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# Decarbonization of New York City Residential Buildings

Julia Davis

Master of Public Policy Candidate
University of Virginia

UVA | FRANK BATTEN SCHOOL of LEADERSHIP and PUBLIC POLICY

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**Disclaimer**

The author conducted this study as part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgments and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, or by any other agency.

**Honor Statement**

On my honor as a student, I have neither given nor received unauthorized aid on this assignment.

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## Glossary

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|---|---|
| **Greenhouse gas (GHG)** | A gas that traps and emits heat in the atmosphere. |
| **New York City (NYC)** | One of the most populated cities in the United States, NYC is a city in the state of New York. |
| **New York League of Conservation Voters (NYLCV)** | An environmental advocacy group based in the state of New York, with active groups in eight regions across the state. |
| **Carbon dioxide ($CO_2$) (Also referred to as "carbon")** | A chemical compound composed of one carbon atom and two oxygen atoms. $CO_2$ enters the atmosphere as GHGs through the burning of fossil fuels. |
| **New York State Department of Environmental Conservation (DEC)** | A NYS department that aims to protect the state's environment and natural resources through regulatory measures. |
| **Energy Star Portfolio Manager (ESPM)** | An online tool that can be used to determine a consumer's energy and water consumption, and GHG emissions output. |
| **NYC City Department of Buildings (DOB)** | A NYC department that regulates the construction and usage of buildings across the city to protect public safety. |
| **NYC Department of City Planning (DCP)** | A NYC department that designs the city's physical and socioeconomical frameworks. |
| **NYC Department of Environmental Protection (DEP)** | A NYC department that aims to protect the city's environmental, public health, and water quality. |
| **NYC Media Department** | A department in the NYC Mayor's Office of Media and Entertainment that is the official media production agency of the city. |

## Executive Summary

New York City is home to over 1 million buildings (Buildings, n.d.). Of these spaces, residential buildings have contributed the largest amount of greenhouse gas emissions and will remain to do so in both short- and long-term projections (MacWhinney & Klagsbald, 2017). The air pollution from greenhouse gas emissions negatively impacts both the city's environment and the health of New Yorkers. For example, New York's average annual temperature has risen about 2.4°F since 1970, precipitation has increased, and sea levels have risen over a foot since 1900 (Department of Environmental Conservation, n.d.). New York City residents face many growing health problems that stem from climate change, including increased heat stress, worsening respiratory conditions, increased risk of contracting food-, water-, and vector-borne diseases, increased severity of allergies, and increased risk of injury or death from more extreme weather events (Climate.ny.gov, 2021). About 16,000 people are either hospitalized or die every year from air pollution-related health conditions, which constitutes 6% of the city's deaths (Kheirbek et al., n.d.; Air pollution and the health of New Yorkers: The impact of fine particles and ozone, 2011).

Recent and ongoing technical innovations have provided promising ways to reduce carbon emissions in the residential sector, including home automation, electrification, and building envelopes (Thayne et al., n.d.). The success of these technologies is highlighted in this paper to provide support for the claim that there are viable technological options to reach net zero carbon emissions by 2050.

Even with a plethora of technologies to minimize greenhouse gas emissions in NYC, there still remains the problem of a lack of engagement and investment in these technological options from New York City residents. The high upfront costs, credit constraints, and uncertainty of the economic benefits all act as barriers to investment (Leung, 2018; De Haas et al., 2021; Davis et al., 2019). However, without immediate and significant movement towards investing in green infrastructure, the city will likely miss its net zero carbon target by 2050 (NYC.gov, 2021). Thus, there is a need for policy action to encourage New York City to advance towards lower emissions and therefore a healthier, more sustainable city.

This paper assesses three policy alternatives to do so: running an educational campaign, providing a public subsidy, and enacting a carbon tax. An educational campaign would affect the demand side of the market and would consist of creating and distributing informational media through a variety of platforms, but with a focus on social media. A public subsidy would affect both the supply and demand sides of the market; it would be paid to property owners through investment grants (from the government) and adjusted rent-charge-related revenues (from their tenants) and paid to tenants through initial and upfront subsidy payments (Zwickl-Bernhard et al., 2022). A carbon tax would affect the supply side of the market, as a $75 to $100 per ton of carbon emissions would be placed on the producers of these emissions.

These options are measured based on their feasibility, cost, effectiveness, and equity. Running an educational campaign that informs NYC residents about the harmful effects of

greenhouse gas emissions and the need for immediate transition to lower emitting residential building systems, as well as educating the public on how to make this transition, was deemed to be the most optimal policy option. An educational campaign is expected to reach a wide, diverse audience across New York City at a relatively low cost of about $100 million. Other educational campaigns of a similar scale and/or topic even suggest that this recommended campaign would mobilize New Yorkers to invest in technologies that reduce their residential greenhouse gas emissions. The paper concludes by suggesting that the New York City Department of Buildings (DOB), Department of City Planning (DCP), Department of Environmental Protection (DEP), and the NYC Media Department work together to design and implement an educational campaign over the course of about a year. Other educational campaigns of a similar scale and/or topic suggest that this recommended campaign would mobilize New Yorkers to invest in technologies that reduce their residential greenhouse gas emissions, effectively bringing the city closer to net zero emissions.

# Introduction

**Introduction**

Residential buildings in New York City emit about 17 million tons of $CO_2$ equivalent per year (MacWhinney & Klagsbald, 2017). In both short- and long-term projections, building emissions remain the largest source of emissions in New York City (MacWhinney & Klagsbald, 2017). The state as a whole has been a leader in producing air pollution for the past 50 years; in 1970, NY released almost 285 million metric tons of energy-related $CO_2$, just behind Texas and California (U.S. Energy Information Administration, 2022). While this number decreased by almost 50% from 1970 to 2020, the still-abundant greenhouse gas (GHG) emissions in New York continues to threaten the health, safety, and sustainability of New York's citizens and environment (U.S. Energy Information Administration, 2022).

The resulting air pollution negatively impacts both the surrounding environment and the health of New Yorkers. Climate trends reveal that New York's average annual temperature has risen about 2.4°F since 1970, precipitation has increased, and sea levels have risen over a foot since 1900 (Department of Environmental Conservation, n.d.). New York City residents face a variety of growing health problems that stem from climate change, including increased heat stress, worsening respiratory conditions, increased risk of contracting food-, water-, and vector-borne diseases, increased severity of allergies, and increased risk of injury or death from more extreme weather events (Climate.ny.gov, 2021). Even more unsettling, about 16,000 people are either hospitalized or die every year from air pollution-related health conditions, making up 6% of the city's deaths (Kheirbek et al., n.d.; Air pollution and the health of New Yorkers: The impact of fine particles and ozone, 2011).

New York City is aiming to achieve a net zero carbon target by 2050 (NYC.gov, 2021). To meet this goal and lower building emissions, the city's current buildings need impactful structural changes. Enacted in 2019, Local Law 97 limits the amount of GHG emissions allowed from specific types of buildings. With these regulations, set to go in effect in 2024, the city is hoping to reduce carbon emissions from buildings by 40% in 2030, and 80% in 2050 (NYC.gov, n.d.). While this law supports the efforts of the city's emissions goals, concerns surrounding non-compliance, non-reporting, and who will carry the cost burdens all weaken the likelihood of securing a carbon-neutral city.

