were also found:

Common Issues

- Lack of EMURB HP retrofit examples results in data deficit
- Currently inability to confirm technical/financial feasibility
- Perceived high level of risk and costs among LDCs/Lenders/Property Owners has prevented adoption
- Lack of benefit awareness reduces implementation priority for owners/boards/residents

Commonly Cited Solutions

- Detailed technical and financial documentation regarding implementation requirements, technology and financing options, performance metrics & life-cycle factors
- Guidelines for stakeholders on how to implement a retrofit
- Presentations from key organizations (e.g. TAF, engineers) to other stakeholders (e.g. property Board of Directors) to increase awareness of benefits
- Improved M&V protocols, along with clear guidelines for LDCs & Property stakeholders

3.2 EMURB MARKET SEGMENTS DEMONSTRATING HIGHEST POTENTIAL FOR FOCUSED HEAT PUMP RETROFIT PROGRAMMING

Four key EMURB market segments that demonstrate the highest potential for focused heat pump retrofit programming based on their high proportion of the Ontario EMURB sector and feasibility issues are as follows (*ranked in order of market share and feasibility*):

TABLE 10: Four Key EMURB Market Segments In Ontario Demonstrating Highest Potential For Focused Heat Pump Retrofit Programming

RANK	OWNERSHIP TYPE	HEATING EQUIPMENT	METERING TYPE	STRUCTURAL TYPE	UNITS PER PROPERTY	AGE	EMURB MARKET SHARE
1	Rental Apartment	Electric Resistance Baseboards	Bulk	Row House Low Rise Mid Rise High Rise	Up to 350	1970s to 1990s	22%
2	Rental Apartment	Electric Resistance Baseboards	Individual	Mid Rise High Rise	100 to 300	1970s to 1990s	16%
3	Condominium	Electric Resistance Baseboards	Individual	Row House Mid Rise High Rise	Up to 500	1970s to 1990s	11%
4	Public Housing	Electric Resistance Baseboards	Bulk	Row House Low Rise Mid Rise High Rise	Up to 700	1960s to 1990s	8%

The majority of EMURBs (70%) in Ontario are heated with electric resistance baseboards. Within that larger grouping rental apartments with electric resistance baseboards built during 1970s – 1990s represent the largest EMURB market segment in Ontario by volume of units and the largest opportunity for electricity conservation. With rental apartments the decision-making process for implementing a retrofit is much simpler compared to other ownership types, such as condominiums, due to the requirement to foster support from a single owner. For these reasons rental apartments are the top ranked market segment for focused heat pump retrofit programming. Condominiums (Individually metered) and Public Housing (Bulk metered) with electric resistance baseboards represented the other largest EMURB segments in Ontario by volume of units.

Many of the EMURB rental apartments are individually suite metered. This can pose as a barrier for conservation efforts due to the issue of split incentives reducing interest from landlords to implement a retrofit. Still, the quantity of EMURB apartment units in Ontario that are individually metered equate to a significant conservation opportunity and warrants the consideration of dedicated heat pump retrofit programming. Furthermore, landlords may be keen to retrofit if shown the benefits of what a new heat pump heating system can do for their property and residents. One such benefit could be the reduction in resident turnover and apartment vacancies. Many rental apartments are occupied by low income groups that may be forced to seek alternative accommodations as heating costs rise. A heat pump retrofit may increase the appeal of suite metered rental apartments and improve resident retention rates, thus a shared incentive for residents and landlords. A heat pump retrofit may also increase property values, from the reduced resident turnover and improvement to building elements, which can certainly benefit a landlord.

Although this analysis of top market segments is based on market share and feasibility to implement conservation measures, with consideration given to the implications of split incentives, the importance of other public priorities in relation to achieving energy efficiency is recognized, such as affordable housing concerns and poverty alleviation.

