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Addressing Energy Efficiency in Rental Units: A Preliminary Cost Assessment of Minimum Energy Standards and Policy Alternatives for Rochester, NY

Bryn Stricker
bns8188@rit.edu

RIT

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Master of Science in Science, Technology, and Public Policy

Department of Public Policy
College of Liberal Arts

Rochester Institute of Technology
Rochester, NY

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Rochester, New York

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Submitted by:

Bryn Stricker

Department of Electrical Engineering	Signature	Date
Department of Public Policy		

Accepted by:

Dr. Eric Hittinger, Thesis Advisor

Interim Department Chair	Signature	Date
Department of Public Policy		

Nathan Lee, Thesis Committee Member

Assistant Professor	Signature	Date
Department of Public Policy		

Jenna Lawson, Thesis Committee Member

Housing Project Manager	Signature	Date
Connected Communities, Inc.		

Dr. Eric Hittinger

Interim Department Chair	Signature	Date

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Abstract

With the rising concern for climate change and energy consumption, global, national, and local policies attempt to reduce carbon emission and energy usage. Starting in 2010, the city of Rochester established a climate action plan which aims to reduce greenhouse gas emissions by 40% in the year 2030 (City of Rochester, NY, 2017). The city recognizes rental homes are a promising source to mitigate energy consumption and carbon emissions, a type of greenhouse gas. Minimum energy standards for rentals (MESR) are a relatively new type of policy which can help achieve energy and carbon reduction goals. By using an existing framework outlined by the Rocky Mountain Institute (RMI), this research aims to investigate the energy and carbon savings as well as an assessment of costs to the city of Rochester. The results help determine that a MESR is a viable policy solution for the city of Rochester to reach its energy and environmental goals. Comparisons to other cities will verify the that the preliminary results are realistic. Conclusions from the results of the cost analysis provides insight on how the city of Rochester should proceed with developing a MESR to address energy efficiency and reduce carbon emissions. Due to Rochester's dense population of low-income households and rigorous climate goals, several aspects of the MESR need to be carefully designed, so rental units become more affordable for tenants and the city can achieve their 2030 greenhouse gas reduction target.

Keywords: minimum energy standards, energy efficiency, residential housing, rentals, Rochester, New York

Introduction

Building codes are an important policy tool and critical component of urban development for the commercial and residential sectors. In response to the energy and economic crises of the 1970s, the National Energy Conservation Act was passed and began requiring states to administer energy standards for new buildings (Kemp, 1978). Since then, the International Code Council (ICC), the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), and the United States Department of Energy (DOE) has continued collaborating to develop and support the adoption of energy standards so that the nation continues to reduce energy, carbon emissions, and associated health risks (Cohan, 2016). For the most part, building codes tend to focus mainly on new development and fall short in incorporating standards meant to address existing structures. As new energy codes are adopted each year by state and local governments, existing residential properties, both home-owned and rentals, are grandfathered into the system leaving approximately 70% of the residential market in the United States unaffected by energy standards (Arena & Vijayakumar, 2012).

In large cities where energy consumption is high, rental properties account for about 50% of the residential market (Arena & Vijayakumar, 2012). In order for a property to be certified as a rental unit, many states and local municipalities have certification requirements that must be met before a tenant can occupy the rental space. The city of Rochester, NY utilizes a Certificate of Occupancy (CoO) that must be renewed every three years for multifamily complexes and every six years for single and double family units (City of Rochester, NY, n.d.-a). By requiring improvements to existing rental properties, cities, like Rochester, can continue to reduce energy consumption and carbon emissions while simultaneously reducing health risks and addressing socio-economic issues in the community. This study aims to better understand the cost associated with implementing a MESR in the city of Rochester in the form of energy saved, carbon saved, and building assessment costs. Better insight on city costs and estimated savings will help identify plausible policy alternatives that could help Rochester reduce their energy consumption.

Background and Literature Review

Motivation for Addressing Energy Efficiency in Buildings

Energy consumption contributes to a number of externalities including but not limited to public health, air quality, and climate change. This is attributed to the vast amounts of carbon that is produced as a result of energy generation, distribution, transmission, and usage. The building sector is responsible for approximately 40% of energy consumed in 2020, and slightly more than half that amount being credited to the residential sector (U.S. Energy Information Administration [EIA], 2021). As energy consumption continues to rise, so do carbon emissions. Not only does this byproduct gradually cause harm to our atmosphere by absorbing and radiating heat which impacts climate change (Lindsey, 2021), but it impacts air quality as well as human health. Improving energy efficiency is known to have economic benefits, too. As a result, governments have added energy policy to their agenda and have made steps toward reducing emissions throughout the last decade by implementing new legislation and community initiatives.

Improving Human Health and Safety

Poor air quality threatens the safety of humans within their own homes. Fine ($PM_{2.5}$) and coarse (PM_{10}) particulate matter are airborne particles with a diameter of less than 2.5 and 10 microns, respectively, and are known contributors to poor air quality. These particulates from fuel emissions, building development, and indoor appliances can antagonize health issues as well and seen in homes across the world (Cincinelli & Martellini, 2017; Pope et al., 2020). $PM_{2.5}$ in particular can infiltrate deeper into the lungs and disturb lung function (Xing et al., 2016). Hence, the link between contributors to poor air quality and major health complications such as heart attack, strokes, respiratory diseases, as well as premature deaths. So far, the city of Gainesville, FL has recognized the importance of this public health issue and cited in their rental ordinance that “public health, safety, and welfare concerns" are the motivations for updating and creating a rental energy standard for the city (City of Gainesville, FL, 2020, p.1).

Health complications can be reduced both inside and outside the home by means of implementing low carbon home improvements. These improvements are incremental and made to the home with the aim to improve energy efficiency and in turn reduce carbon emissions from energy consumption (Hipwood, 2018). A full list of health impacts associated with low carbon home improvements from existing research has been summarized by Hipwood. Some of the key findings include reduction in stress associated with financial burdens and physical security, increase in comfort, and perception of space being safer to occupy. Improved comfort levels due to home improvements have helped reduce overcrowding in homes and reduce tension in family relationships, as well.

Economic Benefits of Energy Improvements

In a capitalistic society, such as the United States, monetary costs and benefits help drive the decision-making process for most citizens. This has been one of the major barriers in adopting energy efficient technologies and energy standards. However, energy efficiency upgrades have shown promising results internationally. Improvements which may be incorporated into building standards may include upgrades to insulation, appliances, lighting, and much more. A French study conducted by Belaïd et al. showcased most retrofit solutions having a positive Net Present Value(NPV) in the residential sector (2021). According to another study by Henderson, et al., metering data collected from over 8,000 homes in the UK revealed improvements to insulation yielded approximately 12% savings in electricity. Ore et al. revealed that the DC House, a historical residential building in West Lafayette, IN, experiences efficiency gains with heating and cooling upgrades between 2.38% and 31.3%, respectively (2021). Despite numerous restrictions on possible upgrades due to the need to preserve the historical characteristics of the building, there are still positive economic results. For typical Canadian homes, Guler et al. assessed a series of residential energy efficiency retrofits in 2001 and concluded that retrofits can have up to 8% energy savings individually. When combining a series of improvements like a minimum energy efficiency standard would suggest, there is the potential to increase energy savings further. In the last two decades, there has been significant progress in energy efficiency technology which may provide opportunity for even greater results moving forward.

Economic gain of energy efficiency improvements is not strictly measured by decrease in utility cost. It can also be measured by increased property value and avoided costs. Research performed by Jafari et al. (2017) suggests the sale price of a home will increase by 12.2% for the average home if energy efficient retrofits decrease energy consumption by half. Also, avoided costs from carbon emissions and other air pollutants are another type of metric which adds to the economic value of implementing improvements (Jakob, 2006; Levy et al., 2016). Other indirect benefits from insulation improvements such as avoiding cost from illness or loss of income has been considered an economic gain, too (Jakob, 2006).

Addressing Environmental Justice for Low-Income Households

Environmental justice is the movement which acknowledges minority groups are at greater risk of experiencing poor environmental conditions within their communities and aims to advocate on their behalf. One minority group that has become particularly important in the energy efficiency conversation is low-income households. Nationally, these households are characterized by "earning 80% or less of area median income (AMI)" (U.S. DOE - Office of Energy Efficiency & Renewable Energy, 2018). These low-income household in urban communities experience a much greater impact from the externalities associated with energy consumption. Through examining trends in Toronto, Canada, Vaz et al. concluded that there was geographical evidence that low income and minority racial groups in concentrated geographic areas experienced poorer health due to unfavorable spatial conditions (2017).

However, environmental inequity is not restricted to outdoor conditions, but includes indoor ones as well. Properties which are in the reach of low-income and other minority groups are poorer quality than those that can be accessed by higher-income counterparts and do not typically have the most energy efficient technologies. The quality of the indoor environment entered the environmental justice conversation in 2011 where Adamkiewicz et al. reported from their research that multiple types of pollutants, including $PM_{2.5}$ and nitrogen dioxide (NO_2), are more prevalent in low-income homes in the United States. This study included examining multifamily housing intersecting the rental energy efficiency conversation and drawing attention to another major reason to pursue action on this endeavor. According to a study by Im et al. which analyzed 10 major U.S. cities, Philadelphia, Washington D.C., and San Francisco, have the highest overall adoption rate of energy efficiency technologies, but also have the highest average rent postings making it hard for low income people to obtain (2017). Socio-economic issues like the great divide between low-income and high-income households poses challenges in achieving environmental justice.

Understanding the Split Incentive Dilemma

With any improvements to a property, typically, the main concern is the cost. Unlike property owners, homeowners directly reap the benefits of making improvements to their home in the form of reduced monthly utility bill cost and maintenance. The split incentive dilemma can be described by comparing two major scenarios: property owners who pay for utility costs and tenants who pay for utility costs (Carliner, 2013). In the first scenario, property owners have more of an awareness of energy consumed in their properties when they are responsible for paying the utility bills. Thus, they are more motivated to make modifications to their property because they can understand that they can benefit from the cost savings of the improvements. On the other hand, when tenants are responsible for paying their utility bills, property owners have little incentive for making improvements to their properties. Aside for the potential increase in property value, property owners do not reap the utility cost savings that would be experienced given new energy efficient improvements. Again, this conflict of interest which is known as the split incentive dilemma is a major issue for cities to progress toward their climate goals. There are a variety of policy solutions that can aid reaching climate goals including a MESR.

Minimum Energy Standards for Rentals (MESR)

MESR has been noted as one of the many potential policy solutions aimed to help resolve the current climate crisis by bridging the gap to include energy efficiency buildings in all sectors (Wrigley & Crawford, 2017). These standards, also referred to as rental energy standards and minimum energy efficiency standards, are specifically designed for rental properties and could have voluntary or mandatory requirements by each state or local jurisdiction. The objective is to improve the overall energy performance of buildings in order to reduce energy consumption, utility rates, and carbon emissions. This policy is typically aligned with an existing policy framework such as a rental license or certification to help successfully implement this policy solution (Petersen & Lalit, 2018).

Improvements suggested by a MESR generally target large energy consuming systems to make a significant reduction to energy consumption. According to Im et al., heating, ventilation, and air conditioning (HVAC) systems, appliances, and lighting all consume a significant amount of energy in the residential sector at 54%, 35%, and 6%, respectively (2017). Additional improvements can be made to the building envelope as well; this is the barrier separating conditioned space of a building from the unconditioned environment outside such as an exterior wall, roof, or foundation of a home. While building envelope improvements do not necessarily use electricity, they do help the overall performance of HVAC systems by containing air used for heating and cooling. Some possible standards may include upgrading technologies such as the thermostat, hot water heater, and appliances, making improvements to the building envelope via sealing leaks, adding insulation, and installing new windows, and replacing light fixtures as recommended by the Office of Energy Efficiency & Renewable Energy (U.S. DOE, n.d.-b).

Key Actors in the MESR Process

In order to establish, enforce, and address the problem associated with energy efficiency and building standards, there are multiple actors involved in the process. MESR is a type of regulatory policy first drafted and proposed by policy makers. Traditionally, state and local governments can adopt the proposed policies either partially or in their entirety. There are addendums and local codes that may be adopted to work toward a specific goal like energy efficiency. For instance, Washington D.C. instituted a green building code that commercial buildings must abide by in addition to other building standards. States and local governments are also responsible for policy enforcement. Some cities utilize a rental property certification program that typically requires the property owner to apply through the local government and have their property inspected by a professional. The inspector must verify that the intended rental unit is safe and meets all of the standards prior to an occupant moving in. Once complete, the owner will receive a certificate to allow tenants to occupy the rental unit.

Multiple Policy Solutions: Variations of MESRs in the United States

One of the most unique characteristics of a MESR is the versatility of viable solutions to tackle the energy efficiency issues in rental units. By varying the energy targets, compliance framework, and timeframe of compliance are just some aspects of a MESR that will change across multiple cities. For starters, cities may set different energy efficiency targets that will require various levels of energy improvements. A MESR may highlight specific changes that are required to achieve compliance, or it may list several different energy efficiency improvements, but the property owner might only be required to a few of his or her choosing to achieve compliance. The International Energy Conservation Code (IECC) may inspire ideas to incorporate in a MESR or may be adopted with some amendments. Standards which reduce energy consumption in air conditioning, spacing heating, and water heating significantly will yield higher efficiency results since this is where energy consumption in residential homes are the highest. When creating a MESR, the number of years for rental units to achieve full compliance must be designed with careful consideration of the local area. A municipality may choose that these energy efficiency improvements need to go into effect immediately, giving only a few years for property owners to adapt, or a municipality may allow property owners several years to make the necessary improvements. Three different cities in the United States have selected different compliance periods for their MESRs which fits their cities' needs. Some cities may consider a phase-in approach to ensure that energy measures are met and lessen the burden on making lots of improvements within a small-time frame. The city of Gainesville, FL has experimented with this approach in their MESR. Overall, there is a lot of flexibility in designing a MESR to fit the needs of a city. A few different examples of MESRs are further discussed to highlight this point.

Boulder, CO

The first city to adopt rental energy standards in the United States was Boulder, CO in 2010 (RMI, n.d.). For the city of Boulder, the MESR known as SmartRegs has been a innovative policy. The final iteration of the drafted SmartRegs policy, Ordinance No. 7726, was enacted January 3, 2011 (City of Boulder, 2010). The general framework of the SmartRegs MESR is depicted in Figure 1. This ordinance was incorporated in the existing rental licensing program and provides two different pathways to meet compliance, the prescriptive and performance pathway. The main difference between these compliance options are the frameworks used to determine the energy efficiency of a home. The performance pathway utilizes the Home Energy Rating System (HERS) with the objective of a single rental unit achieving a score of 120 or higher. Alternatively, the prescriptive pathway utilizes a separate scoring method where rentals must achieve a score of 100 using an energy efficiency score table as developed by the city (see Appendix A). Property owners had up to eight years from its inception to make the necessary improvements outlined in the standards (Barret et al., 2011, p. 197). Therefore, all rentals had to meet the SmartRegs requirements by January 2, 2019 (City of Boulder, 2010). There are certain rentals that are granted exceptions to the ordinance such as those which are made from "innovative materials," a part of a historic building, meet the criteria for a permanently affordable housing, or "technically impractical" to improve. The purpose of the MESR is to work towards the climate action goals addressed in Boulder's Climate Action Plan (CAP).

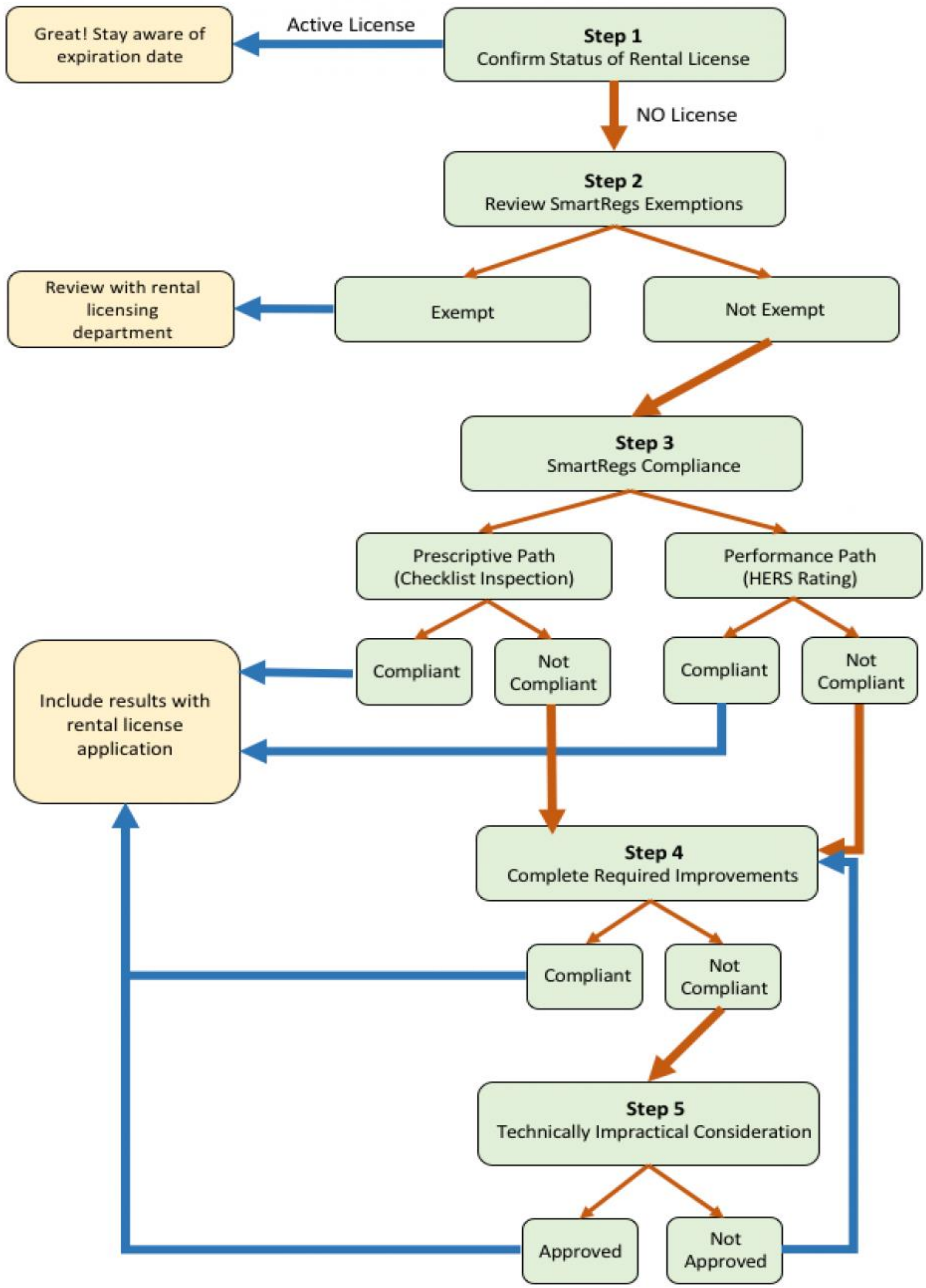


Figure 1: Compliance Framework of Boulder's SmartReg Policy (City of Boulder, 2022)

The recent adoption of these standards provides little to no data on the policy's long-term effectiveness and makes it hard to convince other communities to consider. The DOE suggests that there are significant improvements to energy efficiency as a result of local rental efficiency standards in Boulder's SmartRegs (Arena & Vijayakumar, 2012). Approximately 4,200,000 kWh are expected to be saved from upgrades from Boulder's 20,000+ rental properties which equates to about $1,100,000 saved per year from energy bills alone (Petersen & Lalit, 2018). More than 8,000 metric tons of carbon dioxide are also expected to be saved annually. Models from nine different case studies yield reduced annual utility costs and reduced emissions (Arena & Vijayakumar, 2012). Rental homes incorporated into the study included a range of homes types such as detached, two-, three-, and multi-family homes. All of the homes were built between 1900 and 1966. Utility bill data was unavailable to incorporate since this study was conducted close to the initialization of the standards and there were barriers of receiving consent to obtain. Estimates using home modeling software have been used as a resource to educate people about the impact of potential energy improvements. Despite the model projections, there is still skepticism around whether these improvements will actually pay off. Further research in the Boulder community will need to be conducted to fully convince other municipalities.