This paper will analyze different policy recommendations to guide NYC towards decarbonization of residential buildings; specifically, an educational campaign, public subsidies, and a carbon tax are all assessed based on their levels of feasibility, cost, effectiveness, and equity. The most optimal alternative, based on the listed criteria, will then be explored further to determine how it would be best implemented in New York City, considering any tradeoffs between the other policy options. The information from this research will support advocacy for the movement towards lower carbon levels in New York City by 2050.

## Problem Statement

In New York City, buildings release the largest amount of greenhouse gases; out of the various types of buildings in the city, residential buildings account for the greatest number of building-based emissions (New York City Council, n.d.; MacWhinney & Klagsbald, 2017). Air pollution, resulting from the overproduction of these GHG emissions, have serious negative externalities on both the state's environmental sustainability and residents' health and safety.

## Client Profile

*New York League of Conservation Voters*

The New York League of Conservation Voters (NYLCV) is a statewide environmental advocacy organization that evaluates elected officials' performance on environment-related issues, endorses candidates that have proven they care about the environment, and campaigns for policies and legislation that protect the environment (NYLCV.org, n.d.). This group supports the decarbonization of buildings to promote a healthier environment for citizens and a more sustainable future for New York City. While the goals and outcomes of decarbonization are clear, the pathways of achieving sustainable reductions in GHG are ambiguous. Thus, NYLCV is interested in understanding what policy options would best move NYC towards net zero carbon emissions by 2050.

# Background

**Historical Trends of Carbon Emissions**

*United States*

Since 1850, carbon emissions in the United States, and around the world, have generally increased, mainly due to industrialization and population growth (Friedrich & Damassa, 2014). Between the late 1800s and the early 2000s, the U.S. remained the top global emitter; in 2005, Asian countries, specifically China, overtook the U.S.'s lead and has become the largest GHG emitter in the world (Friedrich & Damassa, 2014). Additionally, in recent history, developing nations have, on average, emitted more greenhouse gases than industrialized nations.

The United States seen a steady and slight incline in the number of emissions produced over the past 50 years (U.S. Energy Information Administration, 2022). Figure 1 depicts this trend, and it shows how, while the country as a whole has not changed significantly in its emission levels, New York state has slowly declined its emissions. Still, New York state's emissions levels are consistently and significantly above the national average.

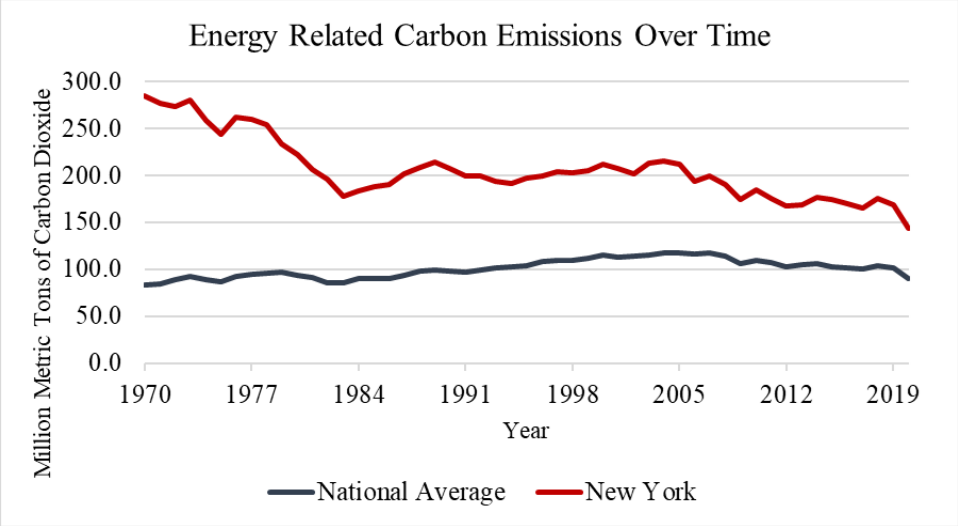


**Figure 1:** The graph shows the trends in energy related carbon emissions between 1970 and 2020. The state average shows a slight increase in emissions over time, although emissions levels have generally started to decrease since 2007. New York state has also seen a general decrease in emissions over the past 50 years, but their emissions levels remain greater than the national average (U.S. Energy Information Administration, 2022).

*Historical Impact of Emissions*

The main implication of abundant carbon emissions is climate change; global warming and climate change happens when greenhouse gas emissions are released into the atmosphere and trap the sun's heat (United Nations, n.d.). While the Earth's temperature has increased by at least 1.8°F since 1880, the majority of global warming has occurred since 1975 (Earth

Observatory, 2023). The world is starting to feel the effects of climate change, as the eight warmest years on record have occurred since 2014 (Fountain & Rojanasakul, 2023). As a result, there have been more frequent and severe weather events, including hotter temperatures, storms, and drought across the globe (United Nations, n.d.). The world is losing animal species at a rate one thousand times greater than any other recorded time in human history, and there has been a global rise in hunger, poor nutrition, health risks, and poverty, all stemming from climate change (United Nations, n.d.).

New York, specifically, has seen an annual temperature increase of about 2.4°F in the past 50 years, along with rising sea levels and precipitation rates (Department of Environmental Conservation, n.d.). Climate change from GHG emissions has negatively impacted New York City residents' health; over 15,000 people are either hospitalized or die each year in NYC from air pollution-related health conditions (Kheirbek et al., n.d.).

## Policy Jurisdiction

### *State Level*

The New York State Department of Environmental Conservation (DEC) was created in 1970 as a way to combine all state programs that aimed to protect the environment into one agency. The DEC's mission is to "conserve, improve and protect New York's natural resources and environment and to prevent, abate and control water, land and air pollution, in order to enhance the health, safety and welfare of the people of the state and their overall economic and social well-being" (Department of Environmental Conservation, n.d.[a]). Region 2 of the DEC is responsible for New York City, ensuring that this area follows environmental regulations and policies. The DEC recently announced over $3 million to support community-based projects that address environmental and public health concerns; almost $1.5 million of this grant will support projects in New York City (Department of Environmental Conservation, 2022).

New York's governor, Kathy Hochol, also recently announced $52 million in awards to assist in the establishment of 12 Regional Clean Energy Hubs; these centers will focus on outreach, awareness, and education across New York State regions to encourage residents' participation in the state's clean energy transition (Governor.ny.gov, 2022). New York City will receive over $19 million in funding through this grant to aid in the transition to energy efficient technologies and infrastructure, with about $8.9 million being invested in Brooklyn and the Bronx, $6.6 million in Staten Island and Queens, and $3.8 million in Manhattan.

