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Sustainable Urban Planning: Turning the Concrete Jungle into Green Buildings

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Abstract

This paper addresses the issue of greenhouse gas emissions – particularly those from buildings – within New York City and discusses ways to construct new sustainable buildings and retrofit existing buildings to both minimize greenhouse gas emissions as well as act as carbon sinks to absorb some of the emissions. Reducing overall greenhouse gas emissions is critical to NYC meeting its climate target goals, as detailed in the mayoral administrations' PlaNYC and *OneNYC* environmental plans. This paper analyzes sustainable architecture and construction and presents various options and policies as to how to turn the city into a green city through the use of sustainable and regenerative buildings. Chapter 1 discusses quantifiable data of greenhouse gas emissions in New York City, with a focus on building and residential emissions, drawn from the GHG report by the Mayor's Office of Sustainability, and details how these emissions are harmful, both to public health as well as to ecosystem services. Chapter 2 studies the history of sustainable architecture, spanning from prehistoric times, ancient cultures, and pre-Industrial Revolution, to where we are now, as well as the architectural history of NYC. Chapter 3 explores the various forms of sustainable construction and the retrofitting of existing buildings that can be implemented in urban planning in order to lower greenhouse gas emissions. Chapter 4 examines current city policies relating to GHG emissions, particularly those that stem from buildings, as well as sustainable affordable housing. Finally, Chapter 5 draws upon the previous chapters to establish specific policy recommendations regarding sustainable buildings that can be implemented in New York City in order to reduce greenhouse gas emissions and help the city to reach its targeted climate goals.

Keywords: greenhouse gas emissions, climate change, New York City, sustainable architecture, mass timber, environmental economics, environmental policies, urban planning

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Introduction: A Green City Success Story

Although the human race has not always lived in a society where buildings were commonplace or even necessary, they are now an integral part of our society. Each building represents someone's home, school, religion, or workplace. Yet these buildings that we spend the vast majority of our life inside of are partially responsible for the issues of climate change that we are facing and which are increasing every day. In 2015, buildings were the fourth highest emitting sector of greenhouse gas (GHG) emissions in the U.S in terms of both direct and indirect emissions, generating 8.6 percent and 29 percent of the total U.S. GHG emissions, respectively (Leung 2018). As population continues to increase, thus increasing the number of households and building use, as well as the effects of global warming causing people to use more air conditioning inside their buildings to stay cool, direct emissions in the commercial building sector are projected to increase by 20.4 percent by 2050 (Leung 2018). This is even with the projected increase in energy-efficient HVAC and lighting systems. As GHG emissions are directly responsible for certain aspects of climate change – such as global warming and extreme weather events – by trapping heat close to the surface of the Earth, and can contribute to air pollution, it is vital that we curb the increases in these emissions as well as attempt to mitigate some of the emissions that have already been released. In order to slow and lessen the effects of GHG emissions on climate change, attention must be paid to the building sector nationwide, particularly in big cities, to retrofit buildings so they are more energy efficient as well as implementing sustainable kinds of construction for new buildings.

The city of Chicago has already made large strides towards reducing their building-related GHG emissions and serves as an example for other cities in the U.S. In 2018, Chicago had the greatest percentage of green office buildings in the U.S., with almost 70 percent of its office buildings green-certified (Holbrook 2018). Chicago's residential, commercial, and manufacturing buildings account for about 70 percent of the city's greenhouse emissions. Between 2005 and 2015, the sector cut its greenhouse gas emissions by about 10% (Holbrook 2018). This landmark GHG emissions reduction is the result of actionable governmental plans and policies, such as the mayor's Chicago Climate Action Plan, with goals to reduce Chicago's GHG emissions by 80% from 1990 to 2050 (City of Chicago 2017). Between 2010 and 2015, they had cut city emissions by 7 percent, which was mostly due to the large decrease in GHG emissions from the building sector (Zullo 2017). The success of Chicago demonstrates that it is possible to reduce GHG emissions from buildings, which thus decreases overall citywide GHG emissions, and places it at the forefront for green building initiatives in the U.S. Now it is time for all cities to follow its lead.

Similar to Chicago, New York City's buildings account for 65.37 percent of its total greenhouse gas emissions. As New York City is a much more populated city, it generates almost 20 million more metric tons of GHG emissions per year than Chicago does. This means it is incredibly important that New York City begins to follow the lead of Chicago and reduce its building-related GHG emissions in order to slow and mitigate the effects of global warming and climate change. In this paper, I will examine ways to minimize and absorb GHG emissions in NYC through the use of sustainable and retrofitted buildings. In Chapter 1, I will use quantitative data to explain the harm that NYC's GHG emissions face both to the public health as well to ecosystem services, the environment, and climate change. In Chapter 2, I will discuss the history of sustainable architecture over time as well as the history of New York City's architecture. In Chapter 3, I will explore different ways to construct sustainable buildings as well as ways to retrofit existing buildings to lower and mitigate GHG emissions. In Chapter 4, I will examine the existing policies of New York City regarding the reduction of GHG emissions, particularly those with respect to building-related emissions, and the economic aspect behind them. Finally, in Chapter 5, I will present new policies to reduce greenhouse gas emissions in the building sector so that the city can achieve its targeted climate goals.

Chapter 1. Greenhouse Gas Emissions in NYC Buildings

As greenhouse gas emissions contribute to both air pollution as well as to climate change, they are affecting natural ecosystems and thus ecosystem services, which are the benefits that ecosystems provide to people and all living organisms. The Millennium Ecosystem Assessment (MA) provides an analysis of the four categories of ecosystem services: provisioning, regulating, cultural, and supporting. These four categories respectively include things such as food and water, the regulation of air and water quality, spiritual and aesthetic value, and habitats (Millennium Ecosystem Assessment 2005). Humans and ecosystems are directly linked, as human well-being is dependent upon these ecosystem services and yet human actions also contribute to changes in ecosystems and thus the services that they provide back to humans. Therefore, it is necessary that we protect our ecosystems and mitigate our impacts on them, both for the benefit of the natural world as well as our own.

In order to truly understand the way that ecosystem services interact with human well-being, it is best to have a clear definition of both of these. The MA defines human well-being as including the basic material for a good life (similar to the physiological needs of Maslow's Hierarchy of Needs), health, good social relations, security, and freedom of choice and action (Millennium Ecosystem Assessment 2005, v). The four categories of ecosystem services include countless different aspects of the environment that support human health. The category of regulating services is the most directly relevant to human well-being and has the strongest link, according to the MA. Climate regulation, flood regulation, and disease regulation all greatly impact human's health and their ability to have a good life, as these can affect human health as well as their access to food and shelter (Millennium Ecosystem Assessment 2005, vi). The provisioning category, which includes services like fresh water, is also directly linked to human well-being as it has the potential to harm human health. While human well-being in general does not rely strongly on the cultural category, this is still important as well in regards to good social relations, an important aspect of human well-being (Millennium Ecosystem Assessment 2005, vi). Cultural services can also be extremely important to certain ethnic groups, such as Native Americans, who place more value into the spiritual aspect of the environment. Many of the constituents of well-being can also be mediated by socioeconomic factors, which leaves lower-income people and countries more greatly affected by the degradation of ecosystem services, which will be discussed later in the chapter.

Greenhouse gas emissions play a dangerous role in the impact that we have on ecosystems and thus our own well-being. Although they ultimately affect at least some aspect of all four of the categories in the MA, they have the most significant influence on regulating services as they impact nutrient cycling by overloading the carbon cycle. Since the Industrial Revolution, anthropogenic GHG emissions have been increasing and the rate of their yearly increase has also been increasing since 2000. Although greenhouse gases naturally exist on Earth and in its atmosphere, humans have contributed to an influx of greenhouse gas emissions primarily through the burning of fossil fuels for energy and production. Humans have also caused massive amounts of deforestation to make room for more buildings or cities, as well as for lumber and timber. Since trees absorb carbon dioxide, which is one of the greenhouse gases, the rate of deforestation means that there are less trees to absorb carbon dioxide.

With these two issues combined, human activity has overloaded the atmosphere with carbon dioxide – and other greenhouse gas emissions – as we are releasing them at too fast a speed than can be cycled back into biomass the way that it should be. This has caused the greenhouse effect – in which gases trap heat in Earth's atmosphere instead of allowing it to escape – to accelerate. While the greenhouse effect is a naturally occurring process, and is one of the things that contributes to Earth's warm temperature that allows humans to survive on the planet, the additional greenhouse gases in the atmosphere from anthropogenic causes are trapping too much heat in the atmosphere and reflecting it back at Earth. This is gradually warming the surface of Earth and thus raising the global temperature, which is one of the factors of climate change. The IPCC's "Summary for Policymakers", which details the way that humans have been the driving force behind climate change and suggests ways to mitigate it, strongly estimates that more than half of the increase in global temperature between 1951 and 2010 was due to anthropogenic increases in GHG emissions (IPCC 2014, 48). Besides the most obvious effect of the Earth's temperature increasing, global warming has many harmful effects on both ecosystems and their services as well as human health and well-being.

Greenhouse gas emissions contribute to the decline of one of the most important ecosystem services, climate regulation. This can occur on a global, regional, or local level (although this paper focuses mostly on the local level in NYC). As discussed above, GHG emissions contribute to a decline in climate regulation through the greenhouse effect, as the gases trap heat in Earth's atmosphere, thus warming the Earth. This is especially prominent in NYC due to the Urban Heat Island (UHI) effect. This effect, which causes urban areas to be warmer than surrounding rural areas, stems from the replacement of natural land with buildings and pavement, which absorb and retain heat, thus trapping the heat inside the city and increasing the city's temperature. As this is especially noticeable during the heat of the summer, this often leads to people using greater amounts of air conditioning, which is one of the factors that contributes to building-related GHG emissions. The UHI effect contributes to extreme high temperatures during the summer, which can lead to heat-related illnesses or deaths. In NYC, over 100 people die each year from causes related to extreme heat; the high temperature and frequency of extreme heat days will only continue to increase (NYC Mayor's Office of Resiliency 2020, 11). This demonstrates one of the ways that human well-being is directly related to ecosystem services, as well as the way that we are a driver in environmental change and our own health detriments.

Climate regulation has a high ecological importance, as it directly enables other ecosystem services, such as provisioning services of production and abundance of food and water (Petrovic, Vale, and Zari 2017, 16). As the U.S. National Climate Assessment found, the rising temperatures that are caused by GHG emissions and the greenhouse effect have led to droughts, declines in surface water, and changes in the amount and timing of precipitation ("Fourth National Climate Assessment" 2018). The issues listed above all contribute to the degradation of another ecosystem service – food production. The agricultural system for which we rely on for the majority of our food is greatly affected by climate change. The increase of droughts and extreme heat events will harm crop yields, as they are hard pressed to withstand extreme climatic variability (Kurukulasuriya and Rosenthal 2003, 9). A decrease in crop yields could cause food shortages all around the world, particularly affecting those who are already impoverished or are close to the poverty line. The increase in global temperature associated with the greenhouse effect from GHG emission will also harm crop yields (Kurukulasuriya and Rosenthal 2003, 22). This is due to several reasons. The first is that higher temperatures mean that the crops would likely need more water to survive, yet higher temperatures would co-exist with water shortages due to decreased precipitation as well as greater surface water evaporation. Second, some crops are unable to withstand the higher temperatures and would simply not be able to grow as well under these conditions. Multiple studies, such as Luo and Lin (1999), have found that crop growth in tropical countries and grains such as rice would be the most affected by the increase in temperature (Kurukulasuriya and Rosenthal 2003, 22). As food is a necessity for human health, GHG emissions which contribute to the degradation of ecosystem services are directly harmful to our well-being.

Warming temperatures from a decrease in climate regulation also contribute to a decrease in biodiversity and an increase in pest and disease outbreaks (Millennium Ecosystem Assessment 2005, 17). The Millennium Ecosystem Assessment states that one of the aspects of human well-being is health, which is directly affected by an increase in the emergence of epidemics, which in turn is caused by a decrease in climate regulation due to an increase in GHG emissions. Another aspect of a decrease in climate regulation is the increase in extreme weather events and climate phenomena. Precipitation rates, hurricanes, and storm intensity will likely increase, which can cause deaths or injuries for humans in these storms. This will be especially felt by people who live on coasts, such as those in New York City, who are already impacted by hurricanes. Extreme climate events can also impact food production and contribute to food shortages and food insecurity as discussed above, which has negative implications for human health and nutrition, particularly for those who are lower-income and already face food insecurity. As climate regulation is directly linked to many different ecosystem services and thus benefits to human well-being, attempts must be made in order to design built environments to better regulate climate by lessening their GHG emissions as well as acting as a source of carbon sequestration.