"Better Rentals, Better City" Guide

Since Boulder's development of rental efficiency standards, RMI has launched a guide to help facilitate policy modeling and development for cities that are currently interested in implementing a MESR (Petersen & Lalit, 2018). Highlighted details of the seven-step guide are as follows:

1. **"Fit:"** Cities need to determine whether the community in question is a right fit for efficiency standards. One of the most effective ways to incorporate these energy

standards in the community is to integrate them into an existing structured program like a licensing program. Alternatively, cities can consider other 'triggers" such as time of sales of properties which may encourage energy efficiency upgrades.

2. **"Impact:"** A preliminary analysis including energy savings, carbon savings, and the costs to the city should be estimated in order to compare against other policy alternatives. A toolkit provided by RMI can aid cities in this process.
3. **"Consult:"** Opening up a discussion to key stakeholders is important prior to developing and implementing the MESR. It is advised that cities hear out public concerns, strongly consider consequences of the fiscal impact on the rental industry and point out valuable outcomes due to policy implementation.
4. **"Finance:"** In order to decrease the financial burden of improvements outlined in a proposed MESR, cities must explore and identify finance tools and programs which will alleviate the burden of up-front costs to the city and property owners.
5. **"Implement:"** The city must strategically develop a plan to roll-out the new MESR policy. This may include determining a system to evaluate energy efficiency within a rental unit, developing an energy target, exploring data collection requirements/reporting mechanisms, outlining different requirements between single and multifamily units, and assessing need for rental home inspectors. For example, Boulder uses the Home Energy Rating System and a custom checklist as their energy efficiency measurement tool (Arena & Vijayakumar, 2012).
6. **"Compliance:"** Before instituting a new MESR policy, several factors should be considered by the city such as the period for full compliance, options for compliance, cost caps, exemptions, and penalties for non-compliance. This is due to the wide variety of

conditions including but not limited to housing types, financial circumstances, and quantity of properties owned. A verification process may also be necessary to ensure property owners are accurately reporting upgrades and that the upgraded systems are installed correctly for optimal energy and carbon reduction.

7. **"Disclosure:"** A system for storing records and data for a MESR is critical for enforcement. It also has the potential to be a great tool used to educate the public about compliance of a rental unit and how energy efficient the unit is compared to others in the area.

After the development of this guide, only two cities, Gainesville, FL in 2020, and Burlington, VT in 2021, have implemented a rental efficiency standard into their rental ordinance (RMI, n.d.). Each of these cities have implemented some of the suggested policy mechanisms as discussed in the next sections. Ann Arbor, MI, Columbia, MO, and Somerville, MA have also begun exploring options for MESR policies following similar tactics from the guide.

Gainesville, FL

Gainesville has also attempted to implement an effective MESR for its city which is unique. Similar to Boulder, the MESR is incorporated into the existing annual permit/inspection program (City of Gainesville, FL, 2020). The updated ordinance outlines thirteen different energy efficiency requirements that must be met by October 1, 2021 and mainly targets the building envelope, the HVAC system, and plumbing fixtures. Of the thirteen requirements, two require additional upgrades by October 1, 2026, to maintain compliance. There is an additional requirement of a programmable thermostat that must be met by October 1, 2026, as well. Enforcement for Gainesville MESR did not begin until after October 1, 2021 and will be conducted every four years with either the owner/tenant present. During this inspection, an updated DOE Home Energy Score will be provided to the property owner which is used to provide useful information to potential tenants prior to a binding lease. The city does acknowledge that there may be exceptions to the MESR which property owners can apply to be excluded from these requirements, however, the city refuses to consider cost or inconveniences as valid reasons for exemptions.

Burlington, VT

Burlington, VT first took this approach to pursue energy efficiency upgrades in 1997, but has since adopted a MESR built into its certification program (City of Burlington, VT, 2021). This new ordinance adopted by the Burlington City Council in May 2021 focused on improving insulation, heating and cooling ducts, hot water piping, windows, doors, and combustion appliances throughout rental units. All of these improvements applied to rental units that used 90,000 British Thermal Units (Btus) or more annually and were expected to be completed by January 1, 2022. Rental units that use less than 90,000 Btus annually, categorized as a seasonal property (rented only from the beginning of April to the end of October), previously participated in weatherization incentive programs in the last 10 years, or have valid permits to be demolished or converted to a nonresidential property were exempt from this ordinance. Temporary waivers could also be granted to property owners if after seeking financial assistance from at least three institutions, they still cannot get the required funds for improvements, if a Professional Building Weatherization Contractor is unavailable to complete the work, or if the property owner is registered to receive financial support through a weatherization program. The City of Burlington acknowledges that making the updates they require in the MESR can be very costly to property owners whose properties require a lot of work. To help reduce the financial burden of upfront costs, a cost cap for improvements was placed at $2,500. Any additional requirements not met after a property owner made at least $2,500 worth of improvements would be forgiven and not impact compliance. Since the beginning of January, little to no data regarding the impact of post-renovation improvements has been analyzed. In the future, this data would help provide better insight on energy cost savings as well as carbon savings.

Alternative Policy Solutions to the Split Incentive Dilemma

Aside for MESRs, there are other policy alternatives that help approach the split incentive dilemma. One potential policy solution is green or energy efficiency leases which rely on the property owner and tenant to agree to work together to maximize efficiency (Bird & Hernández, 2012). However, the major issue with this agreement is assuming that the property owners will uphold their end of the agreement which mostly focuses on providing and maintain the necessary improvements for efficiency. Upfront cost for energy efficient retrofitting can be alleviated by another potential solution known as energy efficiency mortgages. This solution attaches loans for improvements to the property instead of the tenant or property owner. Unfortunately, there has been complication with this solution as seen in the Property Assessed Clean Energy Financing (PACE) where major mortgage lenders refused to provide mortgages for properties participating in the PACE program. While green building codes are another great solution to help solve the energy efficiency problem, these codes mostly target new construction and do not try to address existing housing stock like a MESR. Low-income rental mandates may be feasible for some city, however, due to the disincentives associated with implementing such a standard, there is risk in reducing low-income rental housing which is already limited. While each solution maybe a solution for the split incentive dilemma, the unique characteristics of the city of Rochester may complicate the implementation or effectiveness of these policy solutions.

Scene in Rochester, NY

The Rental Market

Unique property attributes pose a number of complexities to the Rochester rental market. For starters, Rochester is regionally dense. However, according to a study by czb, LLC, a nationally recognize community development firm, the majority rentals properties are either single family dwellings, duplexes, triplexes, or quadplexes which disperses the population of people throughout the city (2021). Compared to the surrounding suburbs, there is a higher amount of small rental units in the city. A larger number of single-family homes were converted into rental units from 2010 to 2019 adding about 3,700 rental units. Approximately 26,000 of 60,000 rental units were built prior to the 1940s and 22,000 were built prior to the 1980s. These properties pose a much higher chance of capital replacements and general maintenance. In the event that these maintenance or replacement requests are ignore, there may be major consequences for the property owners or tenants including greater building damage, reduced quality of living, and health hazards. As a result, few energy conscious rentals are available on the market. With 83.4% Rochester's of home stock built prior to 1970 (City of Rochester, NY, 2017), it is possible to see significant changes to these existing structures and their energy usage, since these structures were not included in the first energy standards. These attributes set the foundation for rental market and cause some concerns.

One of the most important concerns regarding the rental market in Rochester is affordability for tenants. Data from the U.S Census and the American Community Survey has depicted that affordability has been an ongoing issue for more than two decades (czb, LLC, 2021). On average, a renter in the city can only afford a unit at a monthly rate of $650 or less However, the average rental unit costs about $850 per month. Rochester's rental market mainly consists of low-income households where 41% of households are extremely low-income, meaning they earn less than 30% of the AMI (U.S. DOE - Office of Energy Efficiency & Renewable Energy, 2018). A gap analysis, as shown in Figure 2, highlights the large deficit of affordable units for households earning less than $20,000 per year.

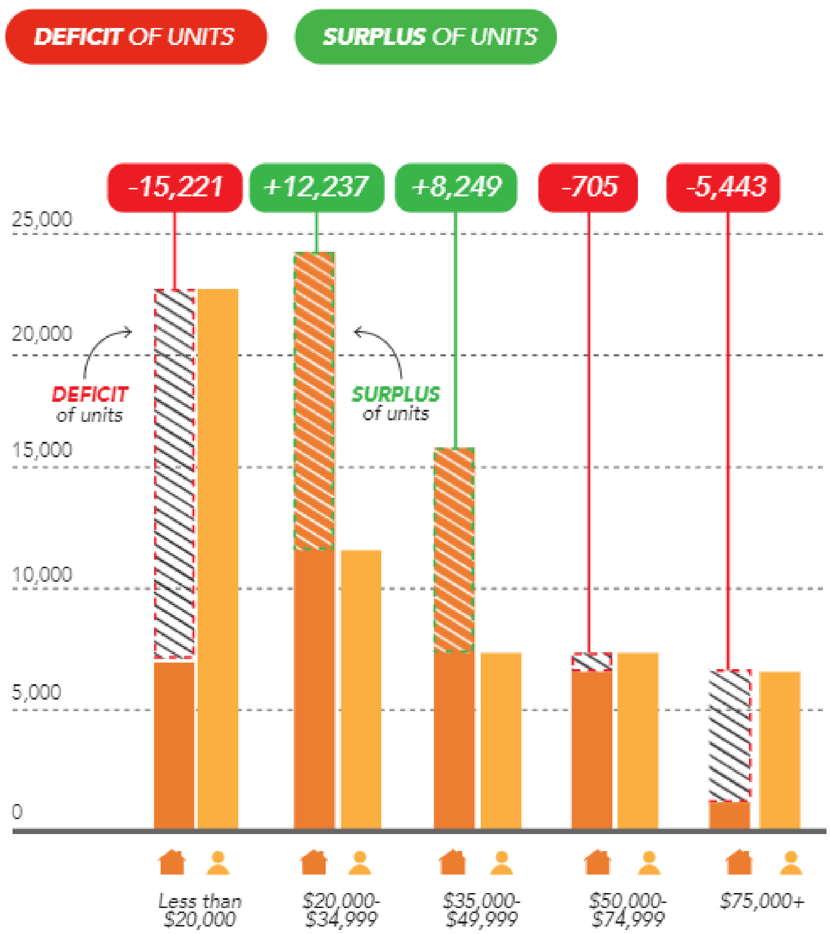


Figure 2: Gap Analysis of Rochester Rental Units to Households, By Income, 2019 (czb, LLC, 2021)

To make matters worse, according to Carliner, "for those lowest-income renters who pay for all utilities, energy costs represent 21 percent of income (2013)." Nationally, high energy burdens are classified by energy bills exceeding beyond 6% of an individual's income and has been apparent in Rochester (American Council for an Energy Efficiency Economy [ACEEE], 2020). Minority groups are no exception to this trend; the ACEEE reports 44% of both Black and

Hispanic households in Rochester experience high energy burdens. Implementing a standard may allow for more opportunities for better living conditions and reduce the financial burden each month from energy consumption.

The willingness and ability for a renter to pay has divided the city from the rest of the surrounding suburbs (czb, LLC, 2021). The majority of neighborhoods in the city of Rochester are "prone to concentrations of poverty, private sector disinvestment, degrading property conditions, and weakening of neighborhood institutions," according to czb, LLC. These areas are referred to as *demand-soft* and low-income renters who reside in the city are put at a greater risk of experiencing these conditions as a result. In contrast, the surrounding areas of Rochester are *demand-strong* areas which experience a healthy demand for rentals and a strong market. On the right in Figure 3, demand-soft and strong areas of the entire city of Rochester are shown. With data collected from over thirty interviews with property owners, there is correlation between the demand type of a Rochester neighborhood and the behaviors of property owners also in that area. Property owners were categorized into five (5) distinct categories based on their characteristics. The first two types are the "true pros" and "contenders" which generally rent to low-risk tenants, manage properties in good shape, have good balance sheets. These are the types of owners seen in the demand-strong areas. For demand-soft areas, "Mom & Pops," "slumlords," and "marginal amateurs" are the category types. Each have little to no regard for balance sheets and typically rent to high-risk tenants. The key difference between the three types is with respect the quality of the property. Mom & Pops tend to manage a property with marginal value while slumlords manage slum properties and marginal amateurs manage properties which are declining in value. The distribution of each type of property owner in the city of Rochester is depicted in the dot map in Figure 3.

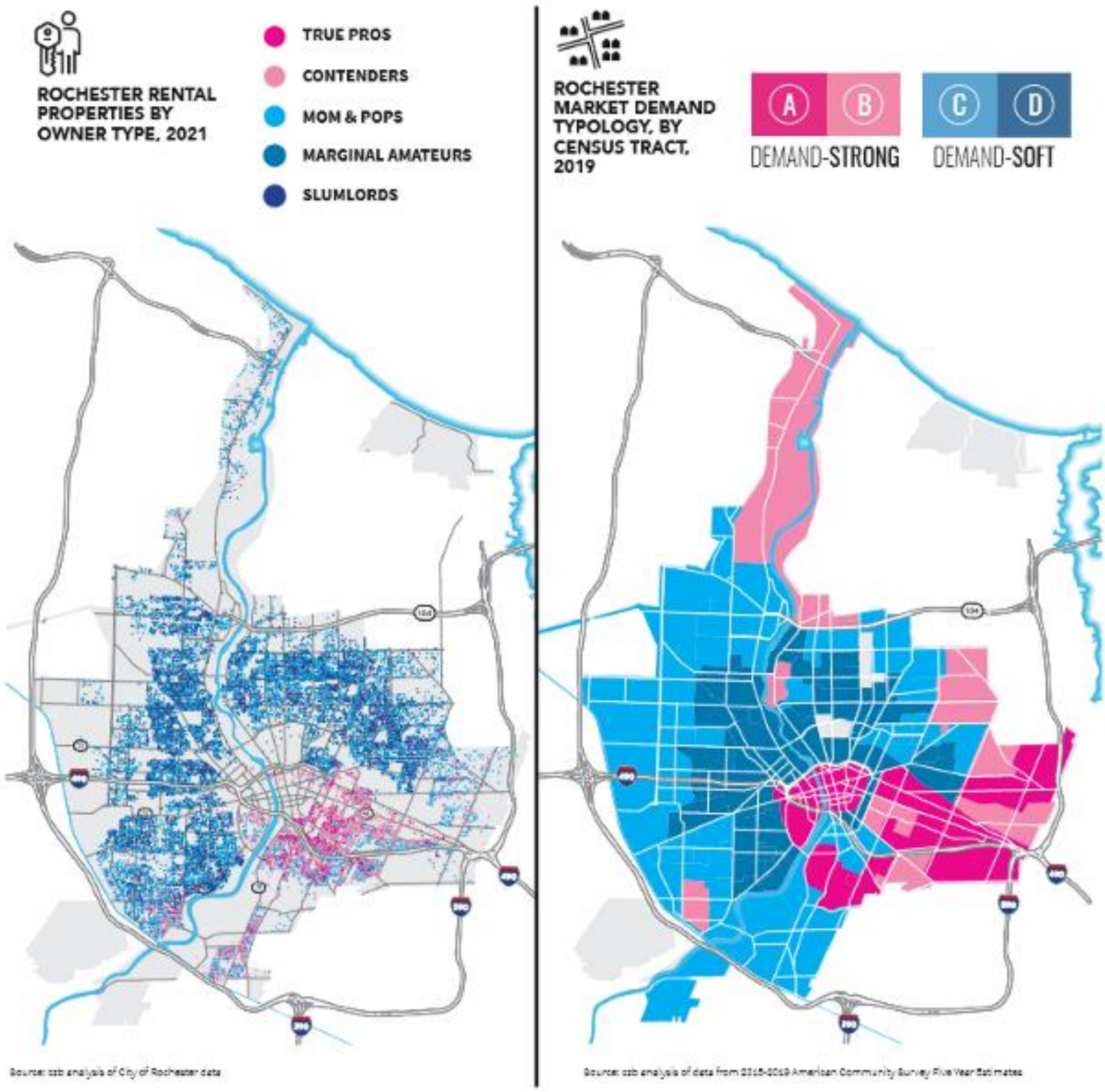


Figure 3: Categorizing Rochester Rental Market by Owner Type and Market Demand (czb, LLC, 2021)

Existing Energy Policies

Similar to Boulder, CO, Rochester has developed its own CAP. Starting in 2010, the main objective is the CAP will help to reduce greenhouse gasses (GHG) by 40% in 2030 (City of Rochester, NY, 2017). The plan highlights the energy sector as an opportunity to work towards their goal and outlines strategies to help achieve, too. Among these strategies, the Rochester CAP proposes implementing a rental property efficiency program to target energy consumption in the residential sector through incentives. So far, Energy Smart Rochester is one of the only programs in the community that encourages residents to voluntarily adopt more energy efficient technologies and practices in residential buildings (City of Rochester, NY, n.d.-b). Despite the rental market accounting for 57% of housing units in the city (City of Rochester, NY, 2017), policies in Rochester do not yet target the large rental property market.