### *City Level*

The New York City Department of Environmental Protection (DEP) "protects public health, critical quality of life issues, and the environment by supplying clean drinking water, collecting and treating wastewater, and reducing air, noise, and hazardous materials pollution." (NYC.gov, 2022). The DEP provides environmental services and support to New Yorkers, aiming to maximize economic, environmental, and social benefits (Department of Environmental

Protection, 2023). The New York City Department of Buildings (DOB) is another identifiable, relevant agency, responsible for enforcing and regulating the city's building codes and laws and providing safe and equitable access to building resources for residents (DOB - Buildings, 2023). The New York City Department of City Planning (DCP) is in charge of designing the city's physical and socioeconomic framework in ways that promote sustainable development, including ways that reduce emissions the city's infrastructure (Department - DCP, 2023).

Local Law 97 is part of the Climate Mobilization Act that was passed by the New York City Council in 2019 as part of former Mayor Bill de Blasio's New York City Green New Deal (NYC.gov, n.d.). This piece of legislation will require most buildings over 25,000 gross square feet to meet new energy efficiency standards and greenhouse gas emissions limits by 2024; these restrictions will become stricter again in 2030 (NYC.gov, n.d.). The emissions limits are determined by the property types set by the U.S. Environmental Protection Agency's Energy Star Portfolio Manager (ESPM) tool, which reveal the energy consumption patterns in New York City buildings (NYC Buildings, n.d.). Local Law 97 aims to reduce NYC building emissions by 40% by 2030 and 80% by 2050 (NYC.gov, n.d.). This law, one of the most ambitious for reducing carbon emissions, will start to be enforced in 2024, affecting large commercial and residential buildings, but typically not regulating changes for smaller or single-family residences.

## Current Costs

### *Costs of an Inefficient System*

Out of the city's 1 million buildings, over 48% received a failing Energy Star energy efficiency grade, per guidelines laid out by Local Law 97; this grade encapsulates a building's energy and water consumption, and greenhouse gas emissions (Buildings, n.d.; 48% of NYC buildings fail on energy efficiency, 2021; NYC Buildings, n.d.). The energy intensive buildings in NYC continue to be of great cost to residents. Electricity in New York produces the second largest share of greenhouse gas emissions, with about 11,000 megawatt-hours of electricity used each day (MacWhinney & Klagsbald, 2017; Cost of electricity in New York, 2022). It costs New Yorkers about $249 per megawatt-hours of electricity, bringing the city's total electricity bill to about $2,739,000 per day, calculated in Appendix A (Cost of electricity in New York, 2022; U.S. Bureau of Labor Statistics, 2022).

### *Dispersion of Costs Among Residents*

Of the residential buildings in New York City, low-income and minority communities face an inequitable share of air pollution and its effects (Nadeem, 2020). Older, poorly maintained residential buildings use the most energy for heating and cooling, compared to newer and better-managed housing that have stricter building and housing codes for greater insulation and reduced leakage to the outside of the building and in HVAC systems (Wogan, 2013). In fact, older residences can use up to twice as much energy per square foot as newer homes (Potter,

2022). Because older buildings have cheaper renting costs, lower-income residents generally must live in poorer-quality housing in NYC (Stef, 2017).

Asian, Black, and Hispanic groups in this city are the poorest demographics, with between 20-22% of each racial/ethnic group living in poverty in NYC (Poverty Tool, 2020). Because cheaper residences are usually the ones that emit more energy, these groups face the harshest health consequences of residential building-based emissions. Economic limitations hinder the capacity of poorer, minority groups to afford necessary changes and updates to their housing structures, highlighting the need for affordable and accessible remedies for outdated, energy-intensive residential buildings in New York City.

*Potential Cost Savings*

Upgrading buildings to reduce carbon emissions has long term cost-saving benefits, but the upfront cost can limit building owners' and residents' abilities to invest in these technologies. It costs about $175 per square foot to build a net zero residence; the average size of a residence in NYC is about 1,000 square feet, and with an estimated 3.25 million homes in the city, the total cost to upgrade all residential spaces to be net zero could be upwards of $570 billion, calculated in Appendix B (What is the Cost of Building a Net Zero Home?, 2022; Vora, 2022; United States Census, 2021). Less intimidating of a cost, it is estimated to cost between $205-300 billion to decarbonize New York City to a level that reaches its goals by 2050 (Hanley, 2021). A third of this money is proposed to be invested in the building and electricity sector (New York State Climate Action Council, 2021). While the upfront costs are a barrier to entry into investing in green infrastructure, this technology has serious economic benefits over time. In fact, green buildings can save up to 50% of energy expenditures and reduce maintenance costs by 12% (Rosenkranz, 2022).

**Comparing New York to Others**

New York has one of the largest carbon footprints in the world, largely stemming from New York City's emissions. The state emitted 143.4 million metric tons of energy-related $CO_2$ emissions in 2020, ranking ninth in greatest number of emissions statewide; Texas, California, Florida, Pennsylvania, Ohio, Louisiana, Illinois, and Indiana (in order from first to eighth) released more $CO_2$ emissions across their states in 2020 than New York (U.S. Energy Information Administration, 2022).

Specific to buildings, New York consumes and emits more pollution than any other state in the U.S. (Gruenwald & Mushegan, 2021). New York's residential sector emitted 31.5 million metric tons of energy-related $CO_2$ emissions in 2020, significantly greater than any other state; California was the runner-up in residential GHG emissions, releasing almost 5 million fewer tons than New York (U.S. Energy Information Administration, 2022). Figure 2 reveals that the residential sector in New York emits a considerably larger amount of $CO_2$ emissions than the national average, and this is consistent over the past 50 years (U.S. Energy Information

Administration, 2022). In New York City, buildings account for 73% of citywide emissions, almost twice as large as the national city average of 40% (Mayor's Office of Sustainability, n.d.).

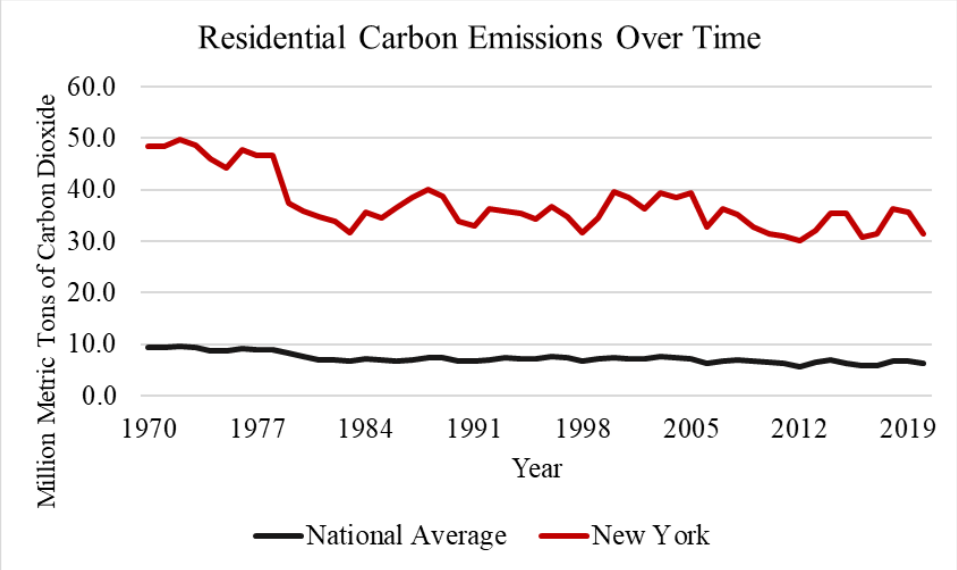


**Figure 2:** The graph shows the trends in carbon emissions in the residential sector between 1970 and 2020. The state average shows a slight decrease in residential emissions over time. New York has also seen a general, but noisy, decline in residential emissions over the past 50 years, but their emissions levels remain much greater than the national average (U.S. Energy Information Administration, 2022).