Another significant EMURB market segment are those units equipped with Packaged Terminal Air Conditioning (PTAC) Units representing 17% of the EMURB market in Ontario. However due to a lack of data the market could not be parsed with accuracy by ownership type, metering type, and/or structural details. Some results from the PTAC market segment analysis are as follows (See TABLE 11):

**TABLE 11: Ontario EMURB Market Segment Analysis -
Packaged Terminal Air Conditioning (PTAC) Unit Market Penetration**

OWNERSHIP TYPE	HEATING EQUIPMENT	METERING TYPE	STRUCTURAL TYPE	UNITS PER PROPERTY	AGE	EMURB MARKET SHARE
Co-operative Condominium Public Housing Rental Apartment	Packaged Terminal Air Conditioner (PTAC)	Bulk Individual	Low Rise Mid Rise High Rise	Up to 550	1970s to 1990s	17%

Focusing on retrofitting buildings with electric resistance baseboards over PTAC units would likely be easier to assess, design, and implement a heat pump retrofit. Firstly, baseboards are comprised of a simpler design compared to PTAC units, and require less specialization for removal. Secondly, energy consumption and efficiency data on baseboard heaters is fairly standard allowing for preliminary stage desktop assessments using a standard coefficient such as 250 watts per linear foot to determine total estimated electricity demand. Comparing the estimated demand to the total electricity demand required for an air or ground source heat pump to provide similar space heating and the approximate cost for the heat pump retrofit could be used for LDC and property owner decision-making models to conduct early qualification of project feasibility.

3.3 ANSWERING KEY PROJECTS QUESTIONS

We now revisit our original list of questions for this project in order to review what we have been able to ascertain and what remains unanswered:

BROADER PROJECT QUESTIONS	CONTRIBUTIONS TOWARDS A BETTER UNDERSTANDING OF POTENTIAL by POTENTIAL CATEGORY	ANTICIPATED KNOWLEDGE OBTAINED FROM MCS	ANTICIPATED KNOWLEDGE ACHEIVEMENT STATUS		
			ANSWERED	PARTIALLY ANSWERED	UNANSWERED
1) What are the total measured potential GHG and Energy savings opportunities available from deploying heat pumps in EMURBs?	• Total Implementation Potential • Economic/Market Potential • Technical Potential	How many EMURBs in Ontario	•		
		Sizes	•		
		Heating/DHW electric use & peak demand		•	
2) What financial capacity is available in the EMURB sector?	• Total Implementation Potential • Economic/Market Potential	Typical ownership structure	•		
		Typical financial capacity of buildings			•
3) What are technical constraints imposed building/site physical attributes?	• Total Implementation Potential • Technical Potential	Age	•		
		Construction type	•		
		Lot size			•
		Zoning/code issues			•
4) What is the Management capacity in the EMURB sector?	• Total Implementation Potential • Economic/Market Potential	Size	•		
		Type of ownership	•		
		Property type		•	
5) What are the Motivations/interests of key decision makers affecting heat pump retrofits in the EMURB sector?	• Total Implementation Potential • Economic/Market Potential	Metering Type (Bulk vs. Individual)	•		
		Stakeholder Priorities		•	
		Identify bias against heat pumps		•	

3.4 RECOMMENDATIONS

This assessment indicates that the total annual electricity consumption for heating in EMURBs is sufficiently large (1,921 GWh) to justify further exploration of the energy savings opportunity present within the sector. However, it should also be noted that the prevalence of EMURBs varies significantly between different regions of the Province, and not all Local Distribution Companies (LDCs) would have a sufficient concentration of EMURBs to justify dedicated conservation programming or outreach.

Conservation programming or outreach to encourage EMURB heat pump retrofits should have a priority focus on large rental properties built between 1970 and 1989, equipped with electric resistance baseboards and bulk metering. Bulk metered rental apartments would be an ideal first target for heat pump retrofits as they would be easier to retrofit than condominiums due to owner control over in-suite equipment, bulk metered apartments avoid split incentives, and they are the most common EMURB property type.