Progression Towards Policy Solutions for Rentals

Currently, the Climate Solutions Accelerator, a local non-profit of the Finger Lakes region of New York, has created an advocacy group interested in implementing standards in order to combat carbon emissions through energy-use reduction. The group is composed of a couple of members from each of the following groups:

- Climate Solutions Accelerator,
- City Roots Community Land Trust, an affordable housing advocacy group,
- Connected Communities, a place-based community revitalization non-profit serving the EMMA and Beechwood neighborhoods in Rochester, NY
- and concerned citizens.

They believe that developing a residential energy standard aligns with aspects of the city's climate action plan. The city's CoO which allows property owners to lease their properties is being updated this year. This policy mechanism already implemented in the city provides a wonderful opportunity to start incorporating more energy efficiency standards for Rochester rental homes and working toward Rochester's climate goals. The group has acknowledged that this is an issue concerned with public health and environmental injustices and the standards need to be composed carefully in order to attract local government attention.

With a well-established rental program like the CoO, it is evident that Rochester is a good "fit" for a MESR according to RMI's guide. There are reasons to believe that creating such standard would not only reduce energy consumption and carbon footprint, but improve health conditions, quality, and comfort of a home, as well as reduce the energy burden experienced by many renters. Thus, Rochester may want to consider adding a MESR like Boulder, CO and customizing it to fit the cities unique characteristics and needs. By implementing this policy, the city will execute their climate action strategy and continue making progress towards climate and energy consumption goals. The next suggested step is to determine the potential impact a MESR could have on the city (Petersen & Lalit, 2018). Results from this analysis can help provide further insight on the outcomes on a MESR and determine whether alternative policy options should be pursued.

Methodology

To understand whether a MESR could be an effective policy solution for Rochester, a preliminary cost analysis for the city is conducted. An existing methodology created by RMI is used to estimate the total energy saved, carbon saved, and determine the approximate number of inspectors that will be needed to implement and enforce a MESR. The framework calculator template is an excel document that utilizes a number of inputs and assumptions for this analysis (Petersen, 2018) (See Appendix B). The template is accessible to the public via RMI's website. RMI suggests that throughout development of a MESR input values should be adjusted in this impact calculator to provide a more realistic estimation for its outputs.

In this model, works to calculate the annual cost for the city to implement, annual energy savings, annual energy cost savings, annual carbon reduction, and the energy inspector needed.

This is done by first attempting to quantify the number of rentals in Rochester, energy inspectors required, cost to the city, energy costs, and carbon reduction. These five categories are used to organize the twenty-five different inputs used in the model used to compute the outputs. Figure 4 shows the relationships between the inputs and outputs of the RMI calculator.

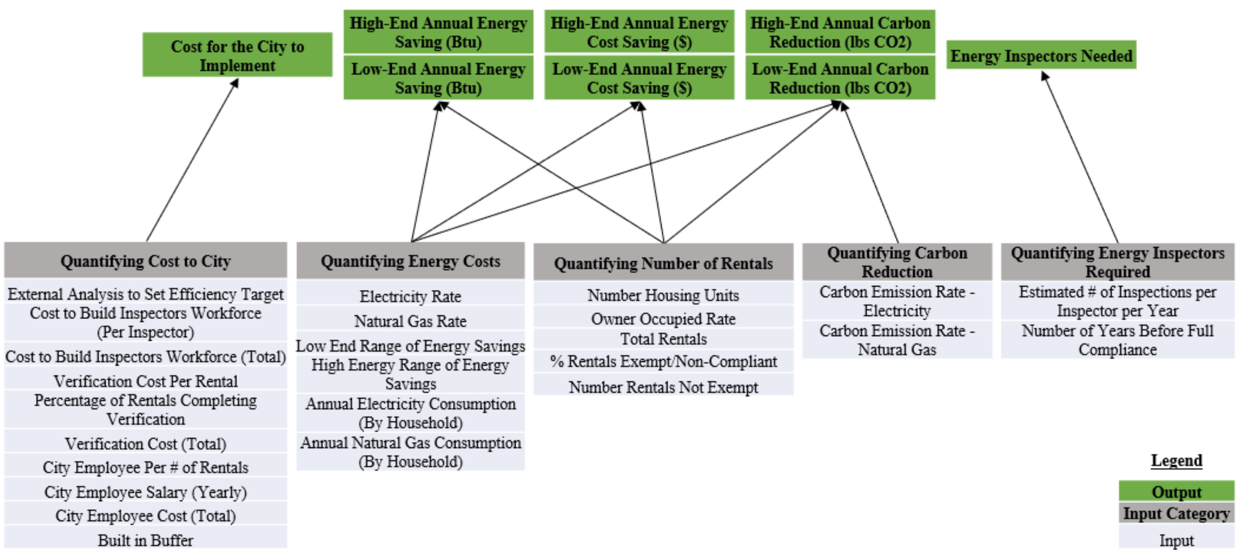


Figure 4: Relationship Between Input Categories, Inputs, and Outputs in RMI's Impact Calculator

The outputs of the model use a variety of inputs from different input categories to generate results for Rochester. The annual cost to the city is quantified by estimating the cost of an energy analysis for the city, the total cost to build the inspector workforce, total verification costs, and costs of additional city employees and spreading it over the duration over the compliance period. The estimation includes a buffer in case of unexpected costs, too. Annual energy savings are dictated by multiplying the annual consumption of both gas and electricity by the number of rental units that must comply to the MESR, converting that result to Btu, and finally multiplying by the high or low energy saving rate to provide a range of savings. The default high range rate theoretically estimates the savings associate with making improvements to the rental unit that comply with the 2009 International Energy Conservation Codes (IECC) whereas the default low range estimates the savings associate with making improvements that will comply with the either 1998 or 2000 IECC (M. Gartman, personal communication, April 26, 2022). The same rates are applied to suggest a range of energy cost saving and carbon reduction too. For energy cost savings, the annual consumption of electricity and natural gas consumed in Rochester are each computed and multiplied by the respected utility rates in Rochester. By summing the two figures together, the annual energy cost savings are approximated. The range of annual carbon savings is computed similarly, but instead of multiplying the annual consumption of electricity and natural gas by the utility rate, it is multiple by the respective carbon emission rate and then the numbers representing avoided carbon emissions from electricity and natural gas are summed together to get total avoided carbon emissions. Finally, the energy inspectors needed to certify a rental unit complying to the new MESR is determined by first dividing the number of rental units by the number of inspects a single inspector can complete in a year and then dividing the resulting quotient by the compliance period. More in-depth details regarding model inputs and outputs are discussion further.

Inputs & Key Assumptions

The template used for the analysis includes twenty-five (25) different inputs. Each input is organized into distinct groups to help quantify the number of rentals, number of energy inspectors required, cost to the city, energy costs, or carbon reduction. The template provides links to data sources which have values for the inputs in different cities, however, most of the links are broken or the data is outdated. Multiple entities were contacted in order to ensure the data values reported for the analysis were comparable to the ones that could be sourced from the previously working links. Table 1 tabulates the complete list of inputs and sorts them into two (2) primary categories: general inputs and city-specific inputs. The following sections will describe each of the input categories and the inputs which fall under that category in greater detail.

Table 1: Complete List of Inputs for RMI City Impact Analysis for MESR Model

	Abbreviation	***Input Name***	***Input Category***	***Value for Rochester, NY***
General Inputs	PRENC	% Rentals Exempt/Non-Compliant	Quantifying Number of Rentals	20%
	ENI	Estimated # of Inspections per Inspector per Year	Quantifying Energy Inspectors Required	1040 inspections per year
	NYBFC	Number of Years Before Full Compliance	Quantifying Energy Inspectors Required	3 Years
	EASET	External Analysis to Set Efficiency Target	Quantifying Cost to City	$50,000
	CBIW	Cost to Build Inspectors Workforce (Per Inspector)	Quantifying Cost to City	$500
	VC_{Rental}	Verification Cost Per Rental	Quantifying Cost to City	$100
	PRCV	Percentage of Rentals Completing Verification	Quantifying Cost to City	1.0%
	CEPR	City Employee Per # of Rentals	Quantifying Cost to City	30,000 rentals
	CES	City Employee Salary (Yearly)	Quantifying Cost to City	$100,000
	BIB	Built in Buffer	Quantifying Cost to City	1.1
	RES_{Low}	Low End Range of Energy Savings	Quantifying Energy Costs	10%
	RES_{High}	High End Range of Energy Savings	Quantifying Energy Costs	30%
	CER_{Gas}	Carbon Emission Rate - Natural Gas	Quantifying Carbon Reduction	14.5 lbs. CO_2/Therm
City Specific Inputs	NHU	Number Housing Units	Quantifying Number of Rentals	100,089
	OOR	Owner Occupied Rate	Quantifying Number of Rentals	36.2%
	TR	Total Rentals	Quantifying Number of Rentals	63,857
	NRNE	Number Rentals Not Exempt	Quantifying Number of Rentals	51,086
	$CBIW_{Total}$	Cost to Build Inspectors Workforce (Total)	Quantifying Cost to City	$3,500
	VC_{Total}	Verification Cost (Total)	Quantifying Cost to City	$51,086
	CEC_{Total}	City Employee Cost (Total)	Quantifying Cost to City	$1,362,293
	R_{Elec}	Electricity Rate	Quantifying Energy Costs	$0.111/kWh
	R_{Gas}	Natural Gas Rate	Quantifying Energy Costs	$0.787/therm
	$ACBH_{Elec}$	Annual Electricity Consumption (By Household)	Quantifying Energy Costs	10.63 MWh
	$ACBH_{Gas}$	Annual Natural Gas Consumption (By Household)	Quantifying Energy Costs	72.84 Mcf
	CER_{Elec}	Carbon Emission Rate - Electricity	Quantifying Carbon Reduction	1117.05 lbs. CO_2/MWh

General Inputs

A general input is an input whose value is defaulted to the value suggested by the creators of the RMI impact calculator. Often, these inputs are educated approximations. Details on the following general inputs are as follows:

- *Percentage of Rentals Exempt/Non-Compliant (PRENC):*

  According to RMI, it should be approximated that 20% of rentals are exempted from complying with the MESR. Potential reasoning may include that the rental has been recently constructed or that it is a mobile home (Petersen & Lalit, 2018).

- *Estimated Number of Inspections per Inspector per Year (ENI):*

  To quantify the number of energy inspectors required for implementing the standard, RMI suggests that inspectors can complete four (4) inspections per day for 260 days out of the year. Thus, the ENI is 1040 inspections per inspector per year.

- *Number of Year Before Full Compliance (NYBFC):*

  The NYBFC is the time it takes for the MESR to be fully implemented into society. RMI's default for the model dictates that the NYBFC should be 3 years. However, the NYBFC historically varies between municipalities. For instance, in Boulder the NYBFC is 8 years while in Gainesville and Burlington it is approximately 6 years and 1 year, respectively. Using a 3 year compliance period is also most useful to Rochester because if Rochester were to utilize its CoO framework to implement a MESR, the CoO requires renewals every 3 or 6 years. This alignment of renewals may be beneficial helped justify modeling the preliminary cost analysis over 3 years.

- *External Analysis to Set the Efficiency Target (EASET):*

  Prior to implementing a MESR, there is a lot of preliminary analysis that should be conducted on the local level to help set a target that is best suited for that particular city. In RMI's guidebook, Petersen & Lalit, suggests the EASET will costs around $50,000 (2018). This can change drastically depending on what prior data the city has.

- *Cost to Build Inspector Workforce per Inspector (CBIW):*

  Estimated cost to recruit and properly educate inspectors are assumed to be $500 which is the value for CBIW in the model.

- *Verification Cost per Rental (VC_{Rental}):*

  An estimated fee of $100 per unit is declared as VC_{Rental} for the city. Rentals may choose to undergo this verification process where this fee would be collected by the city.

- *Percent of Rentals Completing Verification (PRCV):*

  Only a percentage of rentals complete the verification steps, so RMI suggests after the compliance framework is formulated that the percentage of rentals completing verification (PRCV) value is modified. For now, the default assumption is 1.0%.

- *City Employee per Number of Rentals (CEPR):*

  City employees are another cost to the city. According to RMI, it is assumed for there is a city employee for every 30,000 rentals; in other words, the city employee per number of rentals (CEPR) input is equivalent to 30,000.

- *City Employee's Annual Salary:*

  A city employee's annual salary (CES) is estimated to be $100,000 per year.

- *Built in Buffer (BIB):*

  Due to the fact that there may be unforeseen costs in the future with developing the MESR, the calculator includes a buffer called built in buffer (BIB) which is predetermined by RMI to be a factor of 1.10.

- *Low End (RES_{Low}) and High End (RES_{High}) Range of Energy Savings:*

  RES_{Low} and RES_{High} define a range of energy cost savings for the city which is one of the primary outputs of the model. Most homes in Rochester were built prior to the 1980s, and by using Figure 5, the energy use intensity in a home can be reduced by approximately 10% when improvement that align with the 1998 or 2000 IECC are made and approximately 30% when improvements from the 2009 IECC are made. Therefore, RMI estimates the energy savings by selected the 1998/2000 IECC and 2009 IECC as models for energy improvements which dictates that RES_{Low} is equivalent to 10% and that RES_{High} is equivalent to 30%.

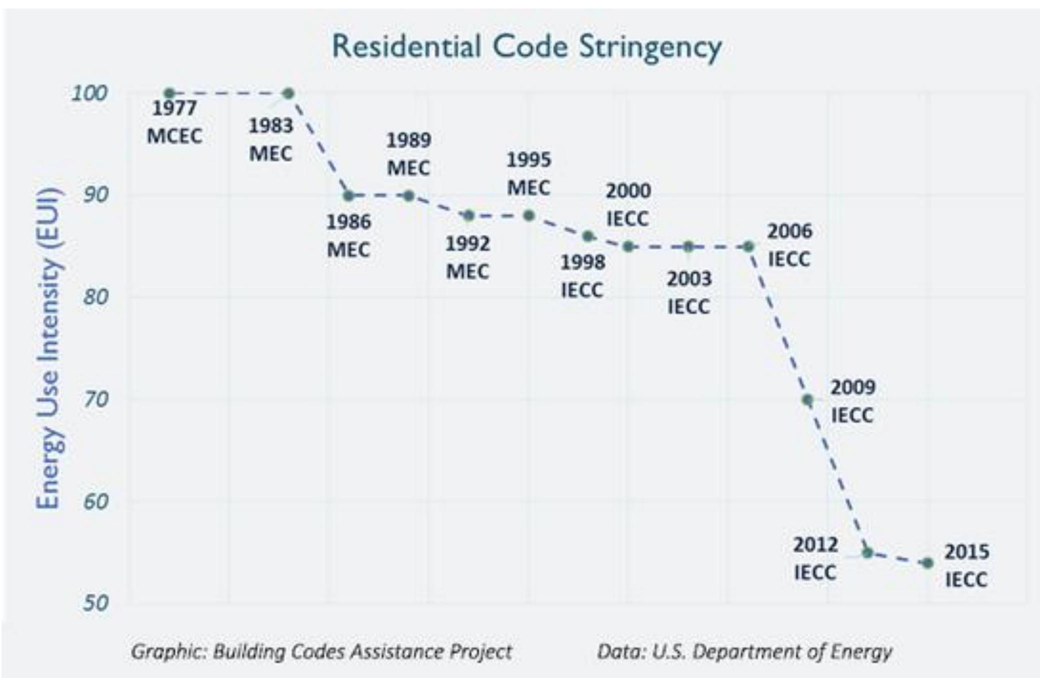


Figure 5: Residential Code Stringency (M. Gartman, personal communication, April 26, 2022)

- *Carbon Emission Rate – Natural Gas (CER_{Gas}):*

  To help define how much carbon is saved, the CER_{Gas} is 14.5 lbs. CO_2/therm which is the national average from ASHRAE Standard 105.

Throughout the process of designing a MESR, these inputs can be redefined as more local information becomes available to provide a better estimation for the city.

City Specific Inputs

A city specific input is an input based on local city data for the city of Rochester and necessary for the RMI impact calculator to perform the most basic preliminary cost analysis. Values for these inputs were extracted from government data sources or calculated as a result of some mathematical function that is composed of other inputs from the RMI calculator. These inputs are considered "required" or "optional inputs" indicated by dark and light blue boxes in the template (see Appendix C). Calculated values can be completely replaced in the event a more well-defined value is found for the local Rochester area. The methodology for defining each of the following inputs are describe below.

- *Number of Housing Units (NHU):*

  To help estimate the number of rental units in the city of Rochester, the total NHU is collected. By using data from the U.S. Census Bureau, a value of 100,089 housing units is reported in the impact calculator (n.d.).

- *Owner Occupied Rate (OOR):*

  Similar to NHU, the OOR was report as 36.2% based on the U.S. Census Bureau (n.d.). This value as well as NHU is used to help quantify the number of rental units in the city of Rochester.