To respond to climate change and global warming, the IPCC sets forth two distinct pathways – climate change adaptation and climate change mitigation. Adaptation is merely adjusting to climate change and its effects and working towards avoiding harm caused by it (IPCC 2014, 76). This can include things such as strengthening or building sea walls to combat rising sea levels or establishing cooling centers in cities for when heat waves hit (Simmons 2019, 1). Mitigation refers to the process of limiting future climate change by either reducing GHG emissions or establishing GHG sinks (IPCC 2014, 76). While adaptation is beneficial to human well-being, as it might reduce some of the impacts that climate change has on the current human population, it is not enough in the face of ever-increasing GHG emissions and global warming. Countries and cities all over the world must work to increase their mitigation efforts in order to prevent even more irreversible damage from occurring from GHG emissions. This requires large-scale efforts and changes in energy use, forms of energy, and the built environment. In line with this, in Chapter 3 I will present ways to design new buildings and retrofit old buildings in NYC to lessen and mitigate GHG emissions and their effects.

Unfortunately, the degradation of ecosystem services disproportionately affects low-income groups and people of color, particularly those in less-developed countries (LDCs). They will be the most impacted by agricultural food shortages, as several LDCs are already experiencing food insecurity, which will only be exacerbated by the decrease in crop yields caused by climate change and GHG emissions. The people in these countries will also be the most harmed by the emergence of new pests and epidemics. One reason for this is because the climate conditions in many of these countries, such as those in Africa, already lead to greater transmission of vector-borne diseases such as malaria (Wilcox et al. 2019). As temperatures and droughts increase, there will be a higher chance of new epidemics developing in these countries and the warmer temperatures will make it easier for the pathogens to spread. Another reason is that LDCs are less equipped to handle epidemics once they occur. This was made clear during the COVID-19 pandemic, as they have fewer medical resources to help those who are deathly ill as well as lacking access to vaccines. Thus, while it is vital to stop the degradation of ecosystem services for many reasons, it is especially necessary in order to try and prevent countries in the GlobalSouth from shouldering more of the burden of the consequences that the GlobalNorth caused, as the North is vastly more responsible for GHG emissions and thus the climate change that has contributed to these issues.

New York City. It is especially important that urban planning in NYC is updated given the quantifiable data on the GHG emissions that the city produces. In 2016, NYC released 52.0 million metric tons of carbon dioxide equivalent (MTCO2e). Residential and commercial buildings accounted for 66% of the total GHG emissions in the city (The City of New York 2017, 4). Of the GHG emissions generated by buildings, the main contributors by far are natural gas combustion and use of electricity, which are responsible for 47 percent and 37 percent of building-based emissions, respectively (The City of New York 2017, 5). As discussed above, GHG emissions are extremely detrimental to ecosystems and human well-being and contribute to global warming. The New York City Panel on Climate Change (NPCC) projected that the regional mean annual temperature would rise by 4.1 to 6.6°F by 2050 (NYC Mayor's Office of Resiliency 2020, 6). With this increase would come issues with ecosystem services, as discussed earlier.

New York City and its people would feel some of these issues more prominently than parts of the US and the world due to its location and urbanization. As NYC is on the coast, regardless of climate change and rising sea levels, NYC is already at risk for coastal flooding, and 400,000 people live within the floodplain (Garner et al. 2017, 11861). However, GHG emissions and their impact on global warming are increasing NYC's flood risk due to rising sea level. This occurs partly because the rising global temperatures melt glaciers and ice sheets, which adds more water to the ocean, and partly because of thermal expansion, which is when the volume of the ocean increases due to the higher atmospheric temperatures. Rising sea levels will mean that flood heights will be greater and storm surges will reach further inland (Garner et al. 2017, 11863). Hurricane Sandy led to 44 deaths and $50 billion dollars of damages in NYC, as well as displacing thousands of New Yorkers from their homes (Garner et al. 2017, 11861). Future floods and hurricanes will likely cause more damage, deaths, and losses to New Yorkers due to the decrease in climate regulation and its effect on sea level.

GHG emissions in New York City also affect air quality, which is one of the regulating ecosystem services. This occurs for several reasons. The first is that rising global temperatures caused by GHG emissions lead to droughts and thus an increase in wildfires. While NYC is not particularly wildfire prone due to its urbanization, wildfire smoke can be carried thousands of miles from California or Colorado, bringing with it harmful particulate matter and air pollutants. There were several days over the summer of 2021 where the air quality in NYC was listed as unhealthy due to wildfires across the country. While this can be problematic for everyone, it greatly affects those with asthma or other respiratory conditions, leading to hospitalization or death for these New Yorkers (EPA 2017, 1). Warming temperatures are also associated with greater instances of warm stagnant air, which increases the formation of ground-level ozone, a harmful air pollutant (EPA 2017, 1). This is again more harmful to those with asthma or respiratory issues, although it can also damage lung tissue in otherwise healthy individuals. This is a problem in NYC as the Urban Heat Island effect, as discussed above, also contributes to warm, stagnant air within the city, which increases the number of days with poor air quality in NYC as compared to more rural areas. Reduction in air quality regulation due to GHG emissions especially affects children in New York City, as the citywide average for child hospitalization rates for asthma is twice that of the national average (Sze 2007, 98). Minority and low-income children will be even more disproportionately affected, as the South Bronx and Harlem (two communities consisting of primarily low-income and minority people) have child asthma hospitalization rates that are more than two and five times higher, respectively, than the city average (Sze 2007, 98). With the decrease in air quality, these hospitalization rates might increase. This demonstrates the way that GHG emissions affect the regulation of certain ecosystem services, thus harming human well-being.

In light of the high GHG emissions currently being released from the city's buildings, as well as the effects that they have on the city's people, the current and previous NYC mayoral administrations have released three plans that both respond to these issues as well as detail ways to combat the rising problems. The purpose of two of the reports, *OneNYC* and *PlaNYC,* is to provide quantifiable data of the city's GHG emissions, including those that stem from buildings, steps to reduce them, and the city's climate goal, which is to reduce GHG emissions by over 30% from 1990 levels (The City of New York 2014, 6). The third report, the *Climate Resiliency Design Guidelines,* sets forth methods of climate adaptation to lessen the effects of climate change on the current population of NYC. All three of these reports and their policies and recommendations will be discussed in further detail in Chapters 4 and 5, although this paper will focus mainly on the city's efforts regarding climate change mitigation. So far, these plans have been partially successful as, in April of 2019, the city had reduced its GHG emissions by 17% below 2005 levels (The City of New York 2019, 10). Yet, in order to truly mitigate the effects of GHG emissions on the environment, ecosystem services, global warming, and human well-being, GHG emissions in NYC must be reduced even further and more initiatives regarding sustainable, energy-efficient, and regenerative buildings must be implemented.

Chapter 2. Sustainable Architecture Through the Centuries

In order to reduce the quantity of greenhouse gas emissions in New York City, as well as to mitigate their effects on global warming, ecosystems and their services, and human well-being, it is necessary to establish sustainable architecture and buildings in New York City. Although New York City does have some sustainable architecture and eco-friendly buildings within its city limits, the average NYC building boasts more of pollution and GHG emissions than green-certification. Thus, in order to present feasible and environmentally-friendly recommendations for future urban planning, it first requires an examination of the history of the different kinds of sustainable architecture, dating back to ancient times.

Historic Sustainable Architecture. As so much of the pollution and GHG emissions that are related to buildings stem from the construction process and the very materials used to construct the building, the most basic form of sustainable architecture requires using materials drawn solely from the Earth. This used to be the only way to construct buildings. In the very beginnings of human history, most of our ancestors were cave-dwellers. This was an entirely sustainable practice, as they did not use any of the Earth's limited natural resources. The caves are naturally insulated, which serves to both maintain and regulate the temperature inside, as well as to act as a form of soundproofing from outside sounds (Yildiz 2015, 29). Their underground nature also provides protection from natural disasters for both the people as well as the dwelling, as many of the caves and rock formations from ancient cultures have survived for millions of years (Yildiz 2015, 34). Caves are also efficient in their land-use, leaving land for agriculture or natural resources, as they do not occupy any land above-ground (Earthwatch Institute 2006).

As civilizations and the human race evolved, cave dwellers ventured out of their caves and began to use more tools to construct their homes, although they still relied on Earth's natural resources and remained connected with nature. Ancient cultures made bricks out of mud, water, and straw. They then molded them and set them out to dry, originally in the sun but, as civilizations advanced, some cultures began to dry their mud-bricks in a kiln instead, which is now referred to as adobe brick (Sowinski 2017, 10). One of the earliest examples of sun-dried mud bricks is from 8000 BC in the city of Jericho, while long withstanding examples of this construction can be seen in the Great Wall of China (from around 2600 BC) and the Alhambra in Spain (1238-1358 AD) (Sowinski 2017, 10). Mud bricks are sustainable for several key reasons. The first is that they use only the Earth's natural materials, which means that there is no pollution involved in the production process, unlike the production of steel and concrete for today's buildings. In fact, a case study of traditional adobe buildings in Cyprus found that they have a net zero carbon footprint (Obafemi and Kurt 2016, 38). The second is that mud-brick walls act as a natural insulator due to their thickness, which increases their thermal mass, thus reducing the need for supplemental heating and cooling (Sowinski 2017, 12). As the heating and cooling of buildings is responsible for a large portion of their GHG emissions, building materials and forms of construction which reduce the need for supplemental heating and cooling therefore lower GHG emissions from buildings. From sundried mud-bricks and kiln-dried clay came terra-cotta, another form of the latter, first used in 10,000 BC in China (Sowinwski 2017, 13) While terra-cotta is typically not used for structural and main components of building construction, it can be used for other aspects such as drainpipes and roofs. Mud-bricks and terra-cotta can both be recycled when they are no longer in working use and can be turned back into terra-cotta or a different form of mud-bricks in order to reduce waste, another sustainable practice.

Following in both degree of sustainability as well as human's chronological use of building materials, is wood. Wood building advanced majorly during the Neolithic period and became especially prominent in Europe during the medieval period, accounting for many barns and monasteries in Europe (Sowinski 2017, 14). In China, during the Han Dynasty of 206-220 BC, the Chinese used a joining technique in their wood buildings where they connected columns by notching wood instead of using nails or screws to hold the boards together (Sowinski 2017, 20). This meant that the buildings could easily be disassembled and the wood used elsewhere, which again reduces waste, as well as reducing the amount of natural resources consumed. In the medieval period, wood buildings in Europe were typically constructed from heavy-timber hardwoods, such as oak, which were cut down and shaped into boards and columns that were laid as the frames of buildings (Sowinski 2017, 15).

As wood is a natural resource, it again does not produce much in terms of pollution during production. Wood, even that which is no longer a part of a living tree, also acts as a carbon sequester, meaning that it absorbs carbon from the atmosphere as opposed to releasing it, which is especially helpful in reducing already-released GHG emissions and mitigating their effect on global warming. However, it is important to note here that, while wood is a sustainable building material and a theoretically renewable resource, humans must be careful with their use of wood for architecture. As discussed in Chapter 1, deforestation of forests leads to less carbon dioxide being absorbed from the atmosphere, contributing to the acceleration of the greenhouse effect. This deforestation was largely due to the want of wood for building materials, as well as for the burning of wood for energy, which is often seen as a cleaner energy source than fossil fuels. Yet the burning of wood also releases greenhouse gas emissions and air pollution. Thus, although wood can be and has been used as a sustainable building material, its use must be carefully monitored so as to not cause more harm than good.

Aside from building materials, the construction design of buildings throughout the course of history also contributed to their sustainability. Ancient techniques involving passive designs for heating and cooling buildings involved none of the machinery, electricity, natural gas, and coal that we use today which are so detrimental to the environment. One technique was called a wind catcher, used commonly in Egyptian architecture in 1300 BC (Sowinski 2017, 28). The wind catcher would be on the roof of a building and would funnel the wind throughout the building to naturally cool it. Nowadays, a similar kind of cooling practice could be implemented through cross-ventilation with strategically placed open windows inside the building. Civilizations such as the Ancient Greeks also used to design their cities and buildings so that buildings were oriented in an east-west direction so that the light of the sun could heat the buildings naturally (Sowinski 2017, 32). Another heating technique from ancient cultures is the clerestory window, which was located near the ceiling of the building and captured the sun's light to heat the building (Sowinski 2017, 35).