Based on stakeholder feedback, demonstration projects and case studies would be helpful to build market confidence in the technical and financial feasibility of heat pump retrofits. Case studies would be helpful to verify the energy-savings and GHG reduction potential. A key driver for the success of any technology is the knowledge of its benefits and shortcomings. More real world examples of heat pump applications via EMURB retrofits are necessary for the sector to accelerate uptake of heat pump retrofits in EMURBs. Organizations, such as TAF, alongside some courageous sector partners, such as LDCs, EMURB Property Owners, and Investors will need to team up and implement some pilot projects if any real information is going to be generated to showcase the excellent potential that heat pumps can offer the sector to reduce GHG emissions and energy costs significantly.

Stakeholder engagement with EMURB property managers has revealed a need for assistance in assessing the financial and technical feasibility of heat pump retrofits, as well as generally raising awareness amongst management, owners, and residents. This indicates that any financial incentives for EMURB retrofits should be complemented by information, outreach and technical assistance targeted specifically at EMURB customers. This might include offering literature on the benefits of heat pumps and/or offer information sessions at a central location for EMURB property owners/managers in the initial phase of considering an electric heating system retrofit.

IESO improving data entry requirements when transcribing energy audits into the IESO MURB database can help to reduce EMURB market data gaps and be shared with LDCs seeking to identify and quantify EMURBs in their service areas. Throughout this exercise a key consideration has been the identification of significant data gaps regarding the EMURB sector in Ontario. Currently the EMURB sector is underreported due to limited requirements for Property Owners and Managers to report on their heating system type and pertinent property characteristics accurately. Additionally, data anomalies exist in some cases due to ambiguous terminology regarding building characteristics, incorrect units of measure, extreme outliers that could only be perceived as entry errors, or just missing data points. A potential way around this could be for the IESO to establish a standardized data entry form used when transcribing MURB energy audits. The data entry fields that would be used for entering MURBs heating system information would limit how the information was entered. In this way reporting begins to be universally understood amongst stakeholders and quality of data begins to increase. This will contribute to gaining a better understanding of the EMURB sector and conservation potential of heat pump retrofits by service area.

Most EMURBs lack central cooling; heat pump retrofits can incorporate cost effective cooling options which may be a key selling point for some stakeholders. However, the impact on summer peak loads needs to be considered. Although heat pumps are considered too risky of a technology solution for EMURB retrofit projects a significant consideration is their ability to offer both cost effective heating and cooling. This characteristic of heat pump technology could increase buy-in from property owners, boards of directors, and residents if AC is not already present in a building, and considered too costly to implement a standalone system. By implementing a heat pump could allow for long-term energy savings for heating, while simultaneously be a system that provides low cost cooling in the warmer seasons without the need for additional equipment.

3.5 NEXT STEPS

Feasibility Studies

TAF will be assessing the technical and financial feasibility of heat pump retrofits in EMURB by conducting feasibility studies in EMURB properties. TAF will choose eight (8) EMURB properties to undergo pre-feasibility studies (similar to an ASHRAE Level 2 energy audit). After evaluating the results from the eight studies TAF will choose four (4) of the original eight to undergo Investment Grade feasibility studies (similar to an ASHRAE Level 3 energy audit).

The information gathered from the feasibility studies is intended to assist TAF in establishing the market potential for heat pump retrofits and quantify the GHG and energy savings potential with a widespread role out of heat pumps in the EMURB sector.

Findings from the MCS will be integrated into the site selection process for choosing the initial eight properties to undergo assessment.

Tools and Resources for EMURB market stakeholders

TAF will be using the findings from the MCS and from the feasibility studies to assist with developing tools and resources for assisting stakeholders implement heat pump retrofits in EMURBs. Such tools and resources will include:

- Retrofit guidelines/checklist
- Measurement & Verification guidelines for LDCs and Property Owners
- Business decision tool (technical/financial assessment); MS Excel spreadsheet template with prepopulated information.

Further areas for investigation

Although this project is first and foremost a research endeavour, TAF would be interested in assisting with implementation of a heat pump retrofit in an EMURB perhaps as a pilot project if findings from the feasibility studies and further market analysis demonstrate a significant level of technical and market potential available. However, at the moment actual implementation of a heat pump retrofit is beyond the scope of this project. Instead we are aiming to provide the tools and resources for property owners and LDCs to implement heat pump retrofits.