While other cities have explored ways in which they could reduce their carbon emissions, these efforts are at a smaller scale, compared to addressing New York's problem. For example, San Francisco found that, when implementing 34 building and transport efficiency technologies, they would be able to reach over 80% reduction in carbon emissions from 1990, by 2050 (Thayne et al., n.d.). However, because San Francisco releases fewer $CO_2$ emissions, it is possible that more would need to be done in New York City to reach the same target.

**Existing Technical Options**

Many emerging and established technologies and innovations have been proven to reduce building emissions, giving hope to solve NYC's problem. These options include home automation, electrification, using sustainable materials, and upgrading building envelopes and insulation, all of which can be employed to existing building infrastructure. This is important because it is estimated that over 90% of NYC buildings today will exist in 2050 (Mayor's Office of Sustainability, n.d.). An analysis of San Francisco demonstrated that, when implementing 34 building and transport efficiency technologies, the city would be able to reach over 80% reduction in carbon emissions from 1990, by 2050 (Thayne et al., n.d.). In terms of building

related technologies, the most impactful on carbon reduction were home automation, electrification, and building envelopes.

*Home Automation*

Home automation systems essentially automate technology systems, including power plugs, lights, thermostats, and humidity sensors (Asadullah & Raza, 2016). Figure 3 depicts how smart technologies can be used to automatically control the various electronic energy systems within a residence (Vigderman & Turner, 2022). The features of home automation systems save consumers energy on what was once wasted usage. It is estimated that families can save between 10-15% of their energy per year when automating their homes (How Can Home Automation Save Money?, 2021). New Yorkers pay about $0.25 per kWh, meaning that, with home automation, this number could drop to $0.21-0.23 per kWh (U.S. Bureau of Labor Statistics, 2022). This could have drastic effects for New York City, who uses about 11,000 megawatt-hours of electricity per day (Cost of electricity in New York, 2022). When applying home automation technologies to the modeling in San Francisco, it was found to be the most efficient in the buildings sector in terms of reducing carbon emissions; the analysis estimated that this method reduced overall annual $CO_2$eq emissions by 3.9%, compared to the business-as-usual 2050 projection (Thayne et al., n.d.).


**Figure 3:** Residents can use smart technologies, including smart phones, to control electronic devises remotely and automatically; this can reduce people's energy consumption and related costs to the consumer (Vigderman & Turner, 2022). Reprinted from Vigderman, A., & Turner, G. 2022. *What Is Home Automation and How Does It Work?*

While cities across the country have made incentives to add automation to new buildings, there currently is a lack of the same push to invest in existing buildings, a necessity for success in reducing energy consumption from buildings. With higher upfront costs, there is little motivation for building owners to invest in home automation systems. The costs vary greatly, averaging around $1,000-$2,000 per home, depending on the products and services that a consumer opts for (Basarir-Ozel et al., 2022).

*Electrification*

Electrification of housing technologies is considered to be another impactful avenue for reducing carbon emissions. This technical option, depicted in Figure 4, consists of converting more energy-intensive home appliances and systems, like those that are gas-powered, to run on electricity (Digitalized House, 2019). In multifamily residential buildings in NYC, heating

accounts for almost 75% of GHG emissions, revealing an influential area to address through electrification (Mayor's Office of Sustainability, n.d.). Again, from the San Francisco analysis, electric heating was deemed the single most impactful level for achieving carbon reduction goals by 2050; without transition to 80% electrification, the city would not reach their target (Thayne et al., n.d.). In New York City, Mayor Eric Adams recently announced a new plan to complete or convert 100 city schools to all-electric heating by 2023; this measure will cost the city $4 billion but expected to reduce greenhouse gas emissions by 120,000 tons per year and remove 20,000 pounds of harmful fine particulate matter from the air. From this, the city is expected to avoid about 100 respiratory incidents, save lives, and reduce hospitalizations (Our Progress, 2022).

However, at the residential-building level, New York State and City need more investments into electrification to reach decarbonization targets. Governor Hochul's budget proposal for FY2023, while it offers increased funding for a variety of environmental programs, does not increase funding for home electrification. As a result, the current funding assists about 25,000 homes in the state per year; to reach decarbonization goals, it is estimated that NY must increase funding by $1 billion per year to electrify at least 250,000 homes (St. John, 2022).

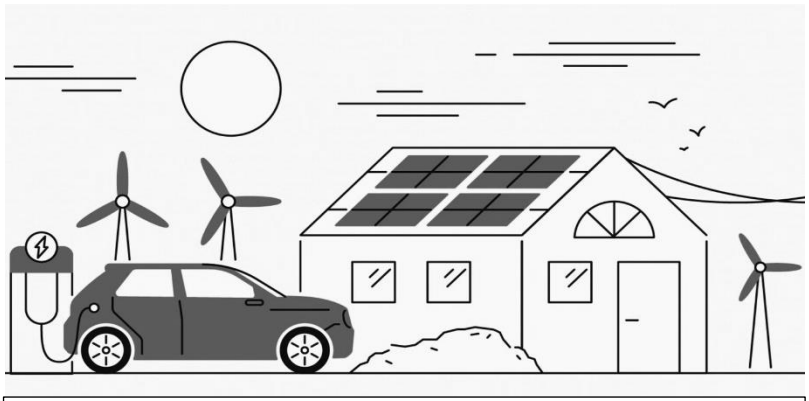

**Figure 4:** Residents can electrify their home through using cleaner energy, from installing solar panels, to investing in electric vehicles, to switching their gas appliances to electric, for example (Digitalized House, 2019). Reprinted from Digitalized Homes. 2019. *Infographic: How Home Electrification Benefits the Environment.*

*Building Envelopes*

Improving building envelopes is a third way NYC can act within existing residential buildings to reduce emissions. Building envelopes, depicted in Figure 5, are any separator between internal and external environments, such as walls, floors, roofs, and windows (Silverman CPM, 2016). By creating better insulation within these building envelopes, residential buildings are able to expel less energy and air pollution out into the surrounding environment. Methods to reduce heating and cooling loads include air sealing, heat recovery ventilation, and additional insulation (Urban Green Council, 2013).