- *Total Rentals (TR):*

  TR is the estimated number of rental units and determined by using both NHU and OOR as expressed in Equation (1). For the city of Rochester, it is approximated that there are 63,857 rentals.

$$TR = NHU \times (1 - OOR)$$

(1)

- *Number of Rentals Not Exempt (NRNE):*

  The NRNE expresses the estimated number of rental units that would be required to be compliant with the proposed MESR. In Equation (2)(2), NRNE is approximated by using TR and the PRENC. Therefore, 51,086 rental units is the approximate value for NRNE.

$$NRNE = TR \times (1 - PRENC)$$

(2)

- *Total Cost to Build the Inspector Work Force ($CBIW_{Total}$):*

  In order to properly enforce the proposed MESR, the inspectors for the city of Rochester must be recruited and properly educated. The relationship between EIN and CBIW defines the value of $CBIW_{Total}$, as seen in Equation (3). Note that EI is energy inspectors needed which is an output that will be later discussed. The total cost is estimated to be $8,500 to help towards the MESR initiative.

$$CBIW_{Total} = EI \times CBIW$$

(3)

- ***Total Verification Cost (VC_{Total}):***

  As one of the costs to the city, the verification costs for each rental unit undergoing verification must be totaled. By using Equation (4), the VC_{Total} can be found.

$$VC_{Total} = NRNE \times VC_{Rental} \times PRCV \tag{4}$$

- ***Total City Employee Cost (CEC_{Total}):***

  Another cost to the city is the people they employ. Equation (5)(*11*) states the relationships between a few of the assumptions, city employee per rental, employee salary, and years before full compliance, and one of calculated inputs, number of rentals non-exempt to determine CEC_{Total}.

$$CEC_{Total} = \left[\frac{NRNE}{CEPR}\right] \times CES \times NYBFC \tag{5}$$

- ***Electricity (R_{Elec}) and Natural Gas (R_{Gas}) Rates:***

  R_{Elec} or R_{Gas} are the rates that a residential consumer is charged for consuming either electricity or natural gas within their residence. The original impact calculator template uses a defaulted reference file which houses SLED data to determine that the New York State average for R_{Elec} is \$0.145/kWh. Similarly, the same reference file uses data from the Energy Information Administration (EIA) to determine R_{Gas} is \$1.163/therm. These data points include New York City data where utilities are traditionally higher than Rochester and will ultimately skew the model. To generate an analysis which is more representative of the Rochester demographic, the utility rates are estimated for both electric and natural gas.

Utility information from Rochester Gas and Electric (RG&E) and RG&E customers were used to compute R_{Elec} and R_{Gas}. RG&E uses different classifications to categorize buildings and determine the utility rate for the consumer (RG&E, 2021a). Any "single-family dwelling units, apartments, religious houses of worship, religious schools, not-for-profit community residences for the mentally disabled, and not-for-profit veterans organizations" is classified as a Service Classification 1 (SC1-Residential) to RG&E. This description best describes most rental units throughout Rochester and will be used to help define a utility rate.

To determine R_{Elec}, the RG&E electric rate summary is analyzed first. The electricity rate for RG&E customers is broken down into delivery charges, supply charges, and taxes and other charges (RG&E, 2021a). There are six (6) contributing factors to the delivery charges. The following factors of the rate are broken down below and described as fixed or variable:

- Customer Charge: fixed, $21.70 per bill
- Bill Issuance Charge: fixed, $0.93 per bill
- Delivery Charge: fixed, $0.04977 per kWh
- Transition Charge (TC) per kWh: Variable per kWh
- System Benefits Charge (SBC): Variable per kWh
- Revenue Decoupling Mechanism (RDM) Adjustment: Variable per kWh

The supply charge can be fixed or variable depending on the energy supplier. If a resident uses ESCO Supply Service, then there will be a rate determined by ESCO. Alternatively, a resident may us the RG&E Supply Service where the rate varies monthly and there is an added merchant function charge which is typically less than a cent per kWh. The final component of the electricity rate is the taxes for delivery and supply which are dictated by New York State and Monroe County.

Next, to fill in the rates for the variable factors, RG&E bills were collected from five different renters residing in various locations throughout the city. Table 2 highlights the rental information from each participating tenant. As shown below, all of the units surveyed are SC1-Residential and from a variety of locations throughout the city. Some properties where these tenants rent had multiple units on the same site. Not all rental unit use both gas and electric in Rochester. Two of the five participants only have electricity supplied to their rental. Also, while many renters are low income, it does not apply to all tenants. Therefore, to understand the maximum cost savings, all financial incentives are ignored for data collection purposes.

Table 2: Rental Information from Tenants who Supplied Energy Bills for Analysis

	Zip	***Service Classification***	***Total Rental Units on Site***	***Electricity***	***Gas***
Tenant 1	14607	1 - Residential	1 unit	Yes	Yes
Tenant 2	14607	1 - Residential	3-4 unit	Yes	Yes
Tenant 3	14608	1 - Residential	3-4 units	Yes	No
Tenant 4	14604	1 - Residential	50+ units	Yes	No
Tenant 5	14619	1 - Residential	1 unit	Yes	Yes

Participating tenants were asked to provide the seven (7) latest RG&E bills. The latest bill statement required the billing period to start before March 1, 2022. The TC, SBC, and RDM Adjustment are charged based on consumption amount and the rate of each was extracted from each bill collected. If one of the charges were broken down into two charges for each month of service, the charges were averaged together to determine an estimate rate that was independent of consumption amount. Bills from similar service dates were compared. Except for the Supply Charge, the monthly rate for each component of the electricity rate is summarized in Table 3. Supply rates vary by the service period on each persons' bill statement. Ultimately, it is the average supply rate throughout the service period and can be calculated for any service period using the historic daily supply rate on RG&E's website (2022).

Table 3: Electricity Rate Summary for Rochester, NY over a Recent Seven Month Period

	Billing Statement						
Electricity Delivery Charges	Jul-Aug 2021	Aug-Sept 2021	Sept-Oct 2021	Oct-Nov 2021	Nov-Dec 2021	Dec-Jan 2022	Jan-Feb 2022
Electricity Customer Charge				$21.70			
Bill Issuance Charge (per bill)				$0.93			
Delivery Charge (per kwh)				$0.0498			
TC (per kwh)	($0.0020)	($0.0020)	($0.0022)	($0.0020)	($0.0017)	($0.0017)	($0.0019)
RDM (per kwh)	($0.0006)	($0.0032)	($0.0032)	($0.0032)	($0.0032)	($0.0032)	($0.0032)
SBC (per kwh)	$0.0057	$0.0057	$0.0057	$0.0057	$0.0057	$0.0053	$0.0050
Tax on Delivery Charge				5.2632%			
Electricity Supply Charges							
Supply Charge (per kwh)	Use RG&E Website based on Billing Service Period						
Merchant Function Charge (per kwh)	$0.0023	$0.0023	$0.0023	$0.0023	$0.0023	$0.0023	$0.0023
Tax on Supply Charge				3.0928%			

After all the data what retrieved, an estimated rate per kWh was determine for each tenant. Equation (6) expresses how each of the monthly electricity rates ($R_{ElecMonthly}$) were calculated where *DC* is the delivery charge, $T_{Delivery}$ is the delivery tax rate, *S* is the supply charge from RG&E or ESCO supply services, and *MFC* is the merchant function charge, and T_{Supply} is the supply tax rate. All monthly rates from a single tenant were then averaged together to get R_{Elec}.

$$\mathrm{R_{ElecMonthly}} = \left[(DC + TC + SBC + RDM) \times \left(1 + \mathrm{T_{Delivery}}\right)\right] + \left[(\mathrm{S} + \mathrm{MFC}) * \left(1 + \mathrm{T_{Supply}}\right)\right] \quad (6)$$

To find R_{Gas}, the same steps were followed. First, RG&E's *Natural Gas Rates Summary* was carefully looked at. The following factors of the natural gas rate are broken down below and described as fixed or variable:

- Customer Charge: fixed, $17.30 per bill
- Bill Issuance Charge: fixed, $0.93 per bill
- Usage Charge: fixed
    - First 3 therms or less included in $17.30 Customer Charge
    - Next 97 therms, per therm $0.27644
    - Next 400 therms, per therm $0.25768
    - Next 500 therms, per therm $0.22969
    - Over 1,000 therms, per therm $0.09782
- Weather Adjustment: Variable
- Gas Supply Charge: Variable
- Merchant Function Charge: Variable
- Taxes and Other Fees: determined by New York State and Monroe County (RG&E, 2021b)

Next, three of the five tenants who provided utility bills use natural gas in their apartments. The rates on their bills were compared against the ones stated in the summary. On the tenants' bills were two other charges which include RDM and TC. These charges vary by month. To estimate a value for each, the values are averaged in the event the billing service period is during two different months. Generally, the tenants who were surveyed use no more than 400 therms of natural gas even during the peak of winter. So, for the purpose of estimating the usage charge, if more than 97 therms were used during a specific month the two usage charge rates were averaged together. Weather adjustment was negated in this estimate of R_{Gas} since over time the total cost fluctuates between being charged and credited. The supply and merchant function charges have a different rate per month, so for each bill there are two rates that are averaged together. Table 4 displays all the charges required for computing the average natural gas price per therm for each month ($R_{GasMonthly}$).

Table 4: Natural Gas Rate Summary for Rochester, NY over a Recent Seven Month Period

	Billing Statement						
Natural Gas Delivery Charges	Jul-Aug 2021	Aug-Sept 2021	Sept-Oct 2021	Oct-Nov 2021	Nov-Dec 2021	Dec-Jan 2022	Jan- Feb 2021
Usage Charge (per therm) - Average	$0.2764	$0.2764	$0.2764	$0.2764	$0.2764	$0.2671	$0.2671
RDM (per therm)	$0.0031	$0.0020	$0.0020	$0.0020	$0.0020	$0.0020	$0.0080
TC (per therm)	$0.0013	$0.0134	$0.0013	$0.0013	$0.0013	$0.0013	$0.0013
Tax on Delivery Charge	5.2632%						
Natural Gas Supply Charges							
Supply Charge (per therm) - Average	$0.3971	$0.4284	$0.4332	$0.4791	$0.5088	$0.4621	$0.4305
MFC (per therm) - Average	$0.0178	$0.0178	$0.0178	$0.0180	$0.0182	$0.0179	$0.0178
Tax on Supply Charge	3.0928%						

By using the data compiled from Table 4 and Equation (7), $R_{GasMonthly}$ was calculated for each month. Then, the monthly rates were averaged together to get R_{Gas} per tenant.

$$R_{GasMonthly} = [(DC + TC + RDM) \times (1 + T_{Delivery})] + [(S + MFC) * (1 + T_{Supply})] \quad (7)$$

To verify the initial R_{Elec} and R_{Gas} values determined by Tenant 1 could be used in the model, the values were compared amongst the other participating tenants' values. A summary of the rates is displayed in Table 5. Each of the R_{Elec} and R_{Gas} values are consistent amongst each of the tenants' rental units. Therefore, $0.11/kWh and $0.79/therm are used for R_{Elec} and R_{Gas}, respectively, in the final model to help determine cost savings.

Table 5: Estimated R_{Elec} and R_{Gas} values for Each Tenant

	R_{Elec} ($/kWh)	R_{Gas} ($/therm)
Tenant 1	$0.11	$0.79
Tenant 2	$0.11	$0.79
Tenant 3	$0.11	-
Tenant 4	$0.11	-
Tenant 5	$0.11	$0.79

- *Annual Electricity Consumption by Household ($ACBH_{Elec}$) and Annual Natural Gas Consumption by Household ($ACBH_{Gas}$):*

  $ACBH_{Elec}$ is the total electricity consumed per year by a single household and used to help quantify energy costs for electricity. The impact calculator template suggests using State and Local Energy Data (SLED), a database provided by the National Renewable Energy Laboratory (NREL) (Petersen, 2018). However, SLED is no longer available. Instead, K. Richardson, Deputy Director of NREL Government Relations, suggested to use data from the State and Local Energy Profiles (personal communication, February 7, 2022). Under these profiles is a tool called the Low-Income Energy Affordability Data (LEAD) hosts the data regarding the average annual cost of utilities based on the 2016 U.S. Census and 2018 American Communities Survey data (U.S. DOE, n.d.-a). With this tool, data can be found on the national, state, and city level.

For the purposes of this analysis, the city of Rochester was first selected on the map below in Figure 6. Using the criteria filters in the LEAD tool, only rental property data was utilized. RV, boat, van, mobile and trailer homes were excluded from the model based on the assumption that these properties will be exempt from the MESR as suggested by RMI. The complete list of criteria selected for the LEAD tool is specified in Figure 6.

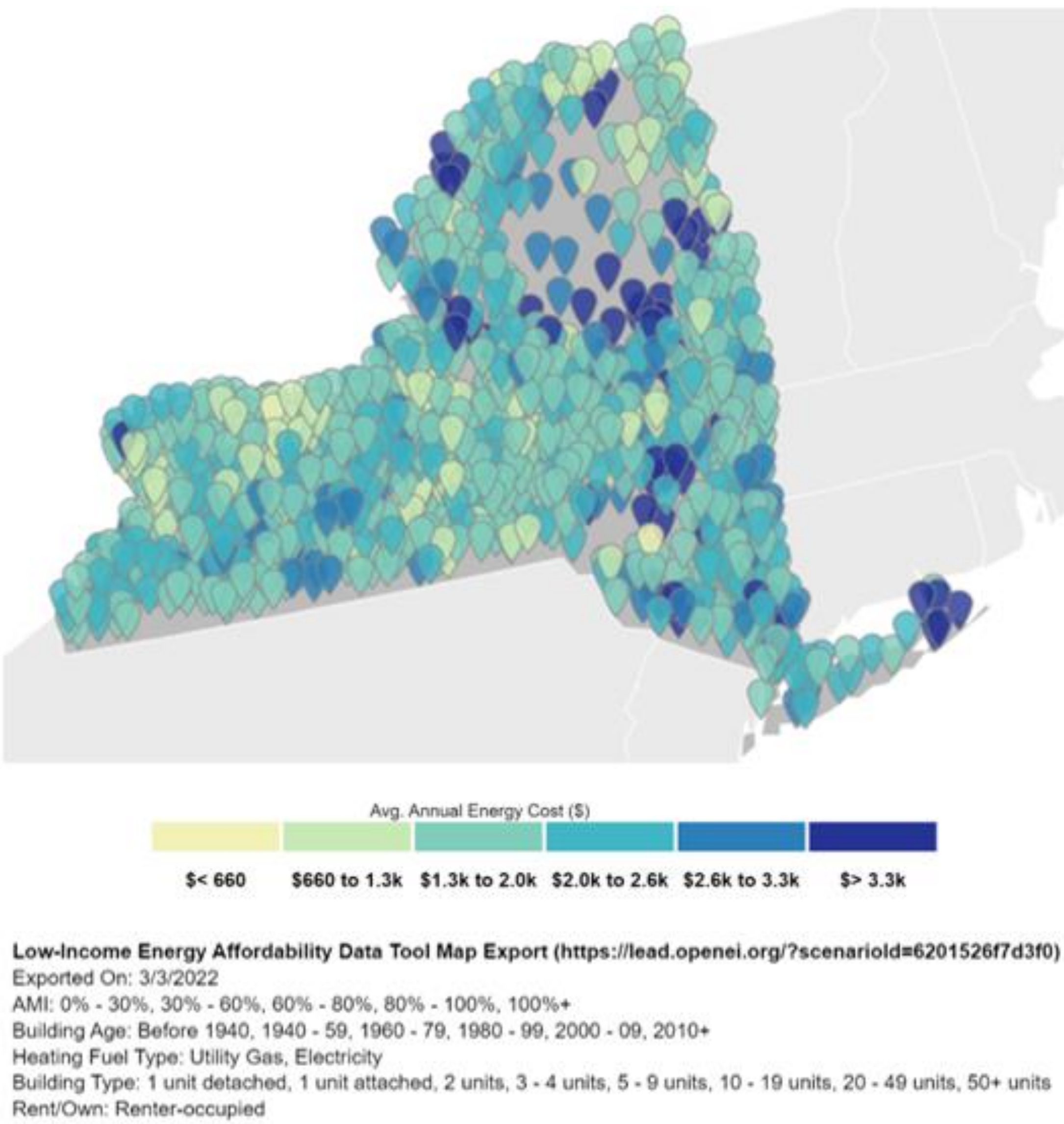


Figure 6: LEAD New York State Map Used to Extract Data Values for $ACBH_{Elec}$ and $ACBH_{Gas}$ for Rochester (U.S. DOE, n.d.-a)

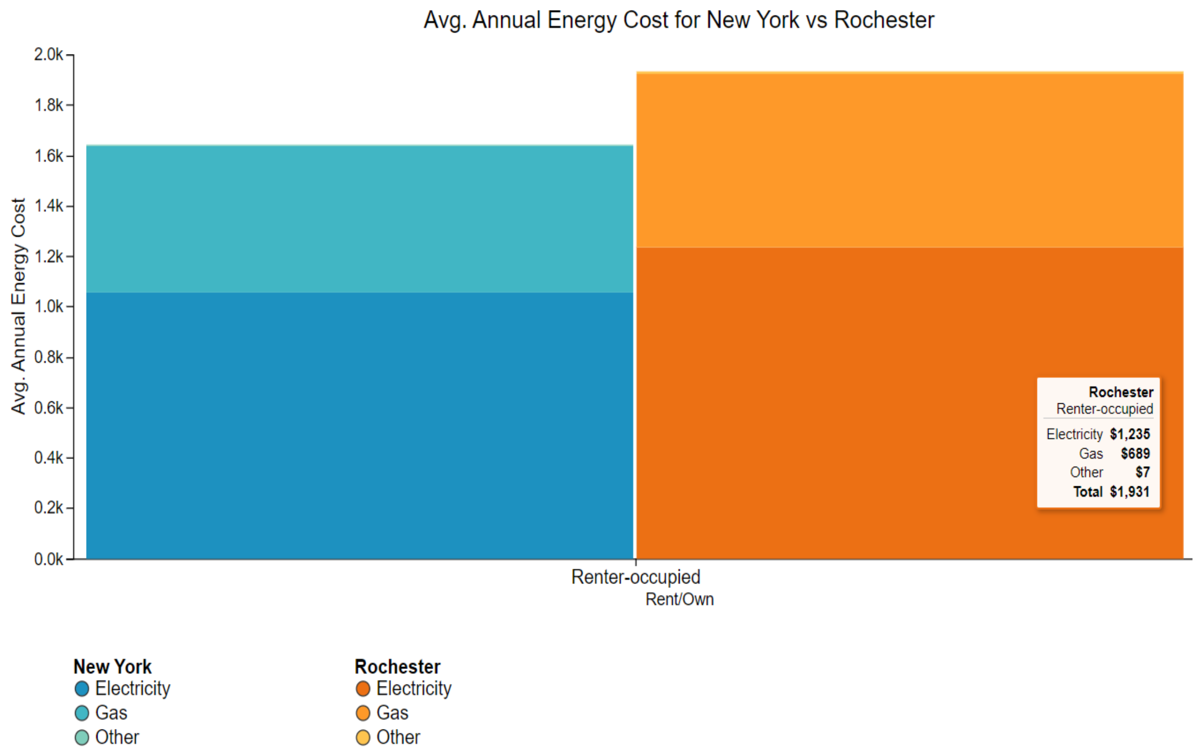


Figure 7: LEAD Average Energy Cost Graph Used to Extract Data Values for $ACBH_{Elec}$ and $ACBH_{Gas}$ for Rochester (U.S. DOE, n.d.-a)

Then, the average annual energy costs for electricity in 2016 is determine using Figure 7 (U.S. DOE, n.d.-a). With this data, $ACBH_{Elec}$ was calculated using Equation (8), where the average annual energy cost is $AAEC_{Elec}$ in USD($), the monthly billing charge is MBC_{Elec} in USD($), and the rate of electricity is R_{Elec} in $/kWh. The $AAEC_{Elec}$ value was adjusted to be represented in 2022 values using the Consumer Price Index (CPI) calculator (U.S. Bureau of Labor Statistics, 2022a). RG&E charges $21.70 per month for MBC_{Elec} (2022) and more information on how to calculate the rate is provided in the next section. The result for $ACBH_{Elec}$ is 10.63 MWh.

$$ACBH_{Elec} = \frac{\left(AAEC_{Elec} - (MBC_{Elec} * 12)\right)}{R_{Elec}} \quad (8)$$

Using the method previously described to calculate $ACBH_{Elec}$, Equation (8) was modified to create a method for calculating the total amount of natural gas consumed by a single household, $ACBH_{Gas}$, as shown in Equation (9).

$$ACBH_{\text{Gas}} = \frac{\left(AAEC_{\text{Gas}} - (MBC_{\text{Gas}} * 12)\right)}{R_{\text{Gas}}} \tag{9}$$

From Figure 7, the average annual energy cost for natural gas in Rochester ($AACE_{Gas}$) was $689 in 2016 and translates to $718.03 in 2022 (U.S. Bureau of Labor Statistics, 2022a; U.S. DOE, n.d.-a). The monthly billing charge for natural gas (MBC_{Gas}) is $17.30. Again, information for how the rate for natural gas (R_{Gas}) is determine is described in a later section but results in approximately $0.83/therm. Therefore, $ACBH_{Gas}$ is 72.84 Mcf.