Additionally, although this project is currently focused on electrically heated properties, the dominant heating source in Ontario's residential sector is from natural gas. TAF is interested in expanding its investigation of heat pump retrofit potential to natural gas heated MURBs for the potential GHG emission reductions that could be achieved.

APPENDIX A: Data Sample used for MCS Analysis

Locations	Sample Size	Owner ship Type	In-suite Heating Equipment	Common Area Heating	Units	FLOORS	Year Built	Metering Type	Electric heating as percentage of annual kWh consumption	Cooling as percentage of annual kWh consumption	AC Equip	Annual kWh	Monthly kWh
Ajax	1	1	1		1	1	1		1			1	1
Barrie	1	1	1	1	1	1	1		1			1	1
Bowmanville	1	1											
Brampton	1	1	1		1	1						1	
Brockville	10	10			10	0							
Burlington	2	2	1		2	1		1	1			1	1
Cornwall	2	2			2								
Guelph	5	5	4	4	5	4		4			4	1	
Hamilton	16	16	16	16	16	16	16	16			16	11	11
Kingston	1	1			1								
Kitchener	10	10			10								
Lindsay	2	2			2								
London	2	2	1		2	1							
Mississauga	3	3		1	1								
Napanee	2	2			2								
New Market	1	1	1		1	1							
Oakville	2	2			2	2		2				2	2
Orangeville	2	2	1		2	1						1	1
Oshawa	5	5	2		6			2			2	2	2
Ottawa	3	2			2	2		2	2	2	2	2	
Peterborough	1	1			1								
Port Credit	1	1			1								

	Sarnia	2	2			2								
	St. Catharines	1	1			1								
	Toronto	81	81	72	7	72	68	57	53	7	2	27	51	51
	Waterloo	3	3			3								
	Whitby	5	5	5	1	5	4		4				5	5
Municipality Anonymized	**GTHA**	**50**	50	50		48	50		23	23	19	24	24	
	NW Ontario	**5**	5	5		5	5						1	1
	SE Ontario	**2**	2	2		2	2							
	SW Ontario	**4**	4	4		4	4		2	2	2	2	2	
	TOTAL SAMPLE SIZE	**227**	**226**	**167**	**30**	**213**	**164**	**75**	**109**	**37**	**25**	**77**	**106**	**76**

APPENDIX B: Methodology for calculating Ontario EMURB estimate

A multistep approach was employed to estimating the quantity of EMURBs in Ontario using a variety of data sources and analysis techniques.

Step 1) Estimating Ontario EMURB sector size using publicly available data.

The multiple sources of data required for this analysis required an adjustment of definitions for MURB. To arrive at values that have a higher data quality TAF used the CENSUS2011 data to normalize the EMURB estimates from CEUD and SHEU2011. Furthermore, the process of normalizing the data involved adjusting the CEUD, SHEU2011, and NHS2011 MURB definitions to align with the CENSUS2011 MURB categories as outlined in TABLE 1 and TABLE 2.

TABLE 1: CENSUS 2011 – Available Multi-Unit Residential Building (MURB) Dwelling Type Categories

STRUCTURAL TYPE	DEFINED BY CENSUS
Row house	One of three or more dwellings joined side by side (or occasionally side to back), such as a townhouse or garden home, but not having any other dwellings either above or below. Townhouses attached to a high rise building are also classified as row houses.
Apartment, building that has fewer than five stories	A dwelling unit attached to other dwelling units, commercial units, or other non-residential space in a building that has fewer than five stories.
Apartment, building that has five or more stories	A dwelling unit in a high rise apartment building which has five or more stories.

CEUD consolidates dwellings counts for all MURB structural types under the single classification of APARTMENTS.

SHEU2011 classifies MURBs under three categories, which are Low Rise apartments, High Rise apartments, and Double/row houses. Double/row houses are defined as any house connected to at least one other dwelling; this includes duplex apartments and semi-detached houses.