An analysis of how NYC buildings can reduce their emissions assess that, through transitioning buildings to more energy efficient infrastructure over 35 years, the total cost for the whole city would be $94 billion. On the other hand, the buildings' energy savings from this transition would save $87 billion (Urban Green Council, 2013). Less direct outcomes would increase the benefits of this technical option, including improved residential health and environmental quality. Similar to the other technologies, the main challenge is encouraging investments into these clean energy technologies, which have higher upfront costs than traditional, carbon intensive infrastructure.

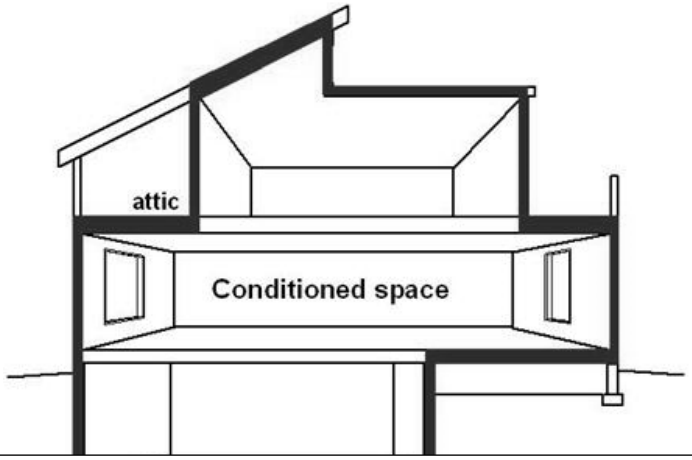


**Figure 5:** A building envelope, shown by the thick outline, is the physical separator between a building and the environment; this structure prevents outside elements from entering the inside of a building, as well as controls the indoor climate (Silverman CPM, 2016). Reprinted from Silverman CPM. 2016. *Construction Term of the Month: Building Envelope.*

## Criteria

While there are clear, existing technical options to reduce greenhouse gas emissions in residential buildings across New York City, there is a need for political action to encourage NYC residents to engage and invest in these technologies. Currently, the high upfront costs, credit constraints, and uncertainty of the economic benefits all deter residents from investing (Leung, 2018; De Haas et al., 2021; Davis et al., 2019). Therefore, different policy options (educational campaign, public subsidies, and a carbon tax) are assessed based on four criteria: feasibility, cost, effectiveness, and equity.

**Feasibility**

The NYLCV is a non-partisan organization that lobbies New York elected officials for possible policy measures to address environmental issues. Therefore, the political feasibility of these alternatives is imperative. The level of feasibility will be evaluated by analyzing past efforts to implement similar policies to the given alternative and their success given the political environment in that time. Comparing that to the current political environment in NYC and New York State, I will be able to determine how likely the alternatives will be to have widespread support.

*Ranking Rubric*

- High: New York City and/or state has designated specific funding towards the alternative; there are clearly defined agencies whose roles explicitly include planning, executing, and regulating the alternative; and/or the alternative is expected to gain majority support from NYC government officials and residents.

- Moderate: New York City and/or state has designated general funding towards the alternative; there are agencies that would likely plan, execute, and regulate the alternative; and/or the alternative is expected to gain slight support from NYC government officials and/or residents.

- Low: New York City and/or state has not designated funding towards the alternative; there are no agencies that would likely plan, execute, and regulate the alternative; and/or the alternative is expected to gain minimal/no support from NYC government officials and residents.

**Cost**

A general, widespread concern of transitioning to cleaner energy is the cost of these projects. Thus, evaluating the price tag of the alternatives will provide insight into the best option in economic terms. I will measure the cost of the policy options by estimating the costs of

similarly run and/or scaled options that have previously been implemented. Since much of the hesitation surrounding decarbonization stems from the costs to producers, consumers, and the government, this criterion is especially relevant.

*Ranking Rubric*

- High: the alternative is estimated to cost society (either producers, consumers, and/or the government) more than $10 billion.
- Moderate: the alternative is estimated to cost society (either producers, consumers, and/or the government) between $1 billion and $10 billion.
- Low: the alternative is estimated to cost society (either producers, consumers, and/or the government) less than $1 billion.

**Effectiveness**

The effectiveness of any policy option is imperative in assessing whether or not it is worth allocating resources for implementation. In other words, the likelihood of an alternative realistically being implemented within New York City will largely depend on how effective the option is. Since the alternatives aim to engage NYC residents to invest in energy-efficient residential technologies, the level of effectiveness will depend on the expected interaction with people and/or the level of greenhouse gas reduction.

*Ranking Rubric*

- High: a majority of NYC residents are expected to interact with or use the alternative, and/or lower the level of greenhouse gas emissions by at least 75%.
- Moderate: a slight majority of NYC residents are expected to interact with or use the alternative, and/or lower the level of greenhouse gas emissions by between 26-74%.
- Low: a minority of NYC residents are expected to interact with or use the alternative, and/or lower the level of greenhouse gas emissions by at most 25%.

**Equity**

The NYLCV prioritizes equitable options for environmental solutions. Therefore, I will measure the equity of each policy alternative by determining what NYC boroughs, and demographic and socioeconomic regions will face the most severe costs of each option, and/or how these sectors will each be impacted by the alternatives. By comparing what groups will face the majority of costs against what groups will face the majority of the beneficial outcomes, I will be able to determine how equitable each option is.

*Ranking Rubric*

- High: the alternative will spread the costs and benefits in a way that disadvantaged communities will face relatively smaller costs and equally as good benefits than more advantaged communities in NYC, and/or different demographic groups will have equally realistic access to the alternative.

- Moderate: the alternative will spread the costs and benefits in a way that disadvantaged communities will face similar costs and benefits to more advantaged communities, and/or some different demographic groups will have slightly more access to the alternative than others.

- Low: the alternative will spread the costs and benefits in a way that disadvantaged communities will face relatively greater costs and fewer benefits than more advantaged communities, and/or different demographic groups will have unequal access to the alternative.

# Alternatives

**Considerations**

Barriers to investment in green infrastructure stem from the high upfront costs that building owners and residents face, credit constraints that hinder larger-scale, more effective investments, and uncertainty in the economic benefits that energy efficient investments can provide (Leung, 2018; De Haas et al., 2021; Davis et al., 2019). This highlights the need for more available access to the development and advancement of residential buildings with respect to energy efficiency. As such, governmental action to tax carbon emissions, provide subsidies, and invest in educating the public could help lift the burden off building owners and residents, moving the city toward lower emissions and therefore a healthier, more sustainable city.

**Alternative 1: Run an Educational Campaign**

People tend to be skeptical of even viable technical options that provide future economic benefits, highlighting the potential need for education campaigns to inform the public about the reduction in energy costs resulting from transitioning to clean energy technologies. Ensuring the successful performance of the new technologies has proven to be more effective than simply reducing the upfront costs (Davis et al., 2019).

The proposed educational campaign would be similarly designed to the recent, comparably scaled NYC Vaccine For All Campaign (NYC.gov, 2020). Previous studies of other educational campaigns have proven to be most impactful when using different types of campaigns, such as TV ads, billboards, social media, etcetera (Peterson et al., 2008). Still, research has determined the single most cost-effective campaign platform to be social media (Kirtis & Karahan, 2011). Thus, running an education campaign will consist of creating and distributing informational media through a blend of platforms (e.g., billboards, posters, op-ed pieces, public press speeches, media advertisements), but with a focus on social media. An educational campaign would affect the demand side of the market, aimed towards NYC residents.