To ensure these figures are plausible for the Rochester region, they were crosschecked against data from New York State and from the Residential Energy Consumption Survey (RECS). According to New York State, the average residential consumer uses 600 kWh per month which is approximately 7.2 MWh annually (New York Department of Public Service, 2022). Using the latest RECS data from 2015, The total average site energy consumption per household in the Mid-Atlantic region is approximately 8.4 MWh (EIA, 2018). This was determined by the total electricity consumed for the Mid-Atlantic region and dividing it by the total number of housing units. For $ACBH_{Gas,}$ New York State reports that the average household uses 740 therms of natural gas from November to March which equates to about 71.4 Mcf (New York Department of Public Service, 2022). Based on the RECS data, approximately 47.86 Mcf of natural gas is consumed on average in the Mid-Atlantic region (EIA, 2018). In both the

New York State and Mid-Atlantic regions, the city of Rochester is located in the northern part of each region which may suggest a cause for greater annual energy consumption.

- *Carbon Emission Rate – Electricity (CER_{Elec}):*

  Initially, the impact calculator suggests using the eGRID2014v2 data tables which is based on state averages to determine the values for CER_{Elec}. However, these values are outdated. Using the AVoided Emissions and geneRation Tool (AVERT), the CER_{Elec} value is replaced with 1117 lbs./MWh which is taken the latest data from 2020 (U.S. Environmental Protection Agency, 2017).

Each of these calculated inputs help dictate the final results, outputs, of the preliminary cost analysis for the city using the RMI impact calculator template.

Outputs

As mentioned previously the main objective for using the RMI tool is estimating the cost to the city, energy saved, and carbon saved. The eight major outputs from RMI's impact calculator are tabulated in *Table 6* and further described below. A complete summary of the outputs can be found in Appendix D.

Table 6: Complete List of Outputs for RMI City Impact Analysis for MESR Model

Abbreviation	***Output Name***
CCIA	Cost for the City to Implement Annually
AES_{Low}	Low-End Annual Energy Savings (Btu)
AES_{High}	High-End Annual Energy Savings (Btu)
$AECS_{Low}$	Low-End Annual Energy Cost Savings
$AECS_{High}$	High-End Annual Energy Cost Savings
ACR_{Low}	Low-End Annual Carbon Reduction (lbs. CO2)
ACR_{High}	High-End Annual Carbon Reduction (lbs. CO2)
EI	Energy Inspectors Needed

- *Cost for the City to Implement Annually (CCIA):*

  The CCIA approximates the total amount of money required from the city to implement a MESR. This figure is estimated by summing all the costs to the city and then multiplying by estimation buffer, and finally dividing by the number of years before full compliance as shown in Equation (10).

$$CCIA = \frac{[EASET + CBIW_{Total} + VC_{Total} + CEC_{Total}] \times BIB}{NYBFC} \tag{10}$$

- *Low-End Annual Energy Savings (AES_{Low}) and High-End Annual Energy Savings (AES_{High}):*

  These two outputs are used to develop a representative range of total energy savings when a MESR is implemented in Rochester. Conversion factors of 3,412,141.63 Btu per MWh and 1,027,000 Btu per Mcf are used as needed so that the low-end and high-end energy savings are reported in Btu. AES_{Low} is estimated using Equation (11) while AES_{High} is estimated using Equation (12).

$$\mathrm{AES_{Low}} = \left[\mathrm{NRNE} \times \mathrm{ACBH_{Elec}} \times \mathrm{RES_{Low}} \times 3412141.63 \frac{\mathrm{Btu}}{\mathrm{MWh}}\right] + \left[\mathrm{NRNE} \times \mathrm{ACBH_{Gas}} \times \mathrm{RES_{Low}} \times 1027000 \frac{\mathrm{Btu}}{\mathrm{MCf}}\right] \tag{11}$$

$$\mathrm{AES_{High}} = \left[\mathrm{NRNE} \times \mathrm{ACBH_{Elec}} \times \mathrm{RES_{High}} \times 3412141.63 \frac{\mathrm{Btu}}{\mathrm{MWh}}\right] + \left[\mathrm{NRNE} \times \mathrm{ACBH_{Gas}} \times \mathrm{RES_{High}} \times 1027000 \frac{\mathrm{Btu}}{\mathrm{MCf}}\right] \tag{12}$$

- *Low-End Annual Energy Cost Savings ($AECS_{Low}$) and High-End Annual Energy Cost Savings ($AECS_{High}$):*

  Like AES_{Low} and AES_{High}, $AECS_{Low}$ and $AECS_{High}$ collectively provide a range of energy savings in dollars for the city of Rochester. To estimate energy cost savings in dollars, a conversion factor of 1000 kWh per MWh and 10.37 therms per Mcf are used determine the cost of electricity and natural gas used in a rental unit. Equations (13) and (14) show the relationships for $AECS_{Low}$ and $AECS_{High}$, respectively.

$$\mathrm{AECS_{Low}} = \left[\left(\mathrm{NRNE} \times \mathrm{ACBH_{Elec}} \times \mathrm{R_{Elec}} \times 1000\,\frac{\mathrm{kWh}}{\mathrm{MWh}}\right) + \left(\mathrm{NRNE} \times \mathrm{ACBH_{Gas}} \times \mathrm{R_{Gas}} \times 10.37\,\frac{\mathrm{therm}}{\mathrm{MCf}}\right)\right] \times \mathrm{RES_{Low}} \tag{13}$$

$$\mathrm{AECS_{High}} = \left[\left(\mathrm{NRNE} \times \mathrm{ACBH_{Elec}} \times \mathrm{R_{Elec}} \times 1000\,\frac{\mathrm{kWh}}{\mathrm{MWh}}\right) + \left(\mathrm{NRNE} \times \mathrm{ACBH_{Gas}} \times \mathrm{R_{Gas}} \times 10.37\,\frac{\mathrm{therm}}{\mathrm{MCf}}\right)\right] \times \mathrm{RES_{High}} \tag{14}$$

- *Low-End Annual Carbon Reduction (ACR_{Low}) and High-End Annual Carbon Reduction (ACR_{High}):*

  To assess annual carbon reduction, Equations (15) and (16) are used to compose an approximate range. These figures are reported in pounds of carbon dioxide (lbs. CO_2).

$$\mathrm{ACR_{Low}} = \left[(\mathrm{NRNE} \times \mathrm{ACBH_{Elec}} \times \mathrm{CER_{Elec}}) + \left(\left(\mathrm{NRNE} \times 10.37\,\frac{\mathrm{therm}}{\mathrm{MCf}}\right) \times \mathrm{ACBH_{Gas}} \times \mathrm{CER_{Gas}}\right)\right] \times \mathrm{RES_{Low}} \tag{15}$$

$$ACR_{High} = \left[(NRNE \times ACBH_{Elec} \times CER_{Elec}) + \left(\left(NRNE \times 10.37 \frac{therm}{MCf} \right) \times ACBH_{Gas} \times CER_{Gas} \right) \right] \times RES_{High}$$

(16)

- *Energy Inspectors Needed (EI):*

  The number of needed energy inspectors is the final output determined from this model. Energy inspectors are full time employees that would enforce the MESR. They may be employees of the local government or from a third-party entity. Equation (17) estimates the number of needed inspectors by dividing the total number of complying rental units by the total number of inspections that can be completed by a single inspector in a year. The quotient is then further divided by the compliance timeframe in years to get EI.

$$EI = \frac{\left[\frac{NRNE}{ENI} \right]}{NYBFC}$$

(17)

With this relationship, it is expected that as the compliance timeframe increases, the number of inspectors will decrease.

Results

By using the RMI impact calculator and Rochester specific data, the analysis provide insight on costs associated with implementing a MESR with a compliance period of 3 years. According to this model, the CCIA, otherwise known as the annual cost for the city of Rochester, is approximately $227,000 dollars. This figure compiles costs for an external energy analysis, cost to build up the inspector workforce, cost for additional city employees, and verification costs. Improvements outlined the IECC 1998/2000 and 2009 standards are used to help define the types of improvements in a MESR for Rochester and estimate the ranges for energy ad carbon saved. Approximately 567 billion to 1.702 trillion Btu of energy will be conserved by implementing a MESR in Rochester and as a result $9.1 to $27.2 million dollars will be saved. The annual carbon saved from a MESR for Rochester is 116.6 to 349.8 million lbs. of CO_2. Therefore, with the addition of a MESR, it is possible that the average rental unit could save between 11.1 and 33.3 million Btu of energy which is approximately $178 to $532 of annual saving on utilities. The average rental unit would also save between 2,282 and 6,847 lbs. of CO_2 annually. Lastly, the final result of this model suggests that approximately seventeen energy inspectors will be required at minimum to help enforce compliance. These energy inspectors can be existing residential building inspectors, but this is not always the case. It is also possible that in the design phase of developing a MESR, the city of Rochester may want separate inspectors enforcing the MESR in which case these inspectors would require a salary and add to the costs to the city. In summary, all outcomes of the analysis are tabulated in Table 7.

Table 7: Summary of Costs to Implement a MESR for the City of Rochester over a 3 Year Compliance Period

Abbreviation	***Output Name***	***Values for Rochester, NY***
CCIA	Cost for the City to Implement Annually	$227 K
AES_{Low}	Low-End Annual Energy Savings (Btu)	567 B
AES_{High}	High-End Annual Energy Savings (Btu)	1.702 T
$AECS_{Low}$	Low-End Annual Energy Cost Savings	$9.1 M
$AECS_{High}$	High-End Annual Energy Cost Savings	$27.2 M
ACR_{Low}	Low-End Annual Carbon Reduction (lbs. CO2)	116.6 M
ACR_{High}	High-End Annual Carbon Reduction (lbs. CO2)	349.8 M
EI	Energy Inspectors Needed	17

Comparison to Other Cities

After results for Rochester were collected, it was important to compare against other cities to (1) decide whether the results are plausible and (2) bring some context of how impactful a MESR in Rochester could be on larger scale. Minneapolis, MN, Philadelphia, PA, Oakland, CA, Washington, D.C., and Boston, MA, are all cities with considerably large rental markets and existing rental license systems like the city of Rochester (Petersen & Lalit, 2018). Due to these characteristics, RMI conducted a cost analysis for each to project the impact a MESR in these locations. The results are displayed in Table 8 alongside the results from the Rochester analysis.

Table 8: Comparing Rochester's Potential Impact of MESRs to Results of Other U.S. Cities

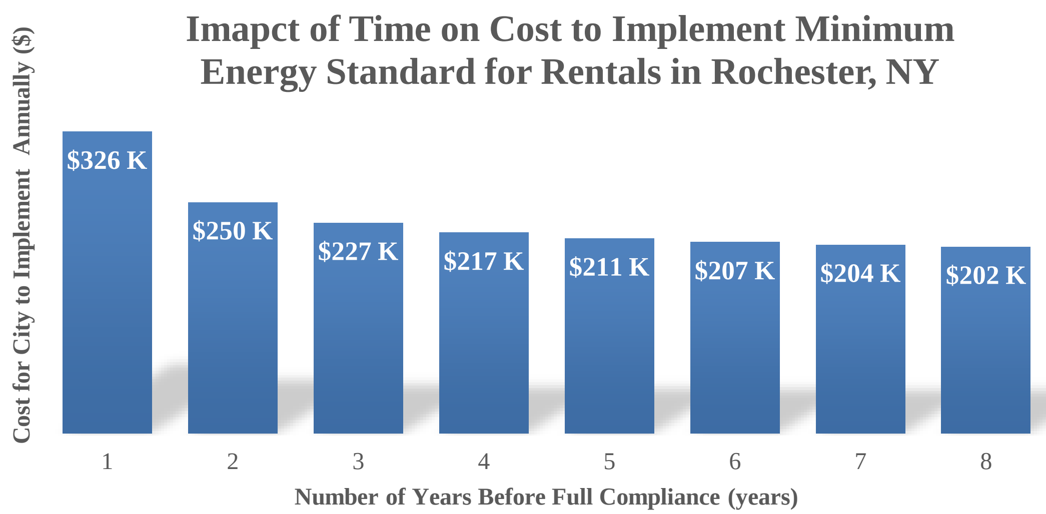
City	***Percent Rental in Residential Market?***	***Quantity of Rental Units***	***Renter's License Process in Place?***	***Cost to City over 3 years***	***Annual Energy Saved (trillion Btu)***	***Annual Energy Cost Saved***	***Annual Carbon Reduced (lbs. CO_2)***	***Energy Inspectors Required***
*Minneapolis, MN**	52%	91,000	Yes, renews annually	$1.12 M	0.82 to 2.47	$15M to $46M	192M to 577M	23
*Philadelphia, PA**	47%	318,000	Yes, renews annually	$4.24 M	1.88 to 5.65	$45M to $134M	378M to 1,134M	82
*Oakland, CA**	60%	102,000	Yes, renews annually	$1.55 M	0.51 to 1.52	$20M to $61M	78M to 233M	26
*Washington, D.C.**	59%	174,000	Yes, renews every 2 years	$1.63 M	1.03 to 3.09	$20M to $61M	224M to 673M	45
*Boston, MA**	66%	179,000	Yes, renews annually	$2.42 M	1.56 to 4.68	$53M to $158M	295M to 885M	46
Rochester, NY	64%	64,000	Yes, renew every 3 or 6 years **	$681 K	0.57 to 1.70	$9.1 to $27.2 M	117 M to 350 M	17

* Information sourced from Petersen & Lalit's Better Rentals, Better City (2018)
** Information sourced from City of Rochester's Certificate of Occupancy (n.d.-a)

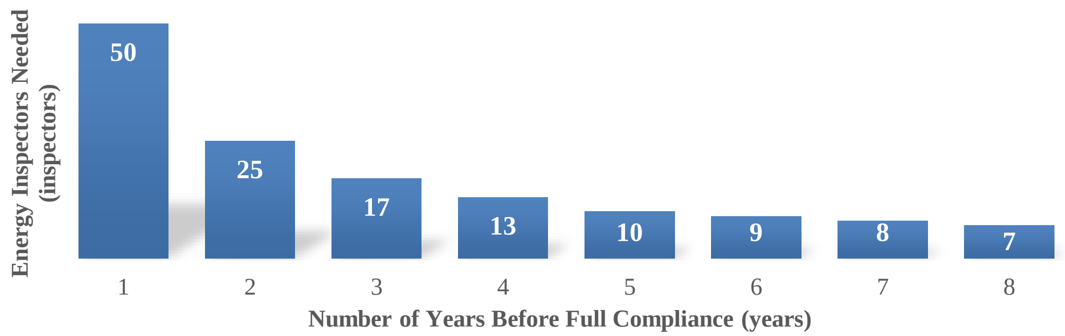
The comparison between results from other cities' cost analyses and Rochester's analysis helps provide greater insight on the result's meaning. For starters, the annual cost to the city of Rochester is significantly smaller than the rest of the cities. This is attributed to Rochester's small quantity of rentals at 64,000 units whereas most of the other cities are larger and have more than 90,000 units. However, with respect to its renter occupied rate of approximately 64%, it still makes Rochester a candidate for implementing a MESR according to RMI and comparable to the other cities with large renter occupied rates. Also, Rochester requires less energy inspectors to help enforce a MESR. Next, it is interesting that the results for annual energy save in Oakland, CA and Rochester are very similar. This is possible if the annual household consumption in Oakland is much smaller than Rochester. Due to the utility rate in Oakland being $0.279 per kWh as of February 2022 (U.S. Bureau of Labor Statistics, 2022b), in Table 8, the average energy cost saved doubles in comparison to Rochester's savings. However, this does not mean that Rochester's results are insignificant. Despite the smaller cost savings on utilities, Rochester has a greater estimated range for annual carbon emission reduction as shown in Table 8. One additional difference between Rochester and the other cities is the existing rental license program. Rochester's program only requires renewals every 3 years for mixed occupancy buildings with one or more dwellings and multiple dwelling, or every 6 years for one or two family units that are not owner occupied (City of Rochester, NY, n.d.-a). Most of the cities analyzed by RMI require the rental license to be renewed every year. Although the rental license renewal process has no direct impact on the outcomes of the analysis, it is important to consider the potential compliance periods for these cities and how they could integrate a MESR into the license program as suggested by RMI. Overall, with the comparisons to other cities, the analysis for Rochester seems to be realistic.