CENSUS2011 provides individual counts for a range of dwelling structural types including Row houses, Apartments with fewer than five stories (low rise), and Apartments with five stories or greater (high rise).

TABLE 3 summarizes how the Multi-Unit Residential Building classifications from CENSUS2011, CEUD, and SHEU2011 align prior to readjustment:

TABLE 2: Multi-Unit Residential Building structural type definition comparison for Natural Resources Canada and Statistics Canada data sources

CENSUS2011	CEUD	SHEU2011	NHS2011
Semi-detached house	Apartments[8]	Double/Row house[7]	Apartments
Apartment, Duplex			
Row house			
Apartment, building that has fewer than five stories		Low Rise Apartments[9]	
Apartment, building that has five or more stories		High Rise Apartments[10]	

TABLE 3 provides estimates for the number of EMURBs in Ontario as provided by CEUD and SHEU2011:

TABLE 3: Ontario EMURB estimates

Multi-Unit Residential Building (MURB) Definition	Data Source	Reporting Year	Estimated Total # MURB Units	% of MURBs that are Electrically Heated	Estimated Total EMURB Units
• "Apartments"	CEUD	2012	1,506,700	16.9%	254,500
• Double/Row House • Low Rise Apartments • High Rise Apartments	SHEU2011	2011	1,667,445	31.6%	526,990

Natural Resources Canada has indicated that the values provided by CEUD and SHEU2011 are estimates arrived at using two different methods. The SHEU2011 numbers are based on survey estimates while the CEUD set are modeling estimates. TABLE 4 summarizes reasons for the variances between CEUD and SHEU2011.

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[7] **Double/Row house:** A house connected to at least one other dwelling, which together form a building. For SHEU2011, duplexes (two dwellings one above the other, not attached to any other structure) are included in this category.

[8] **Apartments:** This type of dwelling includes dwelling units in apartment blocks or apartment hotels; flats in duplexes or triplexes (i.e. where the division between dwelling units is horizontal); suites in structurally converted houses; living quarters located above or in the rear of stores, restaurants, garages or other business premises; caretakers' quarters in schools, churches, warehouses, etc.; and private quarters for employees in hospitals or other types of institutions.

[9] **Low Rise apartment:** Dwellings within triplexes, quadruplexes and apartment buildings of fewer than five stories.

[10] **High Rise apartment:** Separate dwellings within a residential structure of five or more stories.

TABLE 4: Reason for Variances between SHEU2011 and CEUD EMURB Estimates	
2011 Survey of Household Energy Use - Main heating energy source by dwelling type for Ontario (SHEU)	Comprehensive Energy Use Database – Residential Sector – Table 24 – Apartments Heating System Stock by Heating System Type - 2012 (CEUD)
1. SHEU2011 figures are directly based on answers from survey respondents. The information is based on 2,203 household respondents from Census Metropolitan Areas (CMA) across Ontario. 2. SHEU numbers are extrapolations from actual respondents and are not manipulated in any way to draw out patterns 3. SHEU2011 provides a single snapshot in time; better for quantifying the state of the EMURB market as it is now. 4. SHEU2011 breaks down quantity of EMURBs by MURB classification (i.e. Row house, Low Rise, High Rise)	1. CEUD figures are derived from modelling estimates. 2. CEUD uses data from multiple sources to establish trends; better for tracking trends overtime as opposed to providing accurate up-to-date figures. However still a valid data source. 3. CEUD is partially based on SHEU results 4. CEUD groups together a number of MURB types including some non-MURBs under the "Apartment" classification.

The methodologies applied to arrive at the EMURB estimates for CEUD and SHEU2011 generate divergent figures, each of which are still considered valid by Natural Resources Canada economists. For this reason TAF has incorporated both estimates into its analysis of the EMURB sector in Ontario. The shortcoming of using these figures is that neither provides an extensive audit of dwellings by structural type. Therefore, to improve data validity TAF has adjusted the EMURB estimate figures to be aligned with 2011 Census figures for dwelling counts by structural type.

