planYC

NEW YORK CITY'S PATHWAYS TO DEEP CARBON REDUCTIONS

DECEMBER 2013

A GREENER, GREATER NEW YORK

The City of New York
NYC Mayor's Office

The City of New York would like to thank everyone who lended their valuable assistance in producing this report:
All correspondence related to this report should be directed to OLTPS, at planyc@cityhall.nyc.gov

Academic Citation:
City of New York, *New York City's Pathway to Deep Carbon Reductions,* Mayor's Office of Long-Term Planning and Sustainability, New York, 2013.

This document was designed by Aaron Lewis .

Cover Photo: Looking south from Manhatta, Empire State Building
Credit: John Lee

Contents

Acknowledgements

Work on this report was funded through New York State Energy Research and Development Authority (NYSERDA) under the Cleaner, Greener Communities Program.

The report was written by the New York City Mayor's Office of Long-Term Planning and Sustainability (OLTPS) the with technical support from McKinsey & Company (carbon abatement strategies and carbon abatement cost curves), Charles River Associates (power sector modeling), AECOM (technical expertise, policy development, and REMI economic modeling), and Couch White LLP (regulatory matters).

This report would not be possible without the contributions from numerous private and public sector partners who generously provided their time and expertise. We are deeply grateful to all of them for their ongoing support.

The Cleaner, Greener Communities Program

In 2011, New York Governor Andrew M. Cuomo announced the establishment of the Cleaner, Greener Communities Program. Administered by NYSERDA, the Cleaner, Greener Communities Program provides resources to New York State communities for the development and implementation of sustainable development practices. The program aims to guide integrated, sustainable solutions, from statewide investments to regional decision-making on land use, housing, transportation, infrastructure, energy, and environmental practices to improve New Yorkers' quality of life.

The Cleaner, Greener Communities Program will provide up to $100 million in competitive grants to the state's 10 Regional Economic Development Council Zones over two phases. Phase 1 provided nearly $10 million to support the development of regional sustainability plans. As New York City already has a sustainability plan in PlaNYC, the City used $1 million in Phase 1 funding to study possible pathways to achieve deep carbon reductions by 2050, the results of which are the subject of this report. In addition, the City used this funding to study the economic impact of PlaNYC's initiatives, to complete an audit of its current greenhouse gas inventory, and to develop recommendations to support the City's completion of a neighborhood-level greenhouse gas emissions inventory. Phase 2 of Cleaner, Greener Communities Program commenced in 2013 and provides implementation funding for projects that will reduce greenhouse gas emissions, save energy, deploy renewable energy, and support the achievement of the targets and goals established by the Phase 1 planning process, providing economic and environmental benefits for the state's communities.

Executive Summary

The City of New York committed to reduce its greenhouse gas emissions by 30 percent before 2030 (30 by 30) as part of its long-term sustainability agenda, PlaNYC. Six years later, emissions have fallen by more than 19 percent, or nearly two-thirds of the way to the 30 by 30 goal. The city's power supply is cleaner; buildings are more energy efficient; and New Yorkers are driving less and generating less waste. The City has also created ambitious policies and programs to foster emissions reductions throughout the public and private sectors.

Despite this local progress, global greenhouse gas emissions (GHG) are rapidly accelerating. If the current trajectory continues, temperatures could rise by 4 to 6°C this century and yield up to six feet of sea level rise. The New York City Panel on Climate Change (NPCC) predicts that local sea-level rise could be even greater. The United Nation's Framework Convention on Climate Change set a goal to limit the rise in temperature this century to just 2°C to prevent "dangerous anthropogenic interference with the climate system." Respecting this limit would require cutting global emissions by at least 50 percent below 1990 levels by mid-century. The European Union and several U.S. states, including California and New York, have pledged to cut their emissions 80 percent by 2050 from 1990 levels (80 by 50).

Cities, too, must act. More than half of the world's population now lives in cities, and cities are responsible for the vast majority of global emissions. New York City alone produces roughly half a percent of total global emissions. The City also has significant tools to promote emissions reductions, including its ability to regulate buildings and land use, collect taxes and offer incentives, create innovative programs and public-private partnerships, and build and operate major infrastructure as well as thousands of public facilities. Investments in resiliency can also be leveraged to promote emissions reductions.

For a city like New York, whose residents and businesses already emit far less on a per capita basis than the U.S. average, the question is: what is the appropriate long-term reduction target and what would it take to get there? The 2011 update to PlaNYC called upon the Mayor's Office of Long-Term Planning and Sustainability (OLTPS) to undertake a study to answer this question.

Study Objectives and Methodology

This study seeks to evaluate the potential for achieving deep long-term carbon reductions in a way that is grounded in practical realities — particularly the complexity and uniqueness of New York City's built environment and infrastructure — and is thoughtful about economic impacts. The goal of the study is to ask whether it is possible to reduce the city's GHG emissions by 80 percent before 2050 from 2005 levels, and if achievable, to identify the lowest cost pathways and highest priority near-term actions needed to reach this goal.

The study begins by evaluating the 'technical potential' for reducing emissions in the four highest impact sectors — buildings, energy supply, transportation, and solid waste. An internally consistent quantitative model is used to determine the abatement potential and cost-effectiveness of more than 70 unique measures across the four sectors. A cost-production model is also used to evaluate options and timelines for decarbonizing the electric grid. A macro-economic model is then used to evaluate the economic and jobs impacts of the 80 by 50 pathway compared to business as usual.

The analysis focuses on existing and emerging technologies and practices rather than pinning hopes on future breakthroughs. It also grapples with key challenges to implementing carbon reductions, including insufficient financing, high opportunity costs, split incentives, behavioral inertia, market constraints, and regulatory obstacles. To test the limits of what is possible, New York City is assumed to act alone, in the absence of Federal policy, and without a significant price on carbon.

Summary of Findings

Technical Feasibility

New York City could achieve 80 by 50 but it would be exceptionally difficult

Achieving 80 by 50 is theoretically feasible but would require change at an unprecedented and technologically-untested scale. It would require large investments in energy efficiency and cleaner energy sources, wholesale transition to low-carbon transportation technologies, and the transformation of the solid waste sector. Up to two thirds of these investments could be cost effective because they would yield energy savings that would offset upfront costs; the rest would yield little or no payback. Regardless of the economics, market barriers would need to be overcome at every step of the way.

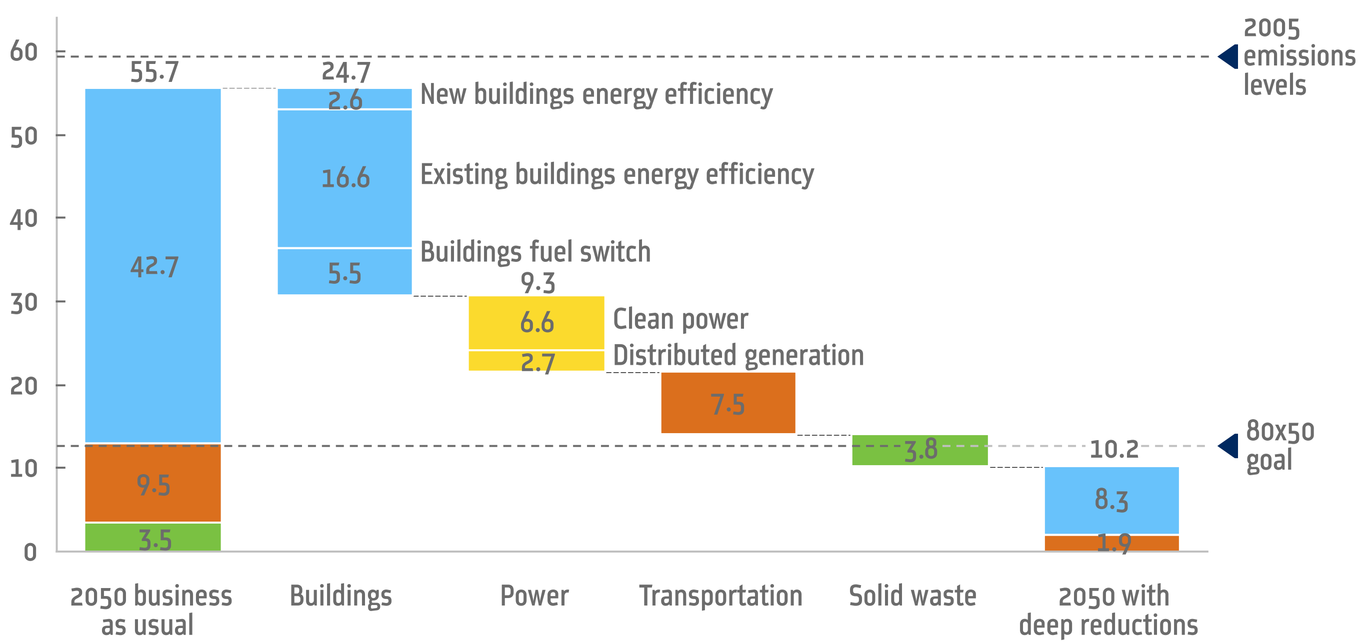
Action on all fronts would be needed

Achieving 80 by 50 would require targeted actions to reduce emissions in every sector, market segment, and technology application. With no shortcuts available, and with no reasonable expectation of breakthrough technologies on the horizon, a portfolio of small actions using currently available practices would be needed. The majority of the reductions would come through energy efficiency in buildings (62 percent), followed by cleaner power (18 percent), transportation (12 percent), and solid waste (8 percent).

Accelerating near-term action would increase the likelihood of achieving 80 by 50

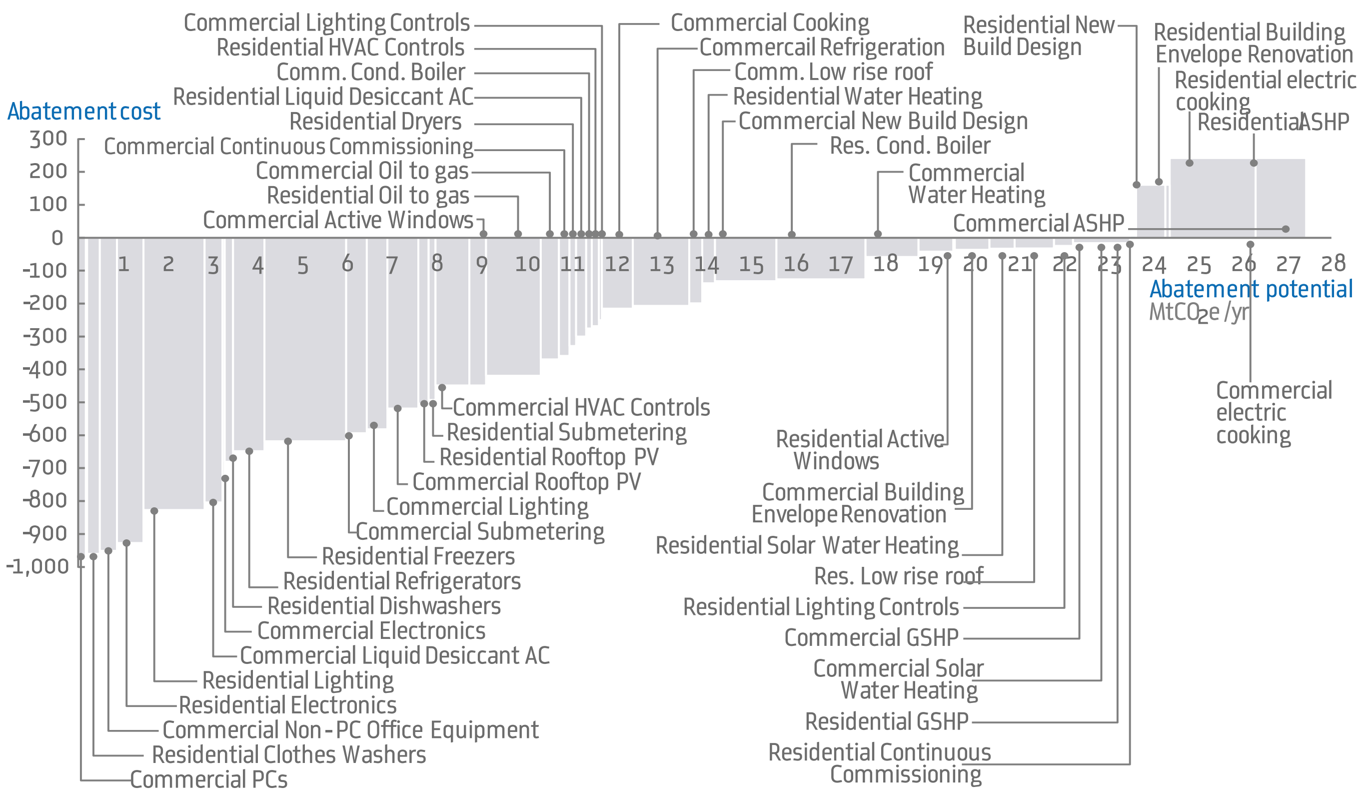
Achieving deep emissions reductions by mid-century would require consistent progress year in and year out. Accelerating attainment of the PlaNYC 30 percent reduction goal by 10 years — reaching it by 2020 rather than 2030 — would put the City on a trajectory to achieve 80 by 50. The sooner the City is able to get on a pathway to deeper reductions, the more likely it is to reach 80 by 50. However, even if the City reaches 80 by 50, it would still emit roughly 60 percent of the total emissions that would be expected under business as usual.

Abatement Potential by Sector
Million Metric tons of Carbon Dioxide Equivalent ($MtCO_2e$)



Source: NYC Mayor's Office

2050 Marginal Abatement Cost Curve for Buildings Sector
$/tCO$_2$e



Source: NYC Mayor's Office

Reductions by Sector

Buildings

Energy use in buildings is directly or indirectly responsible for 75 percent of the city's carbon emissions. Substantial opportunities exist to cost-effectively save energy, with the potential to yield up to 27.8 million tons of emissions reductions (43 percent of 2005 emissions). To achieve 80 by 50, New York City must retrofit a large majority of today's existing buildings; convert onsite combustion of fossil fuels to renewable or low-carbon energy; construct new buildings 75 percent more efficiently than existing construction standards; and greatly improve the efficiency of appliances and electronics.

A foundation for action is already in place. The Greener, Greater Buildings Plan is demonstrating the important role that public disclosure of energy performance data can play in encouraging activity in the marketplace. The NYC Clean Heat program shows that a combination of regulations, resources, and partnerships can help building owners to accelerate investments in building systems. And the New York City Energy Efficiency Corporation (NYCEEC) is successfully working with private lenders and businesses to increase the availability of financing.

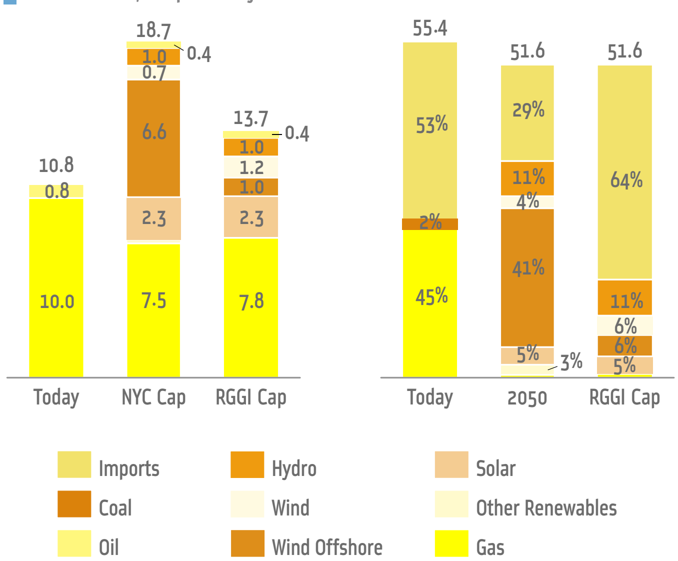
Capturing the full potential of these reductions, however, could be extraordinarily difficult. The sheer scale of the undertaking, spread across nearly one million buildings, is far beyond what the current marketplace for energy efficiency can support. The City would also need to provide encouragement to building owners to undertake efficiency measures when they face limited access to capital and competing needs, and may also be unable to realize the benefits of their investments because building tenants may receive a large portion of the energy savings. Finally, there is a widespread need for education and technical assistance.

Power

New York City's power system is already one of the Nation's cleanest and most reliable. Two thirds of the city's electricity is generated from natural gas, which is far cleaner than coal or heavy oil, while carbon-free hydro and nuclear resources supply the remainder. Achieving 80 by 50, however, would require the power system to become even cleaner. Assuming that electricity demand from other sectors decreased by as much as 36 percent, some inefficient and carbon-intensive generation could retire, but significant gas-fired generation capacity would need to remain online to maintain reliability. The remaining supply would have to be decarbonized almost completely.

The city has already made significant progress in decarbonizing its power supply in recent years. Electricity is more than 30 percent less carbon-intensive today than it was in 2005 because power plants have switched from heavy oil to cleaner and less expensive natural gas, inefficient plants have retired, and several new state-of-the-art facilities have come online. The City is also supportive of developers' plans to import up to 1 gigawatt (GW) of hydropower from Quebec and build up to 700 MW of offshore wind turbines in the waters off of the Rockaway peninsula. Meanwhile, the City is working closely with utilities, research partners, and private businesses to accelerate the growth of clean distributed generation — including photovoltaic solar (PV) and combined-heat and power (CHP).

Installed In-City Capacity and Generation Mix
GW and TWh, respectively



Source: NYC Mayor's Office

To reach 80 by 50, the City would need to overcome unprecedented technical challenges to interconnect large-scale renewable energy resources like solar and wind that only operate intermittently. It would also be necessary to fundamentally rethink the current regulatory model in the power sector. Costly investments in cleaner sources would also be necessary and tradeoffs would need to be made among competing resources — for example, determining the appropriate role of nuclear power. Equipment installed today may still be around by mid-century, but that should not deter investments in more efficient technologies like natural-gas fired cogeneration that are still far from optimal from a carbon emissions standpoint.

Transportation

New York City's expansive mass transit system allows New Yorkers to drive much less than other Americans. Because New Yorkers take so many fewer car trips, they emit 75 percent less CO_2e than the per capita American average. Yet transportation in New York City is still responsible for over ten million tons of annual emissions, or 20 percent of our citywide total. Nearly all of these emissions stem from the combustion of fossil fuels in on-road vehicles. To achieve 80 by 50, the city must almost entirely shift from automobiles powered by fossil fuels to other less polluting technologies and modes of transportation.

PlaNYC is already fostering positive changes in the transportation sector by focusing on actions that the City can undertake on its own: making streetscapes more lively and pedestrian-friendly; zoning for neighborhood density and diversity to reduce the need for car travel; expanding mobility options through launching the Select Bus Service program and the nation's largest bike share program; and creating electric vehicle charging infrastructure. The City's automotive fleet also operates over 5,000 hybrid and alternative technology vehicles and is utilizing up to 20 percent biofuels in all diesel vehicles.

Capturing the full potential of transportation emissions reductions would require navigating a complex web of City, State, and Federal policies and many layers of private sector involvement to expand investment in the region's transit system — a task as necessary as it is challenging. Full regional collaboration, as well as perseverance, would be needed to make longer-term, transformative investments to enhance transit service and connectivity. Consumer education, behavioral change, and accelerated adoption of cleaner technologies would also be essential. Finally, the City and region would need to find creative ways to mitigate traffic congestion and fund transit improvements in a challenging fiscal and political environment.

Solid Waste

New York City generates more than 11 million tons of waste each year — the equivalent volume of 3,000 large trucks every day. Emissions from the solid waste sector are 22 percent lower today than they were in 2005 because New Yorkers are generating less and the City is using cleaner modes of transport, but solid waste still accounts for nearly 5 percent of total emissions. The potential exists to reduce emissions by up to 3.5 million tons and even to achieve carbon neutrality in the sector. This would require significant increases in recycling rates and waste reduction efforts. It would also require diverting the majority of organic waste from landfills and converting waste into energy at state-of-the art facilities.

The City is making tremendous strides to improve the sustainability of the waste sector. To support the PlaNYC goal of diverting 75 percent of solid waste from landfills, the city now accepts all rigid plastics for recycling — the largest expansion to the recycling system in its 25-year history. The City is also conducting successful pilots to collect and process organic waste from residential buildings and public schools; and it is partnering with leading restaurants to divert food waste from landfills. Finally, the City is continuing to implement the Solid Waste Management Plan by shifting from truck-based transport to less polluting rail and barges.

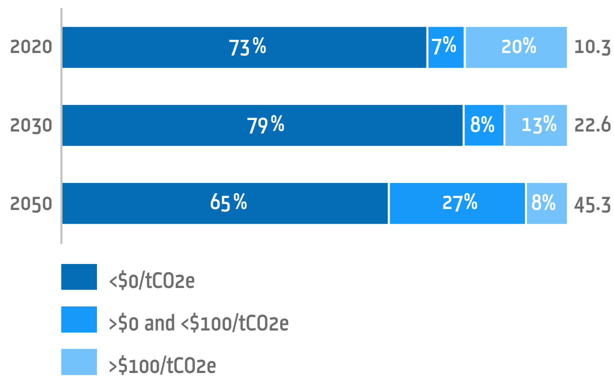
Nevertheless, the City faces significant challenges in decarbonizing the waste sector. Aggressive and sustained efforts would be needed to change behavior and engage more New Yorkers in recycling. Significant private investment in the region's waste processing infrastructure would also be necessary, but investment would only occur if the policy environment is conducive. Finally, New Yorkers would need to continue reducing the amount of waste they generate, which will be challenging since they already produce far less waste per capita than most Americans.

Economic Impacts

Many carbon abatement measures would be cost-effective

Roughly two-thirds of the measures evaluated in this study would be cost-effective from a societal standpoint, meaning that economy-wide benefits would outweigh costs. This assumes that investments are made with financing at a low interest rate of 4 percent, which is equivalent to a long-term government bond. In reality, most residents and businesses would incur higher costs of capital and seek greater economic returns. Nevertheless, ample opportunities exist to save money and yield quick paybacks for individual actions and economy-wide.

Abatement Potential by Cost per Ton
% of total; Metric tons CO_2e

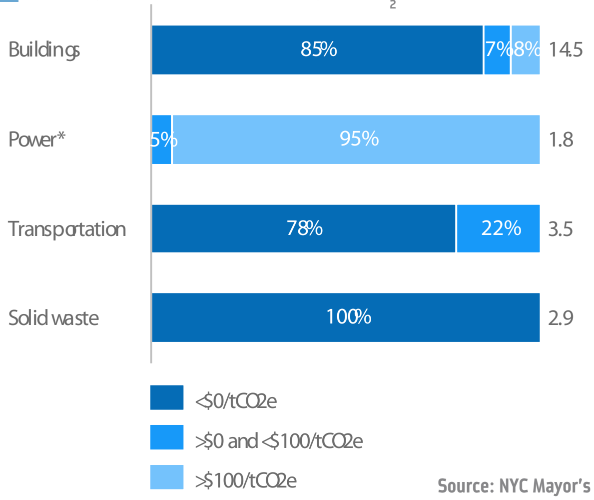


Source: NYC Mayor's Office

Costly investments in energy infrastructure would be required

Since New York's power sector has already captured most 'low-hanging fruit' through fuel switching to natural gas (although significant potential remains in the buildings sector), it would be expensive to achieve substantial additional reductions. Up to $5 billion of incremental investment would be needed per year and retail electricity prices could increase by up to 9 percent above the business as usual case. Individual buildings would also need to make costly investments to transition away from fossil fuels.

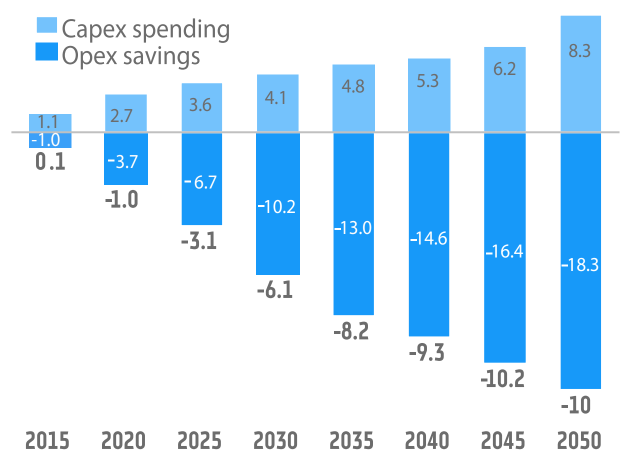
2030 Abatement Costs By Sector
% of sectoral abatement: Metric ton CO_2e



Source: NYC Mayor's Office

*For the sake of this analysis, "Behind the meter" technologies such as solar PV and combined heat and power are included as demand reduction measures in the building sector.

Changes in Annual Capital Spending and OpEx
$ billions; net difference in bold



Source: NYC Mayor's Office

Achieving 80 by 50 could promote local economic growth and competitiveness

Although capital spending on carbon reduction could displace other types of spending, it would yield a net-savings on total energy costs across the local economy and would therefore increase competitiveness. This would be the case even if power prices increase as the grid decarbonizes. By 2030, this could yield up to 18,000 new jobs and $1.9 billion of economic activity a year.

But acting alone would increase costs and lead to inefficiencies

Although theoretically possible, the City could not realistically achieve 80 by 50 by acting alone. Federal or at least regional action is needed to create a level playing field and send a price signal to the entire marketplace. Unilateral actions, on the other hand, could create market distortions and economically inefficient outcomes. Although it is less desirable than action at the Federal level, increased coordination at the regional level could lead to cost savings. In the power sector, regional coordination would enable the City to reach 80 by 50 for 30 percent less cost than if it pursued the goal on its own.

80 by 50 may not be the right goal for now but New York City could still aggressively accelerate its emissions reductions

80 by 50 makes sense as a global goal — but it may make less sense for New York City, which is already relatively energy efficient. While it may be possible to achieve an 80 percent carbon reduction through retrofitting hundreds of thousands of buildings, cheaper opportunities are available outside the region — including, for example, the retirement of remaining coal-fired power plants —which may make the scale of the challenge within the five boroughs more manageable. Whatever the exact goal, New York City could become a proving ground for innovative technologies, financing methods, and programs aimed at achieving deep carbon reductions.

Challenges

2050 is far enough away that the future is highly uncertain

Technologies evolve and behaviors change faster than the city's physical landscape — and they will change by 2050, too, in ways that we cannot imagine. Trying to bet on which power generation technology will be more economical in 2050 would be impractical. For example, few would have predicted the shale gas revolution even as recently as 2003. By 2050, the landscape of carbon abatement will change dramatically, upending even the best-informed assumptions made in 2013. Orienting towards the 2050 goal is critical but it cannot dominate today's decision-making or else it could deter interim steps that are positive but far from perfect.

Businesses and residents face barriers to acting – even when abatement measures are cost-effective and will yield paybacks

More than two thirds of carbon reduction opportunities may yield positive economic returns at the societal level, but this may not be the case at the level of individual tenants, landlords or business owners who may demand higher returns from their investments. Action may also be hindered by insufficient education and awareness of opportunities; technical challenges and the hassle of implementing measures, particularly those that need to interface with regulatory bodies or utilities; and insufficient access to financing. Even when these barriers are not especially challenging to overcome, other issues compete for decision-makers' attention. A landlord, for example, may have a long list of priorities that yield a better return on investment and time spent than a potentially disruptive building retrofit.

A portion of abatement measures is not economical without carbon prices

At least a third of the abatement measures will not make economic sense even at a low societal discount rate unless there is a substantial price on carbon or strong market signal. Whether investing in solar thermal systems in an era of cheap natural gas or building out large-scale offshore wind farms, some abatement measures will require incremental spending that will not be recovered through operational savings. This barrier could prove more powerful than any other.

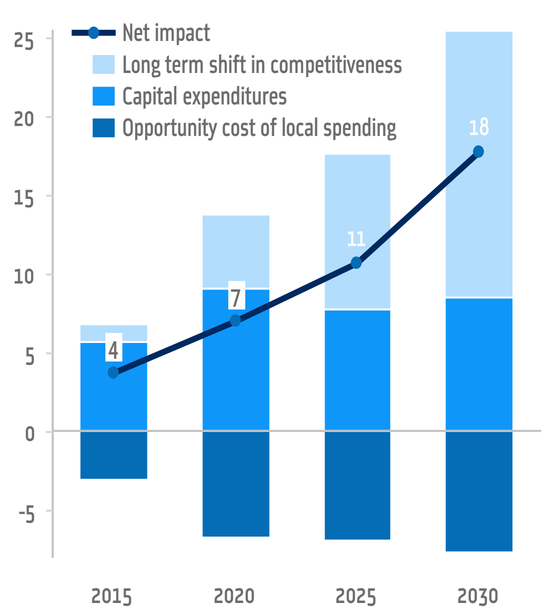
Multiple parties need to be involved, and value capture is complicated

An individual opportunity may make sense on the fundamental economics, but if it involves value capture across sectors, consumer classes or multiple parties, then high transaction and coordination costs could interfere. In commercial buildings, for example, owners may find it difficult to justify installing better lighting if tenants are going to capture the benefits of energy savings. Likewise, on large transportation infrastructure projects, coordinated planning, budgeting and project management — not to mention perseverance and political will — would be needed across agencies and levels of government. Aligning incentives and objectives will be challenging at every scale and for every project type.

Infrastructure may need to be upgraded

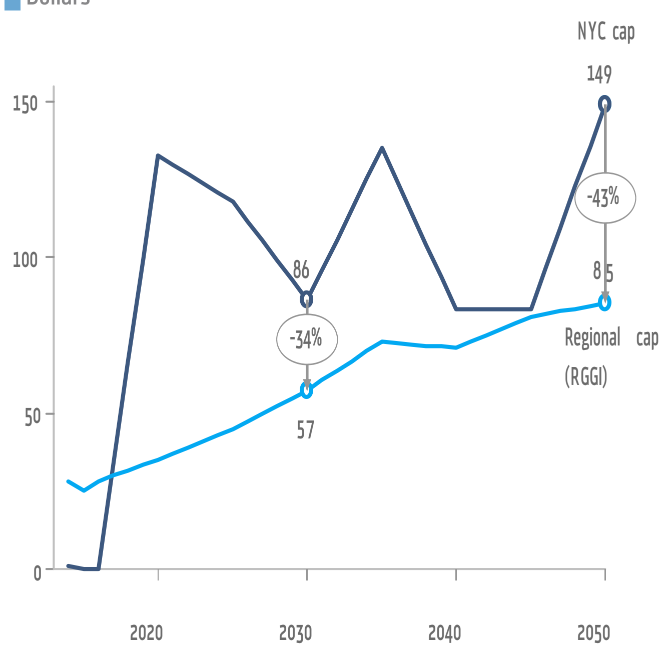
Once barriers are overcome and incentives are aligned,

Employment Impacts by Type
Thousands; by type of impact



Source: NYC Mayor's Office

Implied Carbon Costs per Ton
Dollars



Source: NYC Mayor's Office

tens of thousands of individual decision-makers may finally decide to take action — but in some cases, having the right infrastructure would be critical. New York City's infrastructure is robust but compared to some other large international cities, it is aging and in need of modernization. Infrastructure and consumer technologies may often need to coevolve to be successful — for example widespread composting of organic waste would depend on adequate processing infrastructure, but developing this infrastructure would require a guaranteed supply of organic waste. Similar dilemmas could occur with electric vehicle chargers and other measures, and would need to be overcome.

Capturing the Potential

Addressing market barriers would be essential

The City is well positioned to assist in overcoming a range of regulatory, information and market barriers that could otherwise inhibit progress towards 80 by 50. For example, the City can work with utilities to streamline and improve the process for interconnecting renewable energy resources into the electric grid. It can coordinate across levels of government to cut bureaucratic red tape that slows the introduction of new technologies. It can encourage private lenders, in coordination with NYCEEC to expand financing options that recognize the value of energy savings. It can work with the real estate industry to foster the realignment of incentives for undertaking efficiency projects. And it can work with key partners to provide technical assistance and information to help encourage the marketplace.

All the tools of government and the private sector would be needed

The typical tools of government are insufficient to achieve such deep carbon reductions. Instead, the City would need to encourage lending institutions to expand and diversify financing options, work with utilities and energy companies to foster innovative investments, partner with community groups and NGOs to spur local action, and collaborate with New York State to increase local uptake of its incentives and technical assistance programs. The City could build on successful models like the NYC Clean Heat program, which pairs regulations with technical assistance, financing, and incentives to accelerate the transition to cleaner heating fuels.

Individual New Yorkers could play a significant role in reducing emissions

Individual New Yorkers could make a significant difference in achieving carbon reductions by choosing to create less waste, use more sustainable modes of transit, and make purchasing decisions that promote energy efficiency and carbon reduction. The City's marketing campaign, GreeNYC, can provide New Yorkers with the information and encouragement they need to make individual choices that can save energy and reduce greenhouse gas emissions.

Decarbonization and resiliency could go hand in hand

As New York City continues to recover from the impacts of Hurricane Sandy, it has the opportunity to integrate carbon reduction and climate resiliency objectives. Approximately two-thirds of in-city electricity generation capacity is located in FEMA's latest 100-year flood zone and a number of plants experienced flooding during Hurricane Sandy; by mid-century 97 percent of the city's generation capacity is projected to be within the 100-year floodplain. Modernizing existing plants could make them better equipped to handle storm surge and other extreme weather risks while improving operating efficiency. Distributed generation could allow a building (or a set of buildings in the case of a microgrid) to continue operating during a grid-wide failure and reduce its carbon footprint, depending on the technology. Implementing the City's resiliency plan, PlaNYC: A Stronger, More Resilient New York, could create many other opportunities to reduce emissions.

New York City could become a laboratory for low-carbon innovation

New York City can demonstrate leadership and foster the commercialization of new low carbon technologies. The City operates 4,000 public buildings, over 300 public housing sites, 15 hospitals and health care centers, and 14 wastewater treatment plants. The City is working with research institutions, Con Edison, NYSERDA, and the private sector to identify and test out promising technologies at these facilities, and make New York a living laboratory.

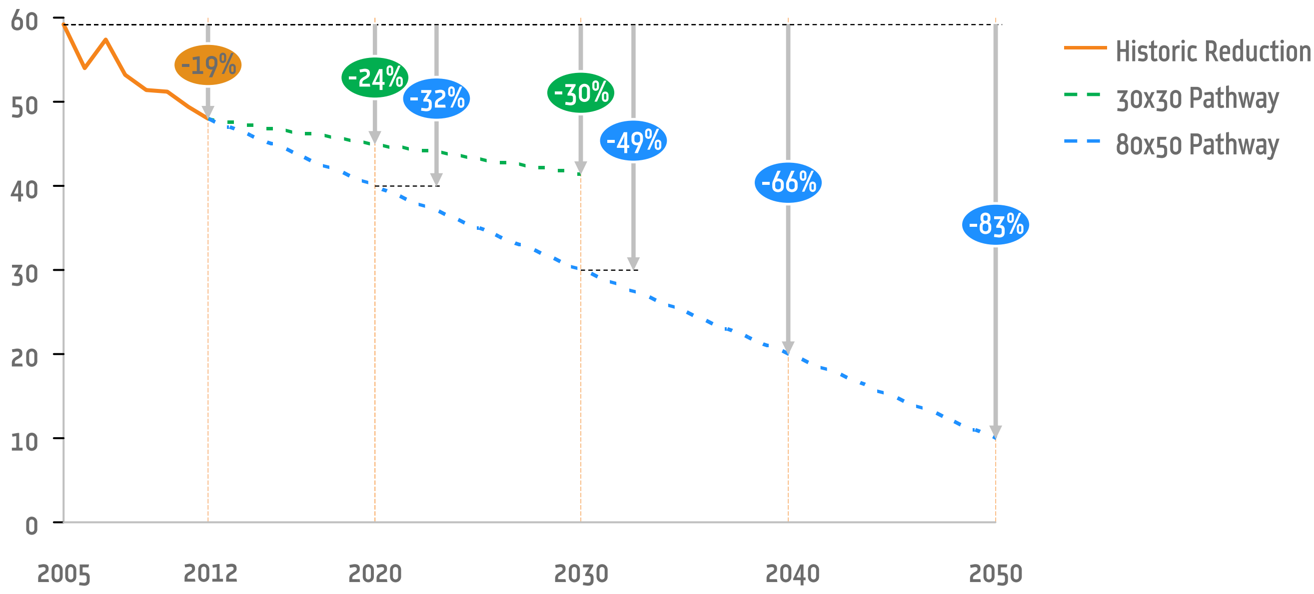
Near-term Actions

Even though the exact shape of a low-carbon city is uncertain today — and the 80 by 50 goal itself may well be too aggressive for a relatively efficient city like New York — the city has both the tools and the momentum to accelerate carbon reduction efforts this decade. As the City is now close to two-thirds of the way to the PlaNYC 30 percent greenhouse gas reduction goal, it could consider accelerating the target date for reaching the goal, from 2030 to 2020. Doing so could put New York City on a trajectory to achieve 80 by 50 while maintaining focus on what is doable today.

To reach a 30 percent reduction, emissions would need to fall another 6.5 million tons below 2012 levels. If the City aggressively implements and strategically expands several existing initiatives it could achieve the 6.4 million ton reduction within this decade. These reduction actions are focused on the buildings, transportation and waste sectors. Several promising near-term opportunities exist in the power sector as well and could be pursued.