Sensitivity Analysis: Impact of Time on Cost to City of Rochester

When designing a MESR, the compliance period of a MESR can be change to better suit the community. As mentioned before, different cities in the United States use different compliance periods to implement their MESR. For instance, the city of Boulder, CO sets their compliance period to eight years where as Gainesville, FL and Burlington, VT set theirs to five years and one year, respectively. By performing a sensitivity analysis with the Rochester model, the costs associated with implementing a MESR can be compared against other MESRs of various compliance periods. Overall, it is expected that by manipulating the NYBFC variable, the CCIA and EI outputs will change because they are time dependent. In the sensitivity analysis, the NYBFC variable varies from one year to eight years. Results from the analysis are depicted in Figure 8.



(a)



(b)

Figure 8: Impact of Time on Cost to Implement Minimum Energy Standards for Rentals in Rochester, NY

Figure 8a displays the annual cost to the city of Rochester to implement a MESR. Costs to Rochester annually exponentially decrease. The most significant change per year occurs between one-year and two-year compliance periods where the annual cost drops by approximately $76,000. However, the total cost of the city would exponentially increase as an additional year is added to the compliance period. For the city of Rochester, the minimum total cost to the city to implement a MESR with a compliance period of one year is $326,000. But an eight-year compliance period would cost the city roughly $1,616,000. With these results in mind, it is recommended the city of Rochester carefully considers the duration of the compliance period.

The amount of energy inspectors needed to enforce the MESR is another output that is impacted by manipulating the number of years to full compliance as shown in Figure 8b. Based on the NRNE value of 51,086 rental units in Rochester, the minimum number of energy inspectors needed over a single year period to complete all rental unit inspections across the city is 50 inspectors. By implementing a MESR over a two-year period, the number of energy inspectors needed is cut directly in half because the inspectors have twice as much time and therefore can complete more inspections. Generally, the number of energy inspectors needed decrease exponentially as the compliance period of a MESR increases. Keep in mind that an energy inspector can complete 1040 inspection per inspector per year (which is the ENI value) is the suggested rate from RMI.

Limitations

In attempts to construct a model that can be applicable to multiple scenarios, the variables are loosely defined. This is a limitation of the existing RMI impact calculator in developing a preliminary cost analysis for a potential MESR in Rochester. Throughout the development of the cost analysis there was some confusion about the definition of energy inspectors and the cost for building workforce inspectors (CBWI). An energy inspector at the most basic level is a professional that enforces energy policies like a potential MESR. However, this model does not suggest whether these roles and responsibilities can be taking on by the existing inspector workforce or if new full-time jobs will be created. This ambiguity leaves a lot of open-ended question for the city such as, Will current inspectors need additional time to complete inspection if a unit needs to meet the new MESR? Will current inspectors' salaries increase now that they have to enforce a new MESR? If the more jobs need to be added to the workforce, would these jobs be temporary (end after full compliance year) or permanent (extend after period for full compliance)? Once these open-ended questions are answered, additional cost may need to be incorporated into the analysis. Due to the term "energy inspector" being vague, it also becomes difficult to accurately provide a value for the costs to build inspectors workforce (CBWI). For the sake of the analysis, a suggested value of $500 was use. According to Petersen & Lalit, the $500 may account for outreach, advertising, and training needed (2018). Verification costs (VC) which is valued at $100 per inspection is another variable that has no clear explanation of why it is costing the city. With further development of a MESR, the city of Rochester may be able to provide better definitions for some of these variables. The creation of new variable may also need to be considered based on the refined definitions of existing variables.

Another limitation of the model is that the suggested values from RMI are potentially misleading. For instance, the external analysis for setting an efficiency target (EASET) is estimated to be $50,000. However, depending on the current data that the city of Rochester has access to, this value could be significantly different. Also, it is possible that an analysis on the rental stock in Rochester is needed to effectively set a target and create a MESR which would drive up this price. In Petersen & Lalit's description of the cost analysis for other cities, they negate the need for including creating an implementation tool in the cost analysis because they assume that the HES or HERS scoring system will be chosen. This assumption could change the results of the cost analysis dramatically in the event the city wanted to utilize a different implementation tool.

There are a few other limitations to the model that need to be understood. One limitation is this model only assesses the cost to the city. It does not evaluate the cost associated with implementing a MESR form the perspective of a property owner who are responsible for the improvements. This limits the amount of insight the model can provide to the city. Another limitation exists because MESR can be deployed in multiple phases. Unfortunately, this model is not completely representative of all the nuances that may exist with a phase-in approach. Continuous modifications to this model are critical to the accurate estimations of energy savings, carbon savings, and needed laborers as aspects of a MESR are defined for the city of Rochester. Overall, this will provide more insightful results.

Discussion

MESR Impact on Rochester Climate Goals

The impact of the MESR on reducing carbon emissions and energy consumption provides great benefits to the city with respect to their CAP goals. One of the rigorous objectives outline in the CAP state that by 2020, the city wants to reduce greenhouse gas (GHG) by 20% from the 2010 level (City of Rochester, NY, 2017). Due to the events of the COVID-19 pandemic, the city is still awaiting results to see if they met their 2020 goal. Regardless, the city is only 8 years away from their next goal in 2030 where they aim to meet 40% GHG emission reduction from the 2010 levels (City of Rochester, NY, 2017). To provide some perspective, the city of Rochester consumed approximately 32.01 million MMBtu of energy and released about 2.2 million metric tons of CO_2 in 2010. Based on the analysis results, a MESR can help reduce the energy consumption by 2-5% and GHG emissions by up to 7%. A MESR targets a very specific industry: residential rental properties. It is narrow focus on this sector has the potential to make a significant contribution to ensuring Rochester's climate goals are achieved. Overtime, a MESR may be able to have a larger impact if the implemented energy efficiency improvements align closely with more recent IECC standards.

Property Owners V.S. Renters: Who is paying for the upgrades?

Although this analysis does not evaluate the costs associated with implementing a MESR to property owners, it is not a situation to be overlooked. A MESR requires the cooperation of property owners to comply with the standards by renovating their properties. However, a major barrier preventing compliance is the financial burden of performing the energy efficiency improvements. Many improvements come with high up-front costs to the property owners. Without any financial incentives or programs alleviating some of the burden, renters may experience raised rental costs. In an analysis which surveyed several renters and landlords, renters declared that they could no longer afford the rent when it was increased to cover the cost of energy upgrades (Wrigley & Crawford, 2017). Im et al. also saw traces of this theme in their research where they determined that by making energy improvements the units' rent would increase. For low-income tenants in Rochester, raising rent prices can destroy the affordability of rentals within the city. In an area already experiencing rental affordability issues, it is essential to mitigate the impact energy retrofits have on rental prices in the long term.

Cost to Property Owners

For the implementation of a MESR, understanding the approximate cost to property owners is imperative. Two major financial barriers hinder the adoption of energy efficiency measures: "energy performance less valued than investment costs" and "high investment costs and no [Life Cycle Cost] perspective" (Palm, 2018). Ultimately, property owners want to know, how soon are energy upgrades going to be paid back? And, what net benefits do they provide? A study conducted in Las Vegas attempts to understand the feasibility of costs associated with different types of energy improvements (Sadineni et al., 2011). Although Las Vegas experiences extreme heat in the Desert Southwest region of the United States, Rochester, NY experience very cold temperatures. In both regions, improving the building envelope is a great start to improving the energy efficiency in a home in order to reduce the energy consumed by heating or cooling the building. These types of building envelope upgrades are among several upgrades Sadineni et al.'s study analyzes. Table 9 is recreated from the study and expresses the costs/benefits from basic energy upgrades, which are better than the 2006 IECC. Upgrades with a benefit cost ratio greater than one is deemed an economically feasible option.

Table 9: Cost Benefits of Basic Energy Efficiency Upgrades (Sadineni et al., 2011)

Energy efficiency component	***Incremental cost/ initial investment ($)***	***Average annual energy cost savings ($)***	***Approximated life span (years)***	***Present value ($)***	***Benefit/ Cost Ratio***
Wall	750	92	40	1721	2.3
Windows	300	82	40	1895	6.3
Doors	120	37	40	867	7.2
Infiltration (cellulose insulation in walls and roof)	650	521	40	13327	20.5
HVAC (AC Unit)	700	90	20	735	1.0
Lighting	200	59	15	535	2.7

The researchers suggest that the lifetime of most energy upgrades exceed the payback period. It is also possible that with a MESR, some property owners will not have to make any energy upgrades.

Energy savings and payback period are not the only measures to assess benefits that can contribute to energy improvement decisions. According to a study from Ireland, there are several social benefits such as benefits to comfort, mortality, morbidity, and reduction in CO_2, SO_2, NO_x, PM_{10} (Clinch & Healy, 2001). To property owners, these benefits are overlooked as incentives for making energy improvements because property owners do not live onsite. However, the overall value of the property increases with energy improvements and becomes more desirable for someone searching on the housing market (Ford, 2019). Hence, property owners can benefit from reduced vacancy rates as well.

Another major concern regarding a MESR requiring energy efficiency improvements is the affordability for property owners. Thus far, there is some evidence that suggests property owners can afford different types of improvements implemented in a MESR.

Arena and Vijayakumar assess nine different rentals in a Boulder case study to examine the nuances of Boulder's SmartReg program. In doing so, they found one detached unit built in 1960 and one unit a part of a two-family building built in 1919 passed compliance with the units' existing features. In other cases, property owners may be able to work with local, state, and federal financial programs to offset the large cost of upgrades. There are a number of existing programs such as EmPower, Energy Smart, Weatherization Assistance Program, etc., for property owners in the city of Rochester (City of Rochester, NY, n.d.-b; New York State, 2020; New York State Energy Research & Development Authority [NYSERDA], 2022). Exploring additional sources of funding may also be necessary, moving forward.

Considerations for Rochester

With a large population of low-income households, ambitious climate goals, and other unique city qualities, it is important for the city of Rochester to carefully think through policy designs. Throughout analyzing the costs and benefit associated with implementing a MERS, there are several general recommendations that should be considered by the city of Rochester as more resources it put towards implementing a policy to improve energy efficiency. A few policy options are proposed based on results from research and the preliminary cost analysis. Finally, potential actors who may be able to assist in pushing a policy initiative forward in the city of Rochester will be discussed.

General Policy Recommendations

Barriers in adopting include but not limited to (1) conflicting interest from stakeholders make it hard to find reason to adopt, (2) increase in certification costs (Burfurd et al., 2012), and (3) potential increase in rent (Im et al., 2017). However, the cost of utility bills will decrease as a result of reducing energy consumption and potentially help gain support. There are several general recommendations for the city of Rochester to consider as they move forward with developing policy to combat energy consumption in rental homes including adding financial incentives, analyzing the inspector workforce, deciding on an inexpensive implementation tool, and conducting more in-depth cost-benefit analyses for energy improvements and MESRs.

Due to the demographics of Rochester renters, financial incentives are highly recommended. Immediately requiring property owners to participate in improving their properties with little to no assistance places a large burden on them. A MESR will have little support from property owners as a result. To make up the cost of the mandatory improvements, some property owners will increase the cost of rent, thus displacing the burden onto the tenants. For low-income tenants, this increased cost will be very impactful to their financial health. To alleviate the cost burdens, there are several state or local programs that could be utilized in conjunction with a MESR in Rochester. For instance, EmPower New York is a possible financial resource focused on providing energy improvements at little to no-cost to eligible residents (NYSERDA, 2022). Compiling a list of financial resources and assistance programs for property owners will help ease the burdens to property owners and tenant and they will be more incline to participate in upgrading rental properties.

Another recommendation for the city of Rochester is to utilize or develop an implementation tool that is relatively inexpensive. The cost analysis evaluated does not incorporate any costs associated with an implementation tool. Instead, it assumes that the HERS and HES implementation tools do not cost the city any money. By utilizing these existing tools, Rochester will not need to add additional costs to develop a new implementation tool.

An important part of any MESR is how it is enforced. Energy inspectors play a critical role to ensure the MESR will be implemented as designed. Therefore, it is important to reevaluate the existing workforce and design a MESR with their needs and capabilities in mind. By assessing the inspector workforce, the city will be able to gauge whether it is feasible to add additional standards for inspectors to enforce or if it is more beneficial to add new full-time inspectors solely focused on MESRs. Deciding on how the existing workforce will be incorporated into the enforcement of a MESR will define what it means to be an “energy inspector.” Once this is more clearly defined, the preliminary analysis conducted in this research can be updated and the results can be reinterpreted such that there is a better understanding of how many existing and new full-time inspectors are needed to support a MESR in Rochester.

Although there is a lack of post-retrofit reports to verify the reduction in energy from literature, robust models help support reduction in energy from MESRs in a series of cases (Arena & Vijayakumar, 2012). Results of energy efficiency upgrades are highly variable according to the different types of buildings (Belaïd et al., 2021). Thus, it would be beneficial for Rochester to run models to evaluate the potential gain with respect to energy use, carbon reduction, health conditions, etc. Also, it would be most effective for Rochester and other cities to install standards, which provide property owners flexibility to select options from a variety of energy improvements, much like Boulder’s SmartReg standard, to lessen their burden.

Establishing standards will theoretically level the playing field by reducing energy consumption and carbon footprint regardless of who is paying the utility bill, thus, helping to solve the split incentive issue. More data on standards in other states will help make adopting new energy efficiency standards more appealing to all stakeholders.

Designing Energy Standards: Energy Improvement Recommendations

The main component to a MESR are the energy improvements that the city requires. So, what energy improvements should the city of Rochester require? The main idea is that the Rochester home stock built prior to the 1980s will now incorporate some kinds of energy efficiency measures. It is unrealistic to expect property owners to upgrade their homes, which currently have little to no energy improvement in place, to the most recent energy efficiency measures due to the current rental affordability concerns and low-income demographic. Utilizing the IECC 1998/2000 and 2009 standards is a more realistic approach to incorporating energy upgrades. The current RMI framework and analysis estimates that the energy improvements implemented in rental units will align with these codes and therefore, should be used as inspiration to draft up suggested improvements.

For residential homes, air conditioning and space heating are the top sources of energy consumption (EIA, 2019). Energy consumption can be reduced directly by improving air conditioning units and space heating. However, these methods may not be accessible to all property owners due to the barrier of upfront costs. Alternatively, property owners may seek to make improvements to the building envelope by adding insultation to better contain heat and cool air. According to the Residential Energy Services Network (RESNET) HERS Index, it too suggests making upgrades to the building envelope or HVAC systems (RESNET, 2021).

Upgrades to exterior walls, ceilings, roofs, attic, foundations, crawlspaces are among of the few components of the building envelope RESNET encourages.

With these improvements, a home will receive an improved home's energy rating based on the HERS implementation tool which is suggested for the city of Rochester to use. The HERS Scoring Index shown in Figure 9 displays the scale used to evaluate property energy efficiency. In this example, a reference unit similar to the rental unit being adjudicated sets a baseline for comparison at a score of 100. The scored rental unit achieves a score of 65. This means that the rental unit has better energy efficiency measures than what is required. For rental units to meeting the IECC 1998/2000 efficiency standards, a HERS score of 120 or less is required (Arena & Vijayakumar, 2012; Petersen & Lalit, 2018)

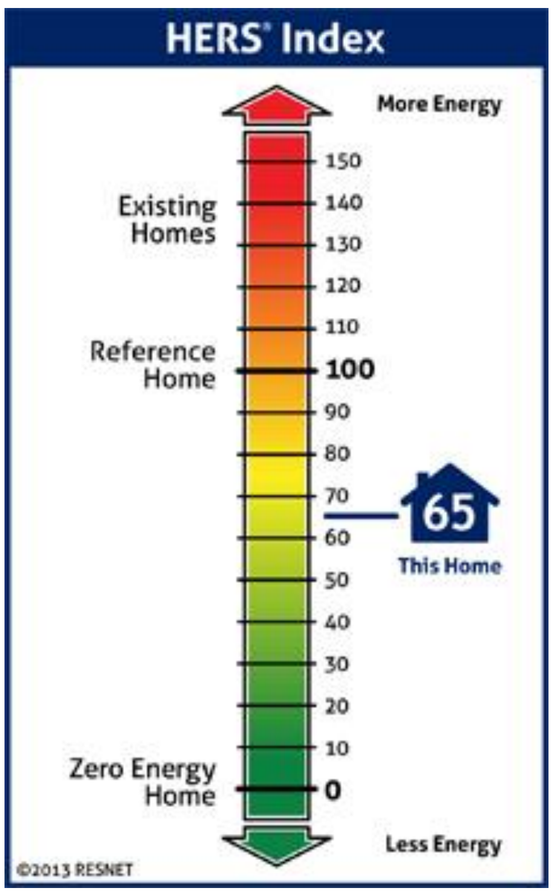


Figure 9: HERS Scoring Index (RESNET, 2021a)

Different climates suggest different improvements to the building envelope. Based on the 1998/2000 IECC climate zoning map in Figure 10, Monroe County is in climate zone 14A. In this zone, the demand for energy is estimated to be between 6,500 and 6,999 heating degree days (HDD) (International Code Council, 2000). HDD measures the difference in degrees a zone's average outside temperature is below 65°F. 65°F is used as the baseline temperature because its assumed heating nor cooling is necessary in a building. Monroe County's climate zone was redefined to be climate zone 5A in accordance with the 2009 IECC climate zoning seen in Figure 11.