TABLE 5: Ontario – Distribution of private households by structural type of dwelling, 2011 Census

Structural type of dwelling	Number of units
Semi-detached	279,470
Row house	415,230
Apartment, building that has five or more stories	789,975
Apartment, building that has fewer than five stories	498,160
Apartment, duplex	160,460

By normalizing the CEUD and SHEU2011 data for Ontario's EMURB sector with CENSUS2011 dwelling count figures TAF estimates there to be several scenarios (high, medium, and low estimates) for the number of EMURBs in Ontario, which are summarized in TABLE 6:

TABLE 6: Estimates for Quantity of Electrically-heated Multi-Unit Residential Buildings (EMURB) in Ontario by using just publicly available data

DWELLING TYPE	PROVINCIAL TOTAL (CENSUS2011)	LOW ESTIMATE		MEDIUM ESTIMATE		HIGH ESTIMATE	
		# EMURB Units	% of Dwelling Type Total	# EMURB Units	% of Dwelling Type Total	# EMURB Units	% of Dwelling Type Total
Row House	415,230	23,309	5.61%	38,043	9.16%	52,777	12.71%
Low Rise Apartment (<5 stories)	498,160	116,860	23.46%	157,589	31.63%	198,318	39.81%
High Rise Apartment (5+ stories)	789,975	150,248	19.02%	256,692	32.49%	363,135	45.97%
TOTAL	1,703,365	290,417	17.05%	452,324	26.55%	615,841	36.15%

Step 2) Finding an EMURB estimate for Toronto.

The TAF research team through consultation with several credible sources were advised that 20 – 30% of the MURB stock in Ontario is anticipated to be EMURBs; and in Northern areas or those areas with limited natural gas heating access it would be more in the range of 30 – 40%. This would therefore mean that the "MEDIUM" and "HIGH" estimates are within the range of accuracy for most of the Province. However, although expert consultation and TAF's own experience with the MURB sector revealed that the "MEDIUM" EMURB estimate of 26.6% would be the more reliable estimate that TAF derived during the initial phase of this study, for Toronto the quantity of EMURBs was thought to be much lower due to the legacy of natural gas heating in the area and expert firsthand knowledge of the Toronto MURB sector.

Furthermore, determining a reliable EMURB estimate for Toronto was found to be important because Toronto (CSD) possesses 38.4% of all MURBs within the province and thus if Toronto was assumed to have a lower EMURB to MURB ratio compared to other areas of Ontario, TAF's EMURB market quantification needed to ensure that it captured the variance between Toronto and the rest of the province.

Using data made available by several sources TAF has managed to develop an enhanced understanding of the EMURB sector in Toronto by being able to analyze data for confirmed EMURBs and apply those findings to a Toronto Hydro dataset for all the MURBs within the Toronto Hydro service area in order to confirm assumptions.

With the help of Toronto Hydro, under a non-disclosure agreement, TAF compared seasonal electricity consumption data for all MURBs within the Toronto Hydro service area to identify which customers were electrically heated. The assumption was that for EMURBs their winter electricity consumption should be higher than milder seasonal periods. Based on Toronto Hydro data anomalies data analysis was not straightforward. Not only was there no clear delineation between Winter and Spring/Fall(SHOULDER) consumption, this also confirmed by analysis of the EMURB database for qualified EMURB and non-EMURB properties, there were issues with erroneous or missing data. TAF and Toronto Hydro worked diligently to experiment with varied data analysis approaches. Finally after data cleaning efforts by both Toronto Hydro and the TAF research team, TAF generated a series of algorithms that would isolate usable from erroneous data records and compare the two months out of a year with the highest heating degree days (WINTER SEASON) to the two months with the lowest heating and cooling degree days (SHOULDER SEASON). Once reliable WINTER/SHOULDER ratios were calculated for MURBs within the Toronto Hydro dataset (2012 to 2014), the quantity of EMURBs present in Toronto could be estimated. Based on a rigorous analysis of confirmed EMURBs and Natural Gas Heated MURBs, the finding was that the majority of EMURBs have a WINTER to SHOULDER electricity consumption variance of 140% and above. The 140% ratio threshold was arrived at through analysis of confirmed EMURB and non-EMURB properties. A comparative analysis of TAF's EMURB and non-EMURB database records revealed that 95% of natural gas heated MURBs have a WINTER/SHOULDER electricity consumption variance of 139% and below and 90% of EMURBs have a WINTER/SHOULDER variance of 140% and above. The results were reliable enough to utilize the 140% threshold for the analysis of the Toronto Hydro dataset.