*Feasibility – Moderate*

New York's governor, Kathy Hochol, recently announced $52 million in awards to assist in the establishment of 12 Regional Clean Energy Hubs, signifying political support for focusing on on outreach, awareness, and education across New York State regions to encourage residents' participation in the state's clean energy transition (Governor.ny.gov, 2022). New York City specifically will receive over $19 million in funding through this grant to aid in the transition to energy efficient technologies and infrastructure, with about $8.9 million invested in Brooklyn and the Bronx, about $6.6 million invested in Staten Island and Queens, and about $3.8 million invested in Manhattan (Governor.ny.gov, 2022).

The New York City Department of Buildings, Department of City Planning, Department of Environmental Protection, and the NYC Media Department would likely be responsible for working together to generate and administer the campaign. The Department of Buildings has a $216.1 million budget, the Department of Environmental Protection has a $1.48 billion budget, and the Department of City Planning has a $45.3 million budget for FY2023, making an educational campaign likely feasible in the economic sense (New York City Council, 2023). While the NYC Media Department does not have a publicly specified budget, their goals are to, "...inform, educate, and entertain New Yorkers about the City's diverse people and neighborhoods, government, services, attractions and activities," making them a relevant contributor to this alternative (NYC Media, 2023).

Following the recent New York City, large-scale COVID-19 vaccination campaign, the city has the media infrastructure in place to run a similarly scaled campaign about investing in energy efficient residential technologies. Given that the city government supported the COVID-19 vaccination campaign in response to a threat to NYC residents' health, it is probable that government officials would be supportive of a similarly sized campaign that also aims to protect NYC's environment and public health. Additionally, a large majority of New York City residents believe that global warming is happening and is an issue, suggesting that there may be general public support to increase awareness about climate change in NYC (Leiserowitz et al., 2008). However, while there are limited available funds to support an educational campaign, it is unspecified exactly what agency or agencies will be responsible for formulating, executing, and managing the campaign, both financially and logistically. For these reasons, the feasibility of an educational campaign is ranked as moderate.

*Cost – Low*

An educational campaign, on average, takes about two months to plan, and it will run for one year (LaRose, 2020). While there is limited similarly scaled data on the costs of educational campaigns for investment in green technology, the cost estimates for this alternative is primarily based on the NYC Vaccine For All Campaign, which consisted of educating city residents to get the COVID-19 vaccination. The New York City health department budgeted more than $140 million for a COVID-19 ad campaign in the first year, primarily for the purpose of spreading information about vaccination (Krauth, 2021). Based on this estimate, it is assumed that about $100 million will be budgeted for a similarly scaled campaign. Thus, the cost of an educational campaign is ranked as low.

*Effectiveness – High*

Similarly sized, and similarly themed, educational projects have proven to be impactful in engaging citizens and encouraging positive behavior. Continuing with the NYC Vaccine For All Campaign, this program prevented an estimated 48,000 deaths, 300,000 hospitalizations, and 1.9 million cases since the start of the campaign in December 2020 (Lanza & Merlino, 2023). An analysis of the campaign concluded that it had an estimated return on investment of about $10.19

in cost savings for every $1 NYC invested in the vaccination campaign, stemming from the lower infection and mortality rates, lower productivity losses, and averted health care use (Sah et al., 2022).

An educational campaign, called the Click It or Ticket Program, was run in the state of Washington between 2002 and 2003 to encourage seat belt usage; an analysis of the program credited it with increasing seat belt usage by 12 percentage points, or 14%. (Salzberg & Moffat, 2004). Considering the costs of this program, it cost about $64,285 to increase good behavior by 1% (Salzberg & Moffat, 2004).

In Crete, Greece, a study measured the effect of changing school curriculum to educate teachers, students, and their parents on topics such as, "acquisition of energy and environment awareness, renewable energy familiarization, rational energy usage and viable mobility (means of transport)... energy-efficient measures at school, simple installations using renewables at school, energy audits and monitoring of energy consumption of the school, hands-on approaches, quantification of effects such as avoided greenhouse gas emissions" (Zografakis et al., 2008). This study determined that education about greenhouse gas emissions and energy efficiency significantly increased all measured energy-efficient behavior and decreased all energy-waste behavior (Zografakis et al., 2008).

From these analyses, it is expected that a large-scale educational campaign will engage a majority of NYC residents to learn about the importance of, and need for, transitioning to clean energy residential technologies. It likely will even mobilize residents to invest in these technologies. For these reasons, the effectiveness of an educational campaign is ranked as high.

*Equity – Moderate*

Well-resourced educational campaigns reach wide audiences by design, largely produced through smart technologies. In New York City, almost 80% of residents own a smartphone. The largest discrepancy in smartphone ownership relates to age, with those 45 and older being at least 25 percentage points less likely to own a smartphone, relative to younger age groups (Menin, 2015). There is not much difference between smartphone ownership between those with varying levels of income, so it is assumed that this educational campaign will reach a range of social, economic, and racial demographics.

Pre-COVID, the NYC Subway system saw almost 1.7 billion riderships (MTA, 2022). With campaign posters advertised in the subway cars, this is expected to reach a wide audience demographically. The campaign, by design, would have materials that differ in information depending on the borough/demographic it is targeting, for highest and most relevant impact.

With wide access to information through social media and public transportation that is used by a range of demographics, most New York City residents will have access to the information provided by an educational campaign. Information should also be targeted and framed to certain demographics in different ways to relay the most practical and relevant information. However, actually implementing lower energy intensive systems generally comes with high costs, especially in the absence of governmental subsidies or credits. Thus, there is a

risk that only wealthier residents will be able to act on this information. For these reasons, the equity of an educational campaign is ranked as moderate.

**Alternative 2: Provide Public Subsidies**

Although efficient technologies have lower long-term costs, the higher upfront costs act as a deterrent for many building owners, who are averse to debt, especially when doubled with uncertainty of cost-benefit information (Davis et al., 2019). Therefore, providing financial means for the public to invest in green energy seems necessary for significant uptake. Specifically, this alternative would affect both the supply and demand sides of the market; it would be paid to property owners through investment grants (from the government) and adjusted rent-charge-related revenues (increased rent or fees paid by their tenants), and paid to tenants through initial and upfront subsidy payments (Zwickl-Bernhard et al., 2022). When done properly, offering subsidies prove to be more welcomed and well-perceived than direct taxes on carbon outputs (ürge-Vorsatz et al., 2011).

Solar tax credits and subsidies are examples of how energy-related government incentives have spurred investment in clean energy, both nationally and within New York State. When interviewed, individuals claimed that the tax credit played an important role in their decision to invest in renewable energy (Gouchoe et al., 2002).