Modern History. In the following centuries, particularly in Western and developed countries, there was a trend away from the sustainable building materials and practices discussed above towards materials like concrete and steel that are used most often today, which contribute to large amounts of pollution and GHG emissions through their production, construction, and inefficient building designs. These ancient sustainable practices were also mostly not out of a concern for the environment but rather a necessity to have shelter and regulate the climate of their dwellings. The modern green architecture movement developed mostly in the 20th century, with proponents such as Frank Lloyd Wright and LeCorbusier, and grew stronger with the advent of the environmental movement in the 1960s and 70s. The goal of sustainable architecture was to enhance the efficiency of energy and materials of buildings in order to minimize the negative impact that they have on the environment (Tabb and Deviren 2013, 13). The greening process of architecture followed similar viewpoints to the environmentalists. A conservationist view involved restoration, upgrades, and rehabilitation to buildings to both keep their historical features and prominence as well as upgrade them to higher environmental and energy-efficient standards (Tabb and Deviren 2013, 80).

In the 1980s, during the Postmodern period, green architecture saw contemporary buildings drawing from ancient residential architecture by incorporating natural ventilation and daylight to provide heating and cooling as well as climate-responsive architectural forms and materials, such as dome houses and shaded courtyards (Tabb and Deviren 2013, 82). Following this period, in the early 2000s, many green architecture projects turned almost exclusively to solar powered buildings and other forms of renewable energy in order to reduce reliance on natural gas, increase the energy efficiency of buildings, and reduce GHG emissions from heating and cooling (Tabb and Deviren 2013, 134). The current green architectural movement is split into varying sections and ideas of sustainable architecture such as natural, which is a form of architecture that uses only non-toxic, natural materials and methods of heating and cooling, conservative, which aims to conserve energy and resource use by reducing inefficiencies and waste in buildings and architecture, and regenerative, which attempts to reuse and recycle building materials and waste (Tabb and Deviren 2013, 144).

New York City Architectural History. Although it might seem almost impossible to imagine New York City without the endless glass and concrete high-rise buildings stretching up to the polluted sky, the city used to appear as a vastly biologically diverse island, with forests, rivers, and swamps where the buildings are today. Among this natural wildlife lived the Lenape people, a Native American tribe who had lived in what they called Manhatta for thousands of years (Sanderson 2009, 3). Theirs is the first architecture ever established in New York City. While they spent the vast majority of their time outside, they did still construct some buildings and homes for protection from weather and to sleep in at night (Sanderson 2009, 113). As they had a rich spiritual connection to the Earth and its organisms, their homes were made entirely from natural resources and are thus one example of sustainable architecture. The Lenape built wigwams as single-family homes and longhouses for seven or eight families, building both of these structures out of trees. Tree saplings made up the perimeter of the house, which they would bend over to create the roof, and would then cover the structure with sheets of tree bark from old-growth trees (Sanderson 2009, 113). They would leave a space in the roof to act as a chimney for smoke to escape from as well. While it was discussed earlier in the chapter that wood, depending on its usage, might not always be considered a sustainable resource, the Lenape people knew its limits and were careful with the amount and the way that they harvested it for their homes, a lesson that American architects and constructors must learn as well.

For centuries, the only architecture in New York City was that of the Native Americans. This changed in the 1600s with the arrival of European colonists. One of the first real structures that they established in New York – other than trading posts – was a fort, built by the Dutch in

1630 (Jackson 1924, 63). It was originally built mostly of earthen materials but, when it began to crumble, they patched the gates and bastions with stone instead, and the church and Governor's house inside were both built of stone and brick as well (Jackson 1924, 66). As the Dutch were some of the first colonists in New England and New York, much of the early architecture in New York resembled Dutch architecture. While most of the other colonies in the US had wood buildings, New York was home to brick and stone structures, as was already typical in Holland (Jackson 1924, 64). In fact, they outlawed wooden chimneys and other kinds of wood structures in order to protect the settlement from fire (Jackson 1924, 70). They outlawed roofs of flag for the same reason, and thus all their roofs were made of tile (Jackson 1924, 71). The Dutch colonists were also no stranger to taller buildings and constructed homes and town halls that were three to four stories high. The architecture in New Amsterdam, which would eventually become New York, vastly resembled the original Dutch architecture in Holland and was thus different from the rest of the American colonial architecture. If the Dutch, who were more prone to tall buildings than the English, had not been the first settlers in New York, it is unclear as to whether New York City would have evolved into the high-rise city it is today.

Following the colonial era was the Industrial Revolution. This marked an important time for architecture as new materials were circulated throughout the architectural industry, namely steel. There were several reasons why steel became such a popular building material. The first is due to the mentality at the time – mass production and the ability to increase the speed of production (Campos and Bernardo 2020, 2). The Industrial Revolution saw a large influx in the production of steel, which made it easy to use this for steel frames of buildings. During this period, there was more of a focus on well-structured buildings as opposed to the aesthetic principles of other eras (Campos and Bernardo 2020, 5). The Empire State Building is a prime example of steel architecture in New York City. Although it was not actually built until 1930, it relied on the new steel foundations that were formed during the Industrial Revolution.

Following the Industrial Revolution, in the late 1800s, was the rise of luxury and high-rise apartment buildings. Previously, shared buildings and homes were viewed as something that only those of lower-income or immigrants lived in, not the rich (Hawes 1993, 23). Thus, one of the first luxury apartment buildings, the Stuyvesant Apartments, was at first viewed rather questionably. Soon new buildings began to follow suit. During this period, many of the buildings resembled French architecture. Apartments and single-family houses had mansard roofs, heavy chimneys, and stone trims (Hawes 1993, 36). French apartments were viewed as fashionable and high-class and therefore helped bridge the gap between the public's perception of poor immigrant apartments and luxury homes. In 1901, a law was passed that allowed fire-proof residential buildings to be ten or twelve stories when they were previously only around six stories (Hawes 1993, 104). This was the slow beginning towards the trend of high-rise buildings that exist today. Most of the architecture of this time was focused on high-class aesthetics and ornamentation (Hawes 1993, 107).

The early 20th century was the time of the Progressive Era, in which new legal rulings and codes changed the definitions of property and land as part of a trend towards capitalism. Land was now just another market force; a commodity to be bought, sold, and profited off of instead of a physical place (Page 1999, 24). This led to the destruction and renovation of buildings that currently existed in Manhattan, particularly along Fifth Avenue, where single-family homes were torn down or repurposed (Page 1999, 26). Those that were torn down were demolished to make space for the department stores that are so famous on the avenue today, and those that were not torn down turned into businesses as well. This was the beginning of the architectural transformation to the modern New York City. In lower Manhattan, the first skyscrapers that were being established downtown became the home for factories and office buildings following the Industrial Revolution. In 1894, Bruce Price designed an office building that was twenty stories high and was the first to use a complete steel frame, which allowed it to achieve its height (Ward and Zunz 1997, 132). As this new skyscraper towered over the nearby buildings, blocking their light and air, other skyscrapers in the vicinity began to spring up, partially out of spite (Ward and Zunz 1997, 134). The skyscrapers initially began as office buildings but were soon rented out to tenants as residential spaces, inspiring the high-rise apartment buildings for the wealthy that were then built along Fifth Avenue. In 1916, a Zoning Resolution was passed that not only divided the city into residential and businesses zones, but also set limits for how tall a building could be, thus limiting the construction of extremely high skyscrapers (Page 1999, 29). Yet, driven by capitalism and the promise of profit, architects still managed to find a way around this law to create high-rise buildings throughout all of New York City.

These high-rise apartment and office buildings led to the design and construction of what used to be New York City's tallest building – the Empire State Building. The Empire State Building was representative of the division that was occurring in New York City at the time – older traditions versus modern ones, immigrants versus "old money" New Yorkers (Flowers 2009, 15). The Empire State Building was one of the first new modern buildings built in the city. It did not resemble the old historical styles, such as the French-based architecture that was so popular in the late 1800s. It was designed to be economically instead of aesthetically pleasing, made primarily of steel and stone. The Empire State Building featured smaller offices than previous office buildings, as well as an efficient use of space that would become more commonplace in the post-war era (Flowers 2009, 17). The building's most notable architectural aspects were its steel frame, tall central tower, and the iconic detailing on the outside (Flowers 2009, 50). At the time, less of the focus was centered around its record-breaking height and more was on the architectural prowess of the design of the building itself, which was more urban and modern than most buildings at the time.

The architects of the Empire State Building were also responsible for changes to the building codes in NYC. The building code at the time stated that structural steel was only allowed to carry 16,000 pounds per square inch (Flowers 2009, 54). There had been proposals to increase the load maximum by 2,000 pounds per square inch but the current mayor, Jimmy Walker, wasn't changing the code. However, in 1930, when the architects for the Empire State Building were serving on the Merchants' Association of New York, the code revision was introduced again and they convinced the mayor to sign off on it, which led to the raising of the steel frame for the Empire State Building (Flowers 2009, 55). Without the change in building code, it is uncertain as to whether it could have been built the way that it was with a steel frame, as well as for whether buildings that followed it would have had to have been constructed differently.

If a trend towards capitalism in the real estate market had started during the early 20th century, it was definitely continuing during the 1930s. Politics were closely intertwined with building construction during this time, as much of the public felt that architects and construction companies were sacrificing aesthetic value and worker safety to economically-cheap designs and construction times, such as the vertical assembly line that the Empire State Building employed, which had been rumored to have killed 42 men (Flowers 2009, 72). The massive skyscraper was said to have been a symbol for capitalism and the ways that it exploited citizens, somewhat ironically given that it was a trend away from the luxury apartment buildings of the old wealthy on Fifth or Park Ave. Like many of the skyscrapers before it, it was a product of the Industrial Revolution and the move towards commercialism. This new modern style carried over into the post-war era.

While new architectural designs in New York slowed down due to World War II, after the war construction began to flourish once again, with new styles reminiscent of the period. Modern architecture in the US was beginning to be accepted as a part of popular culture, used in advertisements for various goods and products as well as serving as a symbol of progress after the war (Flowers 2009, 89). While the architecture of the 1930s, as seen in the construction of the Empire State Building, represented producer and office culture, the modern architecture that followed the war seemed to represent consumer culture, which had boomed given the restrictions that took place during the war. Similar to the Empire State Building, the design of post-war, modern buildings was economics and convenience over aesthetics.

After the post-war Modernist era, New York's arguably most influential architect entered the scene – Robert Moses. Although he worked on many aspects of New York's infrastructure, such as highways and beaches, this paper will focus only on his work in terms of buildings. Some of the buildings that Moses planned were pool buildings as part of his work as the park commissioner. Post-Great Depression, these buildings were in line with the values of the New Deal and idealized America – complexes that provided leisure activity, convenience, and safety (Ballon and Jackson 2007, 80). Moses also wanted the buildings to look like sound vernacular modern architecture. The goal of buildings during this time was to be grandiose as well as efficient, economical, and hygienic, the latter of which was a newer requirement (Ballon and Jackson 2007, 81). In the wake of the passage of Title I of the 1949 Housing Act, which provided federal subsidies for cities to clear their slum neighborhoods, Moses led the charge on slum clearance and the urban renewal that followed (Ballon and Jackson 2007, 94). Moses believed this urban renewal should be focused on middle-class apartments, bringing back the middle-class who had left for the suburbs and making the downtown city a focus again, thus leaving low-income, Jewish, and minority communities essentially homeless (Ballon and Jackson 2007, 106). It was during this time period that college campuses around New York City began to develop and grow, as one aspect of Moses's plan was centered around higher education. This was the start of the Fordham Manhattan campus and the large growth of NYU (Ballon and Jackson 2007, 107).

Ironically, although Moses was a strong urban planner, he was not as invested in the design aspect of buildings, which then fell to someone else. The site planning that followed created the New York City that exists today. Apartment buildings were typically high-rise and distanced from the street, often including underground parking garages as NYC had entered the automotive age (Ballon and Jackson 2007, 108). While buildings were originally semi-spaced out to make room for cars, they were soon built closer together so that cars and buildings were completely segregated. Housing projects, which were built in the cleared slum areas, typically featured a one-story commercial strip at the front of the avenue and the projects were built behind it (Ballon and Jackson 2007, 108). Moses also believed that buildings should align with public taste and thus encouraged new buildings to be based off the historical background of the neighborhood they would be built in (Ballon and Jackson 2007, 245). He was also a proponent for housing superblocks, which is where many residential apartment buildings surround a green space, although superblocks are no longer as common as they were during the mid-20th century.

Moses set the stage and the standards for the architects at the time and much of the construction that followed, building New York's architecture into the city that it is now.