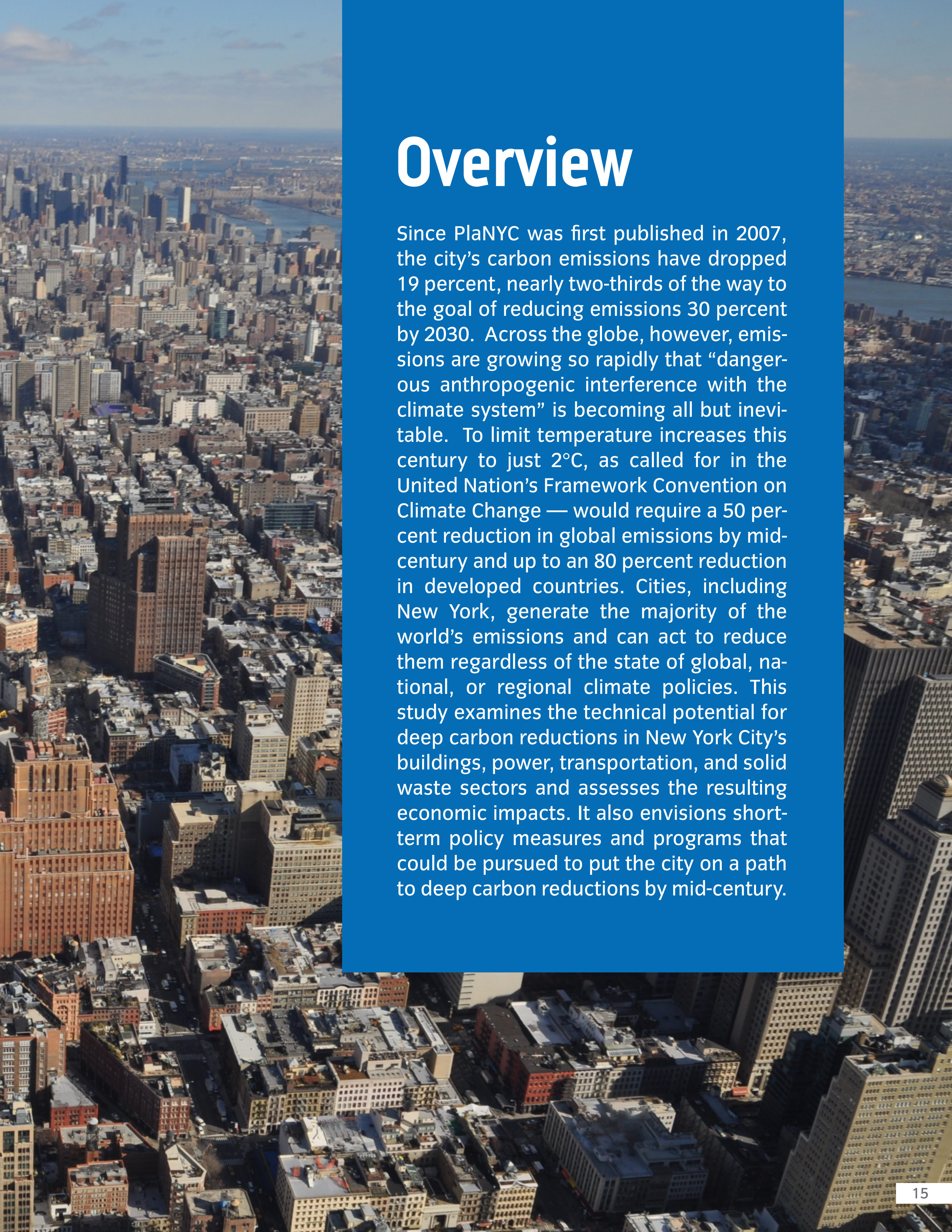
Achieving 30 by 20 would require tremendous effort and consistent reductions of 2 percent per year through the end of the decade. This will not be easy, but New Yorkers stand to gain along the way. Reducing energy consumption in buildings will lower operational expenses and create jobs. Converting to cleaner fuels in buildings, electrifying vehicles, or using biodiesel in vehicles will improve air quality. Diverting waste from landfills will save city residents and businesses on waste export costs and could promote local industries. These and other measures could reinforce and strengthen New York City's global leadership in responding to climate change, while making the city more competitive, livable, and resilient.

GHG Emissions Pathways
Metric tons CO_2e; % reduction vs. 2005 in a give year



Source: NYC Mayor's Office

Aerial view of the City looking South from



Overview

Since PlaNYC was first published in 2007, the city's carbon emissions have dropped 19 percent, nearly two-thirds of the way to the goal of reducing emissions 30 percent by 2030. Across the globe, however, emissions are growing so rapidly that "dangerous anthropogenic interference with the climate system" is becoming all but inevitable. To limit temperature increases this century to just 2°C, as called for in the United Nation's Framework Convention on Climate Change — would require a 50 percent reduction in global emissions by mid-century and up to an 80 percent reduction in developed countries. Cities, including New York, generate the majority of the world's emissions and can act to reduce them regardless of the state of global, national, or regional climate policies. This study examines the technical potential for deep carbon reductions in New York City's buildings, power, transportation, and solid waste sectors and assesses the resulting economic impacts. It also envisions short-term policy measures and programs that could be pursued to put the city on a path to deep carbon reductions by mid-century.

Why 80 by 50?

New Construction in Long Island City, Queens

New York City committed to reducing citywide greenhouse gas emissions by 30 percent before 2030 as part of its comprehensive sustainability agenda, PlaNYC, in 2007.[1] Six years later, the city's emissions have fallen by over 19 percent. The City's power supply is cleaner, its buildings are more energy efficient, and residents drive less and generate less waste. If the city is able to reduce its emissions by one percent each year over the next 16 years — only half the rate of annual reductions since 2005 — it will reach the 30 percent goal by 2030.

Despite this local progress, global emissions are rapidly accelerating: in the past five years, they have outpaced the highest of the four scenarios that the Intergovernmental Panel on Climate Change (IPCC) developed. If emissions continue on this trajectory, temperatures could rise by 4 to 6°C by 2100 and yield up to six feet of global sea level rise. (See chart: *Emissions and Temperature Rise Under Different Scenarios*).[2]

To limit the increase in temperatures to 2°C in the next century — a limit that the United Nations Framework Convention on Climate Change (UNFCCC) says is necessary to "prevent dangerous anthropogenic interference with the climate system" — global emissions would have to be reduced by at least 50 percent below 1990 levels by mid-century. Because developed countries have contributed the majority of atmospheric emissions to date and have high per-capita emissions rates compared to the global average, they would need to reduce their emissions even more aggressively, by up to 80 percent by 2050 — hence "80 by 50."

Adoption of the 80 by 50 goal is growing at the national and sub-national level. The European Union adopted the 80 by 50 goal in 2005; the United Kingdom followed in 2008. Several U.S. states including New York and California have also adopted non-binding commitments to 80 by 50, but on a national level, the United States has committed to reduce its emissions by only 17 percent from 2005 levels by 2020. Some regional efforts such as the Regional Greenhouse Gas Initiative (RGGI) in the Northeast have set more aggressive targets but have experienced political challenges in implementing programs to reduce emissions.

Cities, too, can act – both because they produce the majority of global emissions, and because they often have the tools to curb emissions even in the absence of national or regional action. New York City is responsible for close to half a percent of total global emissions if consumption is taken into account – and City government has substantial tools to promote emissions reduction. These include its ability to regulate buildings and land use, collect taxes and offer incentives, create public-private partnerships, offer technical assistance, and develop and operate major infrastructure as well as thousands of public facilities.

Study Objectives

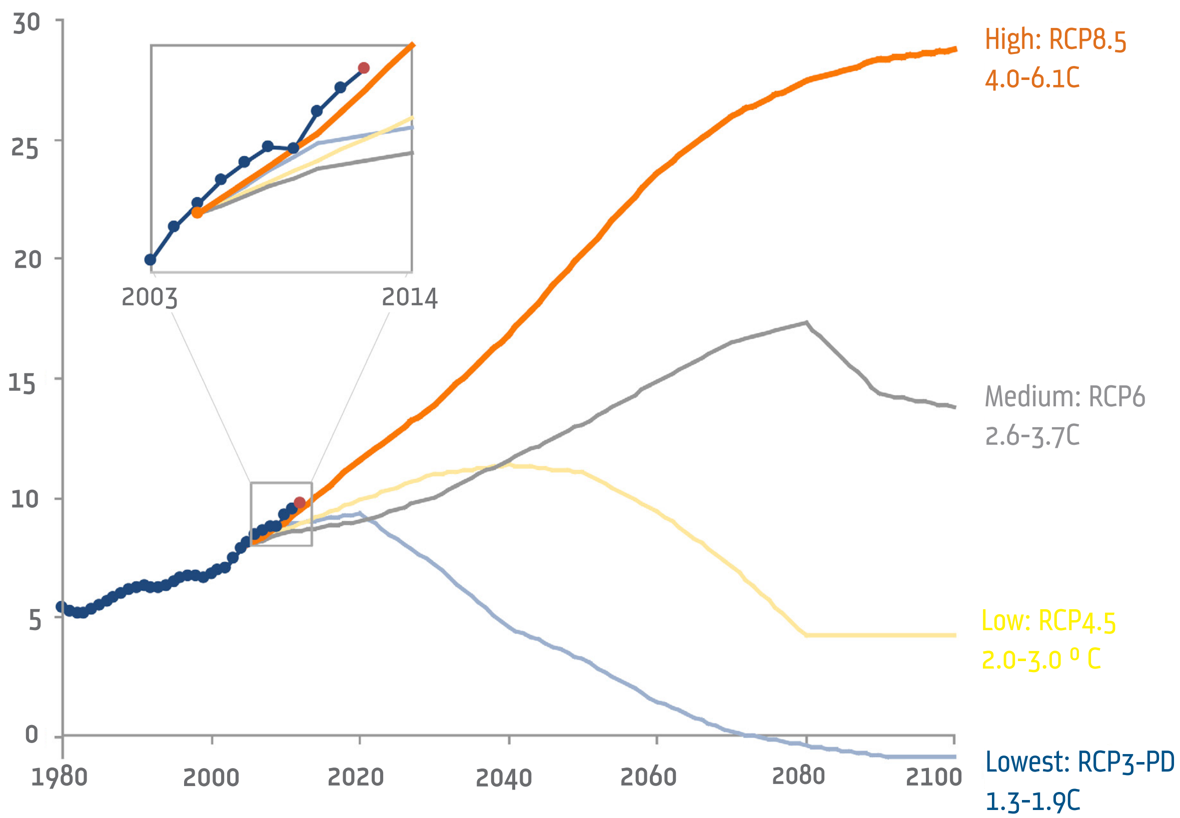
The 2011 update to PlaNYC called on the Mayor's Office of Long-Term Planning and Sustainability (OLTPS) to examine the feasibility of achieving 80 by 50 in New York City. The ensuing research was informed by other long-term studies conducted locally and abroad.[3] This resulting document is a research study, however, and should not be misinterpreted as an endorsement of the 80 by 50 target. The appropriate long-term reduction target for a city like New York — which has already reduced emissions aggressively and is far below the U.S. national average in per capita emissions — might well be lower and policy makers' focus may be better suited to shorter timeframes. Still, it is important to pose long-term questions, diagnose problems, and assemble possible solutions with a level of rigor that the seriousness of the challenge requires. This report does not advance specific policy proposals, but instead examines how New York City could move towards 80 by 50, or a more near-term accelerated goal, if it chooses to.

Study Approach

Because the city's carbon emissions come from four very different sectors – buildings, power generation, transportation, and solid waste – the study examines strategies in each one individually at first. The study analyzes over 70 individual carbon reduction measures in all four of the sectors, building on both city data and expert- and experience-driven assumptions about the kind of actions that realistically could be accomplished.

It is also important to consider how the four sectors interact and function as a whole. For example, making

Emissions and Temperature Rise Under Different Scenarios
Billions tons of CO_2e per year from fossil fuels, cement production, and gas flaring



Source: NYC Mayor's Office

buildings more energy efficient reduces the amount of clean power that is necessary, while electric vehicles are only as clean as the electric grid is. The study accounts for these interactions so that changes in one sector are reflected in all others. A collective "package" of least cost measures across the four sectors is then assembled based on both the technical potential and economic analysis. This package, or pathway, to 80 by 50 is then evaluated for its impacts on jobs and the economy.

Converting technical potential into real emissions reductions can be extremely challenging. The economics of a carbon abatement measure might be attractive in theory, but any number of barriers may arise — financing may not be readily available, regulations might be too complex, or the opportunity cost, may simply be too high. Furthermore, actions to reduce carbon would lie in the hands of millions of people making countless daily and long-term decisions.

With this in mind, the study carefully evaluates the barriers to implementing carbon abatement measures in each sector and then proposes potential ways to overcome those obstacles.

GHG Accounting Scopes

New York City's GHG inventory follows standard international conventions for municipal GHG emissions reporting. The City's inventory includes Scope 1 emissions from buildings and industrial facilities within the city, vehicle operated within the city, and solid waste and wastewater managed within the city; Scope 2 emissions from electricity and steam used in buildings, industrial facilities, streetlights, and transit systems within the city; and Scope 3 emissions from solid waste generated within the city but disposed of outside of the city's boundary.

GHG accounting practice has historically classified emissions by "Scopes" per the World Resources Institute/World Business Council for Sustainable Development's Greenhouse Gas Protocol, the world's corporate GHG accounting standard and the standard upon which many other GHG accounting protocols are based. Following the WRI/WBCSD guidance, New York City defines Scopes as:

Scope 1: Direct emissions from on-site fossil fuel combustion or fugitive emissions from within the city's boundary

Scope 2: Indirect emissions from energy generated in one location, but used in another, such as district electricity and district steam

Scope 3: Indirect emissions that occur outside the city's boundary as a result of activities within the city's boundary, e.g. emissions from exported solid waste. Examples of Scope 3 emissions that are not included in New York City's inventory include emissions from extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services.

New York City's current GHG inventory includes all Scope 1 and Scope 2 emissions, and includes Scope 3 emissions from solid waste generated within the city's boundary but disposed of outside of the city. The City may revise its GHG reporting approach to include additional sources (including consumption-based emissions) as applicable GHG protocols evolve.

New York City's Emissions Profile

Energy and GHG Fundamentals

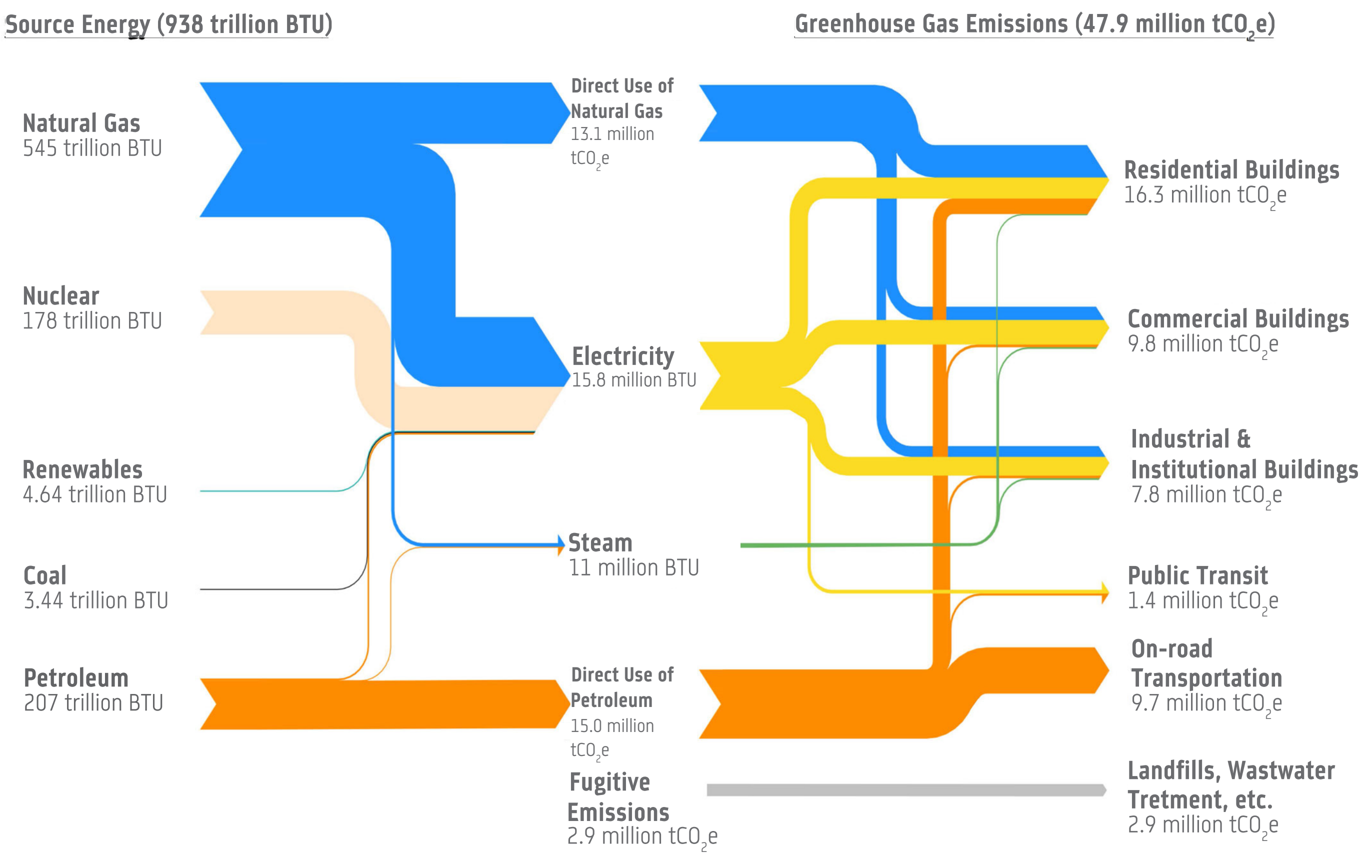
New York City consumes enormous amounts of energy, and most of it — 81 percent — comes from the combustion of fossil fuels. This combustion occurs on a centralized basis — at power plants to create electricity and steam — and on a distributed basis — in countless buildings and vehicles to provide basic services and mobility.

Energy use in buildings accounts for 71 percent of the city's total emissions footprint. Of these emissions, roughly 55 percent come from the on-site combustion of natural gas and liquid fuels to produce heat and hot water, and to cook; while the remaining 45 percent of emissions stem from electricity production and consumption. The transportation sector contributes another 23 percent of the city's total emissions. Of these emissions, liquid fuel consumption in vehicles accounts for 85 percent, while the remainder stem from electricity used to power subways.

Fugitive emissions from landfills, the wastewater treatment process, and the energy sector account for the remaining 5 percent of the city's emissions.[4]

In total, the city emitted nearly 48 million metric tons of carbon dioxide equivalent (CO2e) in 2012. The City's emissions methodology only includes Scope 1 and Scope 2 emissions; emissions from aviation are not included (though strategies to reduce emissions from planes while they are on the runway are part of this report); neither are consumption-based emissions, which would capture the emissions embedded in the goods that New Yorkers consume. The methodology for capturing consumption-based emissions is evolving, and future GHG inventories are likely to include at least some of them. (See sidebar: *GHG Accounting Scopes*)

Energy and GHG Emissions Flows
Petajoules and $MtCO_2e$

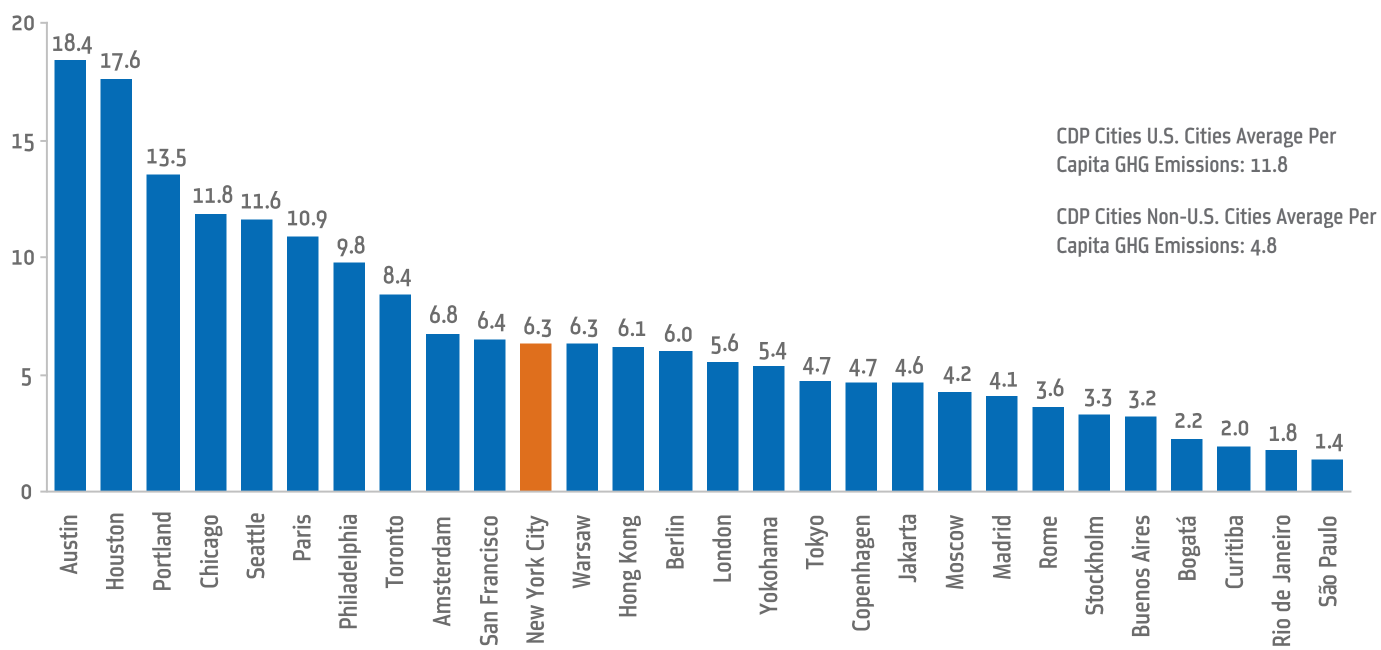


Source: NYC Mayor's Office

New York City's Emissions Relative to Other Cities

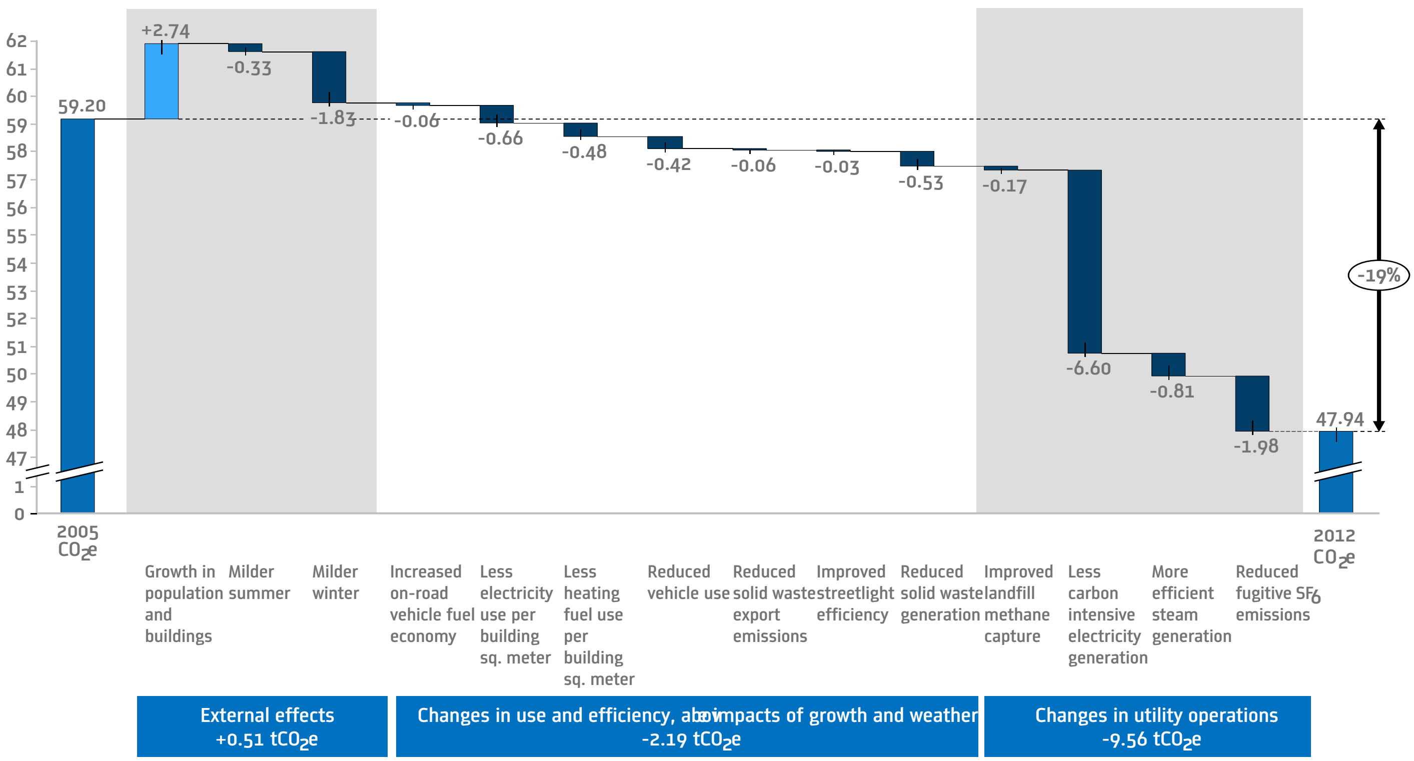
New York City uses large amounts of energy – but per capita, its dense built environment and extensive mass transit system make it one of the most energy efficient cities in the U.S. In a recent study of urban emissions done by the Carbon Disclosure Project (CDP), the average New Yorker was responsible for 44 percent less carbon pollution than the average US urban dweller. On the international level, New York City is competitive but a number of global city's have even lower per capita emissions levels. (See chart: *Per Capita GHG Emissions for Selected U.S. and Global Cities*)

Per Capita GHG Gas Emissions for Selected U.S. and Global Cities[5]
Emissions in $MtCO_2e$



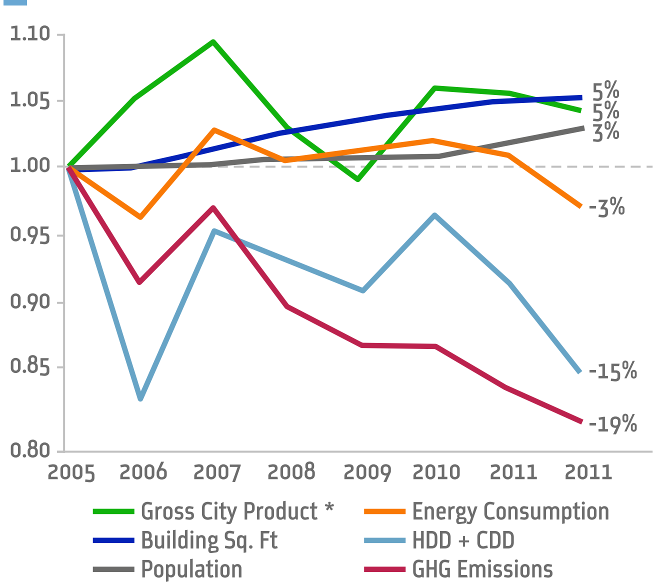
Source: Carbon Disclosure Project

2005 to 2012 GHG Emissions Reduction Drivers
$MtCO_2e$



Source: NYC Mayor's Office

Energy, Emissions, and Economic Indicators
Indexed to 2005



Source: NYC Mayor's Office

Emissions Reduction Since 2005

New York City's emissions fell by 19 percent between 2005 and 2012, and the city is now nearly two-thirds of the way to meeting the 30 by 30 goal. The majority of reductions stemmed from cleaner power as a result of fuel switching from coal and oil to less carbon intensive natural gas, as well as the introduction of state-of-the-art power plants that replaced old, inefficient units. Improved energy efficiency in buildings and automobiles, fewer car trips and less waste have also contributed to the reductions. Emissions and energy use fell even as the city's population, building area, and economy all grew compared to 2005. If this trend continues, it would represent a significant structural change, as energy use has closely mirrored economic growth throughout history. (See charts: *2005 to 2012 GHG Emissions Reduction Drivers* and *Energy, Emissions, and Economic Indictators*)

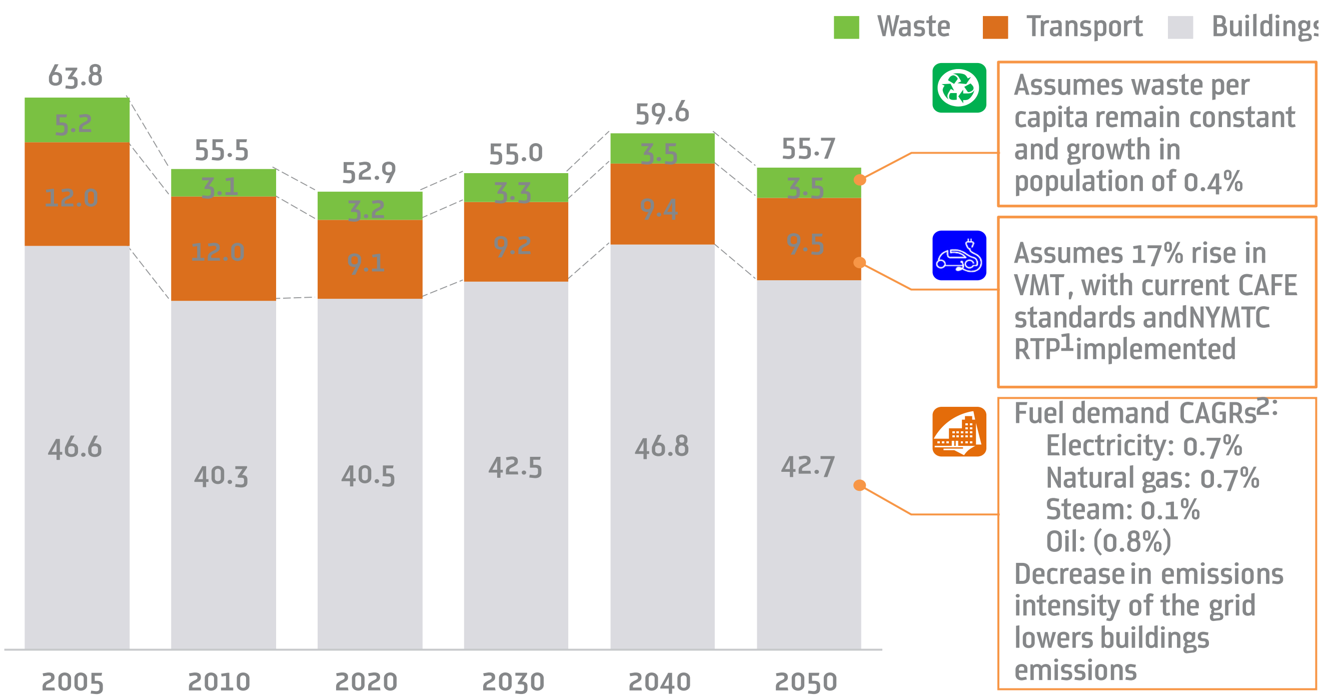
Technical Methodology

The analysis informing this report began with developing projections for the growth of greenhouse gas emissions between today and 2050, assuming that no aggressive action is taken to reduce emissions. Once these projections – the "business as usual" scenario — were developed, quantitative models helped estimate the technical potential for reductions in four key sectors–buildings, power, transportation, and solid waste — and to assess the cost-effectiveness of each individual action as well as impacts to the economy.

Under the 'business as usual' scenario (BAU), 2050 GHG emissions would stand at 55.7 MtCO2e – roughly similar to emissions today and far above the 12.7 million ton cap that the city would need to abide by in order to achieve 80 by 50. Conservative assumptions about economic growth and energy prices underlie the BAU projections. With these assumptions, emissions would fall between now and 2020 due to a continued switch from coal to natural gas in the power sector; then increase for two decades after that in line with growing population; and ultimately fall as renewables become economically viable in 2040-2050 and displace fossil fuel generation. The relative contribution of sectors to carbon emissions remains relatively constant: in the 2050 BAU, buildings would contribute 77 percent of emissions, while transport would contribute 17 percent, with the balance coming from solid waste and fugitive emissions (See chart: *Carbon Emissions Under the BAU Scenario*).

With the business as usual scenario in place, the technical potential for carbon reduction was evaluated using three different models: a Marginal Abatement Cost Curve (MACC), the North American Energy and Environment Model (NEEM) from the consulting firm Charles River Associates, and the REMI Policy Insight model, run by AECOM.

Carbon Emissions Under the BAU Scenario



Source: NYC Mayor's Office

The first model, the MACC, estimates the potential for emissions reduction in the buildings, transportation, and solid waste sectors by evaluating over 70 different carbon abatement measures. This bundle of potential measures focuses on existing technologies and makes the following conservative assumptions:

- **Learning curves are ambitious but achievable,** based on historical factors and expert insight about the pace of advancement that improves technology or lowers costs.
- **Equipment is replaced at the end of useful life to minimize costs,** rather than replacing it on an accelerated basis to achieve energy savings or carbon reductions.
- **No carbon price exists,** or any other significant Federal or regional action to reduce carbon that would lead to a price signal in the marketplace.

For each measure, the model calculates its annualized capital cost and operational savings, estimates the resulting carbon reduction, and computes the societal cost of abatement in dollars per ton. The calculations are completed for a point in time every 5 years and the results are displayed on a graph — a so called "marginal abatement cost curve". On the curve, the lowest-cost measures are on the left, the highest-cost ones are on the right; the width of the bar indicates each measure's carbon abatement potential in millions of metric tons, and its height indicates its societal cost of abatement per ton – whether positive or negative. (See chart: *2050 Marginal Cost Curve for Building Sector*)

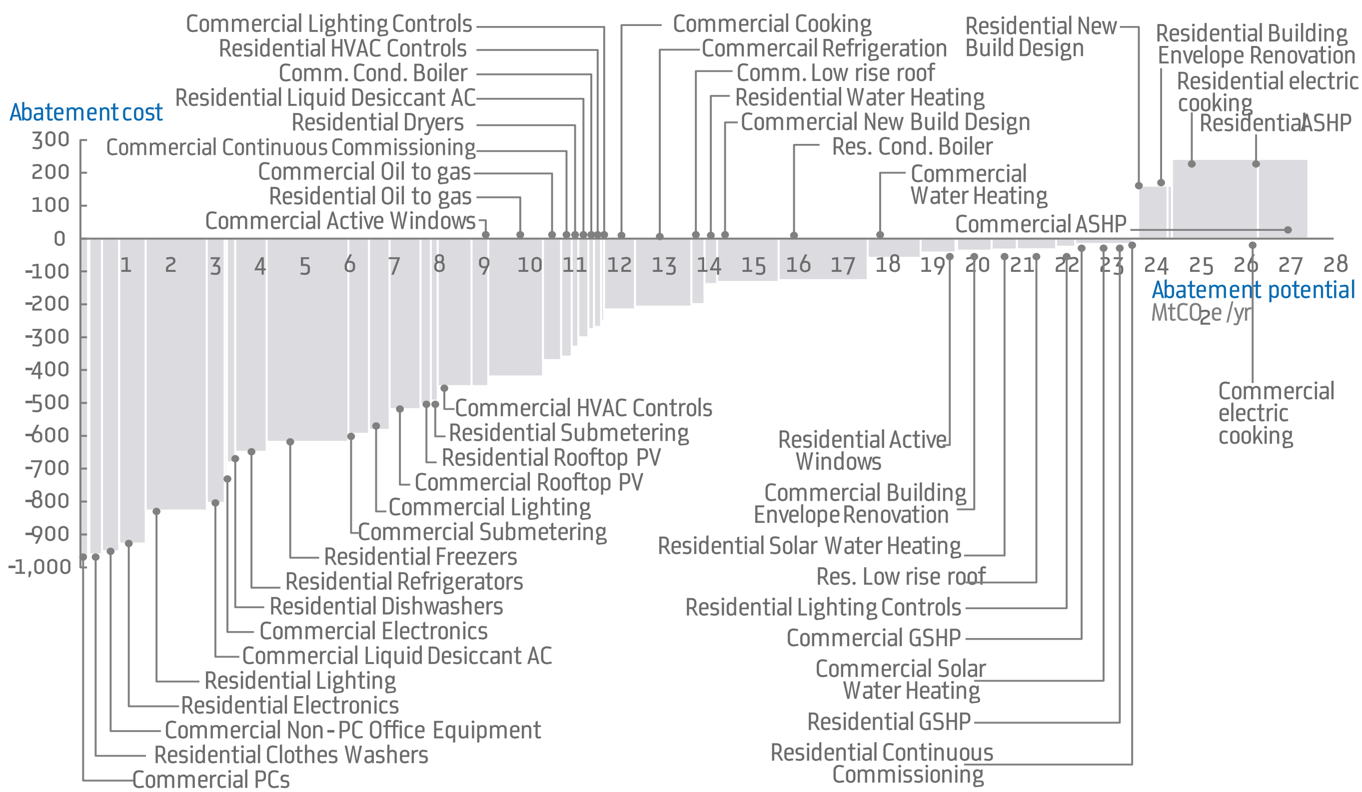
The purpose of introducing the concept of societal cost is to be able to quickly compare the relative cost-effectiveness of different carbon abatement measures without going into the details of each potential decision-maker's constraints and preferences. Its main simplifying assumption is that all measures can be financed at a 4 percent discount rate — roughly equivalent to a long-term government bond. The concept is helpful – but it also has important limitations. For one, it does not differentiate between winners and losers for any given measure. If, for example, a landlord pays for better lighting, but tenant captures the savings that outweigh the capital investment, the model would consider the measure to have a negative societal cost (e.g. a societal benefit), however the landlord would experience it as a loss. Likewise, if an investor can only access financing at a 10 percent interest rate, he or she would be unlikely to undertake an energy efficiency measure that only achieves a reasonable payback if lending is done at 4 percent. The cost curve would not capture either of these nuances.

A second proprietary model developed by the power sector consulting firm Charles River Associates, was used to find the least-cost solutions to supplying power to the marketplace while complying with the carbon reduction trajectory. The Charles River NEEM model North American Energy and Environment Model (NEEM) assumes a carbon cap for New York City that declines linearly from 2012 to 2050. This serves as a simplified modeling tool and effective proxy for the power sector subsidies that would be required to achieve 80 by 50 — it does not indicate that the City is advocating for a city-level carbon cap. As the modeled cap declines each year, the model determines the lowest cost mix of providing electricity using existing conventional generation and new, lower carbon resources while remaining below the carbon cap. The model incorporates the demand projections produced by the MACC for the buildings, transportation, and solid waste sector. In turn, it supplies the MACC with power price calculations for the 80 by 50 pathway, which the MACC then uses to adjust demand projections again based on assumptions about the elasticity of power demand. This iterative approach brings the two models to near-convergence and ensures consistency across all four sectors.

Once the calculations are completed for all sectors, a model called REMI Policy Insight was used to estimate the jobs and economic impact of the 80 by 50 pathway. The REMI model is a standard tool of economic analysis that integrates features of econometric, input/output and computable general equilibrium models to estimate the impact of policy measures on local economies throughout the U.S. A New York City specific version of the REMI model looked separately at 150 different local sub-sectors and analyzed the impacts of undertaking each individual carbon abatement measure — as well as decarbonization in the power sector — on jobs, gross regional product, and personal income through 2030[6]. The model accounted for one-time capital outlays, the opportunity cost of local spending, operational savings, and changes to long-term regional competitiveness.