*Feasibility – Low*

The DEC recently announced over $3 million to support community-based projects that address environmental and public health concerns; almost $1.5 million of this grant will support projects in New York City (Department of Environmental Conservation, 2022). Currently, there 69 related programs in New York State, either as regulatory policies or financial incentives, to encourage residents to invest in energy efficiency; although, many of these programs do not sufficiently subsidize a full transition to clean energy (DSIRE, n.d.).

The city government has previously signified its need to help bring down the costs of energy efficiency improvements, including through working together with affordable housing agencies and local utilities (Mayor's Office of Sustainability, n.d.). That being said, there has been little action taken on the government's part to substantially reduce the cost of an energy efficient transition for NYC residents. With the recent COVID-19 pandemic, the city has shifted its spending priority to mitigate negative pandemic-related effects, pushing large spending on energy efficiency to the "back burner" (NYS State Comptroller, 2023). It seems unlikely for NYC to prioritize massive subsidies in their financial budget in the near future. For these reasons, the feasibility of providing public subsidies is ranked as low.

*Cost – High*

Research has shown that subsidies to both property owners and property renters are effective in transitioning residential spaces to be energy-efficient; however, these transitions are

only substantial with significant, “massive” subsidies (Zwickl-Bernhard et al., 2022). The California Solar Subsidy Initiative cost about $440 million in rebates for about 35,000 installations (Hughes & Podolefsky, 2015). With an estimated 3.25 million homes in the city, if even only half of the residences were to upgrade to energy efficient technologies, an initiative with similar structure would cost over $20 billion (United States Census, 2021). For these reasons, the cost of a public subsidy is ranked as high.

*Effectiveness – Moderate*

Assuming that a public subsidy is substantially and massively funded, this alternative has been estimated to have a high effectiveness in decarbonizing residential spaces (Zwickl-Bernhard et al., 2022). An analysis of the California Solar Subsidy Initiative, while costly, revealed that increasing rebates from $5,600 to $6,070 was predicted to increase installation by 10%; in fact, there was likely to be 53% fewer installations without a subsidy (Hughes & Podolefsky, 2015).

However, the effectiveness of a public subsidy largely depends on the scale of a subsidy; less funded subsidies do not have as great of an influence in encouraging people to transition to more energy efficient technologies (DSIRE, n.d.). Because the effectiveness is conditional on the size of a subsidy, the effectiveness of a public subsidy is ranked as moderate.

*Equity – High*

Contingent on correct set up and large-scale subsidies, researchers have found that this is an equitable way to transition to green technology in the residential sector (Zwickl-Bernhard et al., 2022). Specifically, when subsidies are paid to property owners from both the government and tenants as investment grants and rent-charge-related revenues and paid to tenants from the government as initial subsidy payments, a public subsidy is an equitable way to encourage a transition to energy efficient technologies (Zwickl-Bernhard et al., 2022). For these reasons, the equity of a public subsidy is ranked as high.

**Alternative 3: Enact a Carbon Tax**

A carbon tax is a carbon pricing tool in which the government sets a price per greenhouse gas emitted that polluters must pay (Center for Climate and Energy Solutions, 2022). A carbon tax can be implemented at any stage, so it would be important to consider at what point would be most effective in reducing emissions. For this alternative, a carbon tax would affect the supply side of the market, as a carbon tax would be placed on producers of carbon emissions.

In order to reach net zero emissions by 2050, climate economists have estimated that carbon should be taxed between $75-100 per ton emitted (Bhat, 2021). The money generated from a carbon tax could then be used to help fund energy efficiency projects in the residential building sector in NYC (Papadis & Tsatsaronis, 2020).

*Feasibility – Moderate*

The New York State Department of Taxation and Finance is responsible for regulating and collecting tax revenues in the state (Tax.ny.gov, 2023). Thus, this agency would likely be in charge of administering and regulating a carbon tax. There are expected to be complications with regulating measurements and compliance of carbon emitters, posing a difficulty in the feasibility of this alternative.

Among experts and the public, a carbon tax on large polluters is generally supported. 70% of climate economists agree that carbon should be taxed by at least \$70/ton $CO_2$ (Bhat, 2021). A Pew Research center survey found that, on the national level, 68% of Americans favor a carbon emissions tax for large corporations (Pew Research Center for the People & the Press, 2022). A more conservative estimate of American sentiment towards carbon taxes was revealed in a survey conducted by EPIC and The Associated Press-NORC Center for Public Affairs Research; in this survey, 49% of respondents were in favor of a carbon tax if the revenues are rebated to households (High, 2019).

While there is general modest public support for some sort of carbon pricing to reduce greenhouse gas emissions, increasing taxes as part of legislation is often difficult to pass and unfavorable from influential, energy-intensive businesses. The politics surrounding tax increases, especially ones that will affect large corporations, often prevent tax policy from being implemented. For these reasons, the feasibility of a carbon tax is ranked as moderate.

*Cost – High*

New York City residential buildings emit 17 million tons of $CO_2$ equivalent per year (MacWhinney & Klagsbald, 2017). Climate economists generally favor a carbon tax of between \$75-100 per ton of emissions (Bhat, 2021). Considering the amount of carbon emissions released every year in the city, a carbon tax is expected to cost between \$1.275-1.7 billion annually to suppliers. Given that a carbon tax would exist until at least 2050, this cost is expected to be huge. Thus, the cost of a carbon tax is ranked as high.

*Effectiveness – High*

A tax of \$100 per ton of GHG emissions is expected to reduce emissions across all buildings (both residential and non-residential) to net zero by 2050; because residential buildings make up the majority of total building emissions, a high-priced carbon tax would be completely effective in reducing GHG emissions in the residential sector (Bhat, 2021; MacWhinney & Klagsbald, 2017). A lower priced carbon tax would still effectively reduce carbon emissions, but not as drastically. For example, a \$50 per ton tax, increasing \$5 per year, could reduce emissions by 26-47%, relative to 2005 levels (Patnaik & Kennedy, 2021). Because a high-cost tax could effectively cut carbon emissions to net zero by 2050, meeting New York City's target, the effectiveness of a carbon tax is ranked as high.

*Equity – Low*

In theory, tax revenue could be used to retrain fossil fuel workers as a way to help vulnerable communities transition to clean energy (Patnaik & Kennedy, 2021). However, it often becomes complicated and unrealistic for governments to effectively facilitate a seamless transition of the workforce (Hamilton, 2017). Additionally, carbon taxes often impact poorer communities more than the rich, as prices rise to consumers; it often becomes complicated and impractical to compensate for the economic loss that poorer communities face (Islam, 2022). For these reasons, the equity of a carbon tax is ranked as low.

## Outcomes Matrix

| | Feasibility | Cost | Effectiveness | Equity |
|---|---|---|---|---|
| **Alternative 1:** Run an Educational Campaign | Moderate | Low | High | Moderate |
| **Alternative 2:** Provide Public Subsidies | Low | High | Moderate | High |
| **Alternative 3:** Enact a Carbon Tax | Moderate | High | High | Low |

The green boxes indicate that the ranking is the "best." The yellow boxes indicate that the ranking is the "middle," or "second best." The red boxes indicate that the ranking is the "worst." For example, Alternative 2 had a cost ranking of high; this box is in red because a high cost was the worst possible ranking option.

# Recommendation & Implementation

## Recommendation & Tradeoffs

In order to encourage the uptake of greener, less energy-intensive technologies in the residential building sector of New York City, I recommend ***Alternative 1***, implementing an educational campaign. The purpose of this campaign is to inform the city residents of the dangerous levels of greenhouse gases that residential buildings emit, and the need for a transition to lower emitting residential building systems. Additionally, it will educate the public about ways to realistically make this transition.

### *Tradeoffs*

When evaluating this alternative based on feasibility, cost, effectiveness, and equity, an educational campaign ranked the highest in comparison to providing subsidies and enacting a carbon tax. It did not rank as highly in equity as did providing public subsidies; while it is expected that a majority of NYC residents will come in contact with the educational campaign and have wide access to the information through social media and public transportation that is used by a range of demographics, this alternative does very little to directly lower the cost of investing in lower energy intensive systems. This highlights maybe the biggest concern to this policy option: there is a risk that only wealthy NYC residents will actually transition to clean energy systems in their residential buildings. However, the cost, feasibility, and effectiveness of an educational campaign outweighs the equity downfall, compared to the other policy alternatives. Still, implementing an educational campaign will come with issues and pushbacks, including who will oversee paying for and executing the campaign, how it will be perceived by the public, and the timeline of the campaign.

## Implementation

As previously stated, there are a few identifiable departments that will be responsible for implementing the campaign: New York City Department of Buildings (DOB), Department of City Planning (DCP), Department of Environmental Protection (DEP), and the NYC Media Department. The DOB is in charge of the city's building codes and laws, and of ensuring safe and equitable building resources (DOB - Buildings, 2023). The DCP directs the designs of NYC's physical and socioeconomic spaces in ways that promote sustainability (Department - DCP, 2023). The DEP is responsible for providing environmental services and support to state residents for economic, social, and environmental benefits (NYC.gov, 2022). The NYC Media Department manages the city's distribution network for information, education, and entertainment (NYC Media, 2023). The DOB, DCP, and DEP have a combined budget of almost $1.75 billion for FY2023, mainly coming from the DEP's budget (New York City Council, 2023). With adequate motivation and focus, it is likely that $100 million of this budget can be allocated to an educational campaign.

Because building emissions cover the areas of focus for all of these departments, they will all have to work together in the organization and implementation of this campaign. That being said, since the DEP has the largest budget for FY2023 of about $1.48 billion, they are expected to lead the operations that involve collecting and providing information and expertise about GDG emissions and clean energy transition in the residential building sector (New York City Council, 2023). About $100 million will be spent on this campaign; because previous studies have highlighted the impact of different types of campaigns for an educational campaign, a variety of campaign strategies will be used, including TV ads, billboards, and social media (Peterson et al., 2008). That being said, the most cost-effective campaign platform alone has been determined to be social media (Kirtis & Karahan, 2011). Thus, with a primary focus on social media advertisements, the NYC Media department will be in charge of producing and distributing the campaign, with the support and information provided by the other three departments.

Public perception of this educational campaign can be a determinant of the level of success of the educational campaign. Referencing a similar-sized educational campaign in NYC (the NYC Vaccine For All Campaign) that was recently run, there are ways to ensure an effective uptake and response to the campaign. This campaign was relatively extremely successful in encouraging people to act and get vaccinated, preventing an estimated 250,000 cases of COVID-19 (Gallahue & Lanza, 2023). This campaign was effective because of their prioritization of ensuring that, "…New Yorkers have the latest, and most accurate, information related to the facts about the vaccine itself, the progress and success of the program and all critical information needed regarding access to vaccination" (NYS Department of Health, 2020). Therefore, for this decarbonization campaign, there should be regular engagement between NYC residents and related experts from the Department of Buildings, Department of City Planning, and Department of Environmental Protection. This will instill public trust about the information being spread and allow the educational campaign to have input from the public (NYS Department of Health, 2020).

Using the lessons learned from the COVID-19 vaccination campaign will also allow for a successful implementation timeline of this educational campaign. The educational campaign should be designed through a series of steps and necessary parts (NYS Department of Health, 2020). First, a call center and website with FAQs should also be set up prior to the roll out of the campaign, to answer NYC residents' questions surrounding greenhouse gases and clean energy options for residential buildings. When designing the media campaign, user-friendly tools should be created for people to understand what energy transition options are available in their area/building, and steps to take to transition their residency to be more energy efficient. The variety of advertisements (including digital, social, print, and broadcast) should be targeted to different communities/regions to communicate positive messaging to a wide, diverse audience (NYS Department of Health, 2020). The Media department should work with the Department of Buildings, Department of City Planning, and Department of Environmental Protection to ensure accurate, clear information is being transmitted to the public, again before the roll out of the

campaign. This process may take two to three months, followed by six months to a year of roll out (LaRose, 2020).

Thankfully, with the recent COVID-19 vaccination campaign employed in New York City over the past two years, the city has existing infrastructure to support the widespread information campaign about reducing residential buildings' greenhouse gas emissions. While different departments will be responsible for providing information and supporting the campaign, this alternative can realistically be implemented in New York City.

## Conclusion

Greenhouse gas emissions from residential buildings are substantially affecting both New York City's environment and residents' health. The city has identified a goal of reaching a net zero carbon target by 2050, one that is likely to be unmet without immediate investment in green infrastructure (NYC.gov, 2021). While there are many effective technical solutions to reduce carbon emissions in residential buildings, there is a disconnect between the need for these options and actually implementing these options. Thus, policy options are necessary to either encourage the uptake of energy efficient technologies, and/or discourage producers from over-emitting greenhouse gases.

Out of three policy alternatives (running an educational campaign, providing public subsidies, and enacting a carbon tax), running an educational campaign in New York City to inform residents about the need for investing in green technologies and ways to realistically do so has proven to be the most optimal, in terms of feasibility, cost, effectiveness, and equity. Relevant New York City departments are advised to work together to formulate and execute a large-scale campaign. In doing so, it is expected that the city will see a significant rise in engagement, awareness, and even investment, in steps towards decarbonizing New York City residential buildings.

# Appendix

**Appendix A: Estimated Electricity Cost Per Day for New York City**

- New York produced about 11,000 megawatt-hours of electricity (MacWhinney & Klagsbald, 2017).
- It costs about $249 per megawatt-hours of electricity in New York (Cost of electricity in New York, 2022; U.S. Bureau of Labor Statistics, 2022).

*Calculations:*
(11,000 megawatt-hours) x ($249/day / megawatt-hours) = $2,739,000/day

**Appendix B: Estimated Cost to Update New York City Residential Spaces to be Net Zero Emissions**

- It costs about $175 per square foot to build a net zero residence (What is the Cost of Building a Net Zero Home?, 2022).
- The average size of a residence in NYC is about 1,000 square feet (Vora, 2022).
- There are an estimated 3.25 million residential homes in NYC (United States Census, 2021).

*Calculations:*
($175 / square foot) x (1,000 square foot / home) x (3,250,000 homes) = $568,750,000,000

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# Thank you.