Chapter 3. Urban Planning: Green and Regenerative Buildings

As buildings are responsible for roughly 2/3 of New York City's GHG emissions, it is vital that the very existence, design, and construction of buildings are altered in order to reduce these emissions. As seen in Chapter 2, there have historically been several different concepts regarding sustainable and green architecture, including using the passive house design in order to increase energy efficiency as well as carefully selecting the materials for buildings in order to reduce or even mitigate GHG emissions. Given these different concepts, there are three main ideas behind sustainable buildings. The first is to retrofit existing buildings to become more energy efficient, as they will constitute the majority of buildings that exist in the city even in 2050, thus it is incredibly important that their GHG emissions are lowered. The second is to construct green buildings, which rely on both passive and active house design to increase energy efficiency as well as the usage of sustainable materials for the construction. Finally, the third concept is that of regenerative buildings – buildings that actually work to mitigate GHG emissions that already exist in the atmosphere.

New York City has many different types of buildings within the city limits and the design and construction examples discussed in this paper can be implemented in most types of buildings. Some of these buildings are city residences, such as brownstones, old law tenements, walk-up apartment buildings, elevator apartments, and luxury apartments. Other buildings are warehouses, factories, parking garages, gas stations, hotels, college dorms, hospitals or other health care facilities, theaters (both those for movies as well as live performances), retail buildings, religious houses of worship, office buildings, museums, libraries, airports, police or fire departments, and schools (City of New York 2021). While this is not an exhaustive list, the buildings listed above comprise the majority of the buildings in New York City. However, this paper presents suggestions for a limited number of buildings instead and focuses the recommendations for these instead. The buildings that are the main focus of this paper are multi-story apartment or office buildings, including but not limited to high-rise buildings. This paper is tailored towards examining the way that green and sustainable urban planning can be implemented in multi-story and high-rise buildings in New York City, with a mix of both passive and active design.

Existing Buildings. The main goal of a green building – while it might have many, even some which are not environmental in nature – is to mitigate global warming through the reduction of GHG emissions, energy conservation, and, in some cases, carbon sequestration (Ching and Shapiro 2014, 7). Unfortunately, in attempts to create green buildings, this goal is sometimes ironically overlooked or minimized. The mainstream view regarding green buildings is that existing buildings must be torn down and rebuilt with a regenerative or other kind of sustainable building that will better mitigate GHG emissions. However, the demolition process, the waste that results from it, and the construction of the new building – regardless of the sustainability of the new building – produce negative environmental impacts, such as GHG emissions through construction, transportation of materials, and the demolition (Merlino 2018, 7). Thus, an extremely important aspect of building a green city is to simply reuse and retrofit the buildings that already exist as much as is possible. Sometimes it is more sustainable and environmentally beneficial to simply make a building greener than an entirely new green building.

In the United States alone, 1 billion square feet of buildings are demolished every year and new ones are constructed in their place (Merlino 2018, 69). This creates mass amounts of waste from the building materials, of which the EPA estimates adds 136 million tons of construction and demolition waste to landfills each year (Merlino 2018, 70). As the landfills are already overflowing with waste, some of which is non-biodegradable or releasing toxic fumes and methane gas into the atmosphere, it is necessary that we limit the amount of new waste we are adding to landfills. Aside from the waste issue, which is a massive problem but could be at least semi-fixed if the materials were recycled instead, the construction of new buildings that follows after the waste uses a high amount of natural resources. In the United States, 60% of resource consumption is related to construction uses (Merlino 2018, 71). As we are quickly running out of certain limited resources, cutting down on construction by reusing existing buildings instead of demolishing them would help to mitigate some of this resource consumption. To add to the problem, out of the resources that are used for construction, only 10% are in the final product, while the other 90% is sent to the landfill, adding even more waste (Merlino 2018, 73). The demolition and construction processes contribute to mass amounts of extra waste in landfills, which is why it is so important to simply retrofit existing buildings instead of demolishing them.

Another reason for merely altering existing buildings is that, depending on which decade the building was built in, older buildings are sometimes more energy-efficient than those from later decades. While buildings from the 1960s through the 1980s are energy inefficient due to the cheap energy that was available at the time, those which were designed and constructed before 1920 use less energy per square foot (Merlino 2018, 36). This is because older buildings typically relied on passive house designs, as discussed in Chapter 2 of sustainable architecture, in order to provide light and heating and cooling to the building. These older buildings thus have greater thermal insulation and large operable windows, which help for both natural lighting as well as ventilation (Merlino 2018, 37). Since New York City has been around for centuries, many of its buildings fit into this bracket of buildings that were constructed before 1920, which means they are already relatively energy-efficient and thus it would be far better to retrofit them to make them even more energy-efficient than to tear them down. Some of the pre-1920 buildings might not even necessarily need to be retrofitted to be greener, which would again save construction materials and waste and these resources could be devoted entirely towards the newer, less energy-efficient buildings.

Retrofitting Buildings. The main focus of retrofitting existing buildings is typically to increase their energy efficiency, which then reduces their GHG emissions. Natural gas combustion, which is used for the heating and cooling of buildings, and electricity are responsible for 47 and 37 percent, respectively, of building-based GHG emissions in New York City (The City of New York 2017, 5). Increasing energy efficiency would thus play a large role in decreasing overall building-related GHG emissions. Given these high percentages, the most important aspect of retrofitting existing buildings is to upgrade their various heating and cooling systems. The most efficient method is geothermal heat pumps, which are placed within the thermal envelope of the building in an insulated area and rely on renewable energy to heat the building (Ching and Shapiro 2014, 192). Heating systems that rely on circulation of energy and materials are also very sustainable, as they do not require large amounts of energy. One example of this is a boiler-tower water loop heat pump system, which adds or withdraws heat from a water loop, minimizing the amount of energy and heating resources that must be consumed (Ching and Shapiro 2014, 196). Current heating systems in buildings can also be upgraded with a change in the fuel used to heat them. Biomass fuels are a good choice for green buildings, as they have a low impact on GHG emissions (Ching and Shapiro 2014, 200). However, they can cause air pollution at times and do also contribute to deforestation, so their sustainability is questionable, although arguably better than coal or natural gas.

On the outer level, the easiest way to make the building more efficient is to reduce infiltration, which refers to the exchange of air between the building and outdoors (Ching and Shapiro 2014, 85). The more infiltration there is, the less energy efficient the building is. Luckily, NYC buildings and skyscrapers don't have as many of the common infiltration sites as single-family homes typically do, such as fireplaces, chimneys, and clothes dryer vents (Ching and Shapiro 2014, 87). However, NYC buildings do typically have window-mounted air conditioners, which allow for air infiltration, as well as cracks and porous insulation in the walls that all buildings have. To reduce air infiltration from window AC units, split air conditioning systems should be used and all piping should be sealed with caulk (Ching and Shapiro 2014, 87). To reduce other kinds of air infiltration, as well as to trap more heat in the building and increase the thermal mass of the walls, sandwich panels can be added to building walls (Ching and Shapiro 2014, 93). This consists of adding thin layers of reinforced concrete to either side of the insulation. When air infiltration is reduced, both heating and cooling can be reduced as well since less of the cold or hot air is escaping, thereby reducing energy use and GHG emissions.

As electricity is responsible for a large percentage of GHG emissions from buildings, part of retrofitting existing buildings must be focused on electricity and lighting. One way to decrease electricity use is through the redesign of windows, which – if done correctly – can also further reduce the need for heating and cooling. Increasing windows and focusing on careful placement to maximize daylight in the building will allow for natural lighting and decrease the need for artificial lights and electricity (Ching and Shapiro 2014, 100). However, this must be done very carefully, as too many windows or non-optimal placements can lead to air infiltration or thermal losses, which would increase energy use. To combat this, the new windows must be high-performance windows, which consist of multiple panes to reduce overall heat transfer and wood-vinyl composite frames which prevent conductive heat loss along the frame (Ching and Shapiro 2014, 98). Building owners can also change the light fixtures in their buildings, as surface-mounted and recessed linear fixtures are more efficient than downlight fixtures (Ching and Shapiro 2014, 149). They can also install dimmer switches, which provide more of a variability for lighting and thus allow occupants to reduce their electricity use.

Another way to reduce emissions from electricity and lighting is through the addition of solar panels. Solar panels, which consist of solar thermal collectors or photovoltaic cells, capture the sun’s energy and can be used to provide electricity throughout an apartment building (Ching and Shapiro 2014, 75). Solar panels are most often placed on the roofs of buildings and can be one of the easiest ways to retrofit a building to lower energy usage for electricity. They can also save the tenants and landlords money for electricity, as the sun’s energy is free and thus the only costs are the upfront costs of installation. For this reason, they are an excellent source of energy for affordable sustainable housing, although corporations such as electrical companies typically discourage their use as it lowers the profit of the electric corporation. Solar panels can be hard to add onto existing buildings, as they require a certain kind of roof shape to work. Fortunately, the majority of New York’s apartment buildings are flat roofs, which have the highest receptivity in terms of roof design and solar panels (Ching and Shapiro 2014, 76). This means that many buildings in New York City are likely eligible for the addition of solar panels. Some buildings in NYC have already implemented solar panels; Fordham University is one of them. On its Rose

Hill campus in the Bronx, Fordham has installed over 2,800 solar panels between the roof of the school's library and the parking garage (Verel 2019, 1). They also purchase some of their electricity from a solar developer in Staten Island, which has an installation with 9,000 solar panels. While these latter solar panels are not on actual apartment buildings, building owners and tenants can choose to enter into business with solar developers and clean energy providers for electricity as opposed to electric companies that rely on fossil fuels for energy.

Freiburg, Germany is a city leading the way in the success of solar panels and renewable energy. In one of its city districts, Vauban, the majority of homes receive their energy from photovoltaic solar panels (Braff 2020). Some of these homes even produce more energy than they need and so they sell it back to the grid, which provides renewable energy for others who may not have solar panels on their own roofs. Freiburg is home to 150,000 m^2 of solar cells and panels, which produce over 10 million kWh each year (Braff 2020). The solar panels are only part of what makes Freiburg such a green city, as it also turns organic waste into biomass energy and has wind farms and hydropower energy sources as well. The amount of clean energy generated each year in Freiburg alone depicts the feasibility and success of solar panels as a renewable energy source, demonstrating the need for installing solar panels on existing buildings in New York City to reduce their fossil fuel reliance.

Electricity – and by default fossil fuel – usage can also be decreased by retrofitting buildings with smart electric grids. Smart grids combine the latest and most advanced technologies to establish automated systems for HVAC, lighting, and power management within the building, which means that the building becomes more active in terms of electricity while the tenant becomes more passive (Cairns and Young 2017, 21). In this way, the building regulates supply and demand of energy use, which minimizes operational costs and footprints of the owner or tenant as well as minimizing the use of resources (Cairns and Young 2017, 23). Since the building is managing how much energy is truly needed, instead of leaving it up to the subjectivity of tenants, there is ultimately less energy used and thus the entire building is more energy efficient. The use of smart grids is most effective when it is combined with clean and renewable energy sources instead of fossil fuels, although retrofitting buildings with fossil-fuel based smart grids is still better than nothing at all. New York City is making a small step towards this as ConEdison, the main energy supplier for New York City and its surrounding suburbs, is currently working on installing smart meters in apartments and neighborhoods across New York City, with the goal to install about 5 million smart meters by the end of 2022 (ConEdison 2021). Although smart meters are not the same as smart grids – and are not as environmentally beneficial – they allow the tenants or building owners to better track their energy usage, which would ideally lead tenants to lower their energy consumption, which would reduce the use of fossil fuels for energy and thus for building emissions overall. Ultimately, NYC should try to retrofit existing buildings and construct new buildings with smart electric grids instead, but installing smart meters to help hold tenants more accountable for energy consumption is a first step.

Sustainable Buildings. As New York City's population continues to grow, or as century-old buildings begin to fade, new buildings must still be built. Yet, in order to reduce their impact on the environment and GHG emissions, they need to be constructed and designed sustainably. One way to do this is through passive house design, which reduces the need for some forms of energy, such as heating, cooling, and electricity. Passive house designs draw on the basis of the ancient styles of architecture which were discussed in Chapter 2. These include things such as high thermal mass of walls and buildings, to keep buildings insulated and trap heat to reduce the reliance on energy-inefficient heating and cooling, and carefully selecting the location of windows in order to best benefit from natural lighting and the heat that it provides, as the Ancient Greeks did (Gauzin-Müller and Fauvet 2002, 49). Another example of passive house design is the bioclimatic approach, which bases building shape, orientation, and layout on the geographic and climatic characteristics of its location, such as wind direction and solar exposure (Gauzin-Müller and Fauvet 2002, 92). This increases efficiency in both heating and lighting, as more natural light is used and less heat is lost, through the use of passive solar energy. This inevitably reduces GHG emissions.

Unfortunately, passive house design can often be used only minimally. While factors such as window-location selection and high thermal mass can be designed and implemented in most new buildings, the bioclimatic approach might not be feasible in NYC as there are already so many buildings and not much land space to choose from when picking a new site for buildings, let alone building orientation. Ideally, sustainable buildings in NYC will implement both passive and active design and features. The majority of the active design features were discussed in the section regarding the retrofitting of buildings. These features can be easily implemented in the construction of new buildings as well. Smart electric grids, solar panels, green roofs, and clean energy sources for heating and cooling of buildings are some of the prime examples for active sustainable design of new buildings.

The optimal green building also relies on carefully chosen materials in order to minimize the amount of GHG emissions produced both in production as well as in the general lifecycle of the building. One way to do this is to mix materials. While timber is one of the most sustainable building materials, and will be discussed in further detail later in this chapter, it has a low thermal mass which allows heat to escape from the buildings, which increases energy use.

Constructing a building of which the majority of materials are timber but adding in concrete layers in the walls to act as thermal sinks thus might be more sustainable than a building that is entirely timber (Gauzin-Müller and Fauvet 2002, 115). However, sustainable development does call for limited use of high-energy and polluting materials, such as concrete and steel, so the entire green footprint of a building must be carefully considered before choosing to introduce concrete to a green building. Another sustainable building material, with its roots in ancient cultures, is that of Earth (Gauzin-Müller and Fauvet 2002, 109). However, it is not used widely in urban areas, likely due to a lack of knowledge as to whether a high-rise, multiple story building could be safely constructed with hardened soil and clay. Therefore, the best choice for a sustainable building material in NYC is timber.

One form of wooden building that has recently begun to increase in construction is that of cross-laminated timber (CLT). CLT is a lightweight panel that consists of several layers (at least three or more) of cut lumber that are pressed and bonded together, with the individual boards stacked in alternating directions (Jones 2019, 54). Since the CLT panels are prefabricated, the architect or designer can work closely with the factory to determine exactly what kind of CLT panel they want for the building and their size, which means the architect has more design opportunity before the contractor steps in, unlike with regular buildings (Jones 2019, 61). The main benefit of CLT buildings is their environmental sustainability – CLT buildings store carbon instead of releasing large amounts of carbon and other GHG emissions into the atmosphere during production the way that cement and steel do. While concrete and steel buildings emit GHG emissions throughout their lifetime simply by existing, even once production is completed, CLT buildings continue to store the carbon that they absorbed while they were living trees throughout *their* lifetime. Floors and walls of buildings made out of CLT panels were found to have resulted in a 1:10 carbon savings compared to concrete or steel buildings (Jones 2019, 49). If all the new buildings in New York City consisted of CLT panels instead of other building materials, thousands of tons of carbon emissions could be eliminated.

Unfortunately, there are some downsides to constructing CLT buildings. The most noticeable one is that CLT buildings consist of wood. Although wood is theoretically a renewable resource, humans have already contributed to much deforestation around the planet, which in turn impacts the ecosystem services and human well-being as discussed in Chapter 1. Thus, the use of CLT must be carefully monitored to ensure that too many trees are not being cut down to construct buildings. Forests from which trees are harvested to make CLT buildings must be replanted. The second downside, in regards to its implementation in New York City, is that the US has not yet adopted code regulations to allow buildings over 9 stories high to be built with CLT, which would be the mainstream use in New York City (Jones 2019, 59). This will be further discussed in Chapter 5 with policy recommendations. Even with these downsides, the benefits of CLT buildings as a green building far outweigh the costs and are the most sustainable option for the construction of new buildings in New York City.

Currently, there are a couple of semi-CLT buildings either recently finished or still under construction in New York City. One of them is Frame 283, built in Clinton Hill, Brooklyn. It is part of an architectural project run by Frame Home and Loadingdock5, who were granted a special exception in order to build with engineered wood in the city (Hughes 2020). While Frame 283 is not a full CLT building, as it also consists of some insulated concrete, the majority of its building resources come from timber, making it one of the first of its kind in New York City. Frame 283 has a low carbon footprint, as it includes solar arrays for energy as well as the fact that its wood was harvested from tree farms with fast-growing trees such as spruces, as opposed to old-growth trees that take years to regrow (Hughes 2020). Frame 283 is five-stories tall, in accordance with the city building code for wood buildings at the time of its construction, and it has 10 rental units, which are all currently full (Hughes 2020). Frame 283 should be considered an environmental and CLT architectural success, which will hopefully encourage city officials to allow for more and taller CLT buildings to be built in the city.

Regenerative Buildings. Given the amount of GHG emissions that already exist in the atmosphere and are contributing to global warming, it is important to not only lessen the amount that we add to them, but also find ways to absorb and reduce them. This is the purpose of the regenerative building. The principles behind a regenerative building are to use materials that have a positive life-cycle, such as those that can be biodegraded safely or recycled, and to increase the amount of renewable energy used in the production process, as well as creating a building which revitalizes its own sources of energy (Attia 2018, 19-21). One of the most important aspects of constructing a regenerative building is the building material – it must be assembled and produced with 100% renewable and non-polluting energy and must be able to be safely reintroduced into natural cycles at the end of its use (Attia 2018, 24).

One regenerative building material, which has just recently been introduced and tested as a building material, is that of hempcrete. Hempcrete is made of the plant hemp, which is used for several things such as health foods and ingredients in organic beauty products, as well as sustainable clothing materials (Schires 2021). To make hempcrete, small slivers of wood from the plant, which are called hemp shives, are mixed with lime and water to create a kind of ecofriendly concrete. Hempcrete is both sustainable, since it’s almost entirely plant-based which means it’s a renewable resource, as well as regenerative. The lime in hempcrete absorbs carbon dioxide from the atmosphere, at which point it turns from calcium hydroxide into calcium carbonate to create limestone (Schires 2021). Hemp is also a quick-growing and easy to grow crop, which makes it even more valuable and sustainable, as it is easier to grow hemp after using it than it is to replace the trees that are cut down to make timber buildings. Replacing timber buildings with hempcrete would also reduce the amount of deforestation, which not only saves trees which are carbon sequesters, as discussed in Chapter 1, but also reduces the GHG emissions that are released in the process of deforestation. Hempcrete also acts as a natural thermal insulator, which helps to increase energy efficiency in buildings by lowering the amount of heating and cooling needed (Schires 2021). Unfortunately, hempcrete likely cannot be used as a foundation or base for a building because it is not as strong as typical bases such as concrete. However, it could still be used for paneling or for walls of building. While it is so far largely untested as a building material for high-rise buildings, which this paper focuses on, it has been used successfully in single-family homes across Europe, thus hempcrete presents a sustainable and regenerative option for other kinds of building materials.

Other than the actual building materials, there are other ways to make buildings regenerative as well. One way to do this is through the use of green roofs, which can be both an addition onto already existing buildings as well as a part of the initial design and construction process of a new building. Green roofs refer to vegetation on the top of a building's roof, either in the form of one flat layer of grass spread over the roof, or grass combined with gardens and trees growing on the roof as well. There are many benefits to green roofs. The first is that, since they are comprised of living vegetation, they are carbon sequesters as the plants and grass absorb carbon from the atmosphere (Cairns and Young 2017, 120). This aspect is what helps to make them regenerative buildings, as they mitigate the GHG emissions that are already in the atmosphere.

Another benefit of green roofs is that the vegetation works to combat the Urban Heat Island effect, a phenomenon discussed in Chapter 1 that leads to extreme heat days in New York City (Getter and Rowe 2006, 1279). This is because the UHI effect is caused from a lack of vegetative surfaces within urban areas, as man-made building materials such as concrete absorb heat from the sun, thus raising the total temperature of the surrounding city. The green roofs provide insulation to buildings, which results in lower indoor temperatures during hot days and vice versa (Getter and Rowe 2006, 1279). This would result in lower energy usage for heating and cooling, which is another important aspect of green buildings. Green roofs also contribute to reduced stormwater runoff because the vegetation on the roof of buildings absorbs the water, which either evaporates from the soil or is used to water the plants (Getter and Rowe 2006, 1278). This benefit is especially important given that, as discussed in Chapter 1, global warming will contribute to increased precipitation and more extreme weather events and green roofs can thus help to combat some damage from these phenomena, as well as absorbing carbon from the atmosphere. Therefore, given all the benefits of green roofs and their regenerative properties, green roofs combined with sustainable building materials such as CLT or hempcrete would be the best option for new green buildings in New York City, and green roofs should also be added to existing buildings to make them more sustainable.

Similar to green roofs in both concept and environmental impacts is the addition of green walls to buildings. Green walls refer to two different regenerative systems – green facades and living wall systems (Cairns and Young 2017, 242). In a green façade, plants are rooted either in the soil on the ground outside the building or in various plant boxes. These plants would then, depending on the type of plant being grown, either adhere directly by themselves to the building wall or be held against the wall by a supporting structure (Cairns and Young 2017, 242). In either scenario, the plants would be a kind of climber plants that would grow straight up the building wall to cover it all. In a living wall system, the plants do not have to be climbers as they are instead planted directly into the wall in various places (Cairns and Young 2017, 243). The plants are inserted into the wall – along with an irrigation system and whatever materials they need to grow – such as through pre-vegetated panels.

Both forms of green walls have the same environmental and regenerative benefits. The first is that, similar to green roofs, green walls can act as an extra thermal insulator on the building wall, which would lessen the need for electric heating and cooling (Cairns and Young 2017, 244). As a large part of greening a building is related to increasing its energy-efficiency, any aspect that helps to reduce the amount of energy needed for heating and cooling helps contribute to the overall energy efficiency. They also help to combat the UHI effect, which is especially important in New York City, as discussed in Chapter 1 (Cairns and Young 2017, 245). Finally, green walls help to turn a regular building into a regenerative building as, since they are comprised of living vegetation, they act to absorb carbon dioxide from the atmosphere. This not only helps to mitigate the greenhouse gases in the atmosphere, but also serves to counteract the emissions that are released by the building during its daily functioning.

An entirely regenerative and carbon negative building is currently in the works by the architecture company Skidmore, Owings, & Merrill (SOM), called Urban Sequoia. Urban Sequoia, which is still in the design stages and thus does not currently have any existing prototypes, would combine a mix of sustainable building materials with carbon-capturing components and systems in order to produce a regenerative building (Berg 2021). The construction materials for the building would largely consist of nature-based materials such as hempcrete, timber, and bio-brick (SOM 2021). Some of these materials, such as hempcrete, would act as carbon sequesters during the building's lifetime. On the outside, the building would be covered with living walls consisting of algae that serve to both absorb some carbon from the atmosphere as well as produce biofuels for electricity in the building (Berg 2021). Urban Sequoia would also feature a Direct Air Capture system within the building, which would extract and store carbon dioxide from the atmosphere. Theoretically, Urban Sequoia would reduce GHG emissions of an average building during production by 50-95%, as well as sequestering 1,000 tons of carbon each year (SOM 2021). SOM is designing Urban Sequoia as a high-rise, although they say the concept would work for any size buildings, which would make it a perfect fit for New York City. Urban Sequoia is a perfect example of a regenerative and sustainable building prototype that should be implemented in New York City in order to reduce GHG emissions.

Chapter 4. The Politics Behind Sustainable Buildings

Behind every building is the building code or city regulation determining the standards to which it must be built. Thus, in order to reduce GHG emissions from buildings, legal guidelines must be implemented to hold building owners and constructors accountable. As sustainable buildings are usually not in line with profit maximization, particularly for residential and luxury buildings, building owners and architecture companies are not likely to implement green standards by themselves. This means that policies regarding green buildings, both on the local as well as the federal level, are incredibly important. New York City has already made strong strides in this direction, as both the previous and current mayors have released extensive reports detailing their long-term plan for the sustainability of the city, particularly as it pertains to buildings, since buildings – as mentioned before – are responsible for the majority of the city's GHG emissions. This chapter will explore these mayoral reports as well as some of the city's existing climate change policies that affect buildings and GHG emissions. While not all of the city's policies will be explained or discussed in-depth in this paper, a complete list of all the policies regarding green buildings can be found in the table below.

Figure 1. New York City's Green Building Laws (IntelliGreen Partners 2021).[1]

Law	**Year**	**Description**
Local Law 86	2005	City-owned or managed buildings must achieve LEED certification
Local Law 88	2009	Property owners must upgrade their lighting systems to be more energy-efficient
Local Law 84	2009	Every building must submit an annual benchmarking report of energy and water usage
Local Law 85	2009	Buildings that are being renovated must meet the latest energy codes and standards under the New York City Energy Conservation Code
Local Law 87	2009	All buildings over 50,000 square feet must submit Energy Efficiency Reports and participate in energy audits
Local Law 43	2010	Buildings must switch to cleaner heating fuels by July of 2015 and must phase out fuel no. 4 by 2030
Local Law 47	2010	Buildings must reduce unnecessary lighting in lobbies and hallways
Local Law 132	2016	Buildings with tenants or offices must install sub-meters
Local Law 133	2016	Amended LL 84 to expand the amount of buildings who must submit a benchmarking report
Local Law 33	2018	Refers to energy efficiency scores and grades for the buildings mentioned in LL 84/133
Local Law 106	2018	Allows a corporation who owes multiple covered buildings to file consolidated energy efficiency reports
Local Laws 92/94	2019	New buildings or buildings under renovation must implement sustainable roofs (solar panels/green roofs)
Local Law 95	2019	Requires buildings to post their Energy Efficiency letter-grade score as determined in LL 33
Local Law 96	2019	Established Property Assessed Clean Energy (PACE) program to fund energy efficiency and renewable energy projects for buildings
Local Law 97	2019	Places carbon caps and emission limits on "covered buildings"
Local Law 98	2019	Requires New York City building code to be amended to include wind turbines as clean energy source as well as

[1] https://igpny.com/nyc-local-laws/

		developing standards to support installation of wind energy turbines
Local Law 116	2020	Allows for delay for rent-regulated buildings to comply with building emission limits

PlaNYC and OneNYC. NYC's two main plans with regard to climate sustainability, set forth by Mayors Bloomberg and de Blasio, feature varying categories of goals related to sustainability. Figure 2 below lays out the suggested policies or initiatives regarding sustainable buildings or the physical environment that are listed in both *PlaNYC* and *OneNYC*.

Figure 2. Building-related Initiatives in PlaNYC and OneNYC

***PlaNYC* (The City of New York 2007)[2]**	***OneNYC* (The City of New York 2019)[3]**	***OneNYC* Technical Working Group Report (NYC 80 x 50 2016)[4]**
Adapt buildings no longer in use for new uses; can be used for affordable housing and contributes to sustainability by limiting unnecessary destruction (p. 23)	Ensure that all citizens have access to safe and affordable housing (p. 45)	Existing buildings must upgrade in order to improve energy efficiency and meet new standards (p. 4)
Build 6,000 affordable housing units (p. 23)	Establish a physical environment that contributes to human health and well-being (p. 45)	New buildings being constructed must have a focus on whole building energy performance (p. 5)
Strengthen energy building codes (p. 103)	Transition to 100% clean electricity (p. 46)	All buildings need to be included (p. 6)
Create an energy efficiency authority and a New York City Energy Planning Board (p. 103)	Strengthen buildings against floods as part of the climate resiliency plan (p. 46)	Tenant or unregulated energy use must be addressed in order to reduce all building energy use (p. 6)
Organize an energy awareness campaign (p. 103)	Meet the UN's Sustainable Development Goals (p. 51)	Building workers need to be trained in order to know how to best operate energy-efficient systems (p. 7)

[2] https://www.nyc.gov/html/planyc/downloads/pdf/publications/full_report_2007.pdf
[3] https://onenyc.cityofnewyork.us/wp-content/uploads/2019/04/A_OneNYC_2050_Interior_r5_v4_ExecutiveSummary_190422_web.pdf
[4] https://www1.nyc.gov/assets/sustainability/downloads/pdf/publications/TWGreport_04212016.pdf

Expand upon existing Clean Distributed Generation for the city's power supply; use waste heat from building's energy to create heating and cooling for buildings (p. 108)		The city government will help to finance energy-efficiency improvements in private buildings (p. 7)
Support the market for renewable energy (p. 103)		The city will develop an 80x50 plan to reduce GHG emissions from buildings (p. 8)
Provide incentives for energy-efficient appliances and electronics in buildings (p. 108)		
Require upgrades to light systems in existing buildings (p. 108)		
Promoting use of cleaner fuel for heating, such as Fuels No. 1, 2, and 3 (p. 127)		
Reduce building energy consumption by 16.4 million metric tons (p. 134)		

PlaNYC, created in 2007 by then-Mayor Bloomberg, is an extensive plan for implementing both sustainability as well as climate resiliency, with the main goal being a reduction in global warming emissions. This is especially important as NYC, by itself, emits an equal amount of GHG emissions to some small countries, such as Ireland and Switzerland (The City of New York 2007, 8). Therefore, a reduction in NYC's GHG emissions would play a large role in the reduction of overall global GHG emissions and the prevention of further global warming. To achieve this, *PlaNYC* features a section on energy, as this is responsible for much of the GHG emissions from buildings. The goals of *PlaNYC* are to create targeted incentives for energy efficiency (one of the categories of building efficiency policies that will be discussed in Chapter 5), as well as to strengthen energy building codes in the city (The City of New York 2007, 103). This plan also established a New York City Energy Planning Board to oversee energy efficiency plans and reduce energy consumption in the city as a whole. As the city found that 85% of its energy usage and GHG emissions in 2030 will come from currently existing buildings, *PlaNYC* places great importance on improving the energy efficiency of current buildings by incentivizing and mandating energy-saving measures, as well as establishing an energy awareness campaign – another key category in building efficiency policies (The City of New York 2007, 106).

When Mayor de Blasio took office, he upgraded *PlaNYC* to create *OneNYC*. As it is based off the original plan, *OneNYC* is also a strategic plan that targets global warming and has similar goals for reducing citywide GHG emissions, although it also includes economic equality and equity (The City of New York 2019, 4). *OneNYC* combines environmental sustainability with social measures as well, such as excellence in education and a safe and vibrant democracy (The City of New York 2019, 43). *OneNYC* also discusses the growing population of New York and the lack of housing to accompany this increase in population. In order to house all these New Yorkers, new buildings will likely be constructed, as *OneNYC* states. Here is where it is imperative that laws govern the kinds of buildings that can be constructed, including their materials, design, and limits to their GHG emissions, in order to prevent building-related GHG emissions from further increasing. In the city's 80 x 50 Technical Working Group report, a subsection of the *OneNYC* plan, they state that the city will require all new buildings to subscribe to an energy performance metric and develop standards for building energy performance (NYC 80 x 50 2016, 5). These two mayoral sustainability plans are the necessary first steps in reducing GHG emissions from buildings citywide and mitigating the spread of global warming.

Affordable Sustainable Housing. One main difference between *PlaNYC* and *OneNYC* is that *OneNYC* fights for environmental sustainability as well as for economic equality and equity, while Bloomberg's *PlaNYC* was focused mainly on environmental sustainability. While this makes *OneNYC* an incredibly ambitious plan, with many different subsections that have to work together, de Blasio recognizes that sustainability and equity are directly intertwined, as sustainability policies and actions often leave those from minorities or impoverished communities behind. Therefore, one of the eight insights that the plan's strategy is based on calls for safe, affordable housing with thriving and ample community resources, which can be seen in Figure 2 (The City of New York 2019, 43).

Affordable sustainable housing has already begun to take place in the city. In fact, out of all the building sectors, affordable housing has the largest percentage of green buildings in the city (Chen 2019). This is likely because green buildings are constructed in ways which are more energy-efficient, which then lowers energy costs for both the building owner as well as the tenant, making rental units more affordable. One example of this is Beach Green Dunes, an affordable rental building in Far Rockaway, Queens with 100 units, each of which is under $1,600 a month, even for a three-bedroom (Chen 2019). Beach Green Dunes relies on passive house principles for heating and cooling, as was discussed in Chapters 2 and 3, which allows both utility costs and GHG emissions to be reduced. As of 2019, Beach Green Dunes was just one of 119 passive house buildings in the city. De Blasio's *OneNYC* will hopefully lead to this number increasing tenfold, as well as many of them providing affordable housing units as the very concept of sustainable buildings makes them more affordable.

There are also currently policies regarding making affordable housing sustainable as well as cheaper. One of them is the Housing Preservation and Development's (HPD) "Solar Where Feasible" policy. Under this policy, any affordable housing project that is financed by HPD must complete a Solar Feasibility Analysis and is then required to install solar panels on the building if it shows a payback of 10 years or less (Housing Preservation and Development 2021). As discussed before, solar energy lowers operating expenses for both the building owner and the tenant, which thus helps to ensure both the affordability as well as the sustainability of the building. There are only three kinds of new affordable buildings that are exempt from this requirement. Two of them refer to buildings where the roof either would not support a minimum solar system size or buildings that could not meet the 10-year payback, which is important to maintain affordability (Housing Preservation and Development 2021). The other exemption refers to buildings that are already installing a green roof that will cover 90% of the roof space. While these buildings would still rely on fossil fuel for energy without solar panels, green roofs have many environmental benefits of their own. This policy is instrumental in maintaining affordable housing, which is especially necessary in NYC, while still fostering and establishing green buildings.

Climate Mobilization Act. In 2019, to bolster the goals outlined in *PlaNYC* and *OneNYC*, the city legislature passed the Climate Mobilization Act (CMA), which consists of several Local Laws that all pertain to different aspects of green urban city planning. This is the most extensive green legislature on a local level against climate change and GHG emissions, both across the country as well as the world. The goal of the CMA is to drastically reduce NYC's GHG emissions from their 2005 baseline levels by 40% and 80% by 2030 and 2050, respectively (NYC Council Members 2019, 3). To do this, the CMA features green roof legislation and implementation, an update to building energy efficiency regulation, the establishment of Property-Assessed Clean Energy financing to provide funding for building upgrades, and legislation regarding the GHG emission reduction of buildings (NYC Mayor's Office of Climate and Sustainability 2019). The various local laws that are part of the CMA, which are also in Figure 1 above, are listed separately in the table below.

Figure 3. Climate Mobilization Act Local Laws (IntelliGreen Partners 2021).[5]

Law	**Year**	**Description**
Local Laws 92/94	2019	New buildings or buildings under renovation must implement sustainable roofs (solar panels/green roofs)
Local Law 95	2019	Requires buildings to post their Energy Efficiency letter-grade score as determined in LL 33
Local Law 96	2019	Established Property Assessed Clean Energy (PACE) program to fund energy efficiency and renewable energy projects for buildings
Local Law 97	2019	Places carbon caps and emission limits on "covered buildings"
Local Law 98	2019	Requires New York City building code to be amended to include wind turbines as clean energy source as well as developing standards to support installation of wind energy turbines

Local Law 97, part of the CMA, created legislation in regard to reducing GHG emissions from covered buildings over 25,000 square feet (NYC Council Members 2019a, 5). One section of the law focuses on energy conservation measures, which must be implemented in covered buildings by the end of 2024. This includes items such as insulating all pipes and water tanks, repairing any leaks, and upgrading lighting in the buildings (NYC Council Members 2019a, 2020). The law also states a method for calculating the annual building emission limits, depending on the type of building. Failure to meet these emission limits will result in building owners and landlords being fined for each ton of carbon over the allowed limit. This fine will hopefully incentivize building owners to comply quickly with the new standards so that they don't lose money, which will lower GHG emissions in the city.

[5] https://igpny.com/nyc-local-laws/

Local Law 95, also a part of the CMA, is a form of public education policy. This law required that, by October 31, 2020, all building owners needed to display the energy efficiency grade of their building at the entrance (NYC Council Members 2019b, 1). The grade was determined through energy usage and annual benchmark reports that were required to be submitted to the city under Local Law 33, as seen in Figure 1. This is a percentile-based policy, which means only a certain percentage of buildings can receive scores of A or B, while the average building would receive a score of C or D. This law was created in order to both educate the public as to how the buildings they live and work in are performing as well as to encourage building owners and tenants to alter their energy consumption or processes in order to increase their score. If all the buildings became more energy efficient, there would be a massive reduction in the GHG emissions that are currently produced by buildings in the city.

Climate Leadership and Community Protection Act. The Climate Leadership and Community Protection Act (CLCPA), or Climate Act, was passed in 2019 for all of New York State as another comprehensive law to reduce GHG emissions and transition to clean energy (Climate Action Council 2022, 2). The CLCPA is one of the most ambitious climate plans in the world, which means that if it works, hopefully other states and countries will follow in its footsteps. Its main goal is relatively similar to that of the CMA, *PlaNYC*, and *OneNYC* – reduce GHG emissions. However, upon further breakdown the CLCPA calls for a carbon neutral economy, for all electricity to be zero-carbon by 2040, and to maintain at least an 85% reduction in GHG emissions from 1990 levels (Climate Action Council 2022, 2).

The passing of the CLCPA created a Climate Action Council, who was responsible for drafting a Scoping Plan regarding their intended outcomes and the reduction of GHG emissions (Climate Action Council 2022, 5). This plan was finished in 2021 and released to the public in

January of 2022, and the Climate Action Council is currently accepting comments from the public regarding the plan thus far. This is an extremely important and exciting aspect of the CLCPA, as most plans like this are typically not open to public comment. The CLCPA is also dedicated towards achieving climate justice and ensuring that disadvantaged communities receive access to renewable energy resources and clean, non-polluted air (Climate Action Council 2021, 31).

Similar to *OneNYC* and *PlaNYC*, the CLCPA has an entire section devoted entirely to buildings and how to reduce their GHG emissions. One of the biggest goals listed here is that, by 2015, 85% of homes in New York should have transitioned from fossil fuel-reliant heating systems to energy-efficient heat pumps powered through clean energy (Climate Action Council 2021, 122). Since energy inefficiency in buildings is responsible for a majority of building-related GHG emissions, as discussed in Chapter 3, the achievement of this goal would contribute to a significant reduction in GHG emissions overall. Another change that the CLPCA calls for in terms of fossil fuel-based energy is the alteration of current gas appliances such as stoves to electric instead (Climate Action Council 2021, 127). By 2024, state codes will be adopted that will prohibit the usage of gas stoves in the construction of new buildings and will encourage older buildings to change out their stoves. This transition will likely be complicated and building owners might require funding from the state for this, as almost all apartment buildings in New York City, even many of the newer buildings, have gas appliances. Replacing all of these fossil fuel-reliant systems with electric appliances instead will have a major impact on GHG emissions, although the transition to electric appliances will have the best result when paired with other changes such as smart grids or solar power in order to maximize the benefits and minimize the GHG emissions.

Climate Resiliency Policies. Although the main focus of this paper is on sustainability and mitigation of climate change, climate resiliency is still an important aspect of sustainability and green building initiatives. In 2017, the NYC Mayor's Office of Resiliency released the preliminary version of the Climate Resiliency Design Guidelines (these guidelines are now on version 4). The purpose of these Guidelines is to incorporate historic and projected data of climate change and severity into the design of city projects and buildings. Due to GHG emissions and other factors, global warming is only increasing in severity and the frequency of extreme heat days will continue to increase as well, especially in NYC due to the UHI effect discussed in Chapter 1. While not all of the recommendations in the Guidelines can be discussed in this paper, a comprehensive list of the Guidelines's calls to action are compiled in the figures below. Figure 4 presents the various categories of recommendations that the Guidelines state, while Figure 5 refers to different construction design strategies to create climate resilient buildings, taken straight from the Climate Resiliency Design Guidelines, Version 4.

Figure 4. Recommendations in the Climate Resiliency Design Guidelines (NYC Mayor's Office of Resiliency 2020).[6]

Recommendation	**Description**	**Citation Page**
Identify critical components in facilities	Buildings need to designate which aspects of the building are critical components and work to protect those in the case of extreme weather events, such as communication systems and emergency generators	P. 8
Adaptable building design	Refers to a type of design that has a flexible protection level, which reduces risk to the building (most necessary for buildings that will be useful past 2050)	P. 9

[6] https://www1.nyc.gov/assets/orr/pdf/NYC_Climate_Resiliency_Design_Guidelines_v4-0.pdf

Buildings that withstand extreme weather	Buildings need to be built or retrofitted to withstand the increasing heat and precipitation risks that come with global warming in order to keep the citizens inside safe	P. 11
Interventions for storm surge and sea level rise	City projects should be evaluated for flood risk, even if they are not currently at risk; if found to be at risk for future sea levels design interventions must be made	P. 29
Complete risk assessment for new buildings	This risk assessment screens for projects that will face a climate-related impact during its lifetime and how that would affect the building or its occupants	P. 34
Perform benefit-cost analysis on new projects	The goal is to establish what climate-prevention strategies would create which benefits for the building and quantify these strategies and benefits	P. 36

Figure 5. Climate Resiliency Design Guidelines "Design Strategies Checklist". (NYC Mayor's Office of Resiliency 2020, 53).[7]

Design Strategies Checklist (not exhaustive)								
	Extreme Heat	Comments		Extreme Precipitation	Comments		Sea Level Rise & Storm Surge	Comments
	Mechanical Cooling System			Select High Elevation Site			Select High Elevation Site	
	Minimize East-West Building Orientation			Select Higher Elevation within Existing Site			Select Higher Elevation within Existing Site	
	Passive Solar Cooling and Ventilation Systems			Green Roof			Raise Building Floor Elevation	
	Cool Roof (SRI appropriate)			Protect Below Grade Areas from Flooding			Waterproof Building Envelope	
	Green Roof (extensive)			On-site Stormwater Management (gray)			Elevate Critical Building Functions	
	Vegetated Structures (planters, walls)			Reduce Impervious Areas			Elevate Critical Equipment	
	Enhanced HVAC System, including space layout optimization, system scalability, and improved controls			Permeable Pavement			Perimeter Floodwall[92]/ Levee (passive or active)	
	More Efficient Building Envelope			Increase Green Spaces and Planted Areas			Dry/Wet Floodproofing	
	Shade Structures			Tree Planting/Preservation			Utility Redundancy Design[93]	
	Structures Covered by Energy Generation Systems			Bioswale			Resilient Materials & Landscape Treatments	
	Light Colored Pavements (appropriate SRI)			Rainwater Reuse Cisterns			Design for Storm Surge Outflow	
	Increase Planted Areas			Stormwater Planter			Install Backwater Flow Prevention	
	Permeable Surfaces and Open-grid Pavement			Grass Filter Strip			Design for Scour	
	Bioswales			Constructed Wetland			Raise Road Elevation	

[7] https://www1.nyc.gov/assets/orr/pdf/NYC_Climate_Resiliency_Design_Guidelines_v4-0.pdf

	Daylighting			Selection of Salt/Flood Tolerant Plantings			Flexible Adaptation Pathway	
	Window shading			Selection of Native Plantings			Constructed Wetland	
	Operable windows			Preservation of Natural Vegetation			Preservation of Natural Wetland	
	Waste Heat w			Other:			Other:	
	Solar + storage							
	Trees and Shrubs							
	Preservation of Natural Vegetation							

The Guidelines call for designers of new projects to assess the relationship between their construction project and the increasing heat of the city (NYC Mayor's Office of Resiliency 2020, 12). Similar to the above aspect, project designers should attempt to design heat resilient facilities in order to ensure public health, as well as to reduce stress on heat-sensitive infrastructure in buildings. The Guidelines also aim to reduce the UHI effect through green roofs and an increase of vegetated structures. Yet this can also be reduced by evaluating differing sources of heat pollution from buildings, as well as implementing HVAC controls for intermittent ventilation, which reduces the amount of heating and cooling in buildings, thus lowering energy-related GHG emissions (NYC Mayor's Office of Resiliency 2020, 14). Given the increasing frequency of extreme weather events, as well as the climate projections made in the Guidelines, one aspect of the Guidelines is thus to prioritize occupant thermal safety in buildings for the case of these extreme weather events, by incorporating passive ventilation and design into buildings in order to keep indoor spaces cool during these events (NYC Mayor's Office of Resiliency 2020, 17).

CLT Building Policies. In 2015, the International Building Code (IBC) included a section on cross-laminated timber buildings for the first time, thus recognizing it as an acceptable building material. This is extremely important, as NYC bases many of its building codes and regulations off of the IBC. However, the IBC set height limits for all types of mass timber buildings, including CLT. They could only be 85 feet tall, and residential buildings could be 5 stories while commercial buildings could be 6 stories (International Code Council 2015). Since New York City is a city of high-rise apartment buildings and skyscrapers, this height limitation technically meant that CLT buildings could not be built in NYC.

Fortunately, the International Building Code of 2021 has updated the regulations regarding mass timber buildings. In the 2021 version, mass timber buildings are allowed to be up to 18 stories in height, depending on the type of building (International Code Council 2021). However, this refers to buildings only that *consist* of mass timber as a major structural component. Buildings with all exposed mass timber, which is what CLT buildings fall under, can still only be 9 stories tall (International Code Council 2021). While this represents a semi-win for policies in regards to mass timber buildings, New York City – which will adopt the new building regulation codes – will still not be likely to construct CLT buildings as they can only be 9 stories tall. The new version of the IBC will also not be fully adopted for a couple of years, meaning that mass timber and CLT buildings are still on hold throughout the United States and New York City.

Policies regarding future building construction and the upgrading of current buildings to meet new energy efficiency standards are vital to reducing overall GHG emissions from both buildings as well as the city. While New York City has certainly gone to greater lengths than the majority of US cities in terms of green building plans for a sustainable city, there are still further policy steps that must be taken in order to reduce GHG emissions and mitigate the effects of global warming and climate change.

Chapter 5. Policy Recommendations

New York City's climate goal is currently to reduce GHG emissions by 80 percent from 2005 baseline levels by 2050 (Lee et al. 2017, 323). While NYC currently already has several policies in place to try and achieve this, as discussed in Chapter 4, these policies alone are not enough. The frameworks that each chapter centered on – history of sustainable architecture in Chapter 2, the urban planning behind the construction and design of green buildings in Chapter 3, and the political aspect in Chapter 4 – must all be linked and understood together in order to create a comprehensive set of policy recommendations. New York City must make new policies that draw on the background of these disciplines as well as tightening and re-enforcing their existing policies.

Barriers and Concepts Behind Policies. One of the main reasons that architects and building owners do not lean towards sustainable buildings is due to the up-front cost of investing in a green building. Energy efficiency in buildings is guilty of a split incentive, as building owners are responsible for covering the costs of investing in energy efficiency, yet the occupants pay the lower energy bills (Managan et al. 2012, 1-35). This reduces the market incentive for the building owners, as their overall profit would be lower. This means that policies must either feature an economic incentive to building owners and architects to invest in energy efficiency or simply mandate it so they have no choice but to comply. The split incentive of energy in buildings is discussed in *OneNYC*'s Technical Working Group Report, as listed in Figure 2 in Chapter 4, as the report calls for policies that regulate or manage the split energy use. Policy options in regards to energy efficiency in buildings stem from 6 categories – codes, targets, awareness, incentives, utilities, and capacity building (Managan et al. 2012, 1-36).

Together, the six categories consist of a comprehensive list of policy options in regards to the built environment, specifically energy efficiency in buildings. The code category refers to building energy codes or new standards that appliances and equipment must meet before they can be installed in buildings, thus reducing the overall building GHG emissions. Targets consist of the government establishing written and published targets for either building efficiency improvement or for government procurement (Managan et al. 2012, 1-37). This category is less related to actual policies and more so establishes goals that will be kept in mind when writing policies in order to reach these goals. The next category, awareness, ranges from public education campaigns regarding building efficiency and sustainable buildings to disclosure and posted grades of energy performance – which NYC has already implemented as part of Local Law 95 – as well as audits and data collection (Managan et al. 2012, 1-37). The incentive category is perhaps the most well-known category behind policies. This includes funds and loans to buildings to meet targets or goals, tax incentives, or carbon caps (Managan et al. 2012, 1-37). The fifth category is policies with concern to utilities, which consists of utility public benefit funds, revenue decoupling (separating the revenue of a utility from consumer use), and dynamic pricing of electricity (Managan et al. 2012, 1-37). Finally, the last category, capacity building, is related to the social infrastructure behind building energy, such as technical assistance and work programs and training (Managan et al. 2012, 1-37). When creating legislation and policies with the goal of increasing energy efficiency in buildings and establishing green buildings, the legislators must keep these categories in mind as they formulate their policies.

Energy Policies. The vast majority of New York City's building-related and GHG emission laws and policies are currently applicable only to building owners, landlords, architects, and construction companies. This is seen in Local Law 97, which places emission limits on buildings as a whole and fines the building owner if the limit is breached. However, while corporations and building owners are largely responsible for the majority of the GHG emissions released as well as capable for the mitigation of GHG emissions through building design, the individuals living and working in the buildings must still be considered as they contribute to building GHG emissions in their daily lives. This is related to a policy recommendation laid out in *OneNYC's* 80x50 Technical Working Group Report, listed in Chapter 4's Figure 2, regarding the regulation of tenant energy use in order to reduce the energy use of the entire building. One way to do this is through a carbon fee on apartment tenants, which would fall under both the incentive and utility policy categories discussed earlier in the chapter. This was recently instituted in Germany. Starting in January of 2021, tenants with oil or gas heating in Germany must pay a carbon price for their consumption of heat (Wettengel 2021). Of course, this would only be applicable to tenants in New York City in buildings where the tenants pay for their heat, otherwise this fee would land on building owners and landlords again. This carbon fee works twofold – it produces an incentive for the average tenant to reduce their heating usage in order to save money, as well as creating a set of funds in the government that can be allocated to further energy efficiency and sustainable buildings. However, as with all individual policies, caution should be taken with regards to income levels and economic and environmental justice when implementing this policy. The goal is not to further disadvantage any lower-income communities, who already spend a greater percentage of their budget on heating costs.

Another energy policy, coincidentally also drawn from Germany as it is one of the leading countries in terms of renewable energy, is that of feed-in tariffs. In 2000, Germany instituted feed-in tariffs as part of their Renewable Energy Sources Act (Hoppmann et al. 2014, 1430). A feed-in tariff is a policy that is supposed to encourage renewable energy production by setting a fixed-price for those who generate renewable energy and compensating them. With the feed-in tariff, Germany created a mass incentive for both homeowners and utility corporations to rely on renewable energy instead of fossil fuel energy. This feed-in tariff is what is majorly responsible for the wide-spread institution of solar panels in Freiburg, the city discussed in Chapter 3. New York City should institute feed-in tariffs with regards to solar panels and other renewable energy sources as well. This would fall under the incentive category of policies and would hopefully incentivize both major utility companies such as ConEdison and building owners to switch over to renewable energy. With feed-in tariffs, they would be compensated for the electricity that they generate. Depending on how much they produce, they would likely also be able to sell some of the electricity back to the grid and make even more money that way. Monetary rewards typically work well as an incentive, and so if New York City instituted this policy it is likely that at least some building owners would install solar panels on their roofs.

Electricity Policies. As electricity, heating, and cooling are responsible for many of the GHG emissions from buildings, there need to be more policies regarding this. One effective one was mentioned above in the utility category – revenue decoupling. Typically, utilities are priced by the company and paid for by the consumer under a rate case (Glatt and Dunkle 2010, 3). Under revenue decoupling, the utility's revenues are separated from its level of sales by ensuring that the utility company will earn a fixed level of revenues, even if there are reasons that energy usage or utility rates decrease (Glatt and Dunkle 2010, 1). This reduces the incentive that electric companies currently have to discourage energy efficiency programs or usage with their customers, as it ensures that they earn a fixed revenue even if their consumers participate in energy efficiency measures. As this helps to increase energy efficient use, this helps to reduce GHG emissions related to heating and cooling coming from natural gas or oil. Although there are many city policies with regards to building energy efficiency – such as Local Laws 88, 87, 47, 132, and 96, which are all described in Figure 1 in Chapter 4 – there are currently no policies that relate to revenue decoupling, or really any that are directed towards utility companies instead of building owners.

Another policy with regards to electricity usage and utility companies would be to mandate the introduction of the smart grid throughout New York City. As opposed to the current grid, which only runs one-way by sending electricity from the utility company to the user, the smart grid sends signals both ways. It also sends communication from the consumer to the utility company as to how much energy they are using and whether or not it is at peak times (U.S. Department of Energy's Office of Electricity 2022). This helps to teach consumers about their energy usage, similar to the smart meter discussed in Chapter 3, and would therefore help to reduce their energy consumption. This would lower the amount of fossil fuel consumed for energy. A smart grid is also better suited to integrate renewable energy sources that are provided by the consumer (U.S. Department of Energy's Office of Electricity 2022). Given the importance of switching from fossil fuel energy to renewable energy, this would be a big benefit of the smart grid. New York City should mandate the smart grid throughout the city in order to increase energy efficiency and reduce energy consumption, which would lower GHG emissions from buildings since energy usage constitutes a large percentage of the total emissions.

Construction of Buildings. As stated in Chapter 4, the International Building Code currently does not allow buildings higher than nine stories to be built entirely of CLT. This is unfortunate since Chapter 3 discussed that, in terms of urban planning, CLT is one of the best forms of green buildings due to its low carbon footprint during production, which means that the current IBC-based policy is detrimental to sustainable buildings in NYC as the majority of NYC's buildings, particularly the newer ones, are over nine stories, which thus prohibits the establishment of CLT buildings in NYC. In terms of policy category, policies regarding CLT buildings would fall under the code section, as policies would need to set building codes and standards for CLT and other mass timber buildings that would allow them to be built as skyscrapers in New York City. High-rise CLT buildings have already been built and function with success in other countries and so there is no reason why they could not be built here. This policy would need to be on an international level, as New York City bases its building codes off the IBC. However, NYC can still update its building codes without regard to the IBC and create a policy that would allow the construction of taller CLT buildings. The necessity of a policy supporting CLT buildings and the greater use of wood in skyscrapers draws from the historical sustainable use of wood in architecture that was discussed in Chapter 2.

It is clear that mass timber buildings can function as high-rise buildings since other countries have already successfully implemented this style of construction. In Brumunddal, Norway, the Mjøstårnet building was completed in 2019. This building consists of offices and restaurants as well as apartments and, at 18 stories high, is the tallest mass timber building in the world (Bianchini 2020). The building materials are CLT and glued laminated timber (glulam). This means that the building consists almost entirely of wood materials and is thus incredibly sustainable and sequesters thousands of tons of carbon. While the 2021 IBC says that buildings with all exposed mass timber can only be nine stories tall, Mjøstårnet is twice this height, consists of all exposed mass timber, and still fulfills fire and structural regulations. Given the success of this building, which is not the only one of its kind in the world, New York City should adopt new policies that allow mass timber buildings to be constructed to a higher height.

Another construction policy would be to require all new buildings to be carbon neutral in operations. A carbon neutral building is when GHG emissions are minimized during all aspects of building operation, throughout manufacturing, production, construction, and the day-to-day usage. Any emissions that do occur are then counteracted by climate-positive initiatives, resulting in a net zero carbon footprint or even a negative carbon footprint. To do this, the building materials must be carefully chosen so that their GHG emissions are minimized in all stages of the building's existence, such as mass timber. Even if the building is not entirely constructed of wood, wooden materials help to contribute to a carbon neutral building. The remaining emissions of the building, such as those which come from heating and cooling, should then be offset through other initiatives, such as solar panels installed for electricity, as discussed as part of urban planning in Chapter 3. Vancouver, Canada, has already mandated that all buildings constructed after 2020 must be carbon neutral (National Academies of Sciences, Engineering, and Medicine 2016, 71). Although Local Law 97 in NYC currently places a cap on buildings' carbon emissions, there is currently no policy regarding carbon neutral buildings. New York City should implement a similar law to Vancouver, which would mitigate any GHG emissions from future buildings that will be constructed. This could be in the form of either a target policy, where the government sets the target for all buildings to be carbon neutral, or an incentive policy, where the government provides funds to all building owners or designers who demonstrate that their building will in fact be carbon neutral.

Limiting Exceptions to Existing Policies. Chapter 4 discussed Local Law 97, which was passed under the Climate Mobilization Act of 2019 and sets a carbon cap on covered buildings in order to reduce their GHG emissions. Under this law, starting in 2024, buildings will have to compile an annual Greenhouse Gas Emissions report and comply with the emissions limit for the year (Department of Buildings 2021). However, Local Law 116 – listed in Figure 1 – omits several different kinds of buildings from having to comply with building limits. These include city buildings, religious houses of worship, and certain rent-regulated, income-restricted, or federal housing projects (Department of Buildings 2021). While it is true that these buildings are in a different sector than the typical residential or commercial building and thus might not have as much financial ability to make the changes that are necessary in order to reduce GHG emissions, they must still be held accountable and should not be exempted from Local Law 97 and its regulations. Thus, one necessary policy is to amend Local Laws 97 and 116 to include all covered buildings, with no exceptions.

However, these buildings might need assistance in complying with their set limits. There are a couple of ways that the government can help these buildings by establishing policies under the targets category. The first would be, as the current penalty for a building exceeding its annual emissions limit is a fine, to allocate the penalty fines as assistance for rent-regulated or lower-income buildings to meet their own emission standards. The second would be to establish the carbon fees on individual tenants in non-rent regulated buildings, as discussed above, and use the revenue from those fees to help lower-income or rent-regulated buildings meet their building emission targets.

Public Education. Education and awareness of issues is one of the strongest tools that the climate movement has at its disposal, as individuals can either advocate for change either on a policy level with federal or local governments or on a more local level such as with companies that they work for, or they can change their own habits with education. Thus, one way to reduce building-related GHG emissions in New York City would be through public education. The city already has one policy in regards to this – Local Law 33, which mandates that all building owners must post their energy efficiency grade somewhere visible on their building. Under this policy, buildings are given letter grades of A-D. As their tenants can see the energy efficiency scores, this provides awareness to the tenants of their building's energy measures and – if the score is not good – they can either change their energy consumption habits or advocate to the landlord or building owner to improve energy efficiency measures in the building.

However, just posting the energy score is not enough, as not all people even pay attention to the building energy signs or know what they mean. As listed in Figure 2, Chapter 4, *PlaNYC* called for a city-wide energy awareness campaign (The City of New York 2007, 103). One way to do this is through education in school. Sustainability education should be sprinkled throughout the years of school, beginning in K-8 and becoming more in-depth in high school. Teaching children about energy efficient lighting and electricity can start conversations between them and their parents or guardians and might encourage the children's guardians to implement more energy efficient measures in their homes. Education also encourages people to change their own habits. Thus, environmental classes instituted in high school would help develop environmentally-conscious students who limit their use of energy consumption and fossil fuel reliance. Unfortunately, environmental education has been marginalized, particularly in developed and Western countries where nature is viewed as less fragile than it is in developing countries (Stevenson 2007, 273). This means that policies must be enacted in NYC in order to ensure environmental education in schools. Environmental education is especially important because public schools have traditionally been viewed as instruments of policy agenda (Stevenson 2007, 272). Thus, environmental education in public schools in New York City would hopefully lead to the next generation advocating for environmental reform, climate change policies, and a lowering of building-related GHG emissions in the city.

Chicago's Policies. As mentioned in the Introduction, Chicago has received a Platinum score on the LEED (Leadership in Energy and Environmental Design) certification score (US Green Building Council 2021, 6). In contrast, New York City is not even one of the LEED-certified cities. Given Chicago's environmental success, especially in terms of green buildings, it is helpful to analyze its existing policies against New York City's to compare and contrast the differences and see how New York City could make improvements to its own policies. There are some similar policies between the cities, such as Chicago's Energy Benchmarking Ordinance, which is essentially the same as NYC's Local Laws 33 and 95, as discussed in Chapter 4 (The University of Chicago Office of Sustainability 2022). However, while these are good laws and policies, clearly, they are not all that is required to be a green city as Chicago is achieving that much better than NYC.

One program Chicago has implemented that has helped to achieve energy efficiency throughout the city is that of the Chicago Bungalow Association initiative. This program provides free energy retrofits to homeowners who earn under a certain median income, as well as guides and workshops to help the homeowners upkeep their homes and retrofit them (City of Chicago 2022a). This program is important as it helps to introduce sustainable affordable housing, which is necessary so as not to disadvantage those of lower-income, as well as providing the opportunity for energy efficiency for those who could not otherwise afford it. As the city government shoulders the cost of the energy retrofits in the homes, this encourages more homeowners to retrofit their homes to be more energy efficient than if they had to pay for it themselves. New York City should implement a similar program, wherein the government pays for certain types of buildings or those owned by people under a certain income bracket to be retrofitted to be energy efficient. Since heating, cooling, and electricity constitute a large majority of the GHG emissions released by buildings, as stated in Chapter 3, any changes made to the energy efficiency of buildings in New York City would help to lower their overall GHG emissions.

Another policy Chicago has that NYC should implement is a green roof policy. In 2013, Chicago had roughly 5.5 million square feet of green roofs across the city (City of Chicago 20022b). Comparatively, in 2016, NYC had a little over 2.5 million square feet of green roofs (The Nature Conservancy 2016, 2). In New York, the majority of green roofs are located on private buildings, while Chicago has made a point to install green roofs on many of their publicly-owned city and municipal buildings as part of their Chicago Climate Action Plan. This means that, in New York, most green roofs are the result of private citizens who are attempting to green their building as opposed to any effort made by the city to create more sustainable buildings. Thus, one policy that New York City should enact would be to mandate green roofs on all new city buildings and to fund the addition of green roofs onto existing public and private buildings. This would help to mitigate building-related GHG emissions as green roofs absorb these emissions from the atmosphere as well as to lower the effects of the UHI in NYC, as discussed in Chapter 3.

It is clear that GHG emissions are harmful and disrupt both ecosystem services as well as human well-being. New York City is especially guilty of contributing to the issue of GHG emissions and how they relate to climate change through the vast amounts of GHG emissions that stem from NYC buildings. These emissions must be slowed and counteracted in order to mitigate the harm that the human race is causing to the environment. This can be done through the retrofitting of existing buildings, the construction of new green buildings that rely on active and passive sustainable design and building materials, and regenerative buildings that act as carbon sequesters to absorb some of the GHG emissions in the atmosphere. There are currently not enough sustainable buildings in NYC, nor enough policies regarding their existence and energy efficiency, and thus it is necessary to alter the current urban planning to be more sustainable and create new policies that mandate energy efficient and sustainable buildings in NYC to reduce GHG emissions in the city and help NYC to meet its target climate goals.

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