Together the three models showed what is technically feasible, how much it would cost and how the economy would benefit, and what the theoretical timeline for achieving an 80 percent reduction would be. This theoretical analysis then needed to be turned into concrete policies and initiatives that the City could undertake if it chooses to pursue 80 by 50. A broad range of stakeholders from the buildings, power, transportation, waste, and environmental sectors advised on possible approaches. This then became the basis for a range of public policy initiatives, programs, pilots, and research studies that together could unlock near-term investments and position the City along the pathway to deep carbon reductions by mid-century.

2050 Marginal Abatement Cost Curve for Buildings Sector
$/tCO$_2$e



Source: NYC Mayor's Office

Credit: NYC Mayor's Office

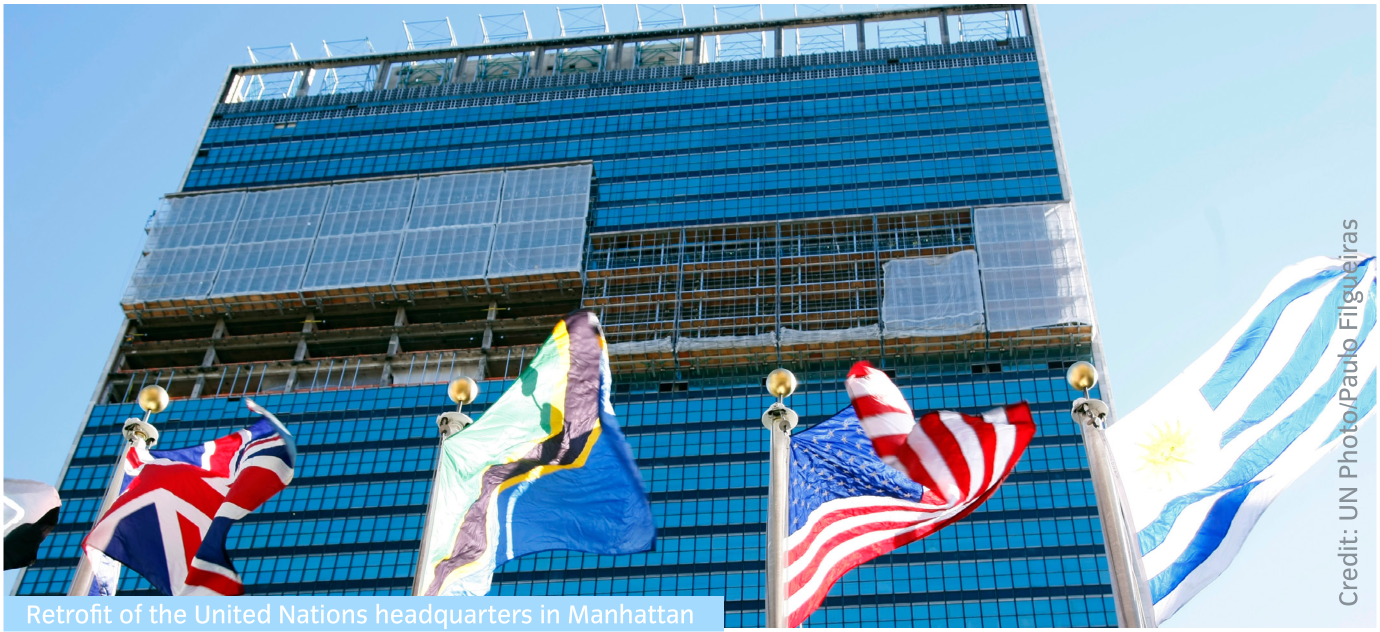
Credit: John Lee; NYC Mayor's Office

Upper Manhattan, looking towards Harlem

Buildings

Almost three quarters of the city's emissions stem from energy consumption that takes place in buildings. In recent years, these emissions have fallen slightly as thousands of buildings converted to cleaner burning natural gas for heat and hot water and as modest efficiency gains were made; meanwhile, the electricity grid has become much cleaner, yielding the majority of the city's 19 percent drop in emissions since 2005. To reach 80 by 50, unprecedented levels of investment would be needed to improve the efficiency of building envelopes, mechanical systems, lighting and appliances, while also continuing strides towards the use of lower carbon fuels. More than 85 percent of the measures evaluated could yield cost savings that would outweigh upfront costs and create a net economic benefit to society, but innumerable barriers would need to be overcome first. Capturing the full potential would require wholesale efforts to educate building decision makers, significant expansion of financing options, better alignment of incentives between owners and tenants, stronger efficiency standards for new buildings, and rapid development and commercialization of energy saving technologies suited for New York City's building stock.

Overview



Retrofit of the United Nations headquarters in Manhattan

From single-family homes to fifty-story skyscrapers, the city's buildings number nearly a million. They provide homes to families and places to conduct business – but they also consume most of the City's energy and account for the majority of its emissions. All together, the electricity that powers lighting, mechanical equipment and plug loads in buildings and the fuels that are burned to produce heat and hot water are responsible for 33.9 million tons of emissions – approximately 71 percent of New York City's total. These emissions dropped slightly in recent years as thousands of buildings took advantage of low natural gas prices and moved away from relatively more expensive fuel oils for heating — but significant potential for emissions reductions remain.

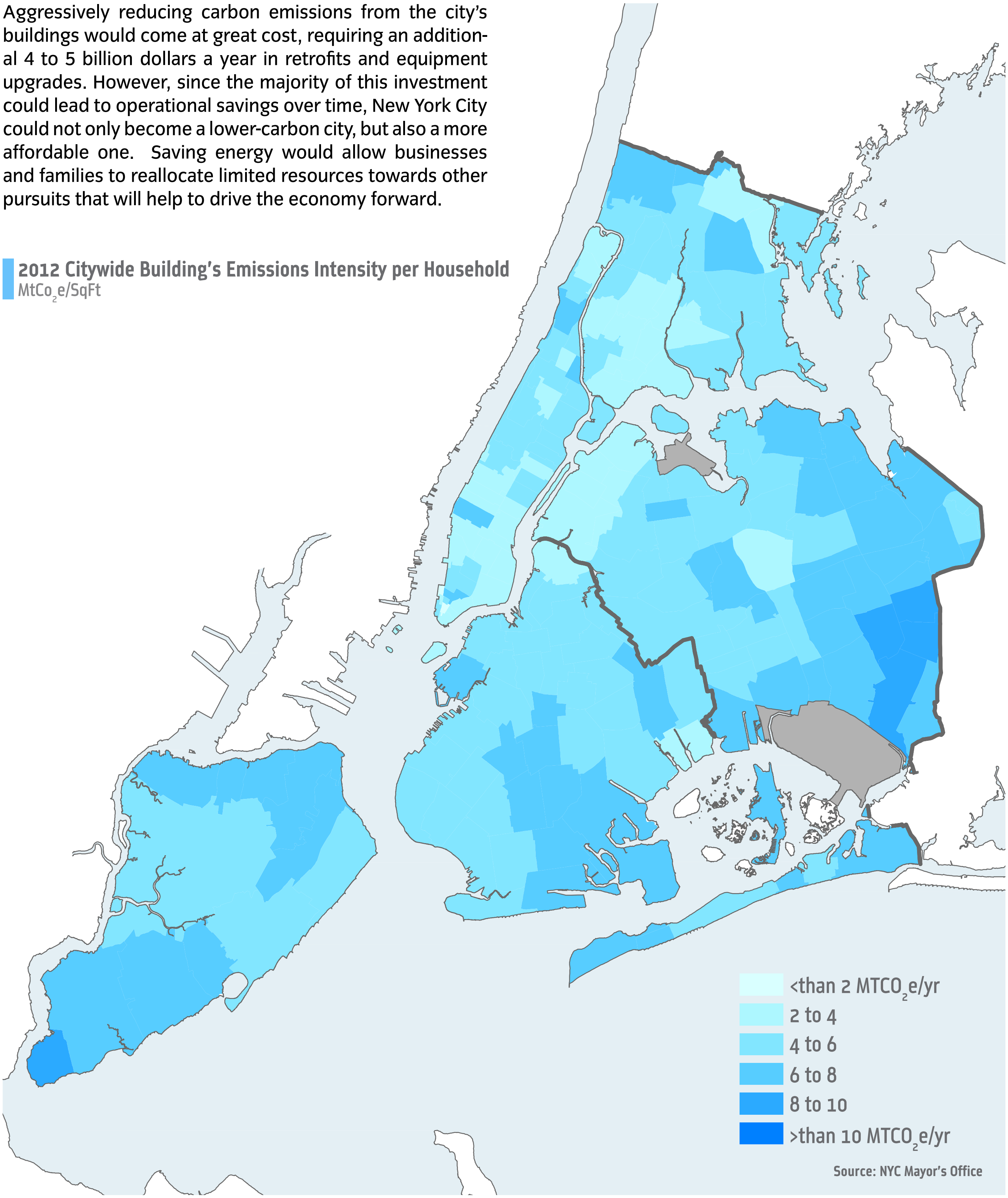
In the future, in both new and existing buildings, envelopes could be built tighter, building systems could be more efficient and intelligent, and renewable energy sources could replace fossil fuels for heating, hot water, and cooking. Taken together, these strategies could produce sufficient emissions reductions to put New York City on a pathway to 80 by 50.

More than 85 percent of the potential measures analyzed for the building sector could yield cost savings that would outweigh upfront costs. But that does not necessarily mean that they would be implemented. Even for measures that make economic sense for an individual decision-maker, multiple obstacles may stand in the way, including limited access to financing, the need for technical assistance, misalignment of interests with tenants, or simply the lack of interest.

The City has already begun to address these obstacles. The Greener, Greater Buildings Plan, a package of laws passed in 2009, laid the groundwork by requiring the city's largest buildings — those greater than 50,000 square feet — to assess, or "benchmark," their energy and water consumption on an annual basis, and also to undertake audits, retro-commissioning and some mandatory upgrades to building systems over a longer term horizon. These laws provide the city's largest buildings with the basic information they need to take advantage of energy efficiency opportunities and begin realizing the resultant cost-savings. However, broader efforts would be needed to put the city on the pathway to 80 by 50.

Aggressively reducing carbon emissions from the city's buildings would come at great cost, requiring an additional 4 to 5 billion dollars a year in retrofits and equipment upgrades. However, since the majority of this investment could lead to operational savings over time, New York City could not only become a lower-carbon city, but also a more affordable one. Saving energy would allow businesses and families to reallocate limited resources towards other pursuits that will help to drive the economy forward.

2012 Citywide Building's Emissions Intensity per Household
$MtCo_2e/SqFt$



Source: NYC Mayor's Office

Buildings Fundamentals

Building Stock

New York City's one million buildings together add up to more than 5 billion square feet of real estate. The building stock varies significantly by age, ownership structure, use, and construction type.

Residential buildings dominate the building sector: they represent 92 percent of the number of buildings and 70 percent of total built area. Residential building types vary greatly, ranging from five-story Victorian era walk-ups, turn-of-the-twentieth century brownstones, pre- and post-war elevator buildings, newly built curtain-wall high-rises, and single-family homes. Ownership types vary as well: the majority of the city's multifamily housing units are rentals, with the remainder primarily cooperatives and condominiums, and there is an overlay off affordable housing regulations that can lead create variation even within individual buildings. Single-family homes are primarily directly owned.

Commercial and institutional buildings — primarily offices, but also hospitals, universities, and municipal facilities — represent 5 percent of the number of buildings, but a disproportionate 22 percent of the built area. They are also some of the city's largest buildings; properties exceeding 1 million square feet in built area are not uncommon. Large real estate companies often control tens of millions of square feet of commercial space and contain a multitude of tenants in their portfolios. However, owner-occupied buildings also occur with frequency among the largest corporations and institutions.

Industrial buildings only represent a small share of the city's space, accounting for 3 percent of the number of buildings and 6 percent of built area. Most are low-rise structures with flat roofs located in the city's industrial areas such as the South Bronx, or Newtown Creek and Sunset Park in Brooklyn.

The overall building stock is old relative to the national norm. The average New York City building was built around 1940 and is 73 years old. Buildings turn over at approximately 0.5 percent a year, with the pace increasing in boom times, such as the years leading up to the Great Depression, during the 1960s, and in the early 2000's. The average lifespan of buildings in New York City tends to exceed the national average, and as a result, over 80 percentof the buildings we have today will still exist in 2050.

Regulatory Framework

New York City government has a broad degree of control over how buildings are designed and built. The City's building codes set criteria for structural integrity, the design of mechanical systems, building envelope, and a whole range of life and safety issues for new buildings and major renovations. The City's Energy Code, which was first adopted in 2009, establishes the minimum energy performance standards for building envelopes, heating and air-conditioning systems, and lighting. In addition, the City's extensive zoning system governs land use, building density and massing, and other criteria at both the individual building lot and neighborhood levels.

A number of recent regulatory efforts that grew out of PlaNYC are beginning to impact the design, construction, renovation, and operation of the city's buildings.

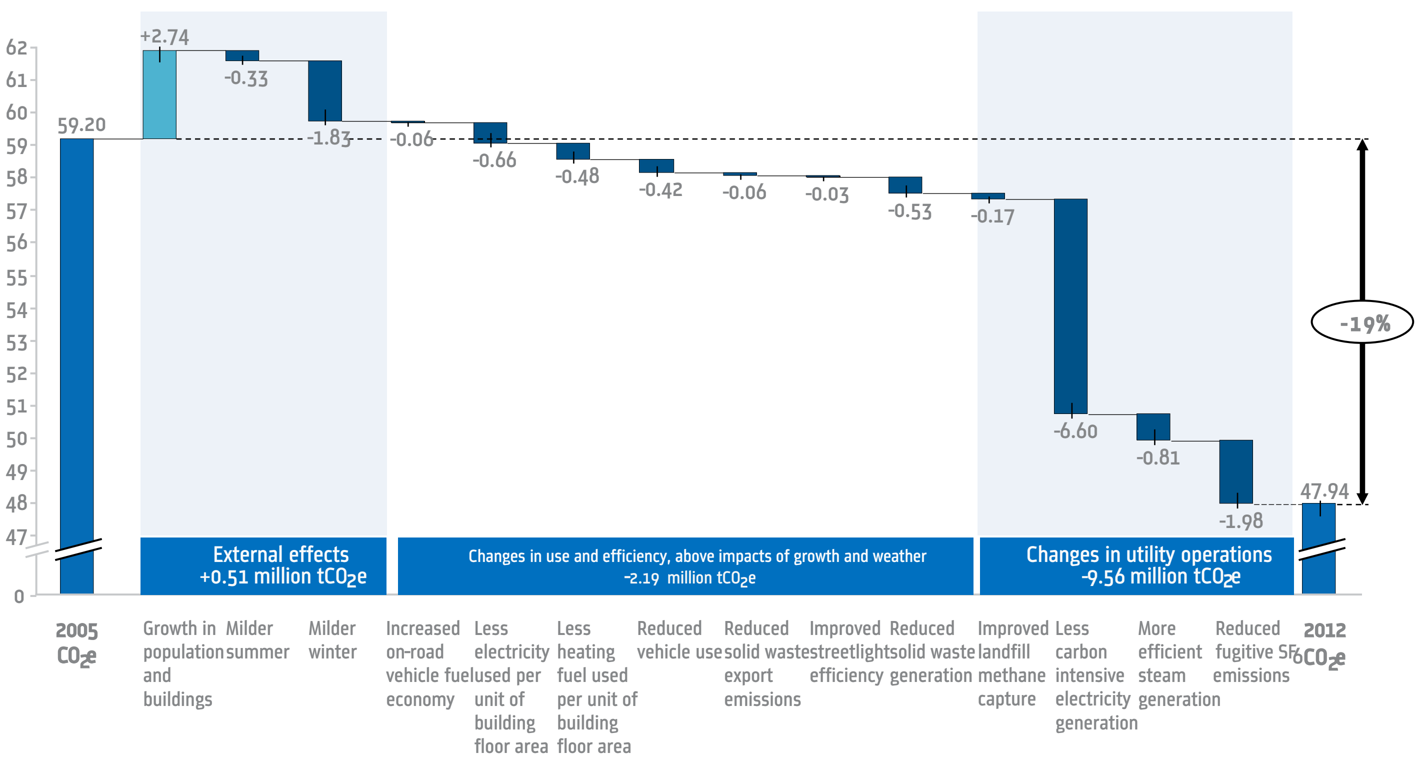
The Greener, Greater Buildings Plan (2009) requires the city's largest buildings – those above 50,000 square feet – to measure and report, or benchmark, their energy and water use every year; to complete energy audits and retro-commissioning of building systems every ten years; and to install sub-meters and upgrade lighting in commercial buildings. The City has implemented almost half of the 111 proposals developed by the Green Codes Task Force (2010), a panel of leading architects, engineers, construction, and real estate professionals that was tasked by Mayor Bloomberg and City Council Speaker Christine Quinn to recommend code changes to promote sustainable construction and operational practices. The City's regulations to phase out the use of heavily polluting No. 6 and No. 4 heating oils and the accompanying NYC Clean Heat program have led to over 3,000 large city buildings converting to cleaner heating fuels such as ultra-low sulfur (ULS) No. 2 fuel, biodiesel, or natural gas. Finally, the City's Zone Green proposal (2012), modified the zoning regulations to remove barriers to energy efficiency and renewable energy technologies both new and existing buildings.

Sources of GHG Emissions

In 2012, buildings were responsible for 33.9 million tons of emissions — or roughly 71 percent of the city's total. Fifty-three percent of these emissions came from fossil fuels — largely natural gas and fuel oil for heating, cooking, and hot water — while the remainder came from electricity consumption. Emissions from electricity consumption fell in recent years as power grid became cleaner; in 2005, electricity consumption was responsible for 50 percent of all building emissions, but in 2012, that number dropped to 44 percent. (See charts: *2005 to 2012 Changes to Citywide Buildings GHG Emissions* and *Citywide Buildings and Streetlight Emissions by Source*)

Residential buildings contribute the greatest share of emissions, accounting for 48 percent of all building-based emissions in 2012. Commercial buildings account for the second largest share, with 29 percent of emissions; and industrial and institutional buildings accounted for the remainder. (See chart: *Building Emissions by Building Type*)

2005 to 2012 Changes to Citywide Buildings GHG Emissions
GHG Emissions $MtCo_2e$

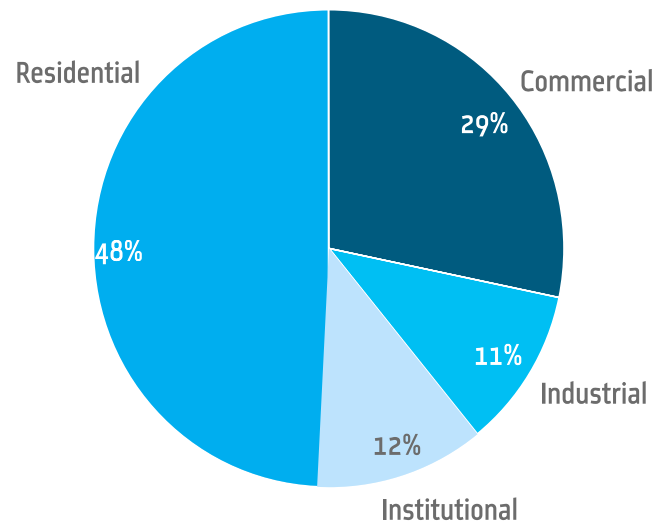


Source: NYC Mayor's Office

Building Emissions by Type

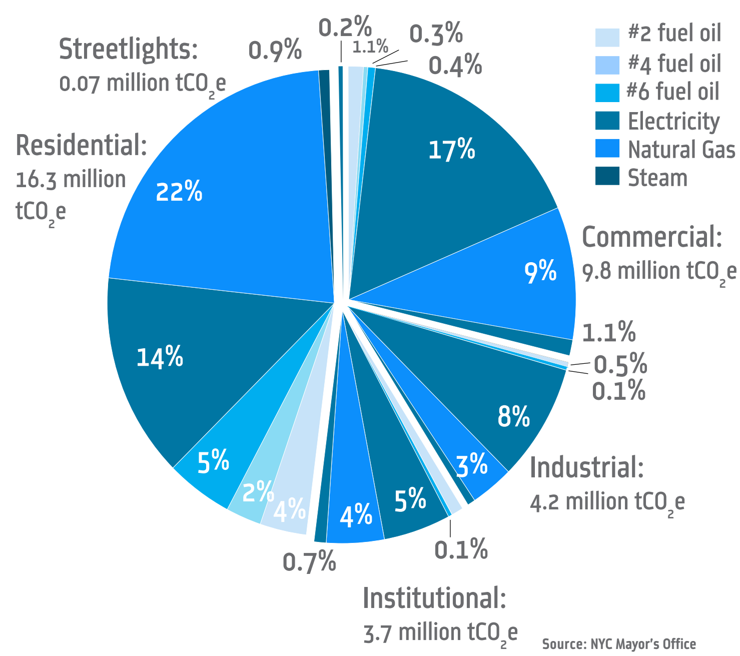
The 2 percent of buildings that are greater than 50,000 square feet in area — those subject to the Greener Greater Buildings Plan — have an outsized impact by consuming nearly 45 percent of the city's energy and producing nearly 45 percent of its emissions. The City's analysis of benchmarking data collected through Local Law 84 revealed wide variations in energy use in these buildings. The per-square-foot energy use intensity within each of the five main building sectors varies between 4 and 8 times between the lowest and highest energy users, suggesting significant potential for efficiency gains. Additionally, analysis of the relationship between building age and energy use reveals that many of the city's least energy-intensive buildings were built before 1930, while a large number of the most energy-intensive buildings were built after 1991. While differences in building usage patterns may account for some of the variation, the evolution of construction methods over time, as well as the changing demands for certain space configurations, also play a role. (See charts: *Variation in Median ENERGY STAR Score and Median EUI by Building Age* and *Variation in Source Energy Use Intensity (EUI) by Sector*)

Building Emissions by Building Type
Percentage of $MtCo_2e$; 2012



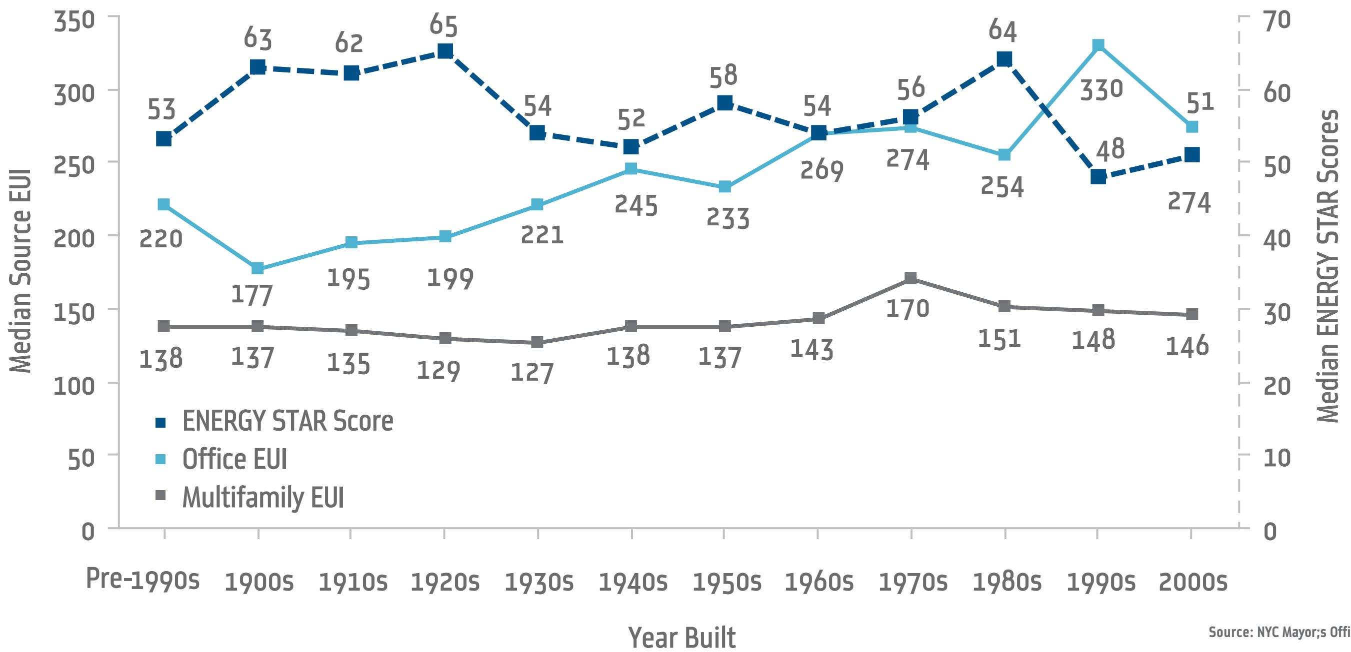
Source: NYC Mayor's Office

Citywide Buildings and Streetlight Emissions by Source
$MtCo_2e$ by source



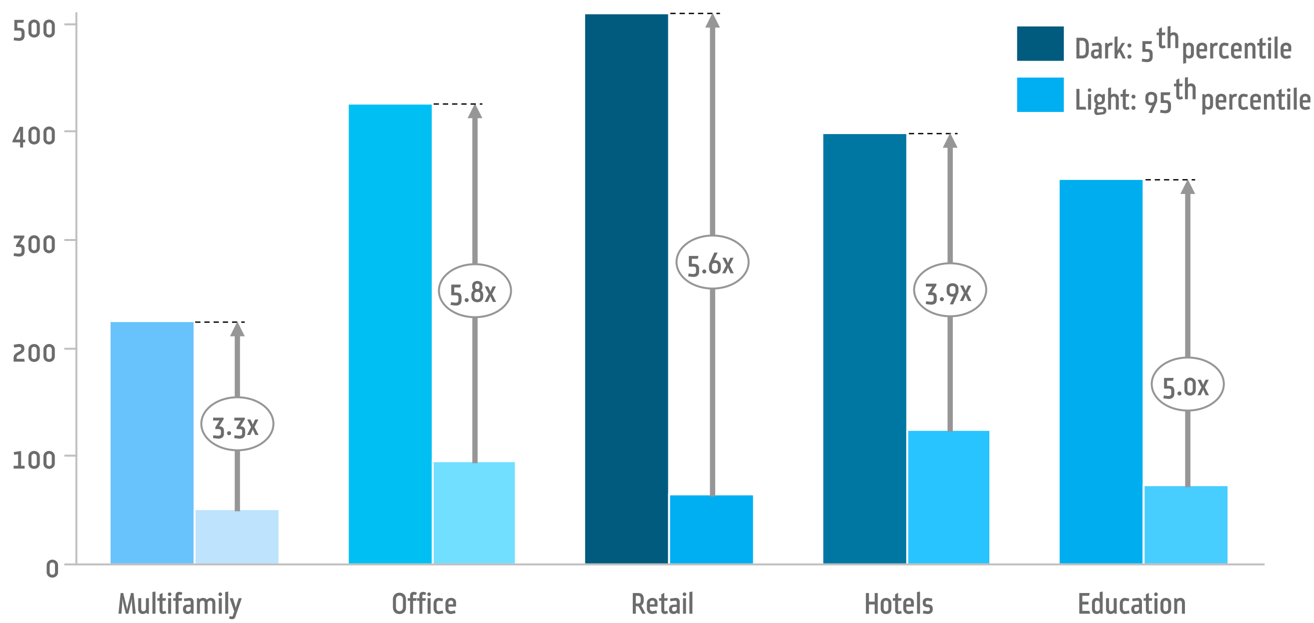
Source: NYC Mayor's Office

Variation in Median ENERGY STAR Score and Median EUI by Building Age
Source EUI (Annual kbtu / sq ft)



Source: NYC Mayor;s Office

Variation in Source Energy Use Intensity (EUI) by Sector
Source EUI (Annual kbtu / sq ft)



Source: NYC Mayor's Office

Technical Potential of GHG Reduction Measures

As % of total 2005 emissions

Measure	%
Building Exteriors	**11.1%**
Roof and envelope renovations	4.7%
Better windows	2.4%
Efficient designs for new buildings	4.0%
Building Systems, Lighting, Submetering, and Endpoint Controls:	**15.0%**
Thermal equipment efficiency and sizing	2.6%
Advanced air conditioning	2.8%
Lighting efficiency and controls	4.2%
HVAC controls	0.6%
Continuous Commissioning	2.6%
Submetering	2.2%
Plug Loads	**2.6%**
Better electronics and appliances	2.6%
Sources of Energy for Heating, Hot Water and Cooking	**13.2%**
Conversion to gas	1.8%
Solar water heating	2.8%
Ground source heat pumps	2.6%
Air source heat pumps	4.8%
Cooking	1.2%
Biogas	--
Biomass district CHP	--
Advanced biodiesel	--

Credit: John Lee, Mayor's Office

Emissions Abatement Potential

The carbon abatement potential from building efficiency measures is significant, but the potential must be understood relative to the costs. Improved building systems and reductions from plug loads have large potential to reduce emissions at relatively low costs, and could result in significant paybacks over time. Upgrades to the thermal performance of walls, windows, and roofs are similarly important, although higher costs require longer periods of time to realize a payback through energy savings. Improvements in building operations and the monitoring and control of building systems offer practical solutions to saving energy that can be immediately realized with little cost. Despite the significant saving potential from energy efficiency, 80 by 50 cannot be reached without reducing fossil fuel consumption in buildings and switching to renewable energy sources. This transition to cleaner fuels on-site can be expensive, technically complex, and challenged by a range of regulatory, financing, and construction obstacles.

Building Exteriors

Building exteriors – roofs, walls, windows – are the first point of energy losses. Renovating and maintaining the exteriors of existing buildings and improving building codes that govern new construction could abate up to 7.0 million tons of emissions.

Roof and envelope renovations

4.7%[a]

3.0 million tons [b]

-$80 per ton [c]

Building envelopes and roofs separate the interior environment from conditions outside. While new buildings are designed to minimize thermal exchange between indoors and outdoors — making it easier to maintain comfortable temperatures indoors — many existing buildings have envelopes that do not meet current standards. Opportunities abound to improve building envelopes, whether through simple measures like weatherization and air-sealing, or through comprehensive façade retrofits. Across the city, there is the potential to eliminate 4.2 million tons of emissions through four types of measures. The greatest reductions could come from renovations to commercial envelope (2.0 million tons at -$110/ton, assuming 50 percent of existing floor space is covered) and low-rise residential roof insulation (0.8 million tons at -$10/ton assuming 50 percent of roofs are targeted). Renovating residential envelopes and low-rise commercial roofs could each reduce emissions by 0.1 million tons (at -$210/ton and -$20/ton, respectively, assuming renovation of single-family homes and high-rise curtain wall residential buildings and targeting of 5 percent of commercial floor space). The blended 2030 cost per ton from building envelops and roofs stands at -$80/ton.[7]

[a] Percentage sector wide reduction
[b] Amount of CO_2e abated
[c] Cost to abate carbon

Better windows

2.4%

1.5 million tons

-$120 per ton

All across the city, leaky and inefficient windows degrade overall building energy performance. Improving windows can save significant amounts of energy and in some cases may be as simple as sealing holes around window-mounted air-conditioning units. For new buildings, using triple-paned glass instead of double-paned glass is an easy way to save energy over the lifespan of the building, and a relatively recent technology called “active windows” that dynamically respond to minimize heat gains in warm months and heat losses in cold months could reduce energy losses by up to 30 percent. Improving the performance of windows citywide could lead to reductions of 1.5 million tons —90 percent of this potential is within residential buildings at -$80/ton and the remainder is in commercial buildings at -$400/ton. The blended cost of this abatement measure is -$120/ton in 2030.

Efficient designs for new buildings

4.0%

2.6 million tons

-$30 per ton

The City’s energy code sets minimum standards for thermal performance but many buildings still use excessive amounts of energy, particularly those with high window-to-wall ratios (e.g. glass curtain wall buildings), which offer limited protection from solar gain and have many thermal loss points. A highly efficient new design paradigm known as Passive House can yield well-insulated, virtually airtight buildings that require little additional mechanical energy to keep indoor air comfortable. Utilizing high-performance design standards to reduce non-plug load energy use by up to 70 percent on the majority of new construction could abate up to 2.6 million tons of emissions, with roughly half of this potential coming from residential buildings. Measures in residential buildings would carry a 2030 cost of $60/ton (assuming 70 percent penetration), but measures in non-residential buildings would be cost-saving at -$110/ton. The blended 2030 average would stand at -$30/ton, falling to -$120/ton by 2050 as costs go down with technological maturation and the economies of scale.

Building Systems, Lighting, Submetering, and Endpoint Controls

Building systems consume vast amounts of energy to provide heating, cooling, and lighting of spaces, particularly if the systems are older and inefficient, or poorly operated. Replacing equipment with more efficient technologies and improving operations could reduce emissions by up to 9.5 million tons at negative costs.

Thermal equipment efficiency and sizing

2.6%

1.6 million tons

-$190 per ton

Thermal equipment in buildings – boilers used for heating, hot water, and cooking – typically rely on the combustion of fossil fuels. Oversizing of equipment often occurs when specifications are based on rules of thumb or taken from equipment manufacturers' generic recommendations, instead of the results of detailed analysis of the required loads. Replacing inefficient equipment with the best available models at naturally occurring retrofit times and conducting proper calculations to "right-size" equipment could abate up to 1.6 million tons of emissions. More efficient boilers – including condensing types – could yield 1.5 million tons of reductions, with two thirds coming from residential buildings. Improved commercial cooking equipment could abate an additional 0.1 million tons. The blended average cost would stand at -$190/ton in 2030.

Advanced air conditioning

2.8%

1.8 million tons

-$400 per ton

Air conditioning is essential to maintain comfort during hot summer days and in densely occupied spaces, but it is a major drain on the city's energy resources. On hot summer days, the increase in air conditioning use can cause electricity demand to spike by 1.4 GW by late afternoon (approximately 20 percent of the night-time load level), which is equivalent to the output of three large gas-fired power plants. Larger and newer commercial and residential buildings can be air conditioned through central HVAC systems; smaller or older buildings use split systems mounted in walls or windows that provide air conditioning for individual apartments or offices. More efficient technologies are available, but they have not yet been adopted commercially at scale. For example, in the early stages of commercialization are air conditioning systems that utilize liquid desiccants, which are able to dehumidify and cool incoming air simultaneously, thus reducing the need to overcool to control humidity and yielding energy savings of up to 30 percent. Adopting similarly efficient air conditioning systems could reduce emissions by up to 1.8 million tons, of which nearly 80 percent would come from large commercial buildings where they would prove to be most economical at -$600/ton in 2030. Costs for residential buildings would be high in 2030, at $370/ton, but they could drop to -$300/ton by 2050. The blended cost for 2030 would stand at -$400/ton.

Lighting efficiency and controls

4.2%

2.7 million tons

-$610 per ton

Lighting in non-residential buildings accounts for almost 14 percent of the city's carbon emissions, and there is great potential for reducing this share both through more efficient lights and through better lighting controls. Most of the potential would come from adopting the most efficient Light Emitting Diode or LED lights, which are becoming more and more affordable and accepted but have not yet been adopted en masse. Replacing 50 percent of existing CFL and incandescent lights with LEDs by 2030 and 90 percent by 2050 could abate up to 2.4 million tons of emissions at the cost of -$670/ton assuming that. Over that time period, costs of LED lighting is expected to fall by 50 percent. Lighting controls would play a smaller, but still prominent role: installing dimmers and occupancy sensors that shut off lights when a room is not in use could reduce emissions by 0.3 million tons, with almost 90 percent of the potential in commercial buildings due (-$200/ton). The blended cost for all measures would stand at -$610/ton.

HVAC controls

0.6%
0.4 million tons
-$330 per ton

Existing HVAC systems are often equipped with inadequate controls. For example, building tenants can find it impossible to control heating or cooling directly, and resort to opening windows to manage temperatures. Installing better endpoint thermal controls like thermostats and electrostatic microvalves could allow better managed space conditioning. This could lead to 0.4 million tons of GHG reductions that would be split evenly between commercial and residential at an average cost of -$330/ton.

Continuous commissioning

2.6%
1.6 million tons
-$190 per ton

HVAC systems require careful tuning and frequent monitoring of building performance data to run at optimal efficiencies. However, building operators often neglect to undertake this important maintenance measure, forgoing opportunities to capture an average of 12 percent energy savings from HVAC operations. Capturing these available reductions through “continuous commissioning” could abate as much as 1.6 million tons of emissions, with 75% coming from commercial buildings at a cost of -$280/ton and the rest from residential, at the 2030 cost of $50/ton, for a blended cost of -$190.

Submetering

2.2%
2.2 million tons
-$460 per ton

Commercial tenants and residents of multifamily buildings often have no ability to understand or control how much energy they use – instead, energy is included in their overall rental bill. Electric submetering of individual spaces changes this by allowing tenants to obtain direct consumption and billing data, which could potentially enable them to undertake energy efficiency measures. Because this action can reduce energy use by an average of 10 percent, implementing submetering citywide – already required of the largest buildings by 2025 – could lead to GHG reductions of as much as 1.4 million tons, split equally between residential and commercial properties at a 2030 cost of -$460/ton.

Plug Loads

Efficient devices and appliances are available today - but they are not universally installed. Deploying the most efficient technologies at the point of equipment turnover could abate up to 1.7 million tons of emissions highly cost-effectively.

Better electronics and appliances

2.6%
1.7 million tons
-$720 per ton

Computers, personal electronics, refrigerators, washers and dryers and other appliances continuously draw power in homes and businesses whether they are being used or not. Although many appliances and electronics have become more efficient thanks to federal Energy Star requirements, usage rates have also increased and many older devices have not yet been replaced. Furthermore, consumers may not opt for the most efficient models available even if they are cost-effective. Making sure that the most efficient appliances and devices are installed at the point of equipment turnover could reduce emissions by up to 1.7 million tons. Commercial and residential electronics are two of the biggest opportunities, at 0.4 million tons each; and with costs below -$700/ton. Replacing commercial computer systems, commercial refrigeration, and residential freezers could yield 0.2 million tons of reduction each at costs below -$570/ton. Average 2030 costs for plug load reductions stand at -$720/ton.

Sources of Energy for Heating, Hot Water, and Cooking

Fuel switching from refined petroleum products to natural gas can reduce but not eliminate greenhouse gas emissions, so while fuel-switching is an effective near-term measure, it is insufficient to reach 80 by 50. Several options are available to further decarbonize heating including solar hot water heating, ground and air-source heat pumps, and biofuels, but marketplace penetration is still very limited. The city could abate up to 7.2 million tons of emissions through a combination of highly cost-effective measures like switching to natural gas from fuel oil and costly ones like solar thermal and electric heat pumps.

Conversion to gas

The City's regulations to phase out the use of heavy heating oil and its Clean Heat program to accelerate the transition to cleaner fuels has coincided with historically low natural gas prices and the availability of new supply in the region. In just two years, over 2,000 buildings have converted from heavy oil to natural gas. Future conversions from oil to gas could contribute up to 1.1 million tons of GHG reductions. Natural gas prices may increase as demand rises, but even then, the 2030 cost of abatement would be hugely negative at -$730/ton.

1.8%

1.1 million tons

-$730 per ton

Solar water heating

Solar hot water heating (SWH) systems heat water through solar energy collected on a rooftop – though it requires a supplemental heat source when temperatures are below freezing and its efficiency drops to near zero. On a cost per ton basis, SWH systems are expected to be more cost effective than photovoltaic solar power (PV) systems through 2030—at which point high electricity prices and technological advancements would give solar PV the edge. However, SWH will likely prevail in terms of abatement potential on a per square foot basis: by 2030, SWH could abate 15 tons of carbon per 1,000 square feet of roof space, while PV could only abate 7, even with performance improvements. SWH systems could abate up to 1.8 million tons of emissions at a 2030 cost of $140/ton, potentially falling to -$50/ton in 2050 as technologies improve.

2.8%

1.8 million tons

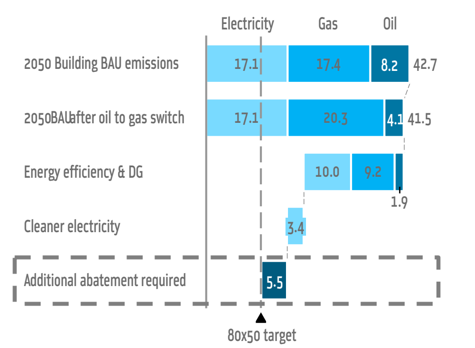
-$140 per ton

Gap to 80 by 50

Fuel-switching from oil to gas, energy efficiency improvements, distributed generation, and cleaner grid electricity may together reduce building emissions from 42.7 million tons in the business-as-usual case to 17 million tons by 2050 — but that is still not enough to reach the 80 by 50 goal. An additional reduction of 5.5 million tons would be required. (See chart: *Drivers of Change to Building Sector Emissions*)

Several technologies discussed in this chapter – ground source heat pumps, air source heat pumps, biogas, biomass CHP, and advanced biodiesel – could potentially cover the gap, though questions about costs and feasibility must be addressed.

Drivers of Change to Building Sector Emissions
Metric Ton CO_2e



Source: NYC Mayor's Office

Ground source heat pumps

Ground source heat pumps (GSHP) use electricity to cycle fluid between a building and underground wells to transfer heat. The ground maintains a stable temperature of approximately 55°F year round, which makes it possible to use it as a heat source (in the winter) or a heat sink (in the summer) through transferring heat from the ground to the building or vice-versa.[9] Three major types of ground source systems are available and their applicability depends on the geology of a given location within the city. (See graphic: *Ground Source Heat Pump Feasibility by System Type*)

2.6%

1.7 million tons

-$30 per ton[8]

Actual penetration of these systems would be limited by the high cost of drilling wells under existing buildings, space requirements, and the complexities of integrating with existing heating systems. GSHPs could abate emissions by up to 1.7 million tons. The assumptions for the proportion of heating load (160 trillion BTU, down from 300 trillion BTU today) that these systems would serve differ by borough.[10] Citywide, the 2050 cost of abatement would stand at -$30/ton.

Air source heat pumps

Air source heat pumps (ASHP) work similarly to a GSHP, but they use outside air as the heat sink, which is less efficient given the seasonal variation in air temperature. They are easier to install than GSHP because they do not require subsurface construction work,[11] but the lower efficiency levels mean that they are less cost-effective overall, costing $140/ton in 2050 compared to -$30/ton for GSHP. ASHP's could abate up to 3.1 million tons if deployed at scale but their ultimate role will depend on the cost and feasibility of other technologies for decarbonizing building fuels.

4.8%

3.1 million tons

$140 per ton[8]

Ground Source Heat Pump Feasibility by System Type
System Types

Source: NYC DDC, NYC Mayor's Office

Cooking

Most cooking in New York City relies on natural gas stoves. Emissions from cooking would not be the first priority for abatement since they are a relatively small source overall. However, on the 80 by 50 pathway, alternatives like induction stoves, which heat up more quickly but cost more than conventional equipment, would eventually need to be considered. If induction stoves were to become the method of choice, the abatement potential would add up to 0.8 million tons at a cost in 2050 of $160/ton.

1.2%

0.8 million tons

$160 per ton[12]

Biogas

Biogas production through wood gasification, relying on sustainably harvested wood from regional forests could potentially satisfy the city's entire remaining heating load. Although biogas is not carbon-free because its production requires energy, it still offers a 70 percent reduction in lifecycle GHG emissions compared to conventional natural gas. It is unclear if there is sufficient sustainable biomass located near regional ports to be transported economically, especially given the risk of long-term competition for supply amongst other cities that follow suit with their own biogas demands. Still, the technology is worth exploring – in Europe, at least three biogas power plants are currently in various phases of completion.[13] Abatement costs of biogas are very sensitive to future natural gas and biomass prices, but conservative assumptions based on current prices of coal gasification plants being built at scale suggest that $16 billion in capital investment would be required to satisfy all of the city's remaining heating needs in 2050 and that abatement costs could run at above $250/ton.

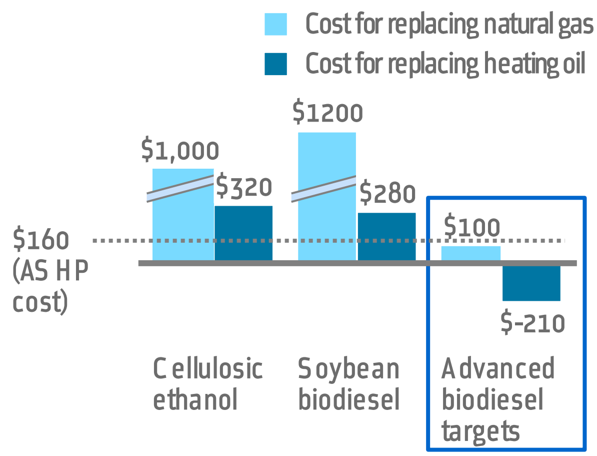
Biomass district CHP

CHP systems use a heat engine to generate electricity and then capture and reuse the waste heat to supply space heating, cooling, or hot water. As a result, CHP systems offer an efficiency improvement over the alternative combination of electricity from New York City's current grid and heat from a natural gas boiler – but the improvement is not high enough to make it a viable large-scale solution on the 80 by 50 pathway (see Power chapter for additional discussion of CHP's electricity production potential). If biomass were used instead of natural gas, however, CHP systems constructed at a district level could provide more than enough abatement to cover the city's residual heating loads, though at a significant cost. Installing distributed systems in all five boroughs – which would require laying up to 4 thousand miles of pipe – could cost up to $27 billion. When coupled with an additional $3 billion in cost for the equipment itself, this would result in 2050 abatement cost of $220/ton.

Advanced biodiesel

Biodiesel from cellulosic ethanol and soybeans has been available for some years now, but its costs were generally too high. Recently, the production of biodiesel using algae or bacteria has started to become viable – and if the emerging trends continue and biodiesel production scales as expected, the fuel could in the future become a large-scale abatement option – especially because it can easily be substituted for conventional liquid fuels in existing heating systems. By 2050, assuming a production cost of $75 per barrel of biodiesel equivalent, abatement costs would come in at $100/ton if replacing natural gas and at -$210/ton if replacing heating oil, potentially offering lower-cost abatement than either biogas or biomass district CHP. (See chart: *Abatement Costs by Biofuel Technology*)

Abatement Costs by Biofuel Technology
US$/ $MtCO_2e$



Source: NYC Mayor's Office

The Costs and Economics of Carbon Abatement for Buildings

The city's building sector is an important part of the economy – every year, New Yorkers spend more than $18.9 billion on electricity and building fuels to power electrical and mechanical equipment, and more than $30 billion worth of construction activity takes place. Reducing the sector's carbon emissions would bring about major changes to these spending patterns, but the economy would benefit overall.

Most of the abatement measures would require incremental upfront investment – for example, purchasing high-performance equipment to replace existing less efficient equipment that is at the end of its useful life rather than replacing in-kind. However, the resulting energy savings would generally well exceed the cost of the incremental investment over the equipment's lifetime. The share of buildings measures that achieve abatement at a negative cost would exceed between 2020 and 2050. (See chart: *Carbon Abatement Costs by Year*)

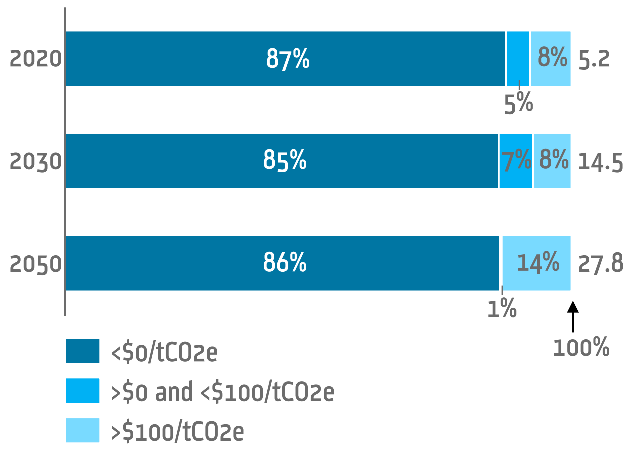
The total required incremental investments would be sizeable: $2.2 billion a year in 2020 and $3.0 billion a year in 2030, peaking at $3.8 billion a year in 2045. This level of spending would be comparable to the annual capital investment programs of Con Edison and the Department of Environmental Protection – but in the context of the city's total annual construction spending of $30 billion, the costs would represent only a 10 percent increase in spending.

The incremental capital expenses would be more than offset by operational savings – already in 2020, the energy savings would nearly approach the incremental expenses at $1.9 billion, and by 2030, the savings from past measures would be more $6.6 billion, or more than double that year's budget for incremental capital spending.

The effect of these abatement measures on employment would be overwhelmingly positive. The incremental capital spending could directly create more than 6,600 local jobs in building-related activities by 2020, while incurring 4,200 job losses in other sectors as spending is redirected, leading to a net gain of 2,200 jobs. The biggest benefits, however would come from lower energy use and lower costs of doing business across the economy. This would make the economy more competitive, potentially adding more than 4,400 new jobs by 2020 and 13,000 new ones by 2030 throughout all sectors. Together, direct and indirect employment gains would net an additional 6,600 new jobs by 2020 and 14,700 new ones by 2030. The resulting impact on GDP and personal income would stand at above $500 million in 2020 and above $1.6 billion in 2030. (See chart: *Employment Impacts of Buildings Sector Carbon Abatement*)

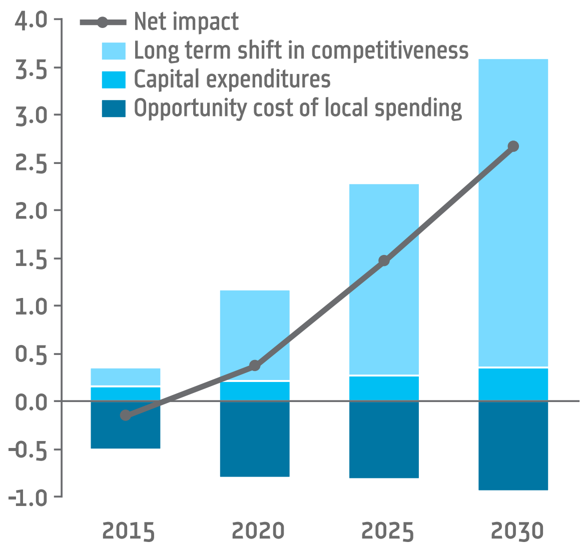
The changes would also create new industries around energy efficiency and retrofits, giving New York City an opportunity to lead in these areas just as it leads in architecture, design, and real estate development today.

Carbon Abatement Costs by Year
Percentage of total; Metric tons Co_2e



Source: NYC Mayor's Office

Employment Impacts of Buildings Sector Carbon Abatements
Thousands; by type of impact



Source: NYC Mayor's Office

Challenges

Awareness is limited about the financial and operational benefits of energy efficiency

While it is possible to identify the city-wide potential for reductions across building classes, individual building owners, operators, tenants and other decision-makers may not understand the full scope of opportunities in their specific buildings. The marketplace does not currently have sufficient levels of education and technical assistance to help decision-makers understand their options and identify available resources.

Financing options that recognizes the value of energy savings are not widely available

Although energy efficiency projects can yield substantial savings, most lenders are not willing to recognize these savings as part of the underwriting of a loan. A variety of factors have limited the development of financing options that recognize the value of energy savings, including lack of performance data, limited expertise in underwriting such transactions, challenges verifying energy savings, and apprehension that changes in building use will diminish potential returns.

Energy costs are relatively low and opportunity costs are high

Compared to other sources of energy, fossil fuels are relatively cheap. In the commercial sector, energy represents only a small fraction of overall rental costs, and building owners are much more likely to spend limited capital on more tangible projects to improve the value of their buildings. In multifamily buildings — many of which have low operating margins and limited available capital — building owners tend to defer capital investments until the end of the useful lives of equipment, or beyond.

Innovative technologies are slow in coming to market and building owners are risk averse

Although most of the potential carbon reductions could be achieved with today's tools, new and emerging technologies could accelerate the pace of change. However, building owners and managers are slow to adopt new technologies without a proven track record or tangible examples of successful implementation in similar New York City buildings.

Capturing the Potential

Strategy 1
Improving Information and Data Transparency

The City's approach to measuring energy efficiency potential through benchmarking has already yielded a wealth of information about the opportunities in the largest buildings. This approach could be expanded and improved.

Better benchmarking and energy performance metrics

Implementation of Local Law 84 — the benchmarking component of the Greener Greater Buildings Plan (GGBP) — has revealed that large buildings have tremendous potential to save energy and water. But in a city as complex as New York, measurement and assessment methods can always be improved. The City is partnering with the Environmental Protection Agency, the Department of Energy, NYSERDA, and research institutions to refine the benchmarking process to better account for the range of usage and economic factors that impact local energy consumption. The City is also partnering with the Federal government and utilities to simplify the process of energy disclosure while maintaining customer privacy and security.

Data transparency for midsize buildings

The city could build on the existing benchmarking program for large buildings by encouraging voluntary — or eventually mandatory — benchmarking for midsize buildings. The segment of buildings between 10,000 square feet and 50,000 square feet accounts for 5 percent of total built area, but it is responsible for nearly 19 percent of energy used by buildings. Expanding GGBP to cover these buildings would bring thousands of new buildings into the marketplace for energy efficiency.

Comparative billing for residential utility customers

Research suggests that people are more likely to conserve energy if they understand how their consumption compares to their neighbors. Utilities across the country are incorporating simple to read, visually dynamic, 'comparative billing' indicators on customers' bills. For households that use higher amounts of energy, the utility bill suggests performance targets and provide tips for saving energy. Some utilities have also created rewards programs for reducing energy use. A research pilot in partnership with utilities and academic institutions could be undertaken to assess the potential benefits of comparative billing in New York City.

Building informatics

As building systems monitoring becomes more and more sophisticated, enormous amounts of data can reveal real-time performance. This can lead to a much better picture of the aggregate efficiency of New York City's building stock, pointing the way to developing new strategies to reduce energy use. Because the volumes of data are staggering, the analysis should be carried out in partnership with specialized institutions, including New York City's existing and newly developed Applied Science Campuses, creating a foundation for ongoing innovative research into the city's building stock and nurturing a knowledge base in energy use metrics.

Strategy 2
Expanding Education and Training

Building operator training

Continuous commissioning of building systems has the potential to eliminate 1.6 million tons of emissions – but capturing this potential requires well-trained building operators. The City could work with key organizations to develop a training program for building operators to become skilled in continuous commissioning that can coincide with the recently enacted Local Law 87 of 2009 that requires periodic energy audits of base building systems and retro-commissioning of those systems.

Demonstrations centers for professionals and practitioners

Despite compelling advances in lighting technologies and controls in recent years, many designers and building professionals lack awareness of the full potential of the possibilities. A new lighting and energy efficiency center known as Green Light New York, due to open in Lower Manhattan in 2014, will begin to address this issue. The center will offer training to a broad range of disciplines as well as a physical venue to exhibit and mock-up emerging and accepted technologies. It will also provide a forum for discussion that will help to promote wider market transformation.

Educating building decision makers

In multifamily buildings that are cooperatively owned and managed, nothing gets done unless board members are educated and enthusiastic about the project. Even then decision-making and project-implementation timelines can span years because of competing demands for attention and limited capital. Reaching 80 by 50 would require cultivating champions for energy efficiency at buildings far and wide. The city could partner with multifamily housing organizations to create programs to train board members and cultivate excitement and follow-through for energy efficiency projects.

Consumer education campaigns

Building decision makers need better information, but so do average New Yorkers. The City's sustainability marketing program, GreeNYC — and its winged mascot, Birdie--encourages New Yorkers to alter their behaviors, from eliminating paper waste to installing energy efficient light bulbs in their homes. The program could be expanded to promote broader messaging about the importance of energy efficiency as well as product-specific plug load reduction campaigns that could be paired with rebates and incentives offered by utilities and NYSERDA.

Strategy 3
Removing Barriers to Energy Efficiency and Incentivizing Action

Aligning interests to undertake energy efficiency

Building owners often cite the existence of 'split incentives' as a major obstacle to undertaking energy efficiency. What they mean is that they cannot achieve a financial payback on their investments because most of the energy savings accrue to tenants – as an obstacle to pursuing energy efficiency projects. The City has already made some progress by working with leading real estate executives to develop terms that could be incorporated into standard commercial leases to specify how owners and tenants could share in both the costs and benefits of energy retrofits. Standardizing this practice could go a long way to overcoming split-incentives.

Improving access to financing

The Greener Greater Buildings Plan has created a marketplace for energy efficiency technologies and services of an unprecedented scale – but major lenders are only just beginning to respond with financing offerings that recognize the value proposition and the stable returns that investments in energy efficiency can yield. In response, the City created the New York City Energy Efficiency Corporation (NYCEEC), which has pioneered energy efficiency financing solutions and provided capital for dozens of clean energy projects that leveraged significant levels of private investment. NYCEEC is taking on the most challenging building segments by financing projects in affordable and market-rate multifamily buildings, Class B commercial buildings, and institutions. Continuing its work with NYCEEC, major lenders, and businesses to diversify and standardize financing offerings, improve performance monitoring, and foster the development of retail infrastructure could greatly benefit the marketplace for energy efficiency.

Providing technical support and assistance

Starting in January 2014, buildings covered by the Greener, Greater Buildings Plan will begin to report the results of their mandatory energy audits. These audits will enumerate specific opportunities to reduce energy use and quantify potential savings, however, buildings are not required to act on the findings. Buildings that choose to act could also encounter the practical difficulties in implementing energy efficiency measures: navigating multiple incentive programs, selecting quality contractors, securing financing, and managing the implementation process. The City could undertake a similar program to the successful NYC Clean Heat program, which utilized a sales-force approach to help thousands of buildings convert their boilers to cleaner fuels ahead of the required timeline through providing technical assistance, general information, and help accessing financing. A similar program can be developed to assist owners and managers of the city's large and mid-size buildings to follow through on the recommendations of their energy audits. It could also seamlessly link them to financing options available through NYCEEC and incentives through NYSERDA and local utilities—thereby acting as a one-stop shop for resources.

Tailoring incentive programs to NYC realities

Multiple NYSERDA and utility incentives are available to encourage buildings to undertake energy efficiency projects — but too many buildings in New York City may be ineligible, particularly those that use heating oil. NYSERDA has recommended allowing all buildings to gain access to state energy efficiency programs — including buildings that utilize fuel oil — and to ease restrictions that prevent efficiency measures that span energy types (for example solar thermal hot water heating). Following through on this recommendation would present a great opportunity to capture additional emissions reductions and the City could help accomplish this by partnering with NYSERDA and the Public Service Commission to develop a near-term pilot program to expand offerings to buildings that are seeking to convert to convert to cleaner heating fuels.

Expanding programs to recognize top achievers

The City launched the Mayor's Carbon Challenge in 2007, inviting 17 local universities to match City government's GHG reduction target of 30 percent in just ten years. Since then the Carbon Challenge has been expanded to include over 50 hospitals and a dozen major corporations. More and more organizations are being attracted to the Carbon Challenge because it inspires high-level commitment among decision makers, provides basic technical assistance and a platform for exchange for facilities managers, and fosters a spirit of competition. The results have been extremely encouraging: university and hospital participants have cumulatively reduced their emissions by 10 percent and six of the participants – NYU, Barnard College, the Fashion Institute of Technology, the Rockefeller University, New York Hospital Queens, and Weill Cornell Medical College – have already reached their 30 percent target already in less than half the time allotted. Expanding the Carbon Challenge or similar recognition programs to multifamily buildings, hotels, retail spaces, and commercial real estate could enroll tens of millions of additional square feet of space and broadly showcase the benefits of energy efficiency for relatively minimal commitment of City resources.

Promoting energy efficiency measures for small buildings

The city has over half a million one- to four-family houses. Achieving 80 by 50 will require action at many of these properties, but programs are not in place to accommodate the extraordinary scale and uniqueness of this marketplace. A program could be developed in partnership with the real estate industry, home inspectors and building trades to target energy efficiency improvements at the time of sale or tenant turnover in these buildings. The 'point-of-sale' is an ideal time to implement simple conservation measures such as pipe insulation, duct sealing, and weatherization and allow prospective buyers to factor energy performance into their decision making.

Promoting efficiency in historic and landmarked buildings

Historic preservation and energy efficiency are often misperceived as competing priorities. With over 30,000 historically landmarked buildings and a world-class community of design and preservation professionals, the city can revolutionize the discipline of energy efficient historic preservation. Demonstration projects jointly carried out by the City, building professionals, NYSERDA and building owners and covering a suite of historic building types could seek up to 50 percent energy savings without compromising architectural character and could create examples that the rest of the industry to follow. Targeted incentives, voluntary performance-based energy standards, and an education program could facilitate these projects and increase market uptake of best practices.

Strategy 4
Strengthening regulations and development incentives

Incorporating weatherization into existing façade improvement programs

Since 1998, the city has required buildings that are larger than six stories to conduct regularly scheduled façade inspections to ensure structural stability and safety (Local Law 11). This program could be expanded to include measures for improving thermal performance of facades through simple weatherization and air-sealing techniques that would be inexpensive to implement and would save building owners money.

Zoning for ultra-efficient buildings and developments

The city's zoning ordinance governs the allowable heights and sizes of new buildings. Over the past decade the City has proactively employed zoning incentives to promote policy objectives such as creating affordable housing, and developing open space and community infrastructure. Zoning can also be used to encourage energy efficiency. One way to do so could be to offer bonuses to new buildings that are built to ultra-high-performance standards or that include on-site clean energy technologies– a measure that would have no fiscal impact to the City and would help to prepare the construction industry for more stringent future codes.

Ensuring Energy Code compliance

New York City's Energy Code applies to both new buildings and major renovations and system replacements, and the codes, through a revision in 2014, will lead to a 30 percent improvement in energy performance compared to the original code adopted in 2009. The City is significantly strengthening code enforcement efforts to achieve 90 percent Energy Code compliance by 2017. Partnering with building trades and professional organizations to provide Energy Code training, and developing incentives with NYSERDA, Con Edison, and the PSC, could accelerate this goal and encourage projects to exceed code standards.

High performance energy conservation codes

The energy code evolves through regular review by building professionals and over time it demands higher performance from new construction and renovations. Further iterations, could be developed in partnership with the International Code Council, the building industry, and research institutions, and by 2015, could potentially yield a 50 percent improvement over today's standards.

Green Codes Task Force implementation

The Green Codes Task Force, convened at the request of the Mayor and City Council Speaker, put forward 111 proposals to increase efficiencies in building energy use and ensure sustainable construction methods. Since the recommendations were finalized in 2008, over 40 of the proposals have been enacted – but many more are still under development or consideration by the City Council and are worth implementing.

Expanding biodiesel use

Biodiesel holds the potential to reduce millions of tons of emissions in the future – and progress has already been made. The City is already showing leadership by using B5 biodiesel in all buildings that utilize heating oil and the municipal fleet is transitioning to B20 for non-winter months. City buildings and fleets can becoming a proving ground for biodiesel use at higher-concentrations and facilitate broader uptake in the private marketplace. In tandem, the City could work with ASTM International and boiler manufacturers to accelerate development of specifications for higher levels of biodiesel use and could also partner with NYSERDA, Brookhaven Labs and private buildings to undertake B20, B50, and B100 pilots. Ultimately, the City could consider increasing the current B2 requirement for heating oil to higher levels.

Enacting performance targets

Over the next decade, the city's largest buildings will be conducting deeper analyses of the potential benefits of improving operations and equipment through energy audits. With the exception of lighting upgrades, building owners are not required to execute specific retrofits; and such a requirement would likely be less cost-effective than allowing businesses to determine the best ways to save. Setting performance targets, however, could help to drive buildings towards improving operations and undertaking retrofits. The City could consider, for example, seeking to raise average energy utilization performance to the top 25th percentile by class as compared to buildings nationwide before 2025.

Strategy 5
Fostering Innovation

Conducting pilot projects for high-potential technologies

A number of promising building technologies could yield substantial carbon reductions but face technical barriers to implementation in New York City, and may therefore be good candidates for pilot projects that would establish their feasibility. One technology worth piloting is ground source heat pumps. Heat pumps are proven in other geographic settings and at several City buildings in New York, but generally they are difficult and expensive to site because of the diversity of the city's underground geology and infrastructure, space limitations, and inexperience in the marketplace. Another technology is liquid desiccant air conditioning, which is only in the early stages of commercialization but shows extraordinary promise. A demonstration program in partnership with a national laboratory partner and industry manufacturer could help foster understanding of these and other promising technologies.

Making New York City a living lab

New York City can demonstrate leadership and foster the commercialization of new low carbon technologies. The City operates 4,000 public buildings, over 300 public housing sites, 15 hospitals and health care centers, and 14 wastewater treatment plants. The City is currently executing a plan to increase its demand response capabilities from 20 MW of peak load reduction to 50MW, in part through the use of an innovative system that will perform automatic peak load shedding. The City could work with research institutions, Con Edison, NYSERDA, and the private sector to identify and test out other promising technologies, making New York's public facilities living laboratories for energy innovation.

Credit: Daniel Novak/ danielnovakphoto.com

Renewable power generation; Windmills

Power

The power supply is both the lifeblood of the city's economy and a major source of its greenhouse gas emissions. The power sector has become significantly cleaner in recent years, but a fundamental reconfiguration would be required to achieve a deep emissions reduction of 80% by 2050. The technical potential for such a low-carbon power sector exists, but the level of capital investment needed would have significant impacts to the city's economy, including higher electricity prices, the costs of policies to incentivize such a shift, and implications for the number of jobs. Power prices would rise by up to 9 percent over a business-as-usual scenario, carbon prices would reach up to $150 per ton, and the impact on jobs would depend on the future energy supply mix. A regional framework would be less costly and more efficient, reducing global greenhouse gas emissions by a greater amount. There are several other challenges to balance including an aging infrastructure and sea level rise. No single strategy can achieve an 80 by 50 goal; rather, a portfolio approach is needed, including: the modernization of existing power plants; increased market penetration of distributed generation technologies such as solar photovoltaic (PV) and combined heat and power (CHP); and investment in large scale renewable energy technologies such as hydro and wind generation.

Overview

Staten Island DSNY Solar Panels

On a late summer evening in 1882, workers at the Edison Electric Illuminating Company power station in Lower Manhattan threw the switches on a set of 27-ton generators, and 800 lamps lit up a 50-square block area of Manhattan's Financial District. In an instant, the electric age was born. For more than 120 years, electricity has illuminated New York City's most iconic landmarks and powered the city's climb to world preeminence.

The city's people and economy depend on power. New Yorkers spend $11 billion a year on electricity. Fortunately, the city is served by one of the world's most dependable and cleanest power generation and delivery systems. The frequency of interruptions to Con Edison's electric customers is the lowest of any investor owned utility in the nation. The per capita GHG footprint of the city's power sector is also among the lowest of any major city in the United States. Locally produced power is primarily generated with natural gas—as opposed to higher carbon intensive fuel oil or coal—and significant amounts of carbon-free energy is already transmitted from outside of the city, primarily from nuclear power.

However, our energy sector faces significant challenges in the coming years. Power plants are aging and in need of modernization. Renewables comprise less than 1 percent of installed generation capacity within city limits. Furthermore, Hurricanes Sandy and Irene have demonstrated that our energy systems are vulnerable to the impacts of climate change, which will include sea-level rise and more intense and frequent precipitation, wind, and heat waves in the future. More than two-thirds of critical generation and distribution assets are located within the 1-100 year flood zone today. These challenges raise fundamental questions about how to reconfigure and redefine the power sector in order to balance GHG mitigation and resilience investments.

Reducing global power sector emissions by 80 percent by 2050 cannot be done by any city alone. Yet, New York City is a test case for many of the key energy policy questions of the day. This includes innovations in energy efficiency financing, integration of renewables in dense urban environments, transition from carbon intensive fuels to natural gas and renewables, tradeoffs in the potential retirement of nuclear power plants, and the emergence of 21st century regulation of an increasingly complex power sector.

The technical potential exists in the regional endowment of renewable resources across the State, Canada, and offshore Great Lakes and Atlantic. However, because of the capital required, the interdependent nature of power systems, and an already-established regulatory and market framework, there are significant challenges to achieving a clean, diverse and resilient portfolio. This chapter explores the lowest cost pathways for the power sector to meet this carbon goal while meeting reliability standards and improving climate resilience.

Conceptual Framework for Power Analysis

To understand perspectives on what the city's energy portfolio should look like under a low-carbon pathway, the City assembled a group of experts including power producers, energy project developers, utilities, environmental stakeholders, and consumer advocates. A key challenge for the 80x50 goal is to meet the electricity demand of the city's businesses and residents in a reliable and affordable manner while significantly altering the generation technology resource base. Not surprisingly, for a system as complex and facing as many potential tradeoffs as the New York power sector, no single vision prevailed. However, several principles emerged.

Principle 1
Pursue a balanced portfolio, as there is no magic bullet

This report attempts to incorporate the best available climate science, technology learning curves, and power sector modeling appropriate for the long time frame of the analysis. However, long-term forecasting in the energy sector is inherently risky and therefore calls for a portfolio approach to resource planning and policymaking, rather than identification of specific technological "magic bullets."

Principle 2
Major changes are disruptive

The advisory group agreed that an 80 by 50 solution would require a major shift in technologies and markets over the long-term, but also cautioned that a realistic approach would take into consideration the utilization of existing assets to the extent possible. Some members of our advisory group also felt that a well-crafted 80 by 50 program should seek to balance the role of regulation and markets to drive private investments.

Principle 3
Meet reliability standards, including costs of integration

At a minimum, any vision must meet the minimum reliability criteria set forth by NERC and NYISO. A realistic analysis must include the "hidden" costs of integrating new resources, including deliverability within the utility distribution network, load balancing of intermittent resources, and the need for long distance transmission.

Principle 4
Balance climate mitigation and resilience

In the aftermath of Hurricane Sandy and recent summer heat waves, some members of the advisory group felt that scarce ratepayer and taxpayer dollars need to be spent on making the power sector not only less carbon intensive, but also more resilient to extreme weather events through storm hardening power assets and other measures. In June of 2013, Mayor Bloomberg released PlaNYC: A Stronger, More Resilient New York, an action plan to protect the city's coastline, critical infrastructure, businesses and communities from the risks of climate change. Although climate resilience is beyond the purview of this particular report, the power sector recommendations attempt to complement the City's planned resiliency measures.

Principle 5
Cities cannot do this alone

A deep reduction in New York City's greenhouse gas emissions is only the beginning, and action will eventually be required at a regional or national scale. While evaluating the viability of pursuing deep carbon reductions at a local level, the study should also emphasize the need for strong Federal and regional action.

Principle 6
Use City government as a test bed for new technologies

With over 4,000 facilities including 14 wastewater treatment plants, over 1,200 schools, hundreds of firehouses and garages, and other properties, the City is a major consumer of energy. In cases of market uncertainty, the City can use its resources to pilot emerging technologies and drive private investment.

Power System Fundamentals

New York City's electricity supply system is designed to keep up with the dynamic needs of its consumers. In-city plants are able to satisfy most of the local demand, but over half of the city's energy is generated in surrounding regions and then transmitted into the city. The system is owned, operated, and regulated by a wide array of private and public entities, all working together to keep the power flowing wherever and whenever it's needed.

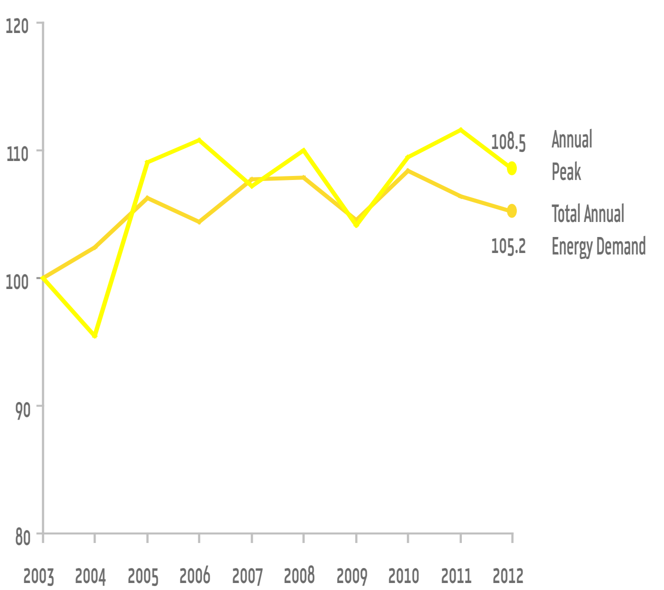
Energy Demand

Electricity is primarily consumed inside the city's buildings – residential, commercial, institutional and industrial– where it powers mechanical systems, lighting, and equipment, adding up to 94 percent of total usage; subways are responsible for 5 percent, and streetlights account for less than 1 percent. In 2012, New York City consumed over 53 TWh, amounting to approximately 0.25% of global electric consumption.

The city's demand for electricity has evolved with changes in the population and building stock, structural changes in the economy, emergence of new electronic devices and equipment, and innovations in energy efficiency. From 2003 to 2008, electricity demand grew at an annual rate of 1.5%. After the Great Recession of 2008 until 2012, however, energy demand reduced at an annual rate of 0.6%. The NYISO now forecasts energy demand in New York City to grow at an annual rate of 0.49% over the next decade. According to the EIA, this trend is consistent with national energy demand and has not recovered with the economy due to lower industrial energy consumption, investments in energy efficiency in buildings, and increasing amounts of distributed generation.

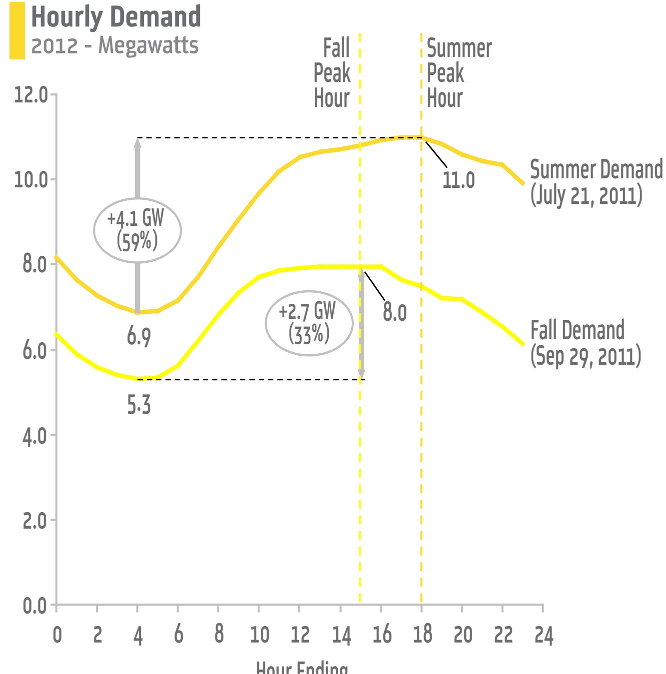
Despite the stagnant growth of aggregate energy consumption, peak demand has grown at an annual rate of 1.1%. As summers get hotter due to climate change, increasing the demand for air conditioning, the growth in peak demand can be expected to continue – projections from the New York City Panel on Climate Change indicate that the city may see 3-4 heat waves per year by the 2020's, and 5-7 heat waves per year by the 2050s, up from an average of 2 today. As highlighted in PlaNYC: A Stronger, More Resilient New York, heat waves have impacted the city's electrical grid more frequently and more significantly than any other type of weather event, including the Long Island City blackout in 2006, and historic peak load days in both 2011 and 2013. (See chart: *Growth in Peak and Annual Demand*)

Growth in Peak and Annual Demand
Index to 2003



Source: NYC Mayor's Office

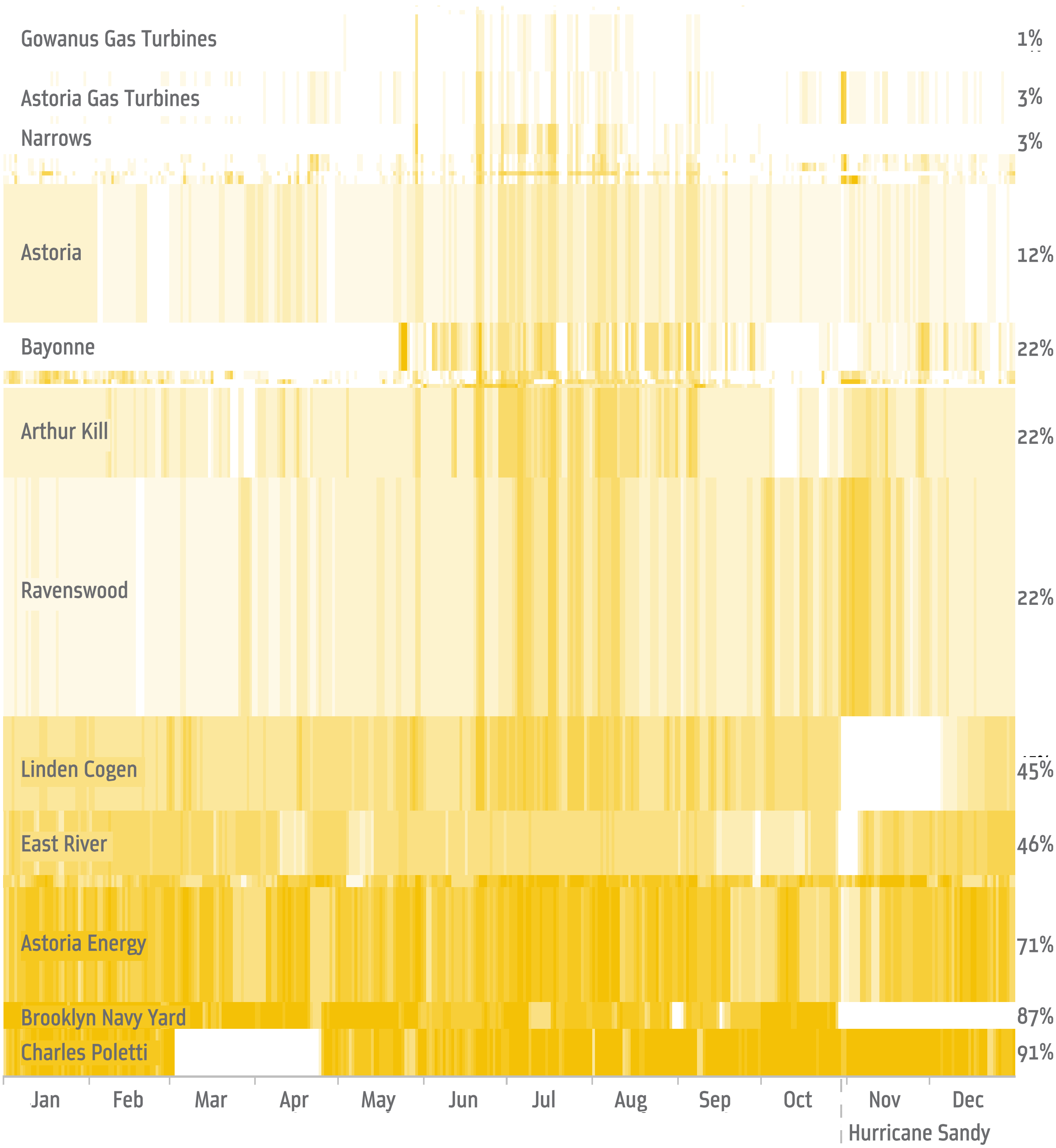
Hourly Demand
2012 - Megawatts



Source: NYC Mayor's Office

Daily Utilization Levels of In-City Power Plants

Color denotes days on which power plant is operational. Width of bar corresponds to size of power plant.



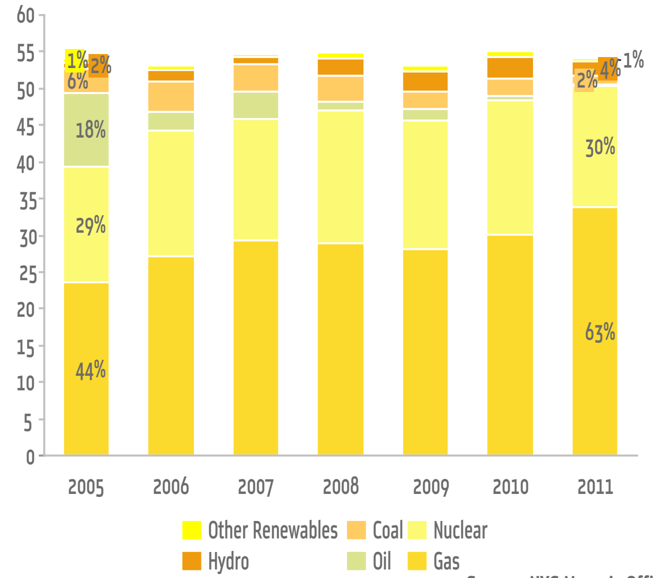
Source: NYC Mayor's Office

Electricity demand also varies hourly and seasonally. On a hot day in July, demand can rise almost 60 percent from 6.9 GW at four in the morning to 11 GW by six at night, while on a balmy day in September it will only go up by a third, from 5.3 to 8 GW within a day. In 2011, peak daily demand was at 6.9 GW in March, but at 11.4 GW in July — an increase of almost two thirds. To maintain system reliability, supply must meet demand at all times, requiring the existence of generation that often sits idle until needed.

Power Generation

The 24 power plants serving New York City directly have a capacity of approximately 10,398 MW, enough to meet at least 86 percent of the city's forecasted peak demand – a reliability requirement by the New York Independent System Operator. However, generation from these power plants provides only half of the electricity needs of New York City, with a majority of the balance originating from cheaper and cleaner sources in New York State and surrounding regions. In addition, most of the generation fleet is located along the waterfront, with more than half concentrated in Astoria and Long Island City in Queens. Today, nearly two thirds of the in-city plants are located within the existing 100-year flood plain, even before taking into account future sea level rise of up to 2.5 feet by the 2050s. (See map: *In-City Electric Generating Facilities in the Floodplain*)

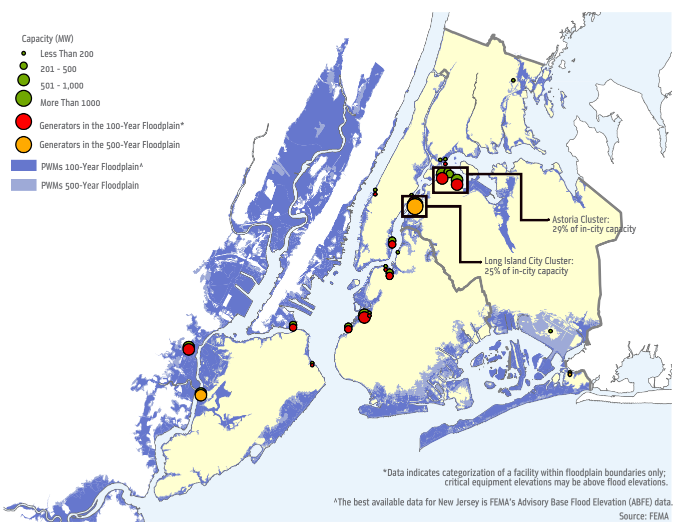
New York City Electricity Supply Mix
In-city and Imported, TWh



Source: NYC Mayor's Office

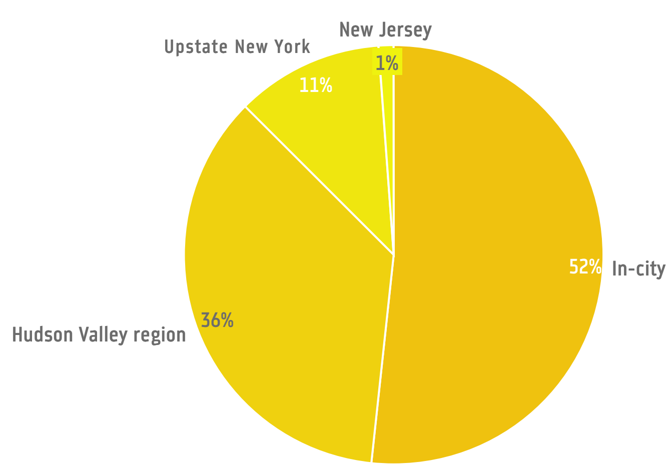
Energy is imported by high-voltage transmission lines that connect the city with up to 6,000 MW of power supply from areas as close as the Hudson Valley, Northern New Jersey, Long Island, and as far as Northern and Western New York State. Each region has a different fuel supply mix serving New York City's demand. In 2011, power transmitted into the city consisted of nuclear (56%), natural gas (31%), hydro (7%), coal (4%), wind (1%), and oil-fired (<1%) generation. (See figures: *New York City Electricity Supply Mix*)

In-City Electric Generating Facilities in the Floodplain



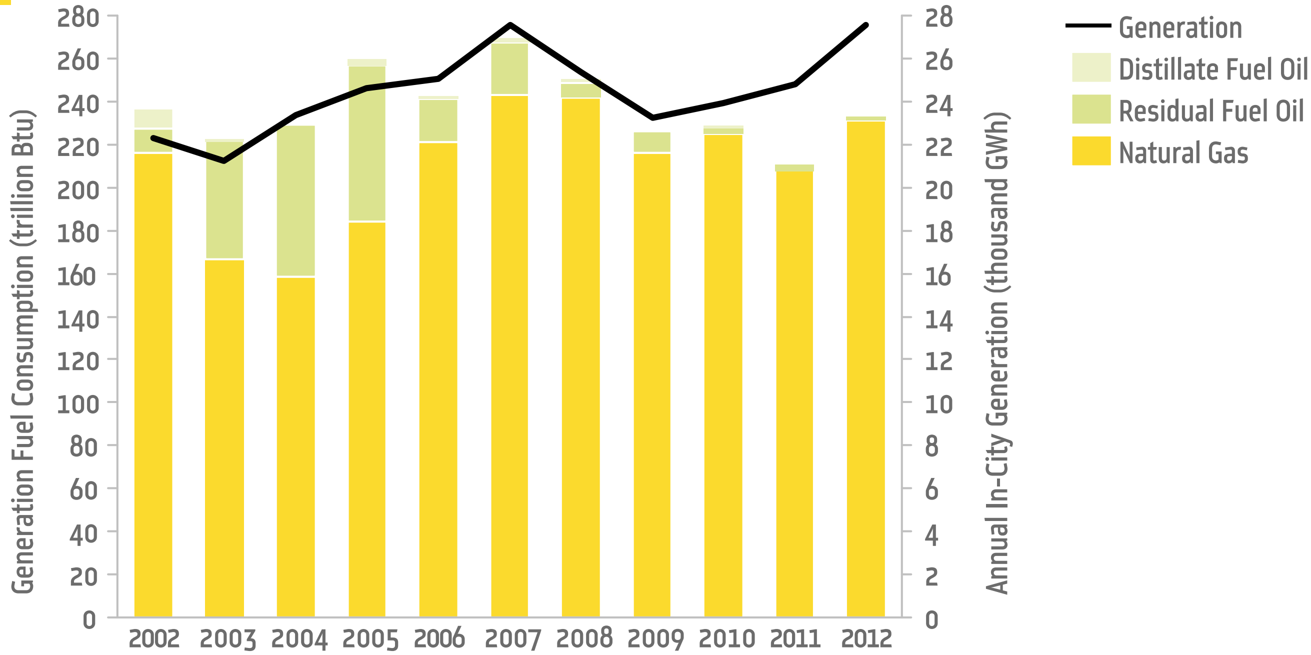
Source: NYC Mayor's Office

New York City Electricity Supply Mix
2012



Source: NYC Mayor's Office

Fuel Purchases for Electric Generation



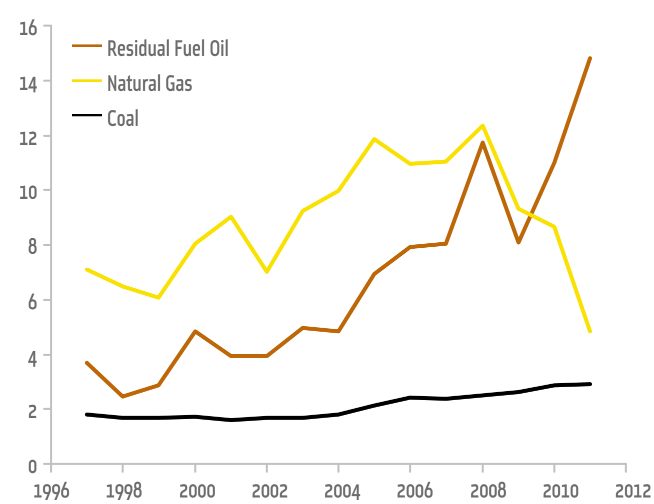
Source: NYC Mayor's Office

Sources of GHG Emissions

The power sector emitted 15.8 million tons of CO2e in 2012, or approximately one-third of the city's total emissions – a large number in absolute terms, but less than three times the U.S. per capita average. Because the majority of in-city generation is capable of burning natural gas — as opposed to more polluting coal or heavy fuel oil — and half of the city's power is imported from cleaner sources located outside of the five boroughs, New York City's power system GHG footprint is relatively low.

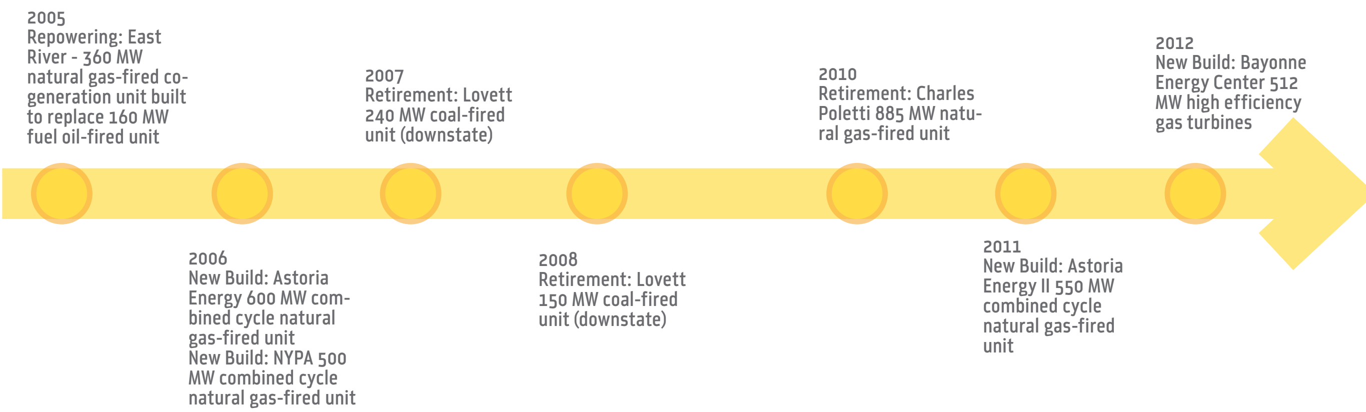
Between 2005 and 2011, the power sector's emissions decreased by 31 percent despite modest growth in demand over the same period. The greatest contributor to carbon reductions came from changes in market fundamentals due to the increase in the price of oil since 2005, and the development of new natural gas resources. As a result, "dual fuel" generators (capable of burning either natural gas or fuel oil) shifted increasingly towards cheaper natural gas. Second, natural gas-fired generators in the region became more competitive in the electricity market relative to coal and fuel oil-fired units, thus increasing their utilization rates. Over this period, heavy oil-fired generation from in-city plants decreased from 30 percent to just 2 percent (and was as high as 50% in the 1980's and 1990's). The city's electric supply mix (including imported generation) is now 63 percent natural gas-fired, with oil- and coal-fired generation accounting for less than 3 percent.

Fuel Prices for Electric Generation in New York State
2005 $/MMBtu



Source: Energy Information Administration

Electricity Generator Retirements and New Additions
2005-2012



Source: NYC Mayor's Office

The development of state-of-the-art power plants also reduced the city's greenhouse gas emissions from the power sector by 1 million metric tons. Over 2,500 MW of new in-city capacity were placed in service over the past seven years and 1,000 MW of old generation were retired. An additional 900 MW of coal-fired generation was retired in the Hudson Valley, resulting in the further decarbonization of power transmitted into the city. These changes helped to improve local air quality, reducing emissions of sulfur, nitrogen, and other criteria pollutants.

New York City's Clean Power Potential

The city's grid has become cleaner in recent years — but there is a long way to go to achieve the deep reductions in greenhouse gas emissions analyzed in this study. No one technology would be able to reduce emissions enough by itself; a cleaner system would have to rely on a portfolio of options including the repowering of existing plants, high penetration of "behind-the-meter" technologies such as solar PV and CHP, and large-scale hydropower and wind generation.

Modernizing Existing Generation

Repowering in-city generation

Today, nearly 60 percent of the power plants in the City are more than forty years old, and most of these plants utilize less efficient "single cycle" design. Repowering these plants with "combined cycle" units that are able to capture and reuse waste heat to generate additional electricity, can boost efficiency from ~30 percent to almost 60 percent, thus reducing carbon emissions by almost one-half for each MWh of electricity generated. Repowering in-city plants could also yield other public policy benefits, including increasing reliability, reducing criteria pollutant emissions, and incentivizing generators to invest in storm surge protection for new equipment. However, repowering fossil fuel-fired power plants alone will be insufficient to achieve an 80 percent GHG reduction.

Achieving deep carbon reductions at the city or regional level would ultimately have significant implications for existing in-city power plants. A carbon policy (such as a declining cap on emissions) would make existing plants gradually become less competitive relative to newer, more efficient plants. However, many of the in-city power plants would need to remain online in 2050 in order to meet critical system reliability standards, requiring additional compensation (for example, in the capacity market).

Repowering Projects in New York City

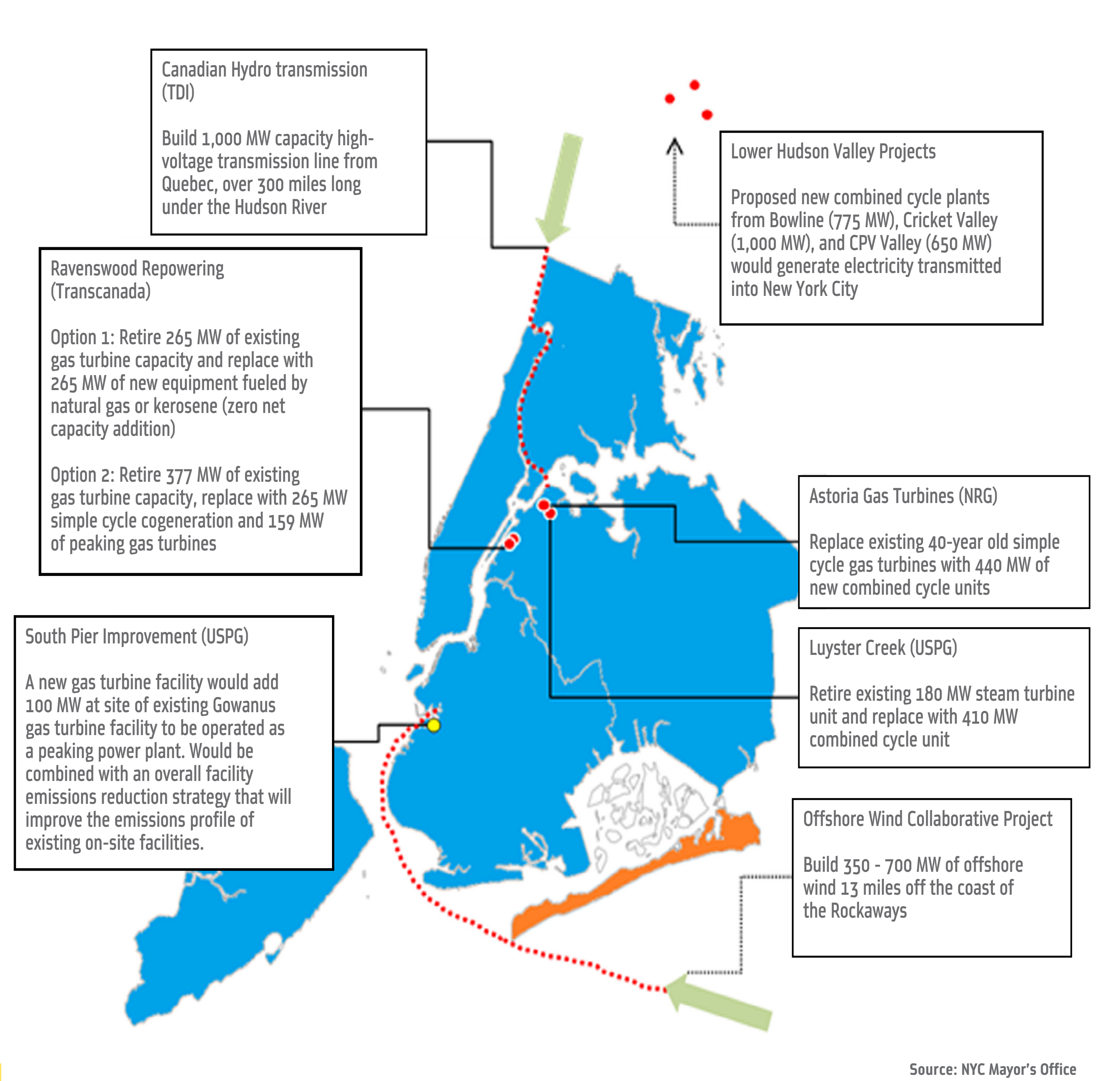
The City of New York has worked with its electricity supplier, the New York Power Authority, to enhance the efficiency and environmental profile of the power sources that serve the city. For example, the City entered into a contractual arrangement with NYPA that allowed the 500-megawatt Astoria Energy II power plant in northwest Queens to be built, and to enter service in 2011. The AE II plant has improved air quality and reduced greenhouse gas emissions in the region by displacing generation from less efficient plants. In a similar fashion, the City supported the 2010 retirement of the former Poletti Power Plant owned by NYPA in Astoria. The highly polluting facility was replaced by NYPA's state-of-the-art 500 MW combined-cycle plant, further reducing emissions. The 500 MW plant, along with AE II, contributed to a 5% reduction in the City's carbon footprint the year following startup.

Carbon Capture and Storage

Carbon capture and storage (CCS), in theory, could mitigate the greenhouse gas emissions of conventional fossil fuel generation by capturing carbon dioxide and then either storing it in geologic formations or reusing it in industrial applications. Since New York City lacks the space necessary for a feasible carbon "sink," CCS would require the siting and construction of dedicated pipelines and compressor stations to pressurize and pump the carbon dioxide to neighboring states. Although CCS may be technically possible, it has not yet been developed at a commercial scale in the power sector, and significant regulatory and engineering questions exist. Therefore, the study does not include CCS in the portfolio of large-scale mitigation measures for in-city gas generation – although it does allow it to emerge as a viable technology elsewhere in the region.

Currently Proposed Power Projects

NYC, New York



Source: NYC Mayor's Office

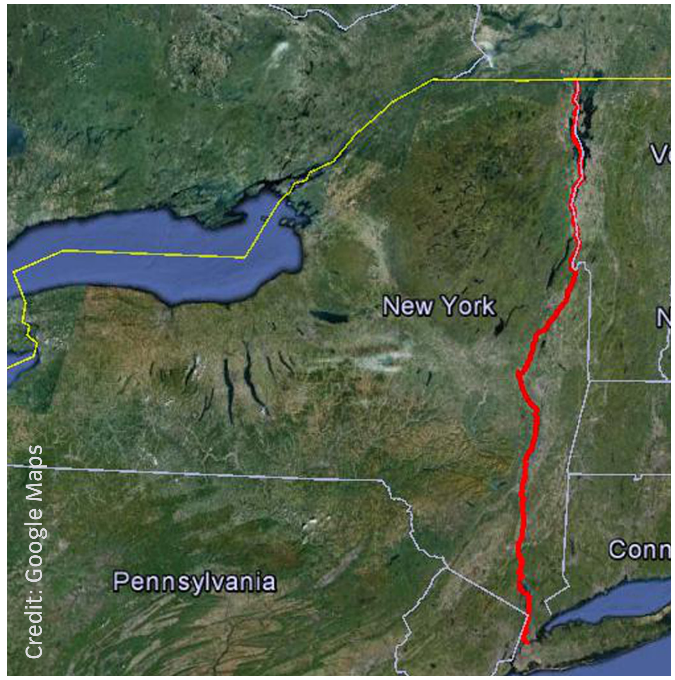
Grid-Scale Clean Energy

The city needs a diverse portfolio of power to satisfy demand, and although repowering can improve the efficiency of generation, it cannot provide a deep reduction in greenhouse gas emissions alone. For that, the city would have to rely on clean resources in other areas, whether new or existing, transmitting power via long distance lines. The three available options – hydro, nuclear, and wind – all have different tradeoffs, including transmission constraints, siting difficulty due to local opposition, and intermittency (in the case of wind).

Hydroelectric power

Hydroelectric power has several attractive features: operating costs are relatively low, it is available nearly all the time, and is most abundant when it is needed. Most of the regional potential lies in the Canadian Province of Québec, located just north of New York State, where, according to the public utility Hydro-Québec, close to 36 GW of capacity is already installed and an additional 35 GW of technical potential exists, of which the utility is planning to capture 5.5 GW by 2016. Because Québec has a winter-peaking demand for electricity, significant excess capacity – up to 10 GW – is already available during the summer months, exactly when New York City's demand is greatest.

Proposed Route for Canadian Hydropower Transmission Line



Source: NYC Mayor's Office

Indian Point Energy Center

Transmission, however, is a challenge: less than 900 MW of transmission capacity links Quebec to New York State, and within the state, weak transmission interconnections make it more difficult for energy to reach the downstate markets. Developers propose a 1,000 MW line directly linking Canadian hydro-power to New York City; this proposal was recently authorized for construction and operation by the State of New York. (See map: *Proposed Route for Canadian Hydropower Transmission Line*)

Nuclear

There are significant questions about the continuation of existing nuclear generation that serves New York City. The nuclear power sector also faces significant regulatory uncertainty, although this could change when next generation technologies, such as modular reactors that promise to be smaller, cheaper, and more reliable, become commercially available. In 2011, the City released its Indian Point Retirement Analysis, describing the impacts of the potential closure of the Indian Point Energy Center. Presently, nuclear power provides approximately 30 percent of the city's electricity; phase out of nuclear energy with natural gas-fired generation is estimated to increase New York City's greenhouse gas emissions by approximately 15%. The city also depends on Indian Point for reliability, as congested transmission lines limit power imports from more distant locations. This study assumes a 20 year extension for both units of the Indian Point Energy Center.

Wind

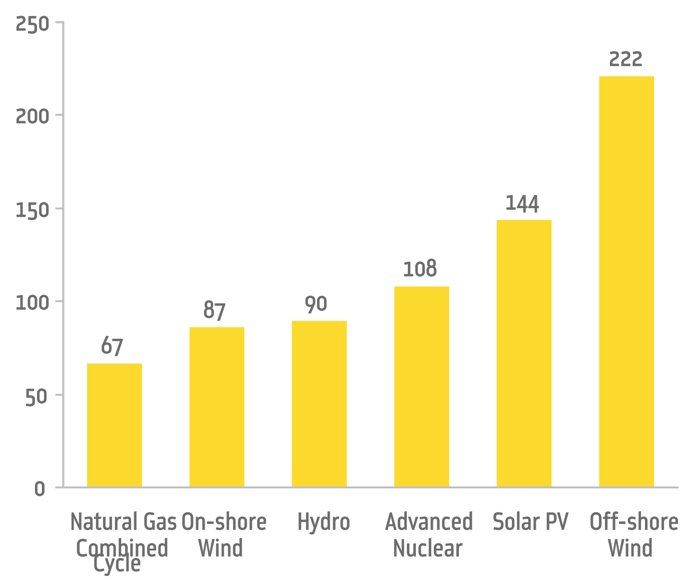
Wind sources represent a small but growing portion of our energy supply mix. Since 2005, NYSERDA has funded large-scale renewable energy projects through the Main Tier of the renewable portfolio standard. Over three-quarters of a billion dollars have supported the development of approximately 1,800 MW of renewable energy, 90 percent of which consists of on-shore wind resources located in Northern and Western New York State. However, only a small portion of the renewable power generated in these far regions has been able to serve demand in New York City and the downstate area.

The technical potential for wind is, however, abundant in New York State, estimated at 29.5 GW (though only 2.8 GW of it is in the most achievable wind classes based on wind power density and wind speed). Surrounding regions also have significant technical potential of wind resources: an additional 7.6 GW of potential is estimated within New England, and 0.8 GW in the New Jersey area. Off-shore wind potential is greater yet: up to 150 GW across different feasibility classes around the region, though for the purposes of this study, it was assumed that a total of 21 GW of off-shore wind is available in the Northeast from New York (2.8 GW), New England (8.5 GW), and the Mid-Atlantic area (9.6 GW).

However, whether on-shore or off-shore, wind is less reliable than hydro or nuclear power. Since wind blows irregularly, wind turbines only produce electricity around 30 percent of the time on-shore and around 40 percent of the time off-shore. The New York Independent System Operator (NYISO) "derates" wind generation to 10% during the summer due to lower average wind speeds. Effectively, a 1,000 MW of on-shore wind generation (nameplate) is estimated to generate 100 MW during summer periods.

Due to a significant decline in the capital and installation costs, on-shore wind generation is nearly cost-competitive with fossil fuel generation. Off-shore wind still has very high capital costs, especially in the US where not a single commercial project has been completed. Although it has also fallen on a per-MWh basis, it is still far costlier than hydro, nuclear, or onshore wind. (See chart: *Levelized Cost of New Generation*)

Levelized Cost of New Generation
$/MWh



Source: EIA -Annual Energy Outlook 2013

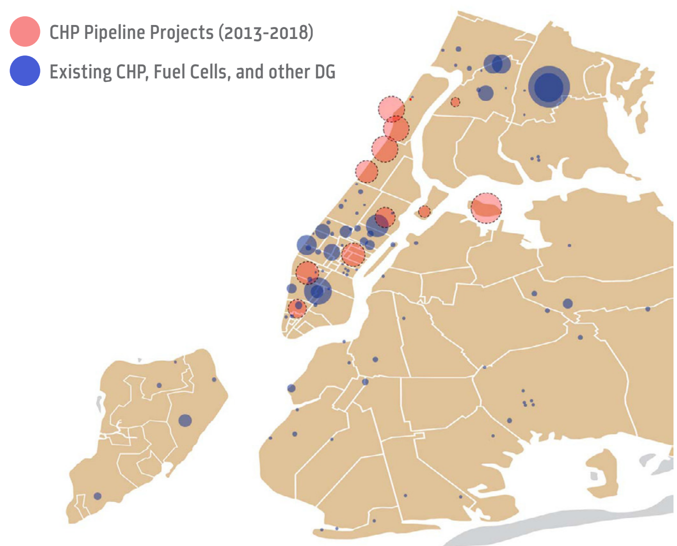
Distributed Generation

Another small but growing source of energy in the New York City market is customer-sited distributed generation (DG). These resources are comprised of several technologies including combined heat and power (CHP), fuel cells, and solar PV. DG resources have grown in recent years from under 50 MW in 2007 to over 160 MW today. With DG, customers have an alternative to the bulk power supply, adding power redundancy and reducing strain on local distribution systems depending on configuration and location.

Combined heat and power units generate electricity using fossil fuels or biofuels, recovering waste heat for onsite heating and cooling needs. They can be highly efficient and less carbon intensive than power generated at power plants — as high as 70 percent efficiency depending on the electric and heat loads they serve, compared with single-cycle units with efficiencies in the 30 percent range and more than the best combined-cycle units with efficiencies of up to 60 percent. CHP units can also be configured to operate during grid outages and reduce strain on certain local distribution networks with high demand, adding resilience to the facilities they serve as well as portions of the grid.

Policy support at the City and State levels have led to increased investment in CHP in recent years. Con Edison has adopted the CHP "offset tariff," allowing larger CHP systems serving campuses to more easily interconnect. NYSERDA has provided incentives through its CHP Market Acceleration Program. As a result of these policies, investment in CHP projects have begun to rise. Recent City-owned CHP projects under development include a 12 MW unit at the North River Wastewater Treatment plant and a 15 MW unit at Rikers Island. Many private investments have been under development as well, including CHP systems at NYU Langone Medical Center, Columbia University, as well as several hotels, and residential and commercial buildings. However, the high capital costs of CHP and the need for large and consistent thermal loads limit its potential application to only certain buildings. (See figure: *CHP Pipeline Map*)

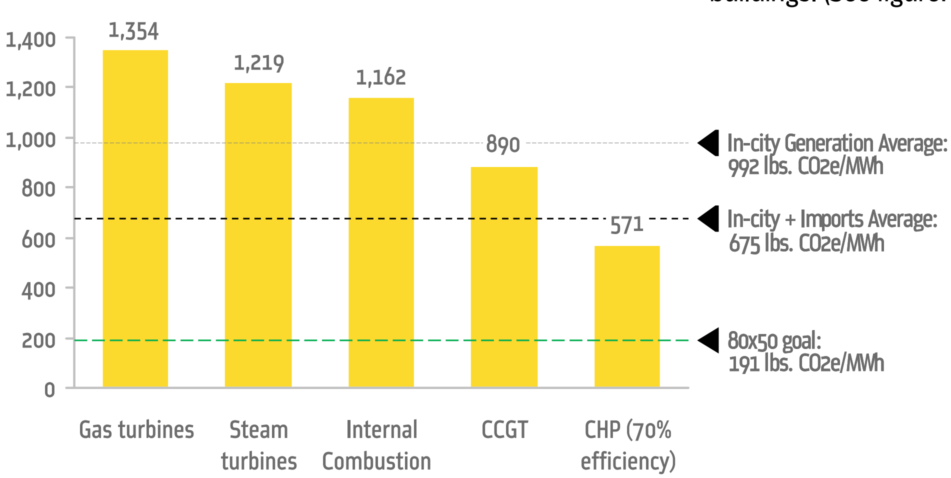
CHP Pipeline Map



Source: ConEd, NYC Mayor's Office

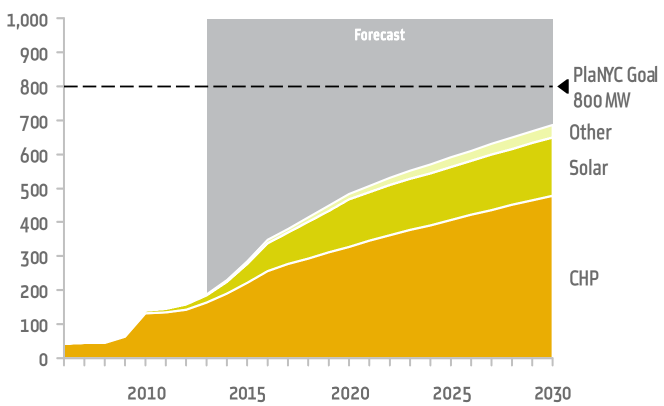
Efficiency of CHP vs. the Grid and Other Technologies

Emissions rate in lbs. CO2/MWh



Source: NYC Mayor's Office

Cumulative Installed Capacity
MW



Source: NYC Mayor's Office

Solar photovoltaic power

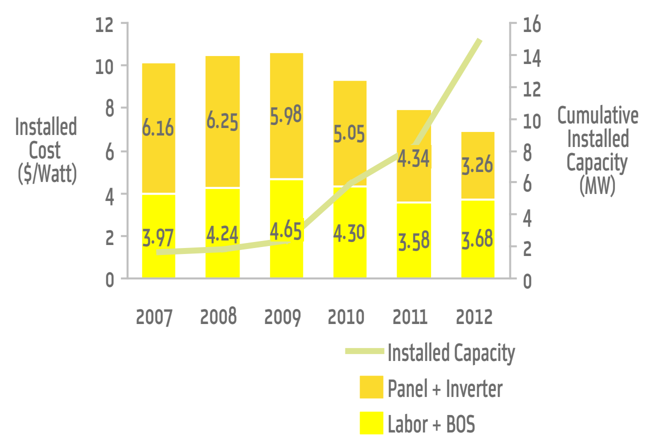
Installed solar PV capacity in New York City has grown from 1 MW in 2007 to just under 20 MW today. However, solar PV is still a small share of overall power production, amounting to less than 0.2 percent of the city's peak load. Investment in PV, however, is growing: the number of installers grew from 4-5 in 2006 to more than 60 in 2013. This growth is the result of several factors, including reduced equipment costs and robust incentive support both at the Federal, State and local levels. (See chart: *New York City Installed Solar PV Capacity and Costs*)

New York City has a sizeable technical potential for rooftop PV with roughly 1.6 billion square feet of rooftop space across approximately one million buildings. However, developing solar PV in dense urban environments with high transaction costs, a complex and varied building stock, and many building owners either without enough knowledge or financeable credit remains challenging. The growth rate of PV in New York City lags behind other regions with similar solar radiance such as neighboring Long Island, New Jersey, and Germany (the global leader).

Several policies at the local, State, and federal levels have attempted to overcome these challenges. At the federal level, the investment tax credit (ITC) for solar PV has been the main driver of investment, reducing business and personal tax liability by 30% of eligible PV system costs, and will continue to do so until the end of 2016. The City currently offers a property tax abatement for systems installed between 2008 and 2015. Working with CUNY, Con Ed, NYSERDA, and the Department of Energy, the City developed the NYC Solar Map: a web-based tool able to easily display the technical potential for PV on any rooftop in the city. Through NYSERDA, the State also offers incentives for PV in the forms of upfront rebates (per installed kW, systems less than 200 kW), and competitive production incentives (per kWh produced, systems greater than 200 kW).

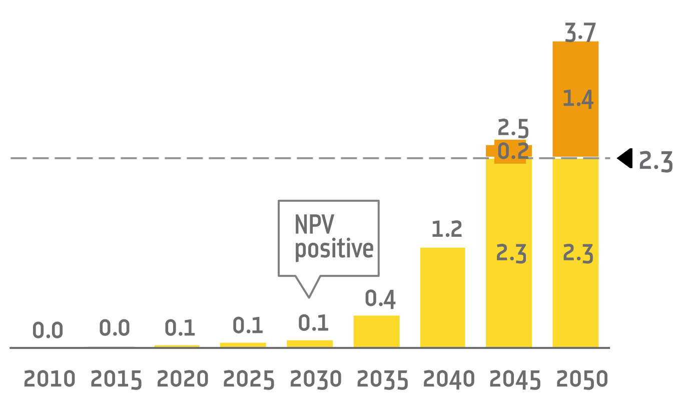
Given the amounts of solar radiance that New York City receives on average and current technological capability, solar panels produce approximately 14 percent of their full theoretical output on an annual basis. Using current commercially available technology, 2.3 GW of rooftop solar PV would provide 5 percent of the city's annual power needs.

New York City Installed Solar PV Capacity and Costs



Source: NYC Mayor's Office

Forecasted New York City Solar PV Capacity
GW AC Cumulative at Private 10% Pre-tax Discount Rate



Source: NYC Mayor's Office

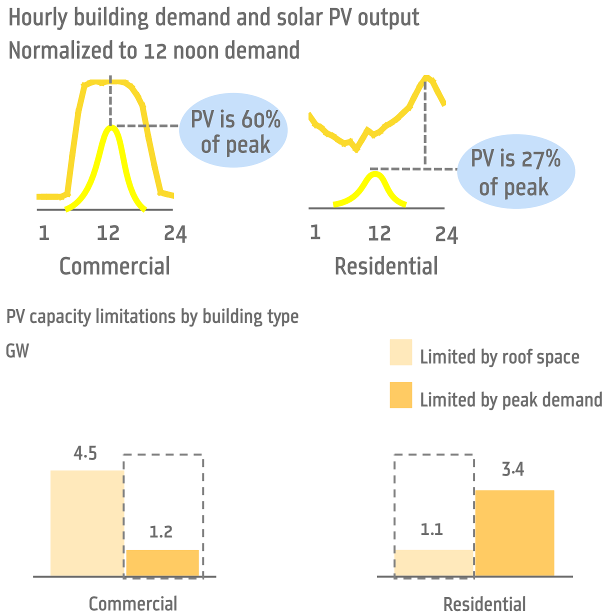
Measuring the Technical Potential for Photovoltaic Solar

The city's available rooftop space could theoretically translate into as much as 16.1 GW of solar PV potential, but only a small share of that potential can be realistically captured. Screening for high-rise buildings (due to technical challenges and costs) and adjusting for estimates of structurally unsound roofs, occupied, or shaded space decreases the potential from 16 GW to 5 GW – but even that amount cannot be fully captured under current "net metering" rules.

As written today, net metering rules allow building owners to offset their retail electricity bills by the amount of electricity generated by their rooftop solar installations, including generation in excess of load that is injected into the network. However, as a conservative assumption, this study assumes that these rules will not be expanded in the long-term.

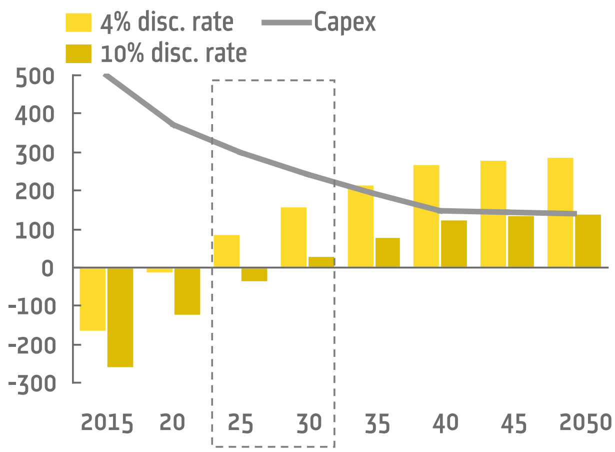
For the purposes of the model used in this study, a conservative assumption was made that the installation rate of solar technologies continues along a historic trend until prices reach grid parity around 2025-2030, by which point a combination of lower solar system costs and naturally higher electricity prices makes solar PV in New York City competitive on a retail basis. Technical potential is estimated at 2.3 GW based on both available roof space and load matching. (See charts: *Forecasted New York City Solar PV Capacity* and *NPV and Capital Expenditure of 100kW System*)

Hourly Building Demand and Solar PV Output
Normalized to 12 noon demand



Source: NYC Mayor's Office

NPV and Capital Expenditure of 100kW System
$ Thousands Pretaxed Unlevered



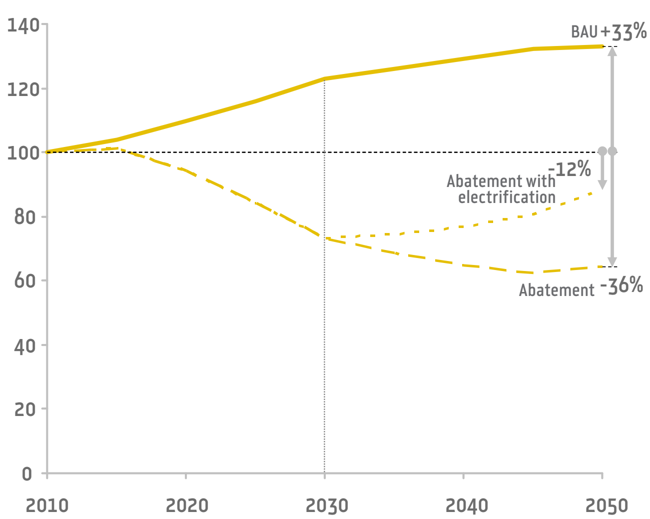
Source: NYC Mayor's Office

The 2050 Power Supply Mix

Several approaches to reach the 80 by 50 goal in the power sector were evaluated, including different scenarios for (1) demand, (2) generation technology constraints, as well as a (3) comparison of a NYC-only emissions reduction versus a regional reduction. Generation constraints were imposed in order to explore different bounds for the penetration of nuclear, hydropower, and renewables technologies, as the development of these resources will be determined in many cases by regulatory and legislative realities (see the previous section for technology constraints).

There are several potential electricity demand pathways. Under a "business as usual" scenario, demand is estimated to increase by 33 percent by 2050 (0.72% annually). Our 80 by 50 Abatement Scenario assumes a 30 percent reduction in aggregate energy demand by 2030. By 2050, demand could either fall further (36 percent) if buildings do not extensively rely on electric heating and power, or rise slightly if they do. (See chart: *Power Demand Scenarios on the 80 by 50 Pathway*)

Power Demand Scenarios on the 80 by 50 Pathway
Indexed to 2010



Source: NYC Mayor's Office

To analyze the feasibility and costs of reaching 80x50, an optimization model for the power sector was used to find the least-cost solutions to supplying power to the marketplace assuming a linearly declining carbon cap to 2050. Several different assumptions were explored to test the robustness of the modeling results, such as the definition of the geographic carbon "boundary," penetration of behind-the-meter technologies, and learning curves of new and emerging technologies. The model tested the results of a carbon cap for New York City, as well as one for RGGI states, that declines linearly from 2012 to 2050. (See charts: *Power Sector Emissions Under Different Cap Scenarios*)

Although the City is not advocating for a city-level carbon cap, it serves as a useful modeling tool and effective proxy for the power sector subsidies that would be required to achieve 80 by 50. As the carbon cap declines each year, the model determines the lowest cost mix of existing conventional generation and new, lower carbon resources needed to stay below the cap. The model utilizes exogenous demand projections that incorporate the deep energy efficiency gains as well as increased electrification (described in the Buildings chapter) that are needed to achieve 80 by 50.

Key Findings

Demand-side measures should be aggressively pursued

The least cost pathway would rely heavily on energy efficiency measures and behind-the-meter distributed generation technologies such as solar PV and CHP. If aggressive demand reduction measures are met, the carbon cap would not be "binding" on the power sector until the early 2030s, and could be met on the margin with cleaner imports as well as the "endowment" from the local power sector switching away from heavy fuel oil from 2005-2011. Conversely, without a significant reduction in demand, the carbon price would be prohibitively expensive.

The technical potential for achieving deep carbon reductions through large scale clean energy exists – in theory

New York City and the surrounding region has ample technical potential to reduce carbon emissions through higher efficiency conventional generation and renewable resources such as Canadian hydroelectric power, Atlantic offshore wind, and distributed solar generation. In theory, the technical potential that is available to New York City for zero-carbon resources is close to 30 GW, which would exceed existing installed capacity in the City even after de-rating capacity factors to account for the intermittency of solar and wind resources. There are, however, significant and untested challenges to achieving this potential.

In-city options for low-carbon generation are limited

The opportunities for decreasing carbon emissions with low-cost or incremental solutions such as fuel switching in the local power sector are limited as the city's generation mix has already shifted almost entirely to natural gas within the past 10 years. Repowering and solar PV would help reduce emissions, but the scale of their impact would not be sufficient for the 80 by 50 pathway. Large scale options such as hydro, nuclear and wind would need to be developed to bridge the gap for the 80 by 50 trajectory. This study limits achievable hydro to 1 GW, not adding any nuclear beyond existing capacity, and closing any remaining gaps through wind generation.

System integration of large-scale intermittent resources is untested in the U.S.

Although Europe has successfully developed more than 3 GW of offshore wind power, no utility-scale resources exist in the US. Navigating and aligning the objectives of numerous layers of government and regulatory oversight would be a process with little precedent that could take many years to work out. There are also significant technical questions regarding how the grid will remain reliable with large amounts of intermittent resources supplying a substantial portion of the energy. The experience of integrating large-scale renewable power resources into European electric grids poses both optimistic and cautionary tales. In Germany, where renewable resources now power up to 20% of peak load, the rising costs of energy have recently caused regulators, legislators, utilities, and private sector actors to rethink costly renewable energy goals. Due to the high penetration of solar PV, California is beginning to implement energy storage to balance the peak generation with non-coincident peak demand.

Meeting 80 by 50 in NYC would require "leapfrogging" to large scale renewables

If the city acts alone without regional or national carbon regulation frameworks, and assuming the constraints on hydro, nuclear, and on-shore wind, most of this capacity would have to come from off-shore wind – almost 7 GW of it by 2050. Carbon prices (or other incentives) would need to rise substantially to incentivize a massive investment in utility scale renewables. Gas-fired generation capacity would also remain, though it would be used primarily for load balancing, as discussed below. In-city or dedicated resources would produce 70 percent of the city's power, and imports would only account for the remaining 30 percent, far less than today.

Within a regional framework, the need for incremental capacity within NYC would be much lower: instead of adding 8.3 GW, the city would only add 3.2 GW of roughly equal shares of hydropower, off-shore wind, and on-shore wind. Those would generate about 27 percent of the city's total energy needs, and the rest would be covered through cleaned-up regional imports. (See charts: *Installed In-City Capacity and Generation Mix*)

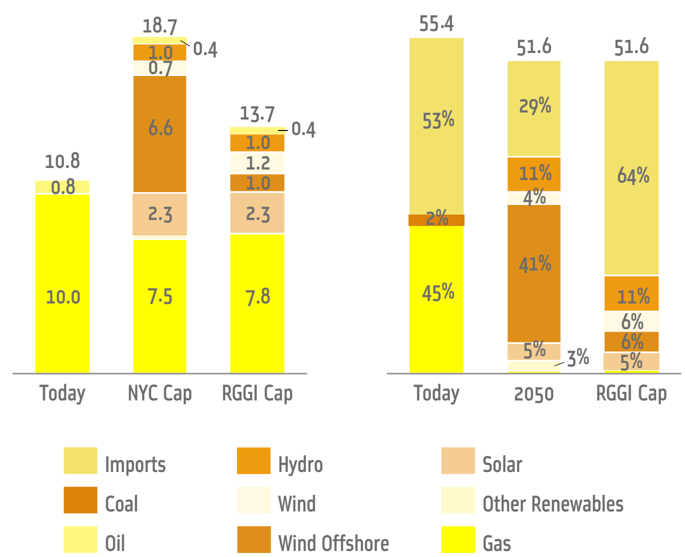
Under a regional GHG emissions reduction strategy, NYC would not meet 80 by 50, but regional reductions would more than offset the effect

With a NYC cap, the city's emissions would fall from 15 million tons today to 4 million tons, allowing it to meet 80 by 50. With a RGGI cap, they would only fall to 11 million tons within a RGGI cap, meaning that the 80 by 50 goal would not be achieved. This, however, is more than offset at the regional level — instead of only dropping 10 million tons if NYC acted alone, RGGI power emissions would drop an enormous 126 million tons within the RGGI framework, dwarfing the city's total emissions. The city may not reach its goal, but from a public policy perspective, this outcome would be preferable – both because of the scale of emissions reductions and because of the economic impacts, explained below. (See charts: *NYC power sector emissions under different cap scenarios* and *RGGI power sector emissions under different cap scenarios*)

The Cost and Economics of Clean Power

The technical potential for a low carbon power system exists if New York City acts without a regional or national solution in place, but it would be costly. Carbon prices would need to reach up to $150 per ton to drive a renewables portfolio for NYC. The development of renewables with transmission requires a significant financial incentive over and above wholesale power prices. A regional strategy would be more economic with the ability to retire coal plants and greater potential to site renewables. (See chart: *Implied Carbon Costs per Ton*)

Installed In-City Capacity and Generation Mix
GW and TWh, respectively

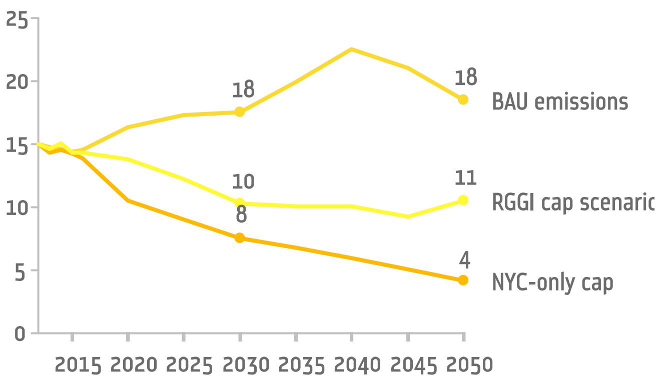


Source: NYC Mayor's Office

Electricity prices would increase, but magnitude would depend on the level of demand reduction

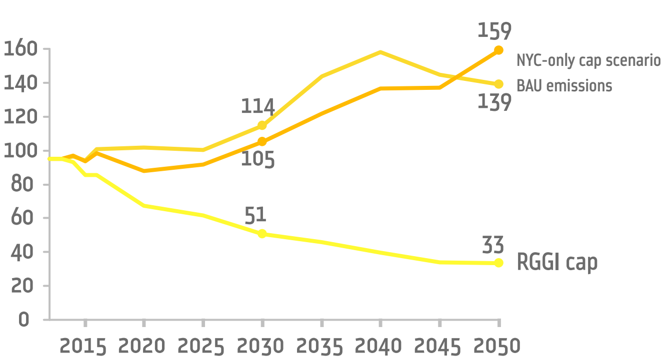
Power prices are expected to increase at a rate of 2.30% annually in real terms under the business as usual scenario: new generation alone would require at least $14 billion of capital investment in the next 37 years. In an 80 by 50 compliance scenario for New York City only, which assumes that demand would be reduced due to energy efficiency, wholesale prices would instead rise by 2.51% annually. Under a regional solution, power prices would rise less, at 2.47% annually.

NYC Power Sector Emissions Under Different Cap Scenarios
MTCO2e



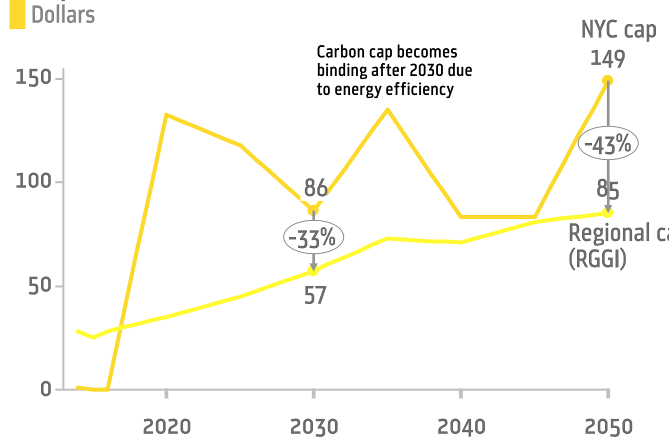
Source: NYC Mayor's Office

RGGI Power Sector Emissions Under Different Cap Scenarios
MTCO2e



Source: NYC Mayor's Office

Implied Carbon Costs Per Ton
Dollars



Source: NYC Mayor's Office

Macroeconomic impacts vary by technology pathway

Employment and GDP impacts of clean power projects are mixed. As with any other investments, they impact the economy in three ways: they create direct jobs in construction, displace them in the rest of the economy through diverting spending from other sectors, and create or displace jobs through changing economy-wide power expenditures.

For solar PV, the positive effect of capital expenditures is slightly outweighed by the negative effect of the opportunity cost of local spending (up to 1,300 jobs created and 1,500 jobs destroyed), but this in turn is more than outweighed by the increasing economic competitiveness. Solar PV installations ultimately translate into savings, and the money that would have been spent on fossil fuels is spent throughout the economy instead (creating 1,200 jobs in the example case, for a net effect of 1,000 jobs created).

For offshore wind, the calculus is different: capital expenditures still create jobs, but the resulting power prices have uncertain economic impacts that depend on assumed technology learning curves, construction costs, and the amount of local economic activity (e.g. manufacturing and research) that could make New York a hub of off-shore wind.

Other Challenges

Finding and siting energy projects are difficult

Large scale energy projects face high capital risk in New York. Onshore wind projects are generally not located close to areas with energy demand. Offshore wind projects have not yet been built to scale in the US and still face a lengthy permitting process at the federal, state and local level. Transmission projects that would deliver wind or hydro power also go through lengthy permitting processes and face significant challenges to financing. For distributed energy, developers often site difficulties in finding customers with the combination of enough technical knowledge, the right building characteristics, and high enough credit. All of these challenges require a lot of developer resources, resulting in projects facing higher costs and taking several years to come to fruition.

Existing infrastructure and regulations do not support the utility of the future

The traditional utility model of centrally located power plants delivering power across a single entity-owned distribution system has been around since the 1800's. As such, infrastructure, markets, and regulations were all designed to support this model. New concepts emerging today in which customers have a choice to generate all or a portion of their own energy would require new ways of assigning costs and benefits of distributed systems. As DG market penetration increases, several questions arise: What will the role of the utility be in a distributed world? What costs are to be borne by individuals vs. all customers? What fundamental changes to energy markets are needed? Greater penetration of distributed generation will not happen until these questions are answered.

Power markets would need a new set of rules

The rules for today's power markets are written based on the assumption that most power generation carries a significant marginal cost. Gas-fired plants need to burn natural gas to produce electricity; they do it with different efficiencies, occupying different positions on the supply curve – and where the demand curve intersects the supply curve, power price is established. Since renewable generation has high capital costs and low operating costs, the traditional paradigm breaks down. especially with increased market penetration. On the 80 by 50 pathway, power market rules would have to change to follow the evolving realities.

Paying a premium for clean energy

The level of investment required to obtain deep carbon reductions poses basic questions about who will fund these investments. Until the capital cost of clean energy is reduced, such projects will require subsidies in the forms of incentives and financing. There are two basic sources of subsidies for energy projects: ratepayers and taxpayers - although practically the same, they have different implications. Using the former source results in higher energy rates, while using the latter either results in opportunity costs or in higher taxes. Ultimately, any subsidy must balance the needs of consumers with their willingness to pay.

Achieving Major Reductions in Power Sector Emissions

Modernizing Existing Generation

Advocate for improved market rules that encourage repowering and cleaner generation

The regulatory rules governing the wholesale electricity markets create barriers and disincentives to repowering. Those rules restrict the ability of repowered units from fully participating in the capacity market and competing against incumbent units for market share. Altering NYISO capacity market rules to remove the disincentive to repowering would be an important step to reducing carbon emissions in New York State and regionally. The City has been involved through public commenting, and should continue advocating for improved capacity market rules to the NYISO and FERC.

Developing Grid Scale Clean Energy

Hydroelectric Power

Study the supply impacts of increased hydropower

The Champlain Hudson line connects the city to only a small part of resources available in Canada. Increased hydro imports could reduce electricity prices for residents of New York City – but the economic, technical, and political constraints of integrating so much hydro power into the city's energy mix would need to be investigated separately. Technical concerns about generation portfolio diversity and system integration, regulatory and political issues surrounding market competition, the impacts within New York State, and environmental questions about new hydropower development in Eastern Canada still remain unaddressed.

Off-shore Wind

Convene Northeastern Atlantic offshore wind collaborative

Scaling up off-shore wind projects would require a regional approach – and one way to jumpstart the discussion would be to assemble a Northeastern Atlantic offshore wind collaborative that would bring together the states of Delaware, New Jersey, Connecticut and Massachusetts along with the Department of the Interior, FERC, and regional transmission operators to create a regional strategy to develop offshore wind resources and transmission interconnections. To support the collaborative's work, the NYISO, PJM East, and the PSC could integrate offshore wind into long-term transmission planning processes.

Pilot a demonstration scale off-shore wind power project

Planning for a large-scale off-shore wind project can take years, but the City can begin acting even as it participates in the long-term planning processes. Specifically, the City could work with the State to explore options to develop a smaller, demonstration scale 20-30 MW project in state waters – similar to what Maine, Rhode Island, New Jersey, and Virginia are pursuing now. A smaller demonstration project would allow New York to advance on the learning curve and test the concept of off-shore wind with relatively minimal capital risk.

Local, State and federal coordination to accelerate siting

Siting and leasing processes can add significant amounts of time to any off-shore wind project timeline. The City can work with New York State and the Department of Interior to expeditiously designate the federal waters off of New York as a Wind Energy Area (WEA) in order to accelerate the siting and leasing processes. WEAs have already been established in waters off of most other Mid-Atlantic and New England states.

Explore measures to lower financing costs

Off-shore wind projects require hundreds of millions of dollars. Working with the State, NYPA, LIPA, Con Edison, the Green Bank, and the Federal government, the City can explore creative financing support mechanisms such as loan guarantees, public-private ownership, and power purchase agreements for offshore wind that will help overcome the challenges of financing offshore wind, a major untapped resource.

Analyze regional economic benefits of off-shore wind

Off-shore wind costs are high, and the share of local spending relatively low – but shifting as much of the production and installation process to New York State could help make the projects more economically attractive. A rigorous analysis of the economic benefits of offshore wind could examine the establishment of a regional hub in New York State. The City could work with the State, the Port Authority of NYNJ and NYSERDA, among others, to develop an economic development plan for off-shore wind. This plan could both identify appropriate sites for offshore wind port facilities and recommend actions that should be taken by the City and State to realize the greatest economic development benefit from this emerging sector.

Distributed Generation (DG)

Develop a "one-stop-shop" for information and permitting

DG development has been subject to a complex permitting and interconnection process that spans several city, state and private agencies including Department of Buildings, Fire Department, Department of Finance, Landmarks Commission, Con Edison, NYSERDA, and more. Multiple handoffs between agencies and separate processes that do not run in parallel result in project delays, increased labor and permitting fees, and high opportunity costs. The City University of New York (CUNY) has begun to examine these issues with the creation of ombudsmen who work with all of the agencies involved, and each agency has simplified their own internal processes, but recent progress has not brought down balance-of-systems costs enough. Developing a standardized installation process spanning every party would reduce the installed cost of distributed generation.

Further, lack of customer knowledge of DG options, available incentives and guides, and complexities of the permitting and interconnection processes has presented a high information barrier to those property owners who are interested and financially able to install DG in the city – and there currently is no repository of the information that property owners need. The City is in the process of developing a web-based tool to better inform property owners, providing them with the information needed to convert interest in DG into actual investments. CUNY and the City will also expand the NYC Solar Map, a tool used to evaluate the feasibility of PV on every rooftop in New York City, to connect property owners with PV developers and installers, as well as evaluate a customer outreach, education and acquisition program.

Pilot emerging models for increasing solar PV

One emerging model that is growing the market in other areas is shared ownership of PV systems, or "community solar." Much of the city's population and businesses do not have access to the roof space required to install PV. Community solar systems conceptually allow those who don't own roof space to invest in solar PV systems. Existing incentives and regulations are untested for group-owned systems. Through the US Department of Energy's Rooftop Solar Challenge, the City and CUNY committed to pilot a community solar project in New York City. This pilot would clarify the eligibility of both the personal income tax credit as well as the NYSERDA standard offer rebate, and test the applicability of this new business model in New York City.

Another emerging model is group purchasing of PV at the local level. By engaging with communities, pooling customer interest, and locking in low installation costs, these programs have proven to cost effectively increase solar PV capacity in other cities. This model is now being adopted through the "Solarize Brooklyn" program, a partnership between the Sustainable Kensington-Windsor Terrace and Sustainable Flatbush neighborhood organizations and Solar One. This group purchasing model will determine the ability of community outreach to reduce customer acquisition costs, and test the permitting and interconnection processes with large volumes of applications for PV installations. Analysis of the successes of, and challenges faced by the Solarize Brooklyn program for expansion across other neighborhoods in the five boroughs will also be conducted.

Evaluate the role of net metering in the short and long term

Net metering allows for a customer to receive energy credits at the retail rate for solar PV generation exported to the grid (i.e. not consumed on-site). Remote net metering allows this to occur across multiple properties, disaggregating the location of demand from the location of a PV system. Both mechanisms allow for investments, but existing requirements for these mechanisms have resulted in the inability of emerging PV ownership models to exist in New York City. In addition, there is no long-term vision for net metering beyond the current aggregate capacity that Con Edison is required to allow to net meter. Short term revisions to net metering are needed to allow for new business models that would drive investments, while a long-term plan that addresses the true value of exported renewable energy is needed for high penetration of PV in the Con Edison system. The City should evaluate short-term and long-term revisions to net metering that satisfy the needs of ratepayers and long-term environmental goals.

Freshkills Park, Staten Island

Expand solar PV on government facilities

Government customers, including City, NYCHA, MTA, and Port Authority, own thousands of buildings and facilities throughout the city: Municipal operations alone consist of over 4,000 buildings including schools, wastewater treatment plants, hospitals, office buildings, garages, firehouses, and other facilities. Together these buildings have a total of 25 million square feet of viable roof space and a vast technical potential for PV estimated to be over 200 MW. Working with NYPA, NYSERDA, NYCHA, MTA, the Port Authority, and other government parties would develop a plan to achieve at least some of the potential.

To overcome high upfront capital costs, the City, in 2013, announced the completion of a power purchase agreement with Tangent Energy Solutions, allowing the City to purchase energy from solar PV systems on its property without owning it. A total of 1.85 MW will be installed between the Port Richmond Wastewater Treatment Plant in Staten Island, Staten Island Ferry Maintenance building, and two high schools in the Bronx. These projects serve as an innovative model for siting privately-owned solar PV on City-owned property without incurring upfront capital costs.

Another innovative approach to solar PV on government property is through private ownership. The City, in 2013, announced the selection of Sun Edison to develop, own, and operate up to 10 MW of solar PV at the former Fresh Kills landfill. However, several regulatory challenges ahead will require careful coordination between the City, State, and Con Edison. Completion of the project will test the technical feasibility and impacts of integrating large scale solar PV into the grid. It will also test new concepts of remote net metering and electrical interconnection, the limits of the existing incentive structure at the State and local levels, and regulations surrounding landfill post-closure care in New York.

Evaluate a feed-in-tariff

Existing incentives have led to growth in solar PV capacity, but are insufficient to achieve scale, with many projects having proven to be too difficult to complete. Building owners still require high credit in order to secure financing, net metering is still required to build many systems, and customers still require the knowledge and interest to contact a PV developer. These requirements alienate a large portion of the New York City market from accessing incentives and investing in solar PV. Feed-in-tariff programs in other regions offer certain direct payment for PV power from the State or utility, circumventing all of the above requirements. The piloting of a PV system will yield an analysis of the applicability of such a program in New York City.

Analyze integration of energy storage

Solar power's potential contribution to carbon emissions reductions is limited by its intermittency — but energy storage can potentially address some of the issues. In one example, a project at the Brooklyn Army Terminal integrates a 100 kW PV system, 400 kWh battery, and a building management system. This project will demonstrate how these technologies interact with each other and the existing Buildings and Fire Codes.

New York City as a Center for Energy Innovation

New York City's dense urban environment is both a challenge and opportunity for reducing power sector emissions. As systems integration will need to take place on an urban level, the city has an opportunity to transform into a 'living laboratory' for clean energy systems. City government could play an important role: it operates roughly 4,000 public buildings, 14 wastewater treatment plants, 11 hospitals, and over 27,000 vehicles across various fleets. With this in mind, the goal of the Living Laboratory concept is to demonstrate leadership and foster market development of new technology — both by promoting innovation in the private sector and by leveraging City assets as a platform for testing and demonstrating commercial viability of new technologies.

Research and private sector innovation

Support world class research on clean energy

Innovation and commercialization in the energy sector not only requires the right policy environment but also world-class engineering expertise and workforce – and that is something that the City can help advance. Cornell NYCTech, a new applied science campus administered through the partnership of Cornell University and Israel's Technion University, is one example: it will focus on both software and hardware in environmental science and green energy. Another applied science research institute, known as the Center for Urban Science and Progress (CUSP), is led by NYU-Poly with a consortium of world-class universities and technology companies, including IBM, Cisco, and Siemens. It will focus on 'urban informatics', or the science of using large data sets to analyze and find solutions to urban operations and sustainability challenges. Both campuses, as well as the Columbia Center on Global Energy Policy, CUNY Sustainability, USDOE Northeast Clean Energy Application Center at Pace University, and other local institutions could play instrumental roles in solving some of the technological challenges behind clean energy deployment.

Evaluate energy from tides and thermal flows

Tidal and thermal flows are one example of an area that could benefit from greater research. The potential is available: New York is one of only a few states that possess sufficient free-flowing waters in tides, rivers, and waves to make kinetic hydropower a viable energy source. Already, the City has partnered with a private sector innovator to pilot underwater kinetic turbines that convert energy from tidal flows into electricity. Turbines are completely underwater, silent, and invisible from shore. They do not require dams or other structures and they have minimal impact on aquatic life. The City could investigate opportunities to expand kinetic hydropower resources and where possible, interconnecting tidal resources with wastewater treatment plants and other industrial facilities.

Another promising area for research is the option of tapping the kinetic and potential energy in water supply and wastewater treatment, including, for example, by using the sewer system to assist in conditioning space (e.g., to serve MTA's Second Avenue Subway Line Stations, thereby reducing the size of cooling towers).

Support clean energy entrepreneurs

Promoting clean energy technology through creating a stable policy framework, cutting red tape, working with utilities and permitting authorities to clarify and streamline installation and interconnection procedures, and provide information resources to decision-makers is a necessity – but the city also needs locally based entrepreneurs who intimately know New York City and the opportunities of starting businesses here. To encourage entrepreneurship, the NYC Economic Development Corporation (EDC) has built a network of "incubators" across the city that provide low-cost office space — currently over 120,000 square feet — as well as training and networking opportunities to hundreds of start-ups and small

Tidal turbine, East River

businesses. Approximately 600 startup businesses with over 1,000 employees currently reside at City-sponsored incubators, and these companies have raised more than $125 million in investor funding. Future efforts could build on what has already been achieved.

Support clean energy technology and energy efficiency demonstration centers

It can take time for new and emerging technologies to be adopted en masse — but New York City can become a hub for demonstration facilities for the public and private sector to have hands-on experience with them. Having physical centers of energy excellence that can showcase implementations of new energy technologies will enable people to tangibly appreciate the benefits of technologies in lighting improvements, clean resources, building management systems, and more. There are already burgeoning centers within the City such as the new lighting center which will be a demonstration of lighting technologies as well as energy efficiency education. More centers for specific resources could help bring more real examples of clean energy technologies directly to future users.

Using City facilities as test beds for new technologies

Pilot advanced systems for monitoring electric consumption and on-demand curtailment

City government is one of New York City's largest energy users, meaning that any improvements to its operations could have a sizable citywide impact. Peak demand management and energy use monitoring are two examples. With peak demand, the City is currently on track to increase its ability to curtail peak loads to 50MW in five years — 5 percent of the City's peak — in part through the use of a system that will perform automatic peak load shedding. To support energy monitoring, the City can pilot facility and campus level equipment and aggregate nodes of energy usage across agencies and facilities. This will improve the City's capability to view energy consumption, therefore improving energy management optimization.

Launch competitive program to pilot technologies at City facilities

Almost 75% of New York City's annual greenhouse gas emissions come from buildings, so the success of any reduction strategy hinges on building efficiency technologies. To that end the City will open up the over 4,000 buildings it operates as a proving ground for new technology. Specifically, the City will work with clean energy partners to develop a process for energy technologies that could be piloted and tested in City buildings and operations, involving both the private sector and governmental partners like the MTA, the Port Authority of New York and New Jersey, the General Services Administration, and State governments. The marriage of readily available City assets and technology entrepreneurship will support growth of New York City as a center for energy innovation.

Pursue "net-zero" energy consumption at a wastewater treatment plant

In December 2013, the City announced one of the nation's first biogas to local natural gas distribution projects at the Newtown Creek Wastewater Treatment Plant.
This innovative partnership will reduce greenhouse gas emissions by diverting waste from landfills, reducing emissions from the plant itself, and producing renewable energy. Several other projects are already underway, including a 1 MW solar PV system to be installed at the Port Richmond facility and a 12 MW cogeneration facility under development at the North River facility. In the next decade, the City could seek to achieve further reductions in energy consumption at other wastewater treatment plants through decreasing demand, increasing onsite power generation, recovering and reusing biogas, and undertaking co-digestion of organic wastes.

The Role of Microgrids

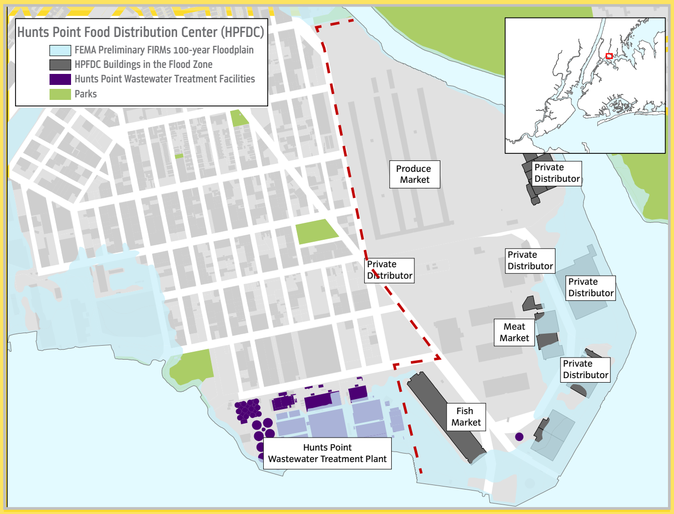
Microgrids, or neighborhood-scale networks of shared DG resources, have the potential to provide both resiliency benefits and reduce emissions, but have very few precedents in New York City. After Hurricane Sandy, while lower Manhattan was without power, a cluster of New York University buildings was powered by a 6 MW cogeneration system serving the campus.

At Hudson Yards, the development team of Related Companies and Oxford Properties Group are planning a large 12 MW cogeneration plant, which will generate power at twice the efficiency of a conventional natural gas power plant and enable “functional occupancy” of its retail, restaurant and office complex during even an extended grid outage. The complex is thermally connected to the developments’ other 3 residential and office buildings to enable the distribution of thermal energy from the cogeneration plant throughout the mixed use neighborhood and the exchange of hot and chilled water so that the development’s 5 individual building plants can be operated like a single plant for optimum energy and operational efficiency as well as maximum capacity and resiliency.

Microgrids that connect multiple customers are a promising new concept that could be applied elsewhere in the city, offering an opportunity to innovate alternative power generation and delivery models while accelerating adoption of smart grid technologies that are key to modernizing the electric grid. The City has several projects underway to study the implementation of microgrids, working closely with New York State, the Pace Energy and Climate Center, the New York State Smart Grid Consortium, and Con Edison to evaluate optimal technologies and business models for microgrids. This collaborative is currently analyzing the feasibility of a microgrid cluster in East Harlem that would serve both the Metropolitan Hospital and the Washington and Lexington NYCHA facilities, and possibly others.

The City is also evaluating distributed power options for the Hunts Point Food Distribution Center in the Bronx, a critical location for the city’s food supply. Ensuring continuous power will limit supply chain disruptions by enabling uninterrupted facility operation and the maintenance of refrigerated storage capacity in the Meat, Fish, and Produce Markets. These options include cogeneration and trigeneration systems (generating electricity, heating, and cooling), the procurement and installation of backup generators, and the protection or elevation of existing utility infrastructure.

Source: NYC Mayor’s Office



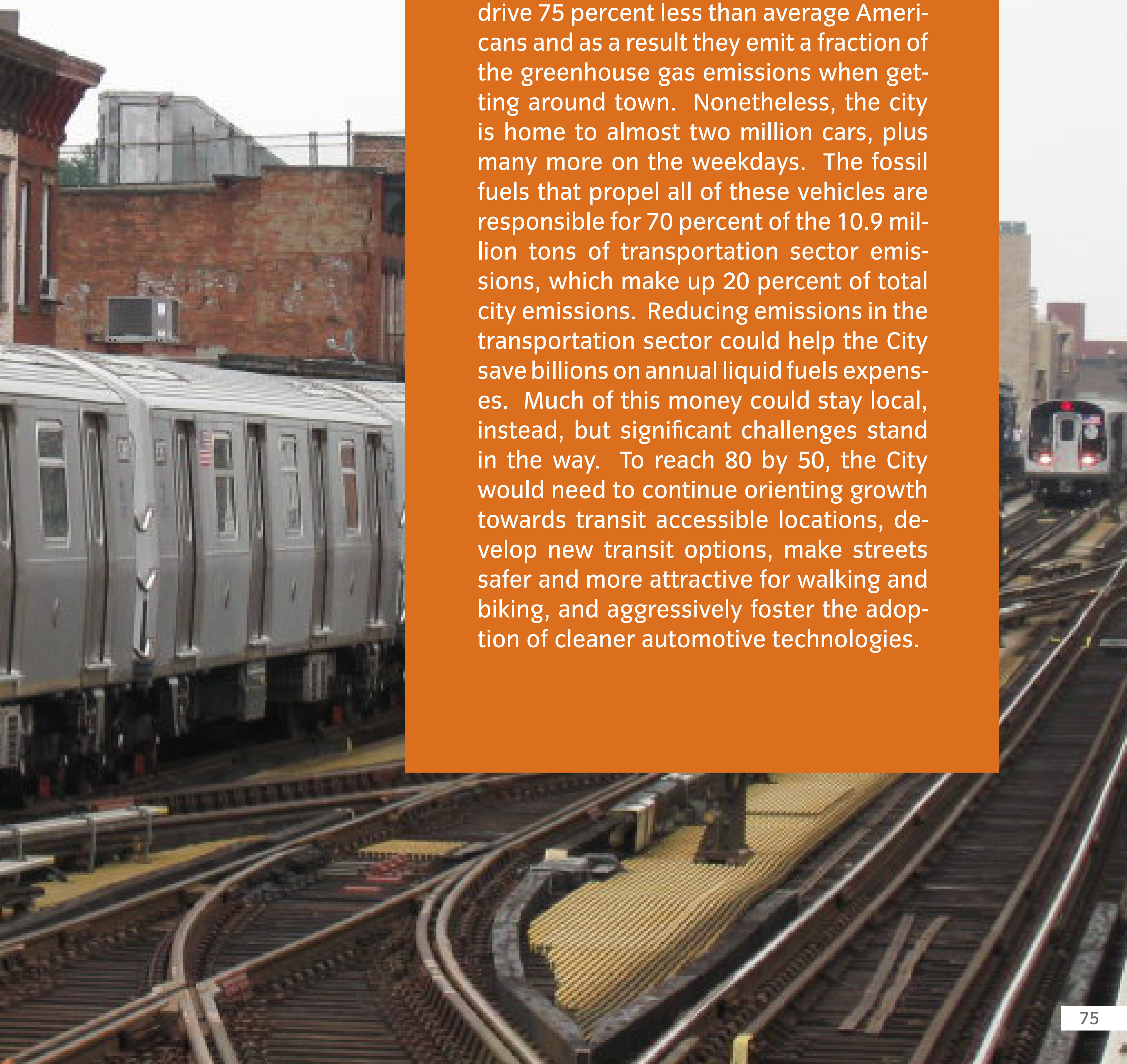
Source: NYC Mayor’s Office

Credit: Adam E. Moreira

R160 M train entering Hewes Street, bound for Middle Village

Transportation

New York City has the most efficient transportation sector in the country because of its extensive mass transit system and dense urban environment. New Yorkers drive 75 percent less than average Americans and as a result they emit a fraction of the greenhouse gas emissions when getting around town. Nonetheless, the city is home to almost two million cars, plus many more on the weekdays. The fossil fuels that propel all of these vehicles are responsible for 70 percent of the 10.9 million tons of transportation sector emissions, which make up 20 percent of total city emissions. Reducing emissions in the transportation sector could help the City save billions on annual liquid fuels expenses. Much of this money could stay local, instead, but significant challenges stand in the way. To reach 80 by 50, the City would need to continue orienting growth towards transit accessible locations, develop new transit options, make streets safer and more attractive for walking and biking, and aggressively foster the adoption of cleaner automotive technologies.



Overview

Cyclist utilizing the Dekalb Ave Bike lanes, Brooklyn

In a city of endless destinations, New Yorkers are always on the move. Subways run round the clock, stretching from Rockaway Beach to Van Cortlandt Park. Federal and state highways are overlaid on a dense grid of busy local streets. A necklace of new ferry terminals and bike paths adorn the city's waterfront. Bustling international airports connect the city to every major destination in the world.

With the exception of walking and biking, all of this movement requires energy — and 99 percent of this energy originates from fossil fuels. All told, the city's transportation system is responsible for 11 million tons of emissions every year, or 20 percent of the city's total emissions. On a per capita basis, this compares well to other cities. Still, the potential exists to reduce transportation emissions further. More New Yorkers, particularly the newest arrivals, could live in dense, mixed-use, transit-rich neighborhoods; new transportation options like bus rapid transit and bicycling could reduce the need for driving; and, most significantly, vehicles on the streets could be far cleaner.

Several major challenges will make it difficult to reduce emissions in the transportation sector. Parts of the city are simply out of reach of mass transit, leaving residents with few options other than to drive. City streets are often better suited for cars and unwelcoming to pedestrians and bicyclists—although the City has made major improvements in recent years. Biofuels and electric vehicles offer great potential for reducing emissions, but demand growth for these new technologies is very gradual. Individuals do not consider the health and economic impacts of traffic congestion—nor do they have a price signal to do so—when they decide to drive. Finally, the City has only limited ability to influence the transportation system, which numerous other entities, public and private, play a role in operating.

City government and its partners nevertheless have tools that can be used to accelerate carbon reductions and put the city onto a lower-carbon pathway. The City is already using some of these tools to advance the goals of PlaNYC and can expand these efforts. Zoning and land use planning can encourage density and mixed-use development in parts of the city that are most accessible to transit. The City can work with the State to improve mass transit service, including expanding the Select Bus Service program that is now serving all five boroughs. The City can expand efforts to make streets safer for walking and biking. And it can foster cleaner transportation technologies like electric vehicles and biodiesel through pilots, purchasing in the City fleet, and early infrastructure development. These efforts will not only help to reduce carbon, but also improve quality of life, clean the air, and make the economy more competitive.

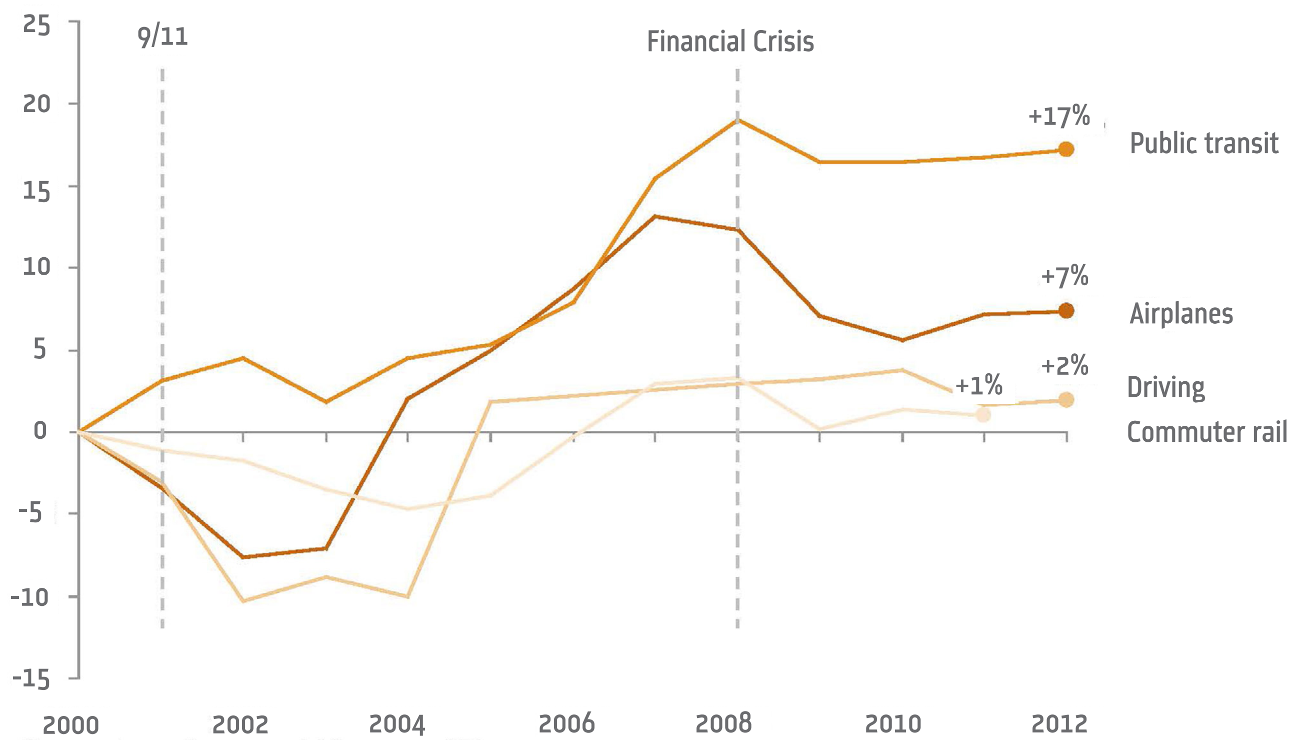
Transportation Fundamentals

The city's transportation system is a dazzling mix of activity, and New Yorkers place upon it high demands for service and reliability. From the city's extensive network of mass transit—rail, subways, buses, and ferries—to its crisscrossing streetscapes that accommodate cars, bikes and pedestrians moving in every direction. Daily commuters, business travelers and tourists are also growing in record numbers and accentuate demand on the transportation system. In fact, on Thursday, October 24, 2013, New York City's subways hit an all-time high for ridership, just shy of 6 million rides in a single day.

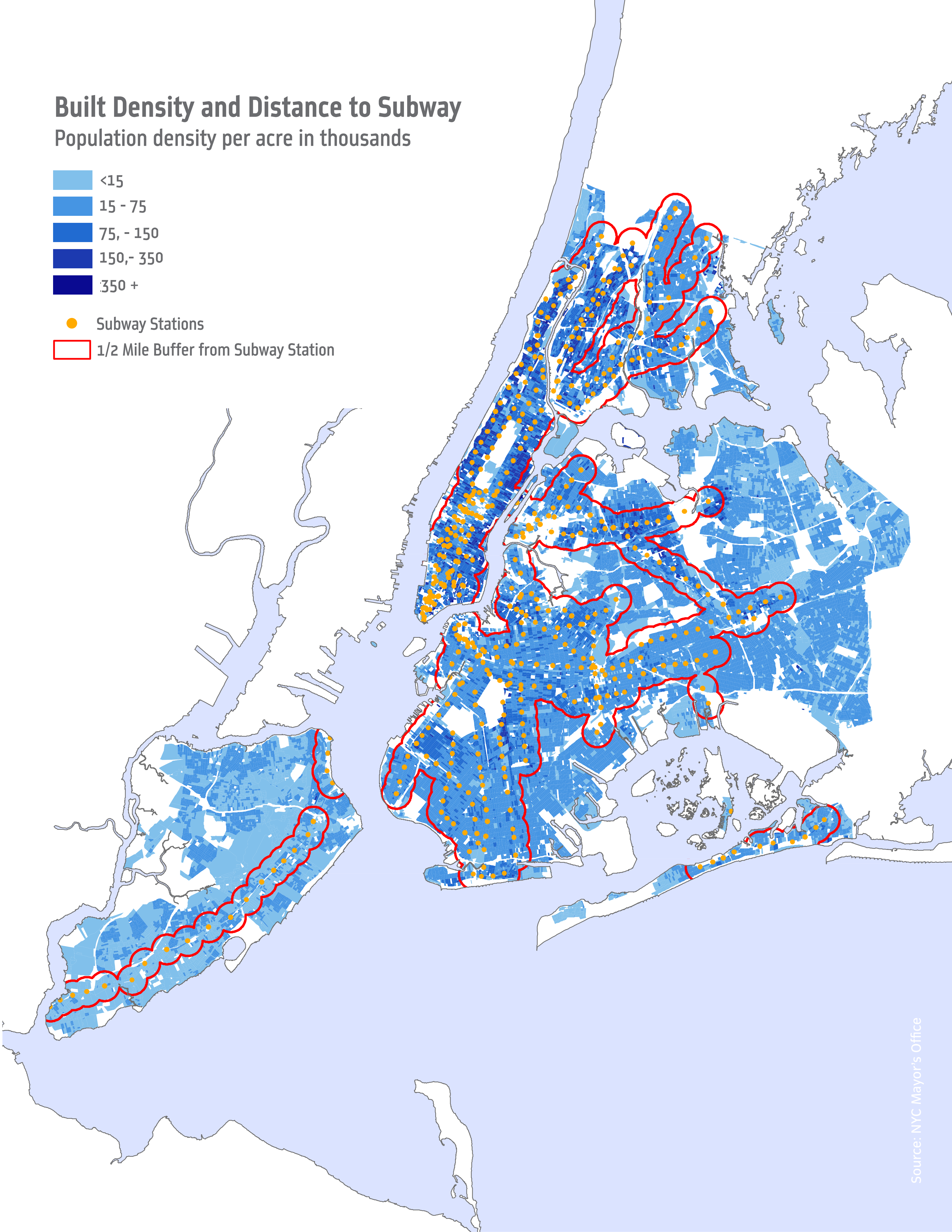
The city's on-road transportation system touches every corner of the five boroughs and allows for the greatest flexibility in travel. Over 13 thousand taxis, 6 thousand buses, hundreds of thousands of bikes, and more than two million private cars and trucks move on more than 6,000 miles of streets, nearly 800 bridges, and through 9 tunnels, connecting points in the city in millions of daily combinations. The bus system offers three types of service: regular local service, express service between boroughs, and Select Bus Service—a form of bus rapid transit that operates at greater speeds thanks to dedicated lanes, fewer stops, and off-board fare collection. The City has over 300 miles of bike lanes and recently launched the nation's largest bike-share system, Citi Bike, covering Manhattan below 59th Street and some parts of Brooklyn.

The subway and rail systems do not offer the range or flexibility of roadways because they operate along fixed tracks to a finite number of destinations, but their strength lie in their scope and capacity. The city's subways carry more than 1.7 billion riders each year along 21 interconnected routes that span 660 miles and connect 468 stations across the five boroughs. Subways are synonymous with density: 42 percent of the city's landmass is within a 10-minute walk to a subway stop, and these areas are home to 75 percent of the

Transportation Usage Patterns, 2000-2012
% change (adjusted for population growth)



Source: MTA, PANYNJ, NYMTC, NYC Mayor's Office


Built Density and Distance to Subway
Population density per acre in thousands
<15
15 - 75
75, - 150
150,- 350
350 +
Subway Stations
1/2 Mile Buffer from Subway Station
Source: NYC Mayor's Office

city's built area and 72 percent of its population. (See chart: *Built Density and Distance to Subway*)

Marine transport used to be extremely important as well, mainly for delivering goods into the city – as recently as the 1970s, the waterfront bustled with commercial activity as ocean going vessels and local barges exchanged their wares. Containerized shipping caused much of this activity to disband throughout the region and the transport of goods shifted to truck. Recently, however, there has been a resurgence of marine deliveries with, for example, the opening of Red Hook Container Terminal; efforts are also underway to improve the connectivity of marine terminals and the freight rail network. The waterfront has also seen a recent renaissance in passenger transportation as ferry lines and terminals have sprung up across the city, including the East River Ferry Service, which launched in 2011 and has exceeded ridership expectations.

Farther into the surrounding region, Port Authority's PATH trains go to New Jersey, Metropolitan Transportation Authority's Long Island and Metro-North railroads connect to towns as far as Montauk and New Haven, and Amtrak's service carries passengers up and down the Eastern seaboard, most importantly to Boston and Washington, D.C. For longer distance trips, airplanes shuttle more than 54 million passengers a year out of the area's three major airports.

Multiple agencies own and operate different parts of the transportation system. The New York City Department of Transportation manages the city's streets and many of its bridges. The Metropolitan Transportation Authority, a New York State agency, runs the city's subways, buses, and regional rail. The Port Authority of New York and New Jersey, a public authority, manages some of the city's largest bridges, most of its tunnels, and the region's airports. Private companies operate taxis and livery cars under the supervision of the City's Taxi and Limousine Commission. And private companies operate most of the city's ferry terminals and port infrastructure, with some public support. Funding for the transportation system comes from a mix of sources, few of which the City directly controls.

During the past decade, the city's population increased by nearly 300,000 people. Over the same time period, transit ridership grew by 17 percent over this period, while driving only went up 2 percent and commuter rail stayed nearly flat. (See chart: *Transportation Usage Patterns, 2000-2012*) In response to increasing demand, major investments are being made to improve the city's mass transit infrastructure: two new subway lines are being built on the Upper East Side and in Midtown West; a new terminal for PATH trains is rising up next to the new World Trade Center building; tunnels for East Side Access, one of the largest public works projects in decades, are under construction and will ultimately save commuters nearly one quarter of a billion hours a week. Several other new transportation options were launched in 2013, including the bike share program, Citi Bike, and lime-colored Boro Taxis that are authorized to pick up passengers anywhere in the city except airports and Manhattan south of West 110th and East 96th Street.

Sources of GHG Emissions

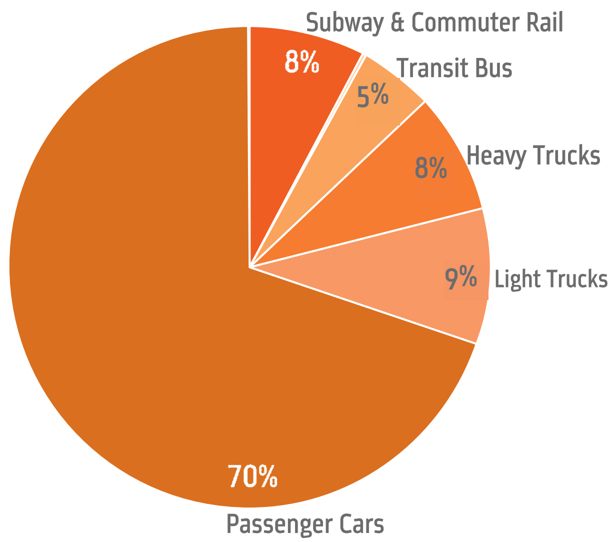
Congestion on the Brooklyn Queens Expressway (BQE)

The transportation system is responsible for 20 percent of the city's total emissions – 10.9 million tons in 2011. Of that amount, passenger cars account for 70 percent while trucks and public transit make up the remainder. Aviation, which is not counted as part of the city's greenhouse gas baseline or its 30% reduction goal, amounts to another 15.0 million tons. Without aviation, the city's per capita emissions from transportation are roughly 6.4 tons per year; by comparison, a single round-trip flight to London creates 1.2 tons of emissions (See chart: *Transportation Emissions*)

Emissions per capita vary by borough. Residents of Staten Island and Queens drive more than those who live in Brooklyn and Manhattan – but still far less in the rest of the U.S., with an average American producing roughly five times the driving emissions of an average New Yorker. (See chart: *Per Capita Emissions from Driving*)

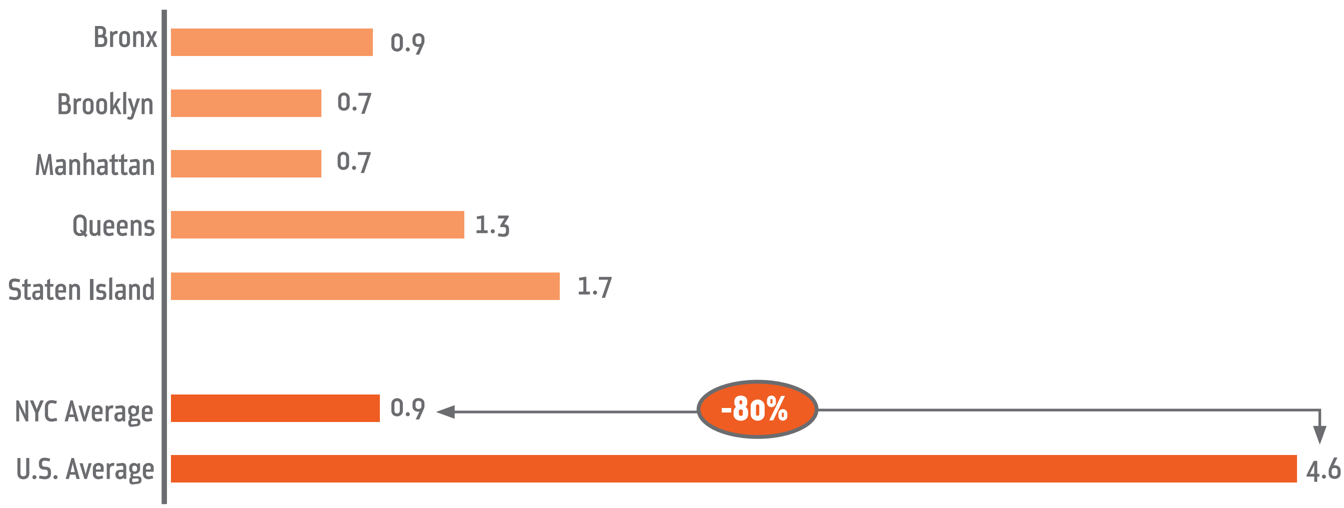
Emissions fell nearly 5% since 2005, when they stood at 11.5 million tons – even as the city's population grew. Most of the decline was due to less carbon intensive electricity for mass transit; lower per capita VMT; and improved vehicle fuel economy. (See chart: *Drivers of Change to Transportation Emissions, 2005-2012*)

Transportation Emissions
$MtCO_2e$



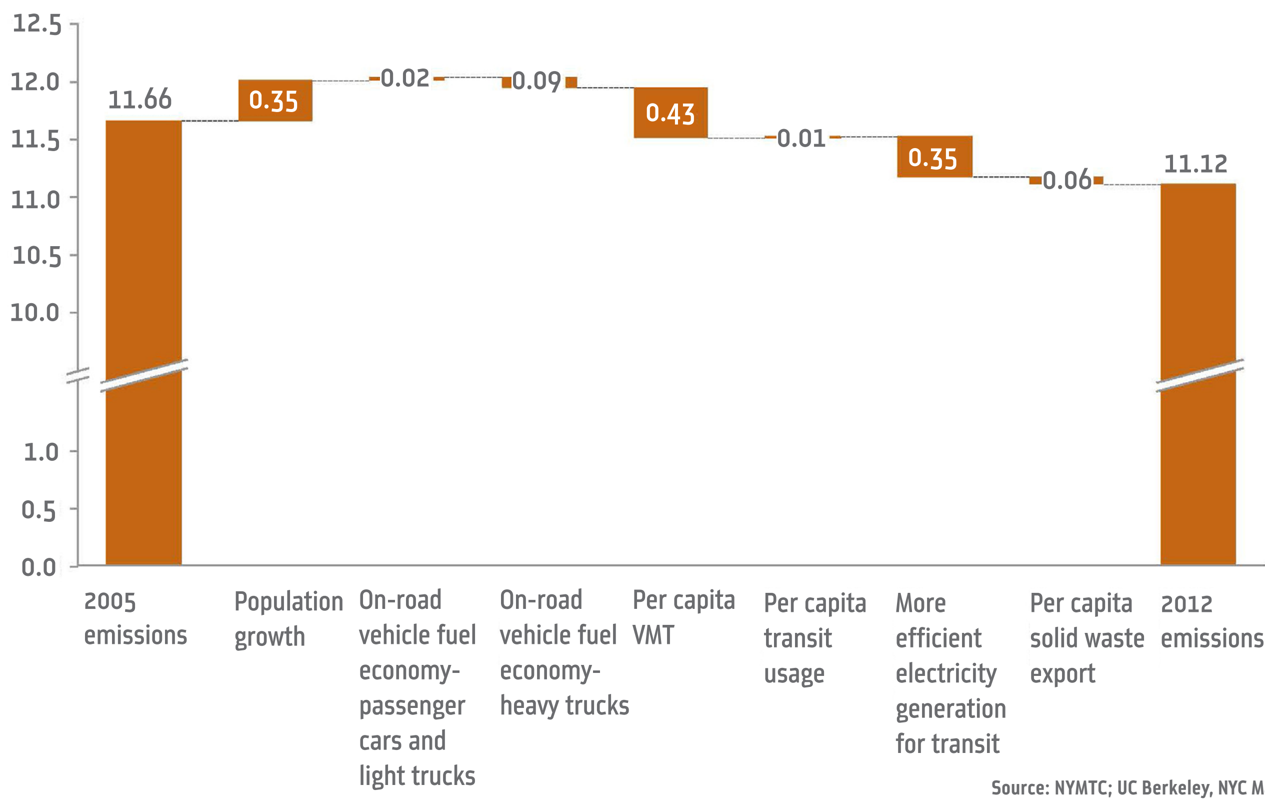
Source: NYC Mayor's Office

Per Capita GHG Emissions from Driving
Metric tons CO_2e per year, 2011



Source: NYC Mayor's Office

Drivers of Change to Transportation Emissions, 2005-2012
Metric tons CO_2e



Source: NYMTC; UC Berkeley, NYC Mayor's Office

Technical Potential of GHG Reduction Measures

As % of total 2005 emissions

Maintaining the City's Density	**not quantified**
Steering growth towards dense, diverse, walkable neighborhoods	--
Subway service	--
Ferry service	--
Commuter trains	--
Shifting to Less Energy-Intensive Forms of Transport*	**not quantified**
Bus rapid transit	--
Bicycling	--
Regional trains and buses	--
Adopting Cleaner Vehicles and Fuels	**8.2%**
Battery electric vehicles	2.6%
Plug-in electric hybrid electric vehicles	2.5%
Conventional Hybrid Vehicles	0.1%
Advanced Internal Combustion Engines	1.0%
Increase the use of alternative bus powertrains	0.2%
Increase use of biofuels	1.8%

Credit: NYC Taxi and Limousine Commission

Emissions Abatement Potential

Maintaining the City's Density

Steering growth towards dense, diverse, walkable neighborhoods

The city's density is one of its greatest assets. Many New Yorkers simply do not need to travel as far as most other Americans, whether because their friends live up the block or because the pharmacy is around the corner – and when they do, they can typically take mass transit. Over the past decade, over 94 percent of new building permits filed with the city were for construction located within ½ mile of transit. Continuing to encourage transit-accessible density as the city grows will help make sure that emissions remain low for new arrivals and existing residents alike.

Expanding Mass Transit

Subway service

Subways make the city's density possible. The system's reach is extensive—72 percent of the city's population lives within a half-mile walk of a subway station. Two expansion projects are also underway. The Second Avenue Subway will connect 96th Street to 63rd Street in the first phase and stretch all the way to Financial District at Hanover Square in later phases, while the 7 line extension will go west along 42nd Street and then down 11th Avenue to 34th Street. Carbon abatement is not these lines' primary function and therefore they are not quantified as part of the 80 by 50 reduction strategy. The Second Avenue Subway will relieve congestion on the 4/5/6 line and make living farther east on the Upper East Side easier for existing residents and more attractive for new ones. The 7 line extension will support impending large-scale development in Hudson Yards that would not be possible otherwise. Nevertheless, creating additional lines and connections over the coming decades could encourage mode shifting and densification in areas that are poorly covered by subways.

Ferry service

Ferries have enjoyed remarkable success in New York City in recent years. Use of the new East River Ferry, for example, more than doubled initial estimates within a year of its launch in June 2011. There is potential to add more ferry service and connect new points along the waterfront—which could help to foster density, improve travel experiences, and make it possible to live in parts of the city that were previously less attractive because of their distance from mass transit. But new ferries are not likely to have a significant effect on reducing New Yorker's driving or carbon emission and so they were not quantified as part of the 80X50 reduction plan.

Commuter trains

Commuter trains are extremely important for the region, as millions of commuters use Metro North, Long Island Railroad, and New Jersey Transit to get into New York City on a typical workday. The train lines have shaped settlement patterns in the NYC metropolitan area, and they have so effectively displaced driving that only 16 percent of workers commute to Manhattan's central business district by car. New commuter lines are not in the works currently, but service will improve once the East Side Access project—one of the region's largest public works projects in decades—allows travelers from Long Island to arrive into Grand Central Terminal instead of Penn Station if so desired. Construction of additional lines or expansion and improvement of existing ones would have similar effects: better access to the city and better service for existing commuters. For the purposes of this report however, the direct emissions potential of any additional lines was not estimated.

Shifting to Less Energy-Intensive Forms of Transport

Bus rapid transit

% n/a[1]

0.4 million tons[b]

$ n/a[c]

A BRT line can cost 50 times less than a new subway line and take months instead of decades to build. It is also faster than conventional buses. The city's Select Bus Service, which uses dedicated lanes and off-board fare collection, and is now located in all five boroughs, offers a 20 percent speed advantage compared to convention lines. Introducing additional Select Bus Service routes throughout the city would have two effects: first, it would save time for passengers who were riding the same routes on regular buses, which would have no effect on carbon emissions, and second, it would encourage those who were previously driving to switch to the bus instead, which would reduce emissions. The exact cause-and-effect abatement potential from expanding SBS coverage is difficult to estimate, but, as an example, increasing the share of trips taken on Select Bus Service to 7 percent – in line with what Ottawa and Bogota achieved with large-scale implementations of their respective systems – would reduce emissions by 0.4 $MtCO_2e$ compared to the business as usual case. Because of the uncertainty in the range of possible reductions attributable to SBS, the cost per ton of carbon abated was not quantified.

Bicycling

% n/a

0.5 million tons

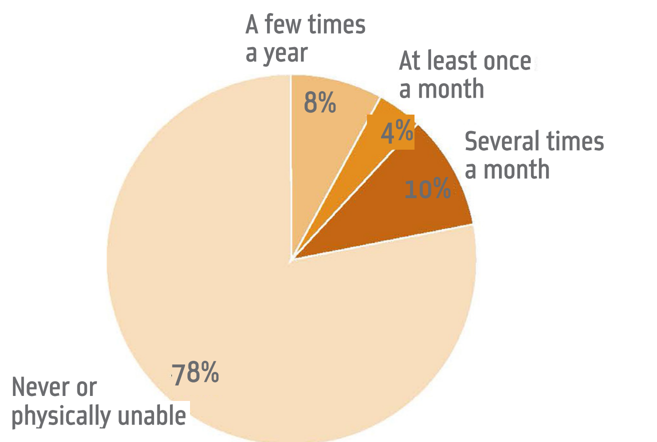
-$300 per ton

Of all the car trips in New York City, 10 percent are under half-mile, 22 percent are less than 1 mile and 56 percent are less than 3 miles – distances that could be readily served by bicycle. In recent years, cycling in New York City has grown much more popular than it used to be: 22 percent of New Yorkers ride a bike at least a few times a year, and NYC DOT's Commuter Cycling Indicator grew 2.5 times since 2000 – though the share of New Yorkers who use bicycles for their daily commutes is still relatively low, at 1 percent. (See charts: *NYC Population Bike Usage Status and NYC DOT Commuter Cycling Indicator*)

[a] Percentage sector wide reduction
[b] Amount of CO_2e abated
[c] Cost to abate carbon

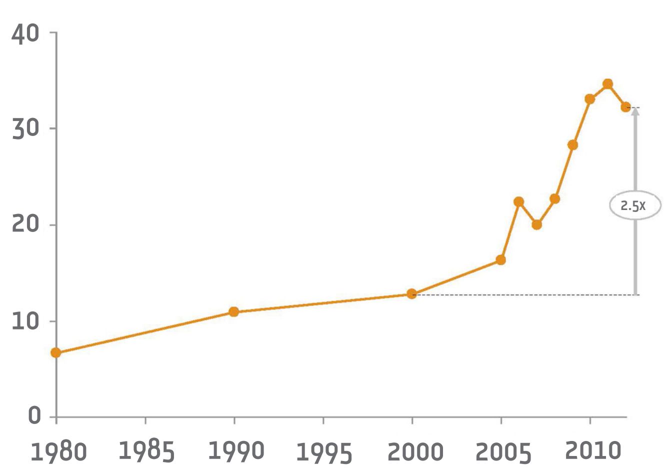
The carbon emissions impact of higher cycling rates is difficult to estimate because of limited data about mode-shifting potential, but it is certainly positive. Bikes do not reduce emissions when new riders switch from subways, buses, or walking, but they do reduce emissions when they replace rides in taxis or private cars. Carbon abatement potential of bikes is highest in areas that rely on cars, whereas in dense areas the expansion of biking and associated infrastructure is likely to bring about more convenience, health benefits, and traffic safety improvements than carbon emissions reductions. A detailed sizing of the carbon reduction potential of biking is beyond

NYC Population Bike Usage Status
% of total population, 2012



Source: NYC DOHMH Community Health Survey

NYC DOT Commuter Cycling Indicator
Thousands



Source: NYC DOT

the scope of this report, but for the sake of illustration, if New Yorkers' share of trips taken by bike increased to 15 percent (which Berlin achieves and Copenhagen far exceeds with its record 33 percent) and just half of those trips displaced car travel–carbon emissions would fall by 0.5 MtCO2e.

Regional trains and buses

% n/a

0.29 million tons

$ n/a

Of the four options for traveling along the Eastern Seaboard – driving, taking a bus, taking a train, or flying – driving and flying are by far the most carbon intensive. Reliable data is not available for the exact number of bus or car travelers between New York and Boston and Washington, D.C., but the share of train travel has risen from 37 percent to 75 percent between Washington, D.C. and New York from 2000 to 2011, and from 20 percent to 54 percent between New York and Boston in the same period. The share could be higher yet: in countries where true high-speed rail took off – Spain and China are two examples – regional trains and buses have become so popular that airlines have largely stopped serving routes under 300 miles. From an emissions standpoint, shifting all existing passengers on routes to Boston and Washington DC from planes to trains would lead to emissions savings of at least 0.1 MtCO2e. Cleaning up the grid in line with the 80 by 50 pathway would increase this potential to 0.29 MtCO2e.[14] As with subway expansions, high-speed trains are not primarily about carbon emissions abatement; therefore, the direct cost per ton of carbon abatement was not calculated.

Adopting Cleaner Vehicles and Fuels

No matter how good the city's transit system is, or how dense and mixed-use its neighborhoods, some trips will still require cars. Moving two tons of metal through space will always require a lot of energy, and reducing the emissions from this movement comes down to three options: switching to different vehicle technologies (hybrid electric and battery electric, for now), making conventional vehicles more efficient, and using biofuels. (See chart: *Vehicles on Road by Powertrain Technology*)

Battery electric vehicles

2.6%

1.6 million tons

-$10 per ton

Battery electric vehicles (EVs), which rely on a large battery pack for all (or nearly all) of their energy and need to plug into the grid to recharge, emit 70% less carbon per mile traveled than conventional vehicles do. Over time, conventional and electric vehicles alike will become cleaner (due, in large part, to strict CAFE standards), but the EV advantage will persist, especially as the grid becomes cleaner. (See chart: *Carbon Intensity of Battery Electric and Conventional Vehicles*)

Electric vehicles could play an extremely important role in carbon abatement, but all across the country, they still represent a tiny share of new purchases. Even in San Francisco, they amounted to only 0.9 percent of new registrations between 2010 and 2012; in New York City, the share was lower yet at 0.2 percent. (See chart: *Electric Vehicle Share of New Auto Sales by Location*)

Today's electric vehicles are far superior to prior incarnations that were plagued by limited range, charging challenges and high cost. Today's vehicles have sufficient range for daily driving, charging is simpler and more options are available, and prices are falling. In 1995, GM's EV1 – the first electric vehicle sold to consumers by a major automaker – was almost twice as expensive as an average vehicle, but today's Nissan Leaf, costs essentially the same as an average car after accounting for federal tax credits. (See chart: *Electric Vehicle Price Dynamics*)

Technology will improve further yet, and if, as modeled, battery electric vehicles represent 2 percent of all vehicles by 2020, 8 percent by 2030, and 41 percent by 2050, they could abate 0.1, 0.4, and 1.6 $MtCO_2e$, respectively. The societal cost of abatement would come in at $80/ton in 2020 (not taking tax credits into account, EVs would still be more expensive than conventional vehicles), then drop to -$10/ton in 2030 as EV prices drop.

Plug-in hybrid electric vehicles

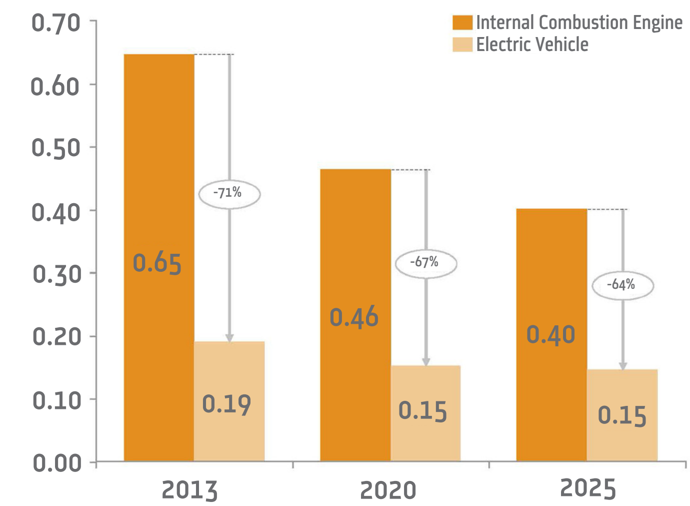
Today's plug-in hybrids can only rely on their batteries for between 7 and 35 miles. Once the battery is depleted, a small gasoline engine engages to extend the vehicle's range (to 340 miles in the case of one such vehicle, the Chevy Volt). Plug-in hybrids are not as beneficial as battery-only EVs, but they are nearly as good, especially for in-city driving. And compared to EVs, they do not induce range anxiety or require as robust a charging network, and because of their smaller batteries they cost less. As modeled, PHEVs could account for 6 percent of all vehicles on the road by 2020, 11 percent by 2030, and 47 percent by 2050, abating 0.3, 0.5, and 1.6 MtCO2e, respectively. The cost of abatement would be $90/ton in 2020 and -$10/ton in 2030 as vehicle prices continue to drop.

2.5%

1.6 million tons

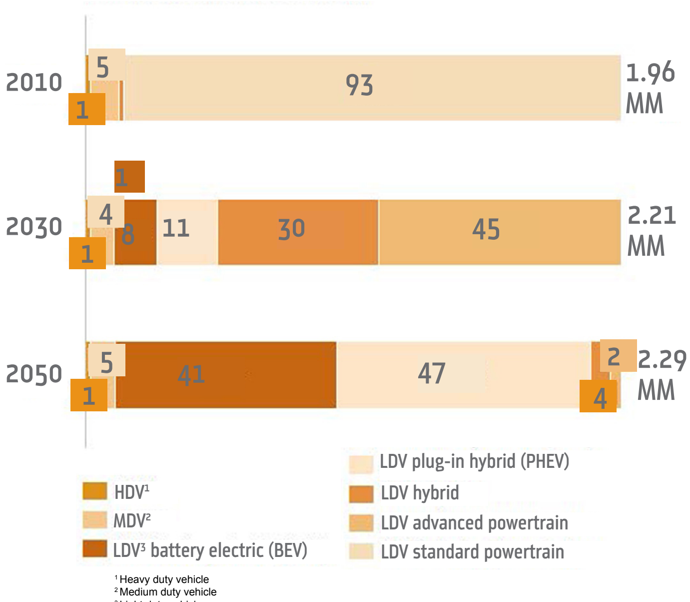
-$10 per ton

Carbon Intensity of Battery Electric and Conventional Vehicles
CO2e (lbs/mile): NYC-specific grid intensity along 80 by 50 pathway



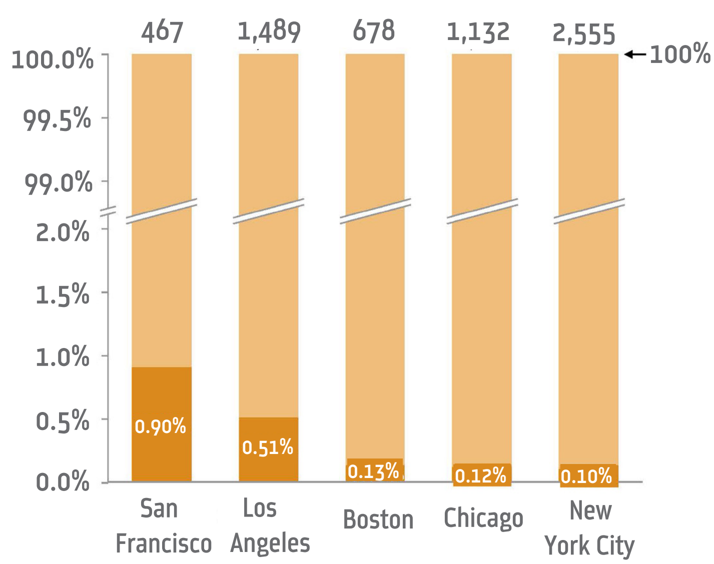
Source: US EPA, NYC Mayor;s Office

Vehicles on Road by Powertrain Technology
% of total vehicle stock (Millions)



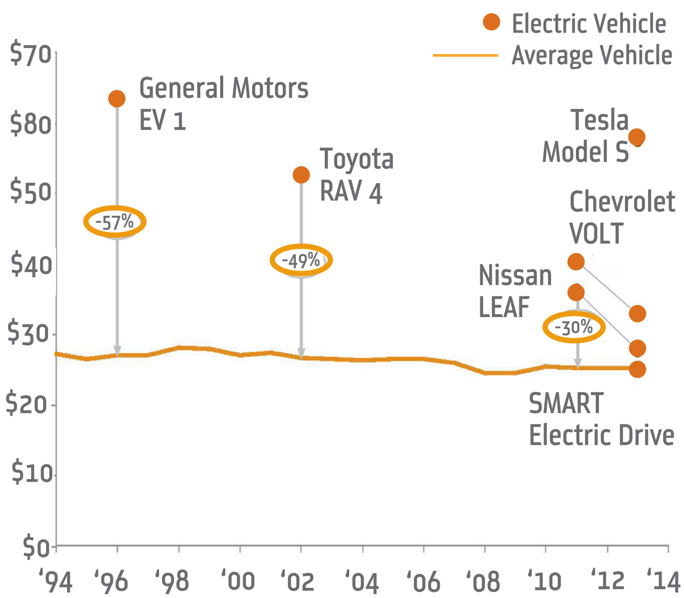
Source: NYC Mayor's Office

EV Share of New Auto Sales by Location; 2010-2012
Battery EV and PHEV as % of total registrations; total registrations in thousands



Source: Polk Automotive

Electric Vehicle Price Dynamics
MSRP in thousands (all values indexed to CPI inflation of 2011)



Source: US DOE; Transportation Department, NYC

Conventional hybrid vehicles

The carbon benefits of conventional hybrid vehicles, which recharge their battery from their internal combustion engines, are small but nevertheless helpful and very cost-effective as an interim step towards 80X50. These vehicles are expected to represent 30 percent of all vehicles in 2030, but practically disappear by 2050, as battery electric and plug-in alternatives continue to improve. The abatement potential is 0.2 MtCO2e in 2020 and 0.1 MtCO2e in 2030, achieved at large societal savings: -$170/ton in 2020 and -$530/ton in 2030.

0.1%

0.1 million tons

-$530 per ton

Advanced internal combustion engines

Federal CAFE standards are leading to dramatic improvements in the fuel efficiency of conventional vehicles, and their impact is already captured in the business-as-usual emissions scenario. However, the standards only dictate improvements through 2025, and their impact on vehicle emissions will be limited by the speed of vehicle turnover. The potential exists for additional emissions reductions from conventional vehicles, whether through more aggressive vehicle standards in the future or through accelerated upgrading to vehicles that meet the standards that are in force today. By 2020, accelerated uptake of more efficient vehicles could abate up to 0.7 MtCO2e; by 2030 and 2050, tighter standards and accelerated switching could abate 0.6-0.7 MtCO2e. Because the incremental costs of cleaner vehicles pay off through fuel savings, the range of abatement costs would be between -$170/ton and -$150/ton.

1.0%

0.7 million tons

-$150 per ton

Alternative bus powertrains

In recent years, MTA has upgraded portions of its 6,000-unit bus fleet to cleaner-burning diesel, compressed natural gas, and hybrid electric units. There is a balance to be struck in the upgrade process: hybrid vehicles may be the cleanest of the three, but they also cost more to purchase and maintain, and the incremental money may be better directed – at least in the short term – to replacing old diesel vehicles in their fleet with more cleaner models. A cleaner mix of buses featuring predominantly hybrids has the potential to abate approximately 0.1-0.2 MtCO2e at a cost of between -$190/ton and -$230/ton.

0.2%

0.2 million tons

-$230 per ton

Biofuels

Different biofuel technologies have been available for some time, but it was only in recent years that their cost and availability expanded enough to make them a viable option for local car fleets. All city vehicles running on diesel currently use B5 year-round and over the next two years the entire fleet will be increased to B20 for the non-winter months. Scaling up biofuel use could abate 0.2 MtCO2e in 2020, and up to 1.2 MtCO2e between 2030 and 2050. Biofuels command virtually no cost premium over conventional fuels which means that the they would lead to negative abatement costs at -$70/ton in 2030.

1.8%

1.2 million tons

-$70 per ton

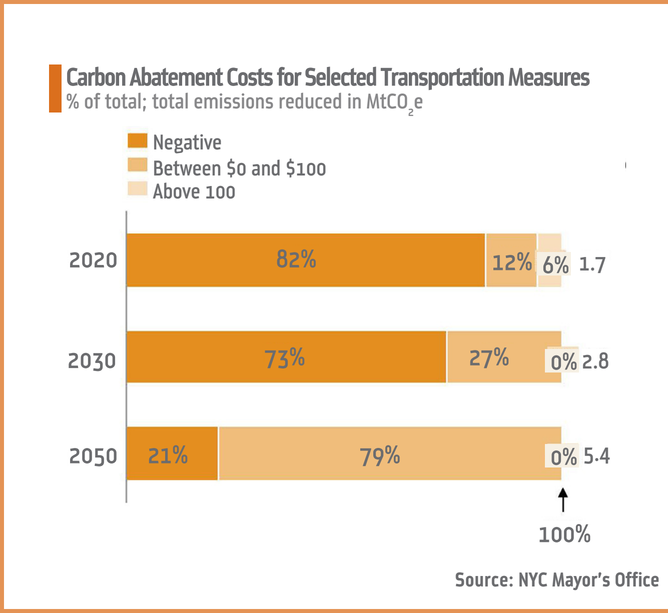
The Costs & Economics of Carbon Abatement for Transportation

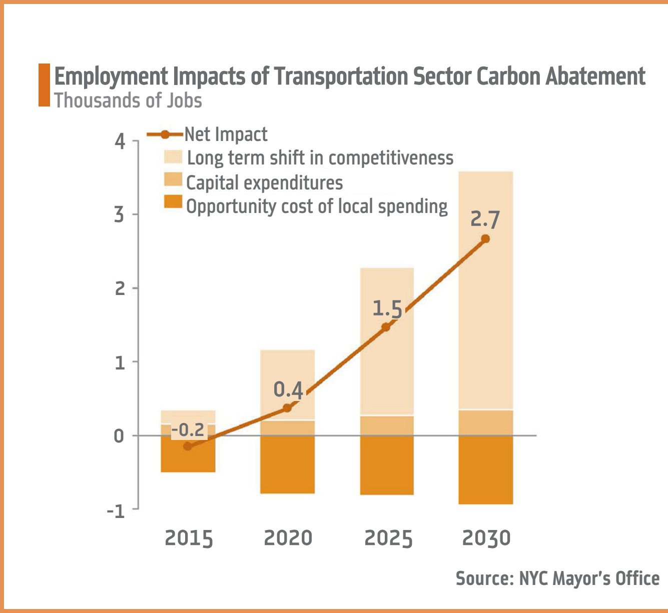
New Yorkers spend $5.4 billion on vehicles, $7.9 billion on transportation fuels, and $5.5 billion on public transit fares each year. More than 90,000 people work in transportation-related jobs, from the 27,000 that support passenger aviation to the 7,000 employed in car dealerships. Decarbonizing the sector would spell a degree of change – but most of the change would benefit the economy in the end.

Many of the abatement measures require upfront investments. Yet through the 2020s and the 2030s, 70 to 80 percent of these measures could achieve carbon reductions at a negative societal cost because of fuel savings. Even assuming, conservatively, that improvements to neighborhoods and mass transit would not significantly affect the amount of driving within the city, the total required incremental investments along the 80 by 50 pathway – on the order of $300-500 million a year, mostly to pay for the higher upfront costs of cleaner vehicles – would be more than offset by the operational savings of up to $3.5 billion a year once decarbonization progresses far enough.(See chart: *Carbon Abatement Costs for Selected Transportation Sector Measures*)

The first order effects of these changes would be positive for the economy. The increase in spending on cleaner vehicles would help car dealerships, but it would be offset by a decrease in activity in other sectors of the economy, leading to net job-year losses on the order of 500-600 annually. However, the positive economy-wide effect of fuel savings would more than compensate for those losses. A net gain in employment would result by 2020; by 2030, as alternative vehicles become more widespread, they would be responsible for more than 2,600 net new jobs and a $300 million increase in gross regional product. (See chart: *Employment Impacts of Transportation Sector Carbon Abatement*)

Existing transportation jobs may experience some disruption: if, for example, demand for liquid fuels falls far enough, gas station employment – currently at 3,000 – might shrink. However, the impact would be contained: dealerships would still sell new vehicles, subway trains will still run, and planes will still be taking off from area airports, providing the same jobs they provide today. In the transportation sector, carbon abatement may be tough to accomplish, but the overall economic impact appears positive.





Challenges

The transit network is vast but still finite and infrastructure is in need of modernization.

Subways make the city run, but they don't go everywhere: 28 percent of New Yorkers do not live within a half-mile of a subway station. Even if a subway station is near, not all routes are convenient: traveling from the Bronx to Queens or from Manhattan to JFK can take a long time – and driving may become the preferred option. Where subways do go, they may not always provide a speed and frequency of service or level of comfort that potential travelers find preferable to other modes.

Walking and biking can be uninviting, unsafe, or both

The city's street grid was laid out in the days of the horse buggy, but more than two million vehicles traverse it today, and it shows. Cars, buses, bicycles, and pedestrians compete for limited space, and while a neighborhood like the West Village can be very pedestrian and bike-friendly because of its small right-of-ways, walking or biking along Queens Boulevard is a different story altogether. The city has made great strides in reducing traffic fatalities through a raft of street design measures, but there is more to be done.

New technologies are available, but adoption has been slow

EVs and biofuels hold a lot of promise, but their adoption is gradual and will take time to get to scale. EVs account for just 0.1 percent of all new vehicles purchased in the metropolitan area since 2010, and biofuels are mainly available only through bioethanol added to gasoline, which does not lead to a significant emissions reduction. Unlike ethanol, biodiesel use is not required and not available in the retail market even though it is far better environmentally. For EVs, the incremental cost, continued concerns about range, and scarcity of charging stations are obstacles to growth despite their increasing affordability.

The economics of driving are not fully efficient

For any practice that carries a cost, reflecting it directly is usually a good idea – charging for electricity per kilowatt-hour instead of monthly makes people watch their usage, and taxing cigarettes deters smoking and recovers some of the indirect costs imposed on society at large from the illness they cause. Driving comes with a multitude of costs, but the only costs that are tied directly in proportion to the amount of miles driven are fuel and maintenance costs. Insurance is priced based on a measure of risk for accidents, but not amount driven, and the negative externalities of driving – congestion and air pollution – are not priced at all.

Planning jurisdiction and operational authority spans agencies and levels of government

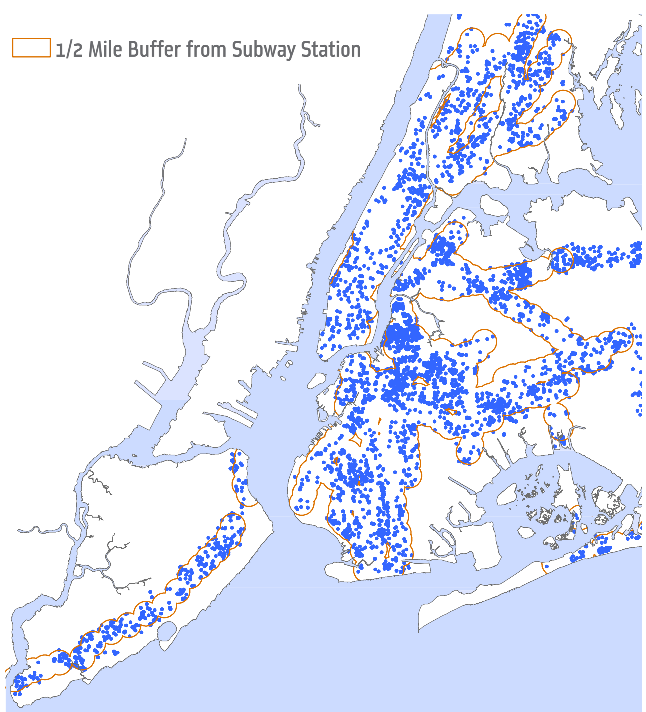
All of the city's systems feature a complex mix of players – but transportation is perhaps the most varied of them all. City government may control streets and zoning, but agencies at other levels of government fund, construct, and operate major components of the city's transportation infrastructure. As a result, major projects often take decades to materialize. Most importantly, vehicle choices come down to millions of individual decisions – and unlike with buildings, where the local building code governs construction, the parameters of those choices are set at the federal level, and then only loosely.

Capturing the Potential

Strategy 1
Zone for Neighborhood Density and Diversity

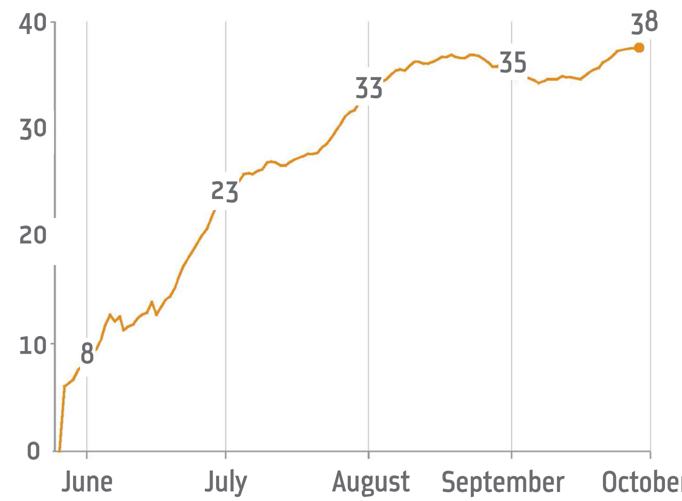
Much of the city is already dense and mixed-use, but opportunities for improvement still exist – and zoning, which determines how a given plot of land can be used and how much can be built on it, is the best tool at the City's disposal. Over 120 City-initiated rezonings were completed in the city in the last decade, allowing greater density in areas close to transit while limiting growth in auto-dependent areas. The combination of City policy and market activity ensured that more than 87 percent of new building permits between 2007 and 2012 were issued in areas within ½ mile of a subway or commuter rail station. (See chart: *New Building Permits and Transit Coverage*). As the city continues to attract new residents and grow,– careful use of zoning proceeding in tandem with transit improvements could ensure that opportunities for development continue to get created in areas where many residents will find car ownership is not a necessity.

New Building Permits and Transit Coverage
2007-2012; all construction types



Source: NYC Mayor's Office

Daily Citi Bike Ridership Trends
Thousands; 2013; normalized for weekly fluctuations

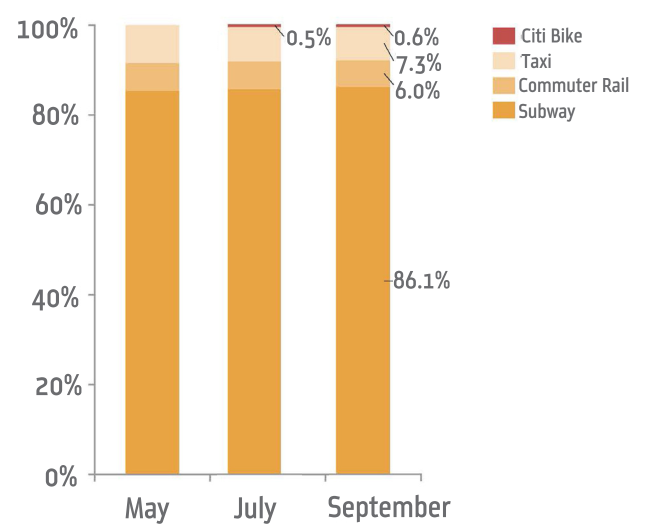


Source: Citi Bike

Strategy 2
Build and Maintain Transit Infrastructure

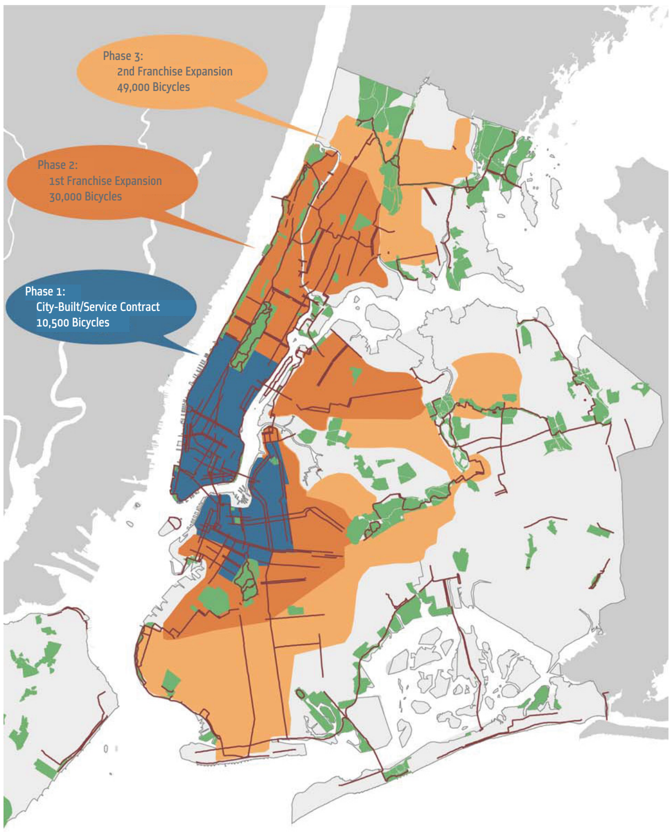
Transit infrastructure takes time to build and is expensive to maintain – but it is indispensable when it comes to carbon abatement. Putting the city onto an 80 by 50 pathway would require improving transit where it already

Taxi and Transit Ridership by Share of Total Monthly Trips
Percent of total; 2013



Source: MTA, NYCTLC, Citi Bike, NYC Mayor's Office

Possible Bike Share Expansion Areas from 2009 Study
Segmented into 3 phases



Source: NYC DCP

exists and taking it to areas that it does not yet cover – while being careful to invest in the options that deliver the greatest marginal benefit for the amount of money spent.

Bus rapid transit

Of all the transit options, BRT lines may have the most to contribute to carbon abatement: they are quick to set up and require little enough investment that multiple ones could be set up along major transport corridors. The city's BRT offering, Select Bus Service, already runs on four routes, and several route expansions are in the works, including on Webster Avenue in the Bronx and Nostrand Avenue in Brooklyn. More SBS routes could continue to encourage drivers to shift away from cars, save time for existing commuters, and make neighborhoods more attractive.

Bicycle share expansion

Citi Bike, the city's bike share-program, saw excellent growth since its launch in May 2013: by October, more than 90,000 annual members had joined, and the daily number of rides was on track to reaching 40,000 – still far below 470,000 daily taxi trips, let alone millions of subway rides, but picking up quickly. (See chart: *Daily Citi Bike Ridership Trends* and *Taxi and Transit Ridership by Share of Total Monthly Trips*)

The system, however, is only in its first phase – and there is potential for it to expand. The 2009 study from the Department of City Planning that evaluated the potential for bike share in New York City envisioned three stages of implementation: the first one, with 10,500 bicycles, would cover the densest areas of Manhattan and Brooklyn; the second one, bringing the system to 30,000 bicycles, would expand into Queens and the Bronx, and further into Northern Manhattan and Brooklyn; and the third one, increasing the capacity to 50,000 bikes, could cover the city as far as Coney Island and Pelham Bay Park, spanning 81 square miles. (See map: *Possible Bike Share Expansion Areas from 2009 Study*)

The damage from Hurricane Sandy to bike share infrastructure stored in the Brooklyn Navy Yard shrank first stage deployment, but most of the area mentioned in the original study is now covered. Covering the remaining areas would make it possible to reduce short car trips and would also make it easier for New Yorkers to access new Select Bus Service routes. However, the main obstacle to the program expansion is funding, both for capital and operating costs. For the first phase, sponsorships by Citibank and MasterCard paid all of the initial capital costs and membership fees are covering the operating costs. The financing model, for subsequent phases, is yet to be established. City capital or private sponsors could pay for the capital costs, but membership revenues may not be enough to cover the operating costs because the number of users per bike would decline as residential density falls. In that case, an ongoing financial commitment from either the City or a private sponsor would be required to expand the system.

Subways

Because subways are so expensive and take so long to build, new lines would not serve as a marginal carbon abatement method for the short or even the medium term. The more immediate concern for the system is to maintain the quality of service on existing lines, and the biggest challenge to that is funding. As with any other transportation option, the system requires taxpayer support and cannot be funded by user fees alone. The finances of the MTA, the New York State agency that runs the city's subway system, would need to be strengthened in order for service to remain convenient and reliable.

One possible exception that could reduce emissions in the short to medium term is the extension of the N line to serve LaGuardia airport, which was last seriously discussed last decade. Because the only transit option for getting to LGA is the bus, the project would have the potential to reduce emissions directly. In the longer term, better connections between Queens and Brooklyn – including possibly those that rely on existing unused right-of-ways – would merit consideration, though as with the current two extensions, economic development concerns would likely drive the decision-making.

Ferries

The East River Ferry service already brings commuters from Long Island City and Brooklyn waterfront to Wall Street. As the city's waterfront continues to be redeveloped, ferries will grow in importance, and opportunities for new routes will arise. The former Domino factory in Williamsburg is just one example of a new project that could benefit from ferry connectivity. As with subways though, new ferry projects would be driven primarily by economic development considerations and would require near-term subsidies.

Streetcars

Streetcars ran in the city's streets up until the 1950s – then, the service was shut down and the rails were removed; the last remaining cars from that era are now rusting behind a Fairway supermarket in Red Hook. Proposals exist to resurrect streetcar service in parts of the city but the marginal cost of construction is still substantial enough that any projects would have to be weighed carefully against cheaper alternatives such as bus rapid transit.

Regional and commuter rail

For rail, the greatest abatement potential lies in launching true high-speed service between Washington D.C. and Boston – and displacing car and airline travel as a result. Amtrak recently proposed a plan to upgrade the speed of its trains by 2041, and while a discussion of the funding and planning challenges of the endeavor are beyond the scope of this report, local support would still be important. For commuter rail, the drivers of expansion would be less about incremental abatement and more about the availability of funding and need for capacity increases. Two rail tunnels connecting to New Jersey under the Hudson River are more than 100 years old and both are over capacity. A new link, perhaps following in the footsteps of the now-suspended project called ARC (Access to the Region's Core), could improve the passenger flow into and out of the city.

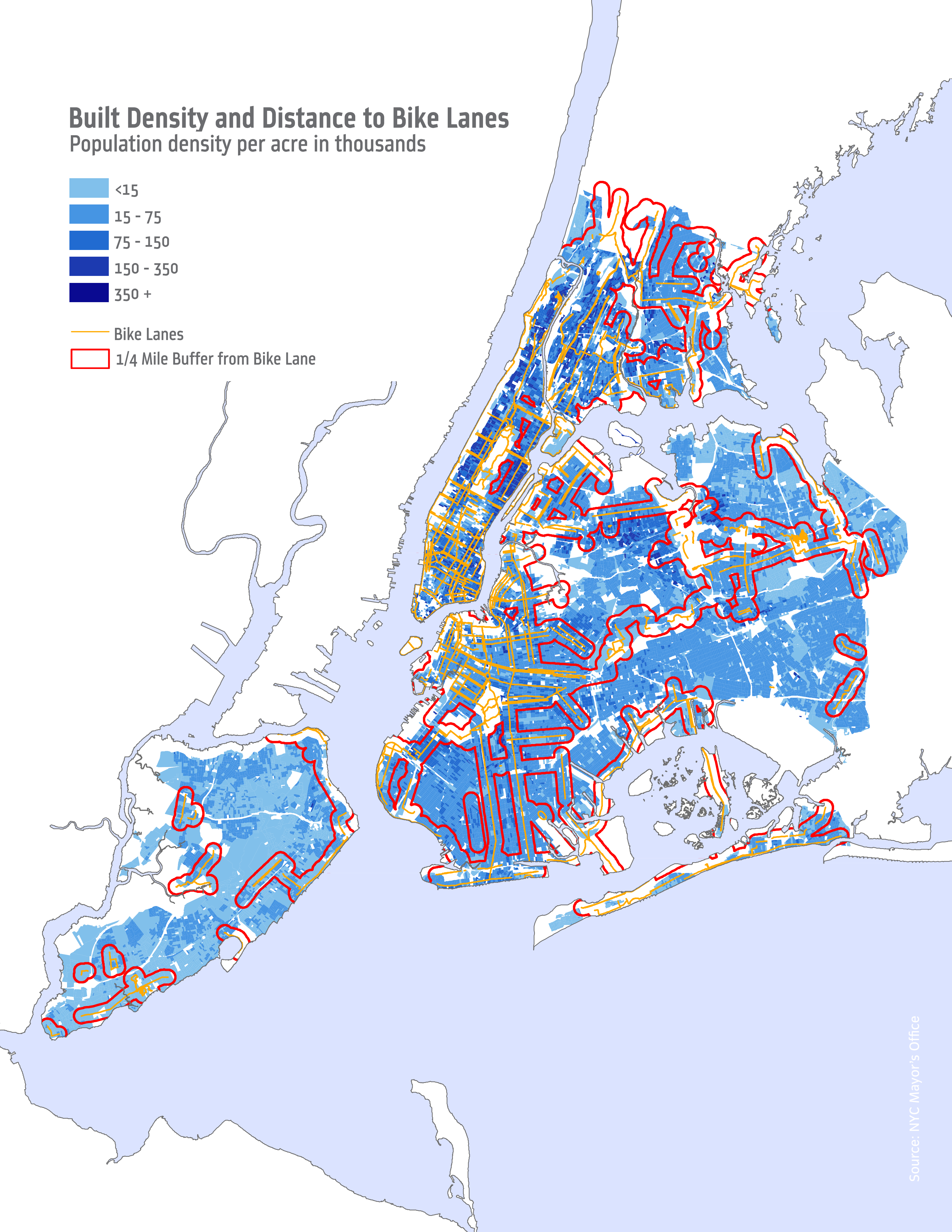
Strategy 3
Improve the Streetscape

Safer, pedestrian-friendly streets

Neighborhood plazas, wider sidewalks, pedestrian islands, and an assortment of traffic calming measures have been popping up across the city and making streets better and safer for all New Yorkers. Seniors and schoolchildren have received special attention through programs like Safe Streets for Seniors and Safe Routes to Schools. Thanks to these and other measures, the city's streets are safer than they have been at any point in the last 100 years. As the city grows and changes, more will need to be done. The difficulty lies in the extremely fragmented nature of needed improvements: no two intersections are the same, and many changes require long approval and community engagement processes. A methodical focus on incremental improvements all over the city – often relying on piloting and testing to quickly establish what works and what does not – has proven to work and could be a template for the future.

Bike lane expansion

Cycling is most effective as a marginal carbon abatement tool in areas that are not well served by transit – it is in those areas that it replaces driving instead of subway rides. Incidentally, these are the areas that aren't well served by the existing bike lane network either (See map: *Built Density and Distance to Bike Lanes*) – which means that focusing the network expansion efforts on those areas may be the best way to capture the carbon abatement potential of cycling. The process can be lengthy and challenging, and each mile of a new bike lane would



Built Density and Distance to Bike Lanes
Population density per acre in thousands
<15
15 - 75
75 - 150
150 - 350
350 +
Bike Lanes
1/4 Mile Buffer from Bike Lane
Source: NYC Mayor's Office

serve fewer riders than it would in a dense neighborhood – but with the bike lane network already well-developed in denser parts of the city, the less dense areas represent the next frontier.

Bike bridge access

The bike lane network may be well developed within some neighborhoods, but the city's boroughs could be connected better. Bridges are part of the answer – and while Manhattan, Williamsburg, and Queensboro bridges all have separate paths for cyclists, the same is not true of all the major connections. Some, like the Verrazano, from Brooklyn to Staten Island, and the Whitestone, from Queens to the Bronx, have no accommodations for bicyclists at all. Others, like the Henry Hudson, Robert F. Kennedy and Marine Parkway bridges, require riders to dismount. Still others have bike paths that could use improvement: on the Brooklyn Bridge, the narrow walkway can be congested for cyclists and pedestrians alike, while on the Pulaski bridge from Long Island City to Greenpoint, the shared pedestrian and bike path can be as narrow as 8 feet. Creating bike paths where none exist and improving them where they do will be critical to making biking in the city more viable.

Strategy 4
Support Cleaner Vehicles

Clean vehicle incentives

Most incentives for clean vehicles arrive in the form of federal tax credits – those for EVs, for example. Still, there are options at the state and local level to encourage clean vehicle ownership among private and commercial users alike. For commercial vehicles, two programs are already available: the Hunts Point Clean Truck Program, managed by City DOT, aims to take at least 500 of the oldest, most polluting trucks off of the streets of the Bronx; the Citywide Private Fleet Alternative Fuel Programs, co-managed by DOT and NYSERDA, offers rebates of up to 80 percent of the increased cost of choosing an electric or alternative fuel vehicle over a conventional one. The NYSERDA Program has been operating for over 10 years and has funded hundreds of clean advanced technology vehicles. Another program is on the way as well: NYSERDA will be providing rebates to commercial sector fleets exclusively for the purchase of new electric trucks. No incentive programs are in place for private vehicles yet, but one option is a local or regional "feebate" program – a revenue neutral initiative that encourages vehicle buyers and car manufacturers to invest in efficiency. Under this framework, vehicles with above average efficiency would receive a rebate while those with below average efficiency would be assessed a fee.

EV charging infrastructure

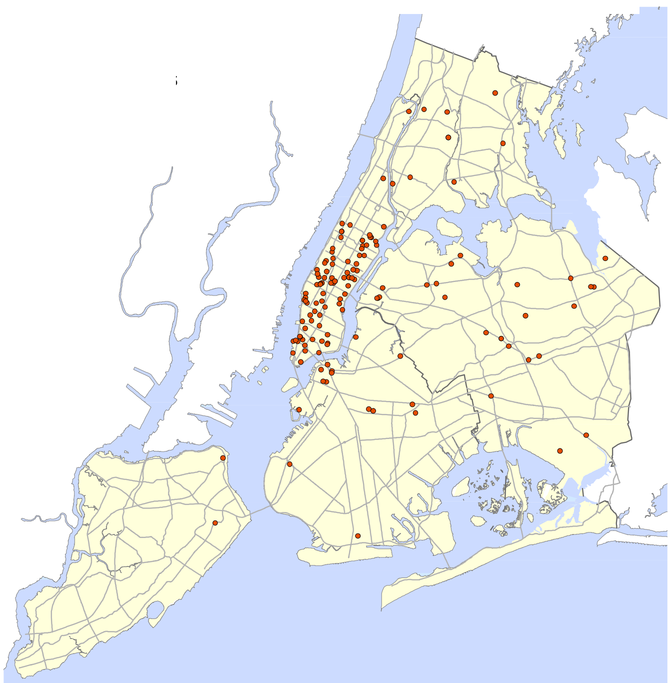
Charging is perhaps the biggest barrier to EV adoption: although there are over 180 public charging stations throughout the city, it is not enough – and only three are of the fastest variety that can charge a vehicle in 30 minutes or less.. To improve charging infrastructure around the city, three strategies could help. First, there could be more EV charging points in garages and parking lots (which is where most of the existing 180 are today). The City has been partnering with the private sector, as well as Federal and State governments to develop these – and more are on the way. (See map: *Existing EV Charging Points*) Second, the issue of parking would need to be addressed: at least some street chargers would need to be available if EVs are to be adopted en masse. A pilot to evaluate the feasibility and utilization levels of dedicated EV parking spots could be a helpful starting point. Finally, the City can implement a recently passed local law that will require 20 percent of new residential and workplace parking to be "charger ready." The incremental cost to developers will be negligible – the measure only requires the installation of wiring and not of actual chargers – but will help prevent costly retrofits in the future.

Electric taxi pilot

If an electric taxi can make it in New York it can make it anywhere. Few vehicles drive as much every day and suffer as much abuse as the New York City's yellow cabs. Several electric taxis, all Nissan Leafs, are already cruising the city's streets as part of an electric taxi pilot, and a Taxi and Limousine Commission study of what it would take to electrify 1/3 of the fleet is underway. Such a fleet would reduce emissions by 90,000 tons a year — but at least three issues arise.

The choice of vehicle is one: the Leaf is not custom-built for full-time taxi operation, and it does not have much passenger space. An electric version of the Nissan NV200, a custom-built taxi designed just for New York or a similarly sized vehicle would likely replace the Leaf in any large-scale electrification, but that vehicle is still being tested and developed.

Existing EV Charging Points
2013



Source: NYC Mayor's Office

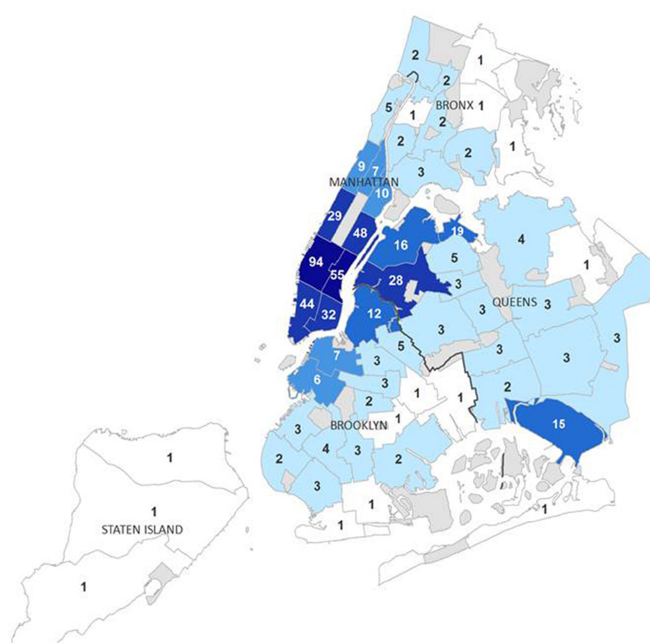
The charging network – or lack thereof – is another obstacle. Because each taxi drives more than 50 passenger miles per 12-hour shift (as well as additional miles spent cruising for fares and traveling to and from home or a fleet garage), it would need to recharge after each shift — and existing chargers are too slow to work with the economics of the industry. A citywide network of quick chargers, which can recharge a battery to 80 percent in 30 minutes or less, would have to be installed instead. Quick chargers would require more space and could draw up to 15 times more power. To get the network installed, City, State, and the private sector would have to cooperate. (See map: *Potential Quick Charge Network for Electric Taxis*)

The economics of the electric sector present a final challenge: electricity is billed not just on the amount of energy consumed, but on the speed it is used. The rationale is that just as it costs more to build and maintain a highway than a dirt road, it costs more to build and maintain a higher voltage electricity distribution system that can supply large amounts of energy quickly. At the price of $12-22 per kW for demand charges could add $30,000 a year to the cost of running a quick charger — these added costs are particularly problematic if a charger has low utilization. Within the taxi electrification effort, it may be possible to rely on mobile technology to increase charger utilization But in the longer term, the City, the electric utilities and regulators may need to address the fundamental economics of standby charges to make quick chargers more viable.

EVs at Hunts Point market

The Hunts Point Food Distribution Center (FDC) is the City's primary food hub, with more than 100 wholesale distributors supplying more than 50 percent of the City's produce, meat, and fish. Most commodities arrive by truck, and most trucks run on conventional diesel. To promote the conversion of truck fleets to alternative fuels, the City is partnering with a private developer to build a retail alternative fueling station in the FDC. In addition to offering biodiesel, CNG, ethanol, and limited conventional fuel, this project also plans to offer electric vehicle charging stations, which will make electric vehicles more attractive and help electrify some of the 12,000 daily truck trips to the FDC.

Potential Quick Charge Network for Electric Taxis
Number of chargers per district



Source: NYC Mayor's Office

Strategy 5
Support Biofuels

Biofuels are already available, but just as with EVs, their adoption has been gradual. Supply is not the limiting factor – plenty of capacity is available locally, however little retail infrastructure exists. To promote biofuel adoption, City and State governments could work to explore biofuel mandates. The City's own fleet could serve as a testing ground for progressively higher biofuel blends. New York City's municipal fleet has emerged as one of the largest purchasers of biofuels on the East Coast: some City vehicles already use blends of up to 30 percent, and blends of up to 90 percent are being tested. The municipal fleet average could approach 30 percent by 2020 already, setting an example for other large fleets around the city. Biofuels requirements for City contractors have not been introduced yet, but could be considered.

Strategy 6
Make Driving More Economically Efficient

Use fees for vehicle travel

Use fees – a regional vehicle miles travelled charge or congestion pricing – can help reduce VMT and increase available funding for transit. New York City proposed a congestion pricing program in 2008, with the idea of charging drivers for entering the Central Business District and using the revenues to fund transit – but it did not advance past the State Assembly despite support from the City Council. Several European cities have successfully put similar programs in place: in one example, bus use in Stockholm's core rose 9 percent after the city introduced a congestion charge; in another, Singapore experienced a 73 percent decline in the use of private cars, a 30 percent increase in carpools, and a doubling of buses' share of work traffic.[15] In the case of New York, a similar use fee tool could offer a 0.3 MtCO2e reduction and generate nearly a billion dollars a year for transit investment.

Dynamic pricing for parking

Dynamic pricing