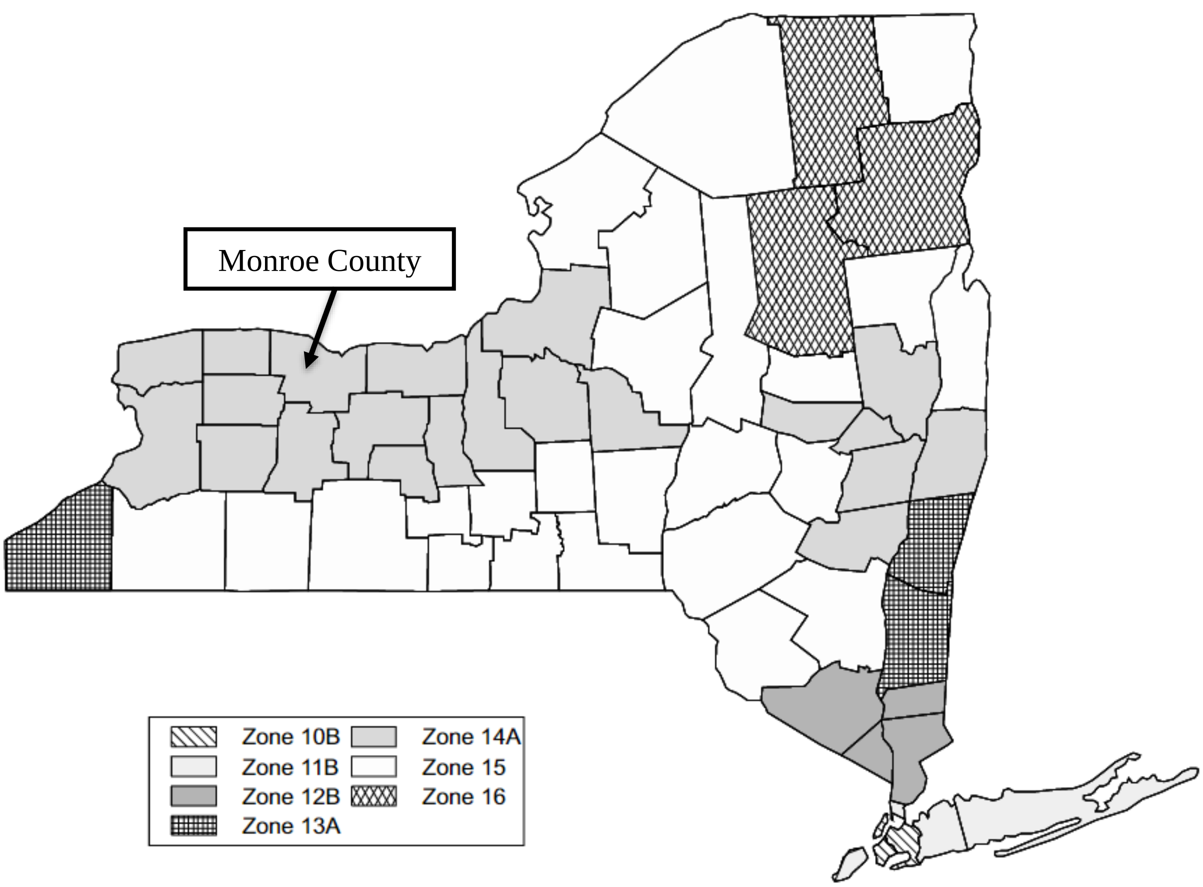


Figure 10: 2000 IECC Climate Zone Map of New York State (International Code Council, 2000)

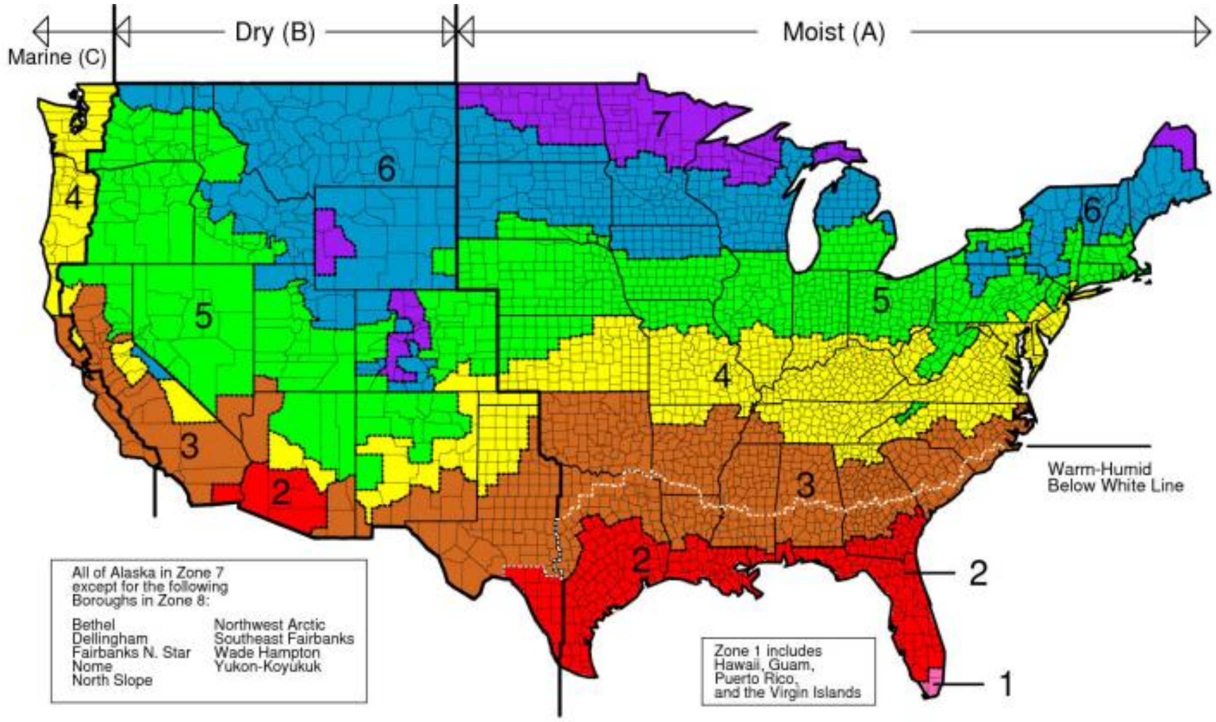


Figure 11: 2009 IECC Climate Zone Map of the United States (National Association of Home Builders - Research Center [NAHB], 2012)

Using the climate zones and different standards, recommendations for building envelope improvements are developed. The codes corresponding to the *low*- and *high-end energy cost savings* are compared in Table 10 and presents the recommended upgrades in the event a property owner wants to improve the building envelope of their property. According to M. Gartman, 1998 and 2000 IECCs are very similar (personal communication, April 26, 2021). Thus, the latest 2000 IECC is used to advise recommendations in accordance with the *low-end range for energy savings* in Table 10. Replacing windows and doors also help improve the building envelope and HERS index scores (RESNET, 2021).

Table 10: Comparison of 2000 and 2009 IECC Prescriptive Residential Building Envelope Requirements by Component (International Code Council, 2000, 2009; NAHB - Research Center, 2012)

		Maximum	Minimum					
Energy Savings in Correspond-ence to Model	**IECC Version**	**Glazing U-Factor**	**Ceiling R-value**	**Wall R-value**	**Floor R-value**	**Basement Wall R-value**	**Slab Perimeter R-Value & Depth**	**Crawl Space Wall R-Value**
Low-End	2000	0.35	49	19	21	11	11, 4 ft.	20
High-End	2009	0.35	38	20 or 13+5[a] 13/17[b]	30[c]	10/13	10, 2 ft.	10/13

a. Wood Frame Wall. " '13+5' mean R-13 cavity insulation plus R-5 insulated sheathing (NAHB - Research Center, 2012)."
b. Mass Frame Wall.
c. "Or insulation sufficient to fill the framing cavity, R-19 minimum (NAHB - Research Center, 2012)."

Other suggested improvements to a home may include upgrading vents, ductwork, HVAC Systems, water heating, and the thermostat because they are also variables in the HERS scoring system (RESNET, 2021). All of these systems significantly contribute to the amount of energy consumed in a home. Converting any lighting to LED lights is another improvement that can be made that will help reduce the consumption in a home. Replacing old appliances in a home to ENERGYSTAR rated appliances can also be particularly useful in reducing consumption. Overall, there are a variety of ways to improve a home to make it more efficient.

Policy Recommendations

Policy Recommendation 1: Single Phase MESR with Financial Support

A single phase MESR with several supportive financial programs is a potential policy solution to tackle the energy efficiency problem. In a single phase MESR, there should be a wide variety of suggested energy improvements of varying costs to choose from. Using the suggested HERS index scoring method, energy improvements can be made in a variety of ways as discussed in the previous section. Ultimately, the improvements made must help a rental unit achieve a HERS score of 120 or less, which is the equivalent to meeting IECC 1998/2000 efficiency standards (Arena & Vijayakumar, 2012; Petersen & Lalit, 2018).

A compliance period of three or six years should be used for the single phase MESR so that the compliance period aligns with the CoO renewal requirements in Rochester. After the MESR is officially adopted, an energy inspection should be completed using the HERS scoring system when a rental unit's CoO has expired. This initial energy inspection will serve as the baseline energy efficiency estimate for the property and determine if a property owner needs to make improvements. If the property receives a score of 120 or less, they will have achieved compliance and there are no necessary improvements that need to be made. Alternatively, if a property receives a score above 120, the owner will need to make improvements before the next CoO expires and a new energy inspection is complete. In extraordinary circumstances, waivers may be granted, but failure to comply should result in fines to the property owner or potentially suspending the CoO for the rental.

There are a multitude of existing and potential financial programs that should be explored in conjunction with developing a MESR. Ultimately, property owners and tenants will be more supportive and willing to abide by the MESR if there is monetary support to alleviate some of the burden. The city should encourage property owners to apply for EmPower New York, an existing NYSERDA program aimed at providing financial for low-income residents. With qualifying low-income tenants, property owners can fill to have most if not all their improvement costs reimbursed (NYSERDA, 2022). There are approximately seven different qualified contractors in Rochester that participate in this program. Additional financial support may include partnerships with RG&E or Bloc Power, but these will need to be researched more in the design and development of a MESR. A partnership with the utility company may allow the delivery or supply rates of energy to be reduced temporarily for rentals, which are actively undergoing improvements to meet the new MESR standard. Bloc Power is a company focused on converting existing building to “greener” ones (Root, 2021). Ithaca, NY has formed a partnership with Bloc Power to electrify most of the city and Rochester may want to consider implementing something similar to tap in the same state and federal incentives that Ithaca has. Manufacturer rebates are another way to keep cost low. By designing a MESR with various avenues of financial support, the policy has the potential to be an enormous success for the city’s energy and environmental initiatives.

Policy Recommendation 2: Multiple Phase MESR with Cost Cap

Integrating new policies into society can be difficult all at once. However, a MESR with multiple phases can help breakdown the policy for easier integration and make costs a little more manageable. This approach is comparable to the MESR that the city of Gainesville, FL has employed. Multiple phases can ensure the city of Rochester is continuously working toward their environmental goals while reducing the immediate up-front costs to property owners.

For a multiple phase MESR, there should only be two phases to keep the overall compliance period small and less expensive for the city. A compliance period of 3 years per phase is suggested so that it aligns with the CoO renewal process. Using the HERS index scoring system as the implementation technique, achieving a score of 120 or less will be the objective of each rental to comply with the MESR policy. The suggested two phase of the MESR is outlined as follows:

- **Phase 1**: First, an initial energy inspection should be conducted for each rental property when a CoO expires. Rental units will be assessed and presented with a score by a licensed energy inspector. Property owners and inspectors will discuss the discrepancies preventing the unit from achieving the objective score of 120 or less. For the first phase, the property owner will need to make energy improvements to make up at least half of the difference in points. For instance, if a rental unit achieved a score of 137 at the initial inspection, then the property owner would need to make improvements, which will help gain at least 8.5 points throughout Phase 1. Once the 3 years of Phase 1 has lapsed, the unit will undergo another energy inspection. To meet full compliance, a score of 128.5 or less must be obtained. After a rental unit has complied with Phase 1, it will move onto Phase 2.

- **Phase 2**: Phase 2 will require a rental unit to make up the remaining points by implementing more improvements over the next 3 yearlong phase. After the duration of phase has expired, the licensed energy inspector will return and reevaluate the unit. This time, the unit will be expected to meet 120 points or less.

In the event the initial HERs score given to a unit is 120 or less, the unit will not be required to make any modifications for either Phase 1 or Phase 2. However, in the future, the city may choose to add an additional phase which may require a HERS score of 100 or less if the MESR policy. This requirement will continue to encourage property owners to make energy upgrades as well as help the city achieve its climate goals through reducing energy consumption and carbon emissions. Failure to meet compliance at any time may result in fines or a revoked CoO.

With a phase-in approach, the total financial burden will be spread out over several years. To further assist spreading the financial burden, cost caps should be implemented at each phase. Tenants will benefit from the improvements, but they may experience some long-term discomfort depending on the extensiveness of the energy upgrades the property owners choose to make. In unforeseen circumstances, such as renovation cannot be completed on time due to labor or material delays, improvements cannot be made due to structural or mechanical reasoning, etc., waivers should be granted on a phase-by-phase basis.

Policy Recommendation 3: Tax Credits

A potential alternative that does not include a MESR to facilitate improving energy efficiency would be introducing possible tax credits. These energy improvements would be voluntary in hopes of gaining more support for the policy. Adding tax credits would incentivize property owners to participate. When developing the tax credit, the property owners' and tenants' income should be considered, so enough credit is given to prevent any major financial burdens from residential retrofits for both parties. Another aspect of the tax credit that should be carefully thought through is the amount of money spent on the energy improvements. Ideally, the more money spent on improvements should correspond to a higher tax credit.

Conclusion

With the use of a MESR, there is a lot of potential for Rochester to reduce their energy consumption and carbon emissions. Using the existing framework by RMI, the city of Rochester could save between 0.567 and 1.702 trillion Btu of energy annually based on a MESR with a 3-year compliance period. This is equivalent to $9.1 to $27.2 million of annual energy cost savings. A MESR can contribute significantly to Rochester's CAP goals by reducing carbon emissions up to 7%. This figure is based on the estimated 116.6 to 349.8 million lbs. of CO_2 avoided annually with a MESR policy. However, this does come at a cost to the city. Approximately $227,000 per year is needed to fund a MESR policy, and seventeen energy inspectors is needed to ensure the policy is enforced correctly.

It comes as no surprise that by increasing the years of a MESR's compliance period, the total cost to implement a MESR increases while the annual cost decreases. These results from the model are similar to those for Oakland, CA which makes the outcomes of the analysis realistic and convincing. In the event the city of Rochester proceeds in the direction of developing a MESR, it is pertinent that this model is updated with the most accurate figures for each of the variables. Each update will provide a more accurate estimate of costs, energy savings, and carbon savings.

This analysis is limited to just evaluating the impact on the city and does not explore the costs associated with implementing the energy improvements required by a MESR. Some literature expresses that property owners displace the financial burden onto the tenants by raising the rent. The city of Rochester has indicated that affordability is already a major concern in the rental market because a significant portion of renters are low-income. Therefore, supporting financial programs is integral in shaping a successful MESR for Rochester. Further exploration into understanding the costs associated with implementing energy improvement is necessary to design a MESR as well.

Based on the results from the preliminary cost analysis, there are a few policy solutions for the city of Rochester. One option is a single phase MESR, which includes multiple financial programs to reduce costs of improvements. Another option is a multiple phase MESR, which includes cost caps to reduce the financial burden of improvements. It is recommended that Rochester use existing frameworks for implementation and enforcement such as Rochester's CoO for rentals that must be renewed every 3 or 6 years. Thus, compliance periods for each of the MESR options should align with the CoO. If the city determines that a MESR is not how they want to tackle to the energy efficiency problem, they could utilize tax credits instead to encourage property owners to make energy improvements and reduce the overall financial burden. A full summary of the analysis results and recommendations can be found in Appendix E.

Moving forward, results of this analysis need to be brought to the attention of the city along with a few policy recommendations. With the members of city council aware of the estimated costs associated with a MESR and the impact on the community, there is the potential to gain support to start designing a MESR and help work towards the city's climate action goals. A MESR has the potential to provide a lot of energy and environmental benefits to the city of Rochester. With the right financial supportive programs, the financial burdens of rental improvements can be alleviated for the property owners and tenants.

Appendices

Appendix A: Boulder Compliance Framework - Prescriptive Pathway Table (Arena & Vijayakumar, 2012)

SmartRegs Prescriptive Pathway Checklist

Need 100 Total Points + Mandatory Water Conservation Measures

This form is to be used by City of Boulder Class G licensed inspectors.

Instructions:
1. Circle the applicable point selection in each category
2. Fill in the Base and Final Points in each category
3. Total the points in the table below
4. Provide a Class G inspector license number and signature
5. Submit the form with the preceding SmartRegs Energy Efficiency Application pages

Unit Address and Number:____

Enter total points in the space below

Total Base Points	
Total Final Points	
Total Water Conservation Points	

Class G inspector - PRINT NAME	License #

Class G Inspector Signature

Mandatory Water Conservation

Must earn two points regardless of whether Performance or Prescriptive SmartRegs Pathway is chosen. Points earned in this category do not count towards Prescriptive 100 point requirement.

Water Conservation Measure	Points
Low flow showerhead*	1
Low flow lavatory faucets*	1
Self-closing faucet valves**	1
High-efficiency or dual-flush toilet*	2
ENERGY STAR washing machine	2
ENERGY STAR dishwasher	2

*Points awarded based on average of all fixtures in unit -
**Points awarded if all faucets are equipped with self-closing valves. -
Please refer to the SmartRegs Guidebook for further clarification. -

WALLS Base:_____ Final:_____

R VALUE	25%	50%	75%	100%
No Insulation	0	0	0	0
>R-3 Continuous	3	6	9	12
R-5 Continuous	4	8	12	15
R-13	5	10	15	20
Uninsulated Basement Wall	5	10	15	20
>R-19	5	11	16	21
Insulated Basement Wall	6	13	19	26
Shared Wall	6	13	19	26

WINDOWS/FENESTRATION Base:_____ Final:_____

U FACTOR	25%	50%	75%	100%
Single Metal (1.2 U-Factor)	0	0	0	0
Single Non-Metal* (.95 U-Factor)	0	1	1	2
Double Metal (.80 U-Factor)	1	2	3	4
Double Non-Metal * (.55 U-Factor)	2	3	5	6
0.35 U-Factor*	3	7	10	13
0.30 U-Factor	3	7	10	14
<0.25 U-Factor	4	7	11	14

INFILTRATION Base:_____ Final:_____

ACH_n	POINTS
≤1.20 ACH_n	2
0.75 ACH_n	4
0.50 ACH_n	6
≤0.35 ACH_n (ventilate per ASHRAE 62.2)	7
TEST STATS:	
ACH_n:__________	Volume:__________
CFM50:__________	n-Factor:__________

CEILINGS Base:_____ Final:_____

R VALUE	25%	50%	75%	100%
No Insulation	0	0	0	0
R-19	6	12	18	24
R-30	6	13	19	26
>R-38	7	13	20	26
Shared Ceilings	7	14	20	27

FLOORS / FOUNDATIONS Base:_____ Final:_____

TYPE	25%	50%	75%	100%
SLAB ON GRADE				
Slab Edge: R-0	2	3	5	6
Slab Edge: >R-5	2	4	5	7
Slab Edge: >R-10	2	4	6	8
Slab Edge: >R-10 AND Under Slab: >R-10	3	6	8	11
BELOW GRADE SLAB (Basement Slab)				
Basement Slab	2	4	6	8
FOUNDATION WALLS (Crawlspace)				
R-0	0	0	0	0
R-2	2	3	5	6
R-11	2	4	6	8
>R-19	2	5	7	9
FRAMED FLOORS (Only Available if No Ducts or HVAC Equipment are Located in Unconditioned Space Below Floor)				
Framed Floor: R-0	0	0	0	0
Framed Floor: R-13	3	5	8	11
Framed Floor: R-25	3	6	9	12
Framed Floor: >R-38	4	7	11	14
Shared Floor	4	8	11	15

DUCT LEAKAGE Base:_____ Final:_____

CFM per 100 SF	POINTS
80 cfm @ 25 Pa	0
60 cfm @ 25 Pa	4
40 cfm @ 25 Pa	9
20 cfm @ 25 Pa	14
<10 cfm @ 25 Pa	17
No Ducts	17

DISTRIBUTION SYSTEM Base:_____ Final:_____

LOCATION / INSULATION	25%	50%	75%	100%
Uninsulated Pipes/Ducts (In Unconditioned Space)	0	0	0	0
Pipes/Ducts Insulated (R-4) (In Unconditioned Space)	1	3	4	6
Pipes / Ducts Within Conditioned Space	2	3	5	7

*Historically designated properties and properties older than 50 years with wooden window frames that rehabilitate and install storm panels will receive credit at the 0.35 U-Value level.

Total this page:__________

HEATING Base:_____ Final:_____

SPECIFICATION	POINTS
Electric, Oil, or ASHP	0
Gas 65% AFUE	0
Gas 80% AFUE	13
Gas 90% AFUE	17
Gas 96% AFUE	19
GSHP (COP 3.3)	29
GSHP (COP 4.1)	38
GSHP (COP 4.8)	43

COOLING Base:_____ Final:_____

SPECIFICATION	POINTS
10 SEER or worse	0
13 SEER	4
15 SEER	6
Direct Evaporative Cooler	6
No Cooling	6
17 SEER	7
19 SEER	8
Indirect Evaporative Cooler	8
GSHP (≥ EER 13.6)	4

LIGHTING Base:_____ Final:_____

HIGH EFFICACY LIGHTING (solar tubes/light tunnels counted as light fixtures)	POINTS
0%	0
25%	2
50%	4
75%	6
100%	7

HOT WATER Base:_____ Final:_____

SPECIFICATION	POINTS
Electric, Oil or Heat Pump	0
Gas 0.56 EF	0
Gas 0.60 EF	1
Gas 0.64 EF	2
Gas ≥0.82 EF	6
Gas Boiler Side Arm (65% AFUE Boiler)	0
Gas Boiler Side Arm (80% AFUE Boiler)	3
Gas Boiler Side Arm (95% AFUE Boiler)	5

WHOLE HOUSE FANS Base:_____ Final:_____

SPECIFICATION	POINTS
Whole House Fan	2

REFRIGERATION Base:_____ Final:_____

SPECIFICATION	POINTS
750 kWh/year	0
650 kWh/year	2
450 kWh/year	3
≤350 kWh/year	4

SOLAR THERMAL Base:_____ Final:_____

SPECIFICATION	POINTS
Points per 20 sq ft of collector surface area	8

PHOTOVOLTAICS* Base:_____ Final:_____

ARRAY RATED OUTPUT	POINTS
Points per kW**	44

OCCUPANT Base:_____ Final:_____

MEASURE	POINTS
Sub-Metering: Real Time Energy Monitoring Device	1
Programmable Thermostat	1
Provide Operation / Training Manual	1
Tenant Attends Energy Conservation Class	1

OTHER Base:_____ Final:_____

MEASURE	POINTS
Heat Pump Desuperheater	1
Electronically Commutated Motor ("ECM")	3
Passive Solar Design	Discretionary – approved by City of Boulder
Innovative Practice	Discretionary – approved by City of Boulder
Technically Impractical: Carbon Offsets	Must be Approved by City of Boulder (8 points per metric ton of CO2 offset)

*Qualifying installations include power purchase agreements, solar leases, or verified subscription in Community Solar Garden.
**Units must earn 70 prescriptive pathway points in other categories to be eligible to earn PV points.

Total this page:__________

Appendix B: Summary Table of Default Inputs

	Variable Abbreviation	*Variable*	*Input Category*	*Variable Description*	*Unit*
City Specific Inputs	NHU	Number Housing Units	Quantifying Number of Rentals	Collected from U.S. Census Data	housing units
	OOR	Owner Occupied Rate	Quantifying Number of Rentals	Collected from U.S. Census Data	%
	$ACBH_{Elec}$	Annual Electricity Consumption (By Household)	Quantifying Energy Costs	SHED Data*	MWh
	$ACBH_{Gas}$	Annual Natural Gas Consumption (By Household)	Quantifying Energy Costs	SHED Data*	Mcf
	R_{Elec}	Electricity Rate	Quantifying Energy Costs	State average data*	$/kWh
	R_{Gas}	Natural Gas Rate	Quantifying Energy Costs	State average data*	$/Therm
	CER_{Elec}	Carbon Emission Rate - Electricity	Quantifying Carbon Reduction	State average data	$\frac{lb\ CO_2}{MWh}$
	CER_{Gas}	Carbon Emission Rate - Natural Gas	Quantifying Carbon Reduction	State average data	$\frac{lb\ CO_2}{Therms}$
	TR	Total Rentals	Quantifying Number of Rentals	$NHU \times (1 - OOR)$	rentals
	NRNE	Number Rentals Not Exempt	Quantifying Number of Rentals	$TR \times (1 - PRENC)$	rentals
	$CBIW_{Total}$	Cost to Build Inspectors Workforce (Total)	Quantifying Cost to City	$EI \times CBIW$	$
	VC_{Total}	Verification Cost (Total)	Quantifying Cost to City	$NRNE \times VC_{Rental} \times PRCV$	$
	CEC_{Total}	City Employee Cost (Total)	Quantifying Cost to City	$\left[\frac{NRNE}{CEPR}\right] \times CES \times NYBFC$	$

	Variable Abbreviation	*Variable*	*Input Category*	*Variable Description*	*Unit*
General Inputs	PRENC	% Rentals Exempt/ Non-Compliant	Quantifying Number of Rentals	20%, "Rough RMI rule of thumb. Should update after developing compliance framework"	%
	ENI	Estimated # of Inspections per Inspector per Year	Quantifying Energy Inspectors Required	"Assumes four inspections per day 260 days per year"	
	NYBFC	Number of Years Before Full Compliance	Quantifying Energy Inspectors Required	Assumed to be 3 years but should change to simulate different compliance periods	years
	EASET	External Analysis to Set Efficiency Target	Quantifying Cost to City	$50,000, "RMI assumption. Should think this through more at beginning of implementation framework"	$
	CBIW	Cost to Build Inspectors Workforce (Per Inspector)	Quantifying Cost to City	$500, suggested change based on city input	$
	VC_{Rental}	Verification Cost Per Rental	Quantifying Cost to City	$100, suggested change based on city input	$
	PRCV	Percentage of Rentals Completing Verification	Quantifying Cost to City	1.0%, "RMI assumption. Should update after developing compliance framework"	%
	CEPR	City Employee Per # of Rentals	Quantifying Cost to City	30,000, "RMI assumption. Should update with city specific assumptions."	employe-es
	CES	City Employee Salary (Yearly)	Quantifying Cost to City	$100,000, "RMI assumption. Should update with city specific assumptions."	$
	BIB	Built in Buffer	Quantifying Cost to City	1.10, Assumed cost buffer for unforeseen costs	-
	RES_{Low}	Low End Range of Energy Savings	Quantifying Energy Costs	10%, "Roughly approximate to bringing existing properties to IECC 1998/2000** efficiency levels. This will be fined tuned after the efficiency target level is set."	%
	RES_{High}	High Energy Range of Energy Savings	Quantifying Energy Costs	30%, "Roughly approximate to bringing existing properties to IECC 2009** efficiency levels. This will be fined tuned after the efficiency target level is set."	%

* Replaced with updated value for city of Rochester for analysis
** Corrected typos from RMI template (M. Gartman, personal communication, April 26, 2021).

Appendix C: RMI Impact Calculator Template

City Impact Analysis For Minimum Efficiency Standards for Rentals

City:
State:

This tool is meant to be a starting point for determining the impact of introducing minimum efficiency standards for rental units in your city. A summary of the impact results are provided, and more detail regarding the calculations and assumptions can be found below.

Results Summary	
Cost For City to Implement Annually	Fill in Dark Blue Boxes
Low-End Annual Energy Savings (Btu)	Fill in Dark Blue Boxes
High-End Annual Energy Savings (Btu)	Fill in Dark Blue Boxes
Low-End Annual Energy Cost Savings	Fill in Dark Blue Boxes
High-End Annual Energy Cost Savings	Fill in Dark Blue Boxes
Low-End Annual Carbon Reduction (lbs CO_2	Fill in Dark Blue Boxes
High-End Annual Carbon Reduction (lbs CO_2	Fill in Dark Blue Boxes
Energy Inspectors Needed	Fill in Dark Blue Boxes

Legend
Calculation Cell
Required Input
Optional Input

Input Assumptions

This sections summarizes the more detailed information used to calculate the city impacts associated with implementing minimum efficiency standards for rentals, and assumptions can be adapted to suit specific cities more accurately. Many inputs will be auto populated with state specific information or Rocky Mountain Institute's assumptions. A short description of what assumptions are associated with each input, as well as a link to find more city specific data is available. Any dark blue cell require user input, any light blue cell recommends user input using city specific resources, and any white cells should be left alone. This spreadsheet was last updated June 2018, so auto populated inputs may be outdated.

		Units	Comments	Resource
Quantifying Number of Rentals				
Number Housing Units		Housing Units	*Enter city into "community facts" input. Select "Housing" tab on left hand side.*	Census Fact Finder
Owner Occupied Rate			*Owner-occupied housing unit rate*	2016 Census Housing
Total Rentals	0	Rental Units	*This tool assumes efficiency standards are implemented for long term rentals. If implementing through short term rentals, this cell will need to be updated*	
% Rentals Exempt/Non-Compliant	20%		*Rough RMI rule of thumb. Should update after developing compliance framework*	
Number Rentals Not Exempt	0	Rental Units		
Quantifying Energy Inspectors Required				
Estimated # of Inspections per Inspector per Year	1040.0		*Assumes four inspections per day 260 days per year*	
Number of Years Before Full Compliance	3.0	Years	*Time from policy is implemented until all rentals need to be compliant*	
Quantifying Cost to City				
External Analysis to Set Efficiency Target	$50,000		*RMI assumption. Should think this through more at beginning of implementation framework*	
Cost to Build Inspectors Workforce (Per Inspector)	$500			
Cost to Build Inspectors Workforce (Total)	$0			
Verification Cost Per Rental	$100			
Percentage of Rentals Completing Verification	1.0%		*RMI assumption. Should update after developing compliance framework*	
Verification Cost (Total)	$0			
City Employee Per # of Rentals	30,000		*RMI assumption. Should update with city specific assumption.*	
City Employee Salary (Yearly)	$100,000		*RMI Assumption. Should update with city specific assumption.*	
City Employee Cost (Total)	$0			
Built in Buffer	1.10		*Assumed cost buffer for unforeseen costs*	
Quantifying Energy Costs				
Electricity Rate	Select State in Cell C4	$/kWh	*Auto populates state or national average based on C4. Use resource to find city specific.*	SLED
Natural Gas Rate	Select State in Cell C4	$/Therm	*Auto populates state or national average based on C4. Work with local utility to find city specific tariff.*	EIA N.G.
Low End Range of Energy Savings	10%		*Roughly approximate to bringing existing properties to IECC 1999 efficiency levels. This will be fined tuned after the efficiency target level is set.*	
High Energy Range of Energy Savings	30%		*Roughly approximate to bringing existing properties to IECC 2006 efficiency levels. This will be fined tuned after the efficiency target level is set.*	
Annual Electricity Consumption (By Household)		MWh	*Scroll to "Electricity Usage", click on the "Per Household/Establishment" button*	SLED
Annual Natural Gas Consumption (By Household)		MCf	*Scroll to "Natural Gas Usage", click on the "Per Household/Establishment" button*	SLED
Quantifying Carbon Reduction				
Carbon Emission Rate - Electricity	Select State in Cell C4	lb CO_2/MWh	*Auto populates state or national average based on C4. Could use utility specific data.*	eGRID
Carbon Emission Rate - Natural Gas	14.5	lb CO_2/Therm	*ASHRAE Standard 105 - National Average. This input does not vary by location.*	

Appendix D: Summary Table of Outputs

Abbreviation	***Output Name***	***Description***	***Unit***
CCIA	Cost for the City to Implement Annually	$CCIA = \frac{[EASET + CBIW_{Total} + VC_{Total} + CEC_{Total}] \times BIB}{NYBFC}$	$
AES_{Low}	Low-End Annual Energy Savings	$AES_{Low} = \left[NRNE \times ACBH_{Elec} \times RES_{Low} \times 3412141.63 \frac{Btu}{MWh}\right] + \left[NRNE \times ACBH_{Gas} \times RES_{Low} \times 1027000 \frac{Btu}{MCf}\right]$	Btu
AES_{High}	High-End Annual Energy Savings	$AES_{High} = \left[NRNE \times ACBH_{Elec} \times RES_{High} \times 3412141.63 \frac{Btu}{MWh}\right] + \left[NRNE \times ACBH_{Gas} \times RES_{High} \times 1027000 \frac{Btu}{MCf}\right]$	Btu
$AECS_{Low}$	Low-End Annual Energy Cost Savings	$AECS_{Low} = \left[\left(NRNE \times ACBH_{Elec} \times R_{Elec} \times 1000 \frac{kWh}{MWh}\right) + \left(NRNE \times ACBH_{Gas} \times R_{Gas} \times 10.37 \frac{therm}{MCf}\right)\right] \times RES_{Low}$	$
$AECS_{High}$	High-End Annual Energy Cost Savings	$AECS_{High} = \left[\left(NRNE \times ACBH_{Elec} \times R_{Elec} \times 1000 \frac{kWh}{MWh}\right) + \left(NRNE \times ACBH_{Gas} \times R_{Gas} \times 10.37 \frac{therm}{MCf}\right)\right] \times RES_{High}$	$
ACR_{Low}	Low-End Annual Carbon Reduction	$ACR_{Low} = \left[(NRNE \times ACBH_{Elec} \times CER_{Elec}) + \left(\left(NRNE \times 10.37 \frac{therm}{MCf}\right) \times ACBH_{Gas} \times CER_{Gas}\right)\right] \times RES_{Low}$	lbs. CO_2
ACR_{High}	High-End Annual Carbon Reduction	$ACR_{High} = \left[(NRNE \times ACBH_{Elec} \times CER_{Elec}) + \left(\left(NRNE \times 10.37 \frac{therm}{MCf}\right) \times ACBH_{Gas} \times CER_{Gas}\right)\right] \times RES_{High}$	lbs. CO_2
EI	Energy Inspectors Needed	$EI = \frac{\left[\frac{NRNE}{ENI}\right]}{NYBFC}$	inspectors

Appendix E: Analysis Results and Recommendation Summary

Rochester, NY Profile

- 57% renter occupied housing (~57,000 units)
  - 41% of renters are extremely low-income.
- Existing rental licensing program, Certificate of Occupancy (CoO), with a renewal period of 3 or 6 years
- Climate Action Plan with city-wide goals aimed at reducing carbon emissions
- Concerns:
  - Affordable Rental Housing
  - Energy Burdens for Low-Income Tenants
  - City Carbon Emissions

Results Summary

Cost for the City to Implement Annually	$227 K
Annual Energy Savings (Btu)	0.567 - 1.702 T
Annual Energy Cost Savings	$9.1 - 27.2 M
Annual Carbon Reduction (lbs. CO_2)	116.6 – 349.8 M
Energy Inspectors Needed	17

Recommendations

General Recommendations and Items to Consider	1. **Financial Assistance Programs** – help alleviate burdens of energy efficiency upgrades to property owners and tenants 2. **Inexpensive Implementation Tool** – HERS scoring idea provides framework that will keep city costs for implementation of MESR policy low 3. **Align with Rochester's CoO** – existing framework will assist in rollout and enforcement of MESR policy 4. **Energy Inspector Analysis** – ensure adequate inspector workforce to enforce policy properly 5. **Multiple Options for Energy Upgrades** – assist property owners with finding affordable and feasible energy upgrade options 6. **Keeping Up to Date with MESR Studies** – new studies help to better understand the specific costs and benefits associated with a MESR policy
Energy Improvement Recommendations	• Building Envelope Improvements – insulation of walls, ceilings, roofs, floors, etc. • HVAC Systems • Water Heater • Thermostat • Lighting • Appliances
Policy Recommendations	• Single Phase MESR with Financial Assistance • Two Phase MESR with Cost Caps • Tax Credits

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