Applying the 140% WINTER/SHOULDER threshold to the Toronto Hydro MURB dataset revealed that 19.2% of MURBs in Toronto are assumed to be EMURBs. To ground-truth these findings, the quantity of confirmed EMURBs found within the Toronto Hydro service area and dataset where checked to see how many fell within the 140% and above category, which turned out to be 80%. Although this means that 20% of the confirmed EMURBs were not captured, it can be assumed that with this approach the quantity of EMURBs that are not captured in the estimate will likely be complemented by captured Natural Gas MURB false positives.

Step 3) Adjusting the Provincial estimate to reflect the Toronto variance

Using CENSUS2011 data for MURB dwelling counts (Row house, Low Rise, High Rise) the TAF research team calculated the estimated quantity of EMURB units in Ontario by using the Toronto estimate of 19.2% and the MEDIUM Estimate of 26.6% for the rest of Ontario. First the Toronto MURB dwelling counts were subtracted from the Ontario MURB dwelling counts, with the MEDIUM estimate applied to the difference to reveal the following:

TABLE 7: Estimated Quantity of EMURB Units in Ontario without Toronto (Census Subdivision)

DWELLING TYPE	ONTARIO TOTAL (CENSUS2011)	Rest of Ontario MURBs (without Toronto)	Rest of Ontario EMURBs (without Toronto)
Row House	415,230	354,935	94,413
Low Rise	498,160	334,265	88,914
High Rise	789,975	360,750	95,960
TOTAL	**1,703,365**	**1,049,950**	**279,287**

Next the Toronto estimate of 19.2% was applied to the CENSUS2011 dwelling count data for the Toronto CSD figures:

TABLE 8: Estimated Quantity of EMURB units in Toronto, ON (Census Subdivision)

DWELLING TYPE	ONTARIO TOTAL (CENSUS2011)	Toronto MURB Units	Toronto EMURB Units
Row House	415,230	60,295	11,588
Low Rise	498,160	163,895	31,499
High Rise	789,975	429,225	82,494
TOTAL	**1,703,365**	**653,415**	**125,582**

Finally the ‘Toronto’ and ‘Rest of Ontario’ EMURB estimates are added together to produce the following estimate for the total number of EMURB units in the Province of Ontario:

TABLE 10: Estimated Total Quantity of EMURB Units in Ontario including Toronto, ON (using analysis results from publicly available data and Toronto MURB database)

DWELLING TYPE	ONTARIO TOTAL (CENSUS2011)	ALL OF ONTARIO EMURB Units (including Toronto)	% Of Total
Row House	415,230	106,001	25.5%
Low Rise	498,160	120,414	24.2%
High Rise	789,975	178,454	22.6%
TOTAL	**1,703,365**	**404,869**	**23.8%**

Step 4) Adjusting the provincial estimate with confirmed EMURB data

Using data from the EMURB database revealed a variance in the proportion of EMURB units by structural type (See Figures 10 and 11 in the MCS). The estimate of total EMURB units in Ontario was adjusted to reflect findings from the analysis summarized in section 2.3.4 of this report.

TABLE 11: Adjusted Estimate of Total EMURB Units in Ontario (Data: Provincial, Toronto MURB database, EMURB database)

STRUCTURAL TYPE	# of EMURB units	% of EMURBs
Row House	36,438	9%
Low Rise (< 5 stories)	89,071	22%
Mid Rise (5 – 9 stories)	93,120	23%
High Rise (10+ stories)	186,240	46%
TOTAL	**404,869**	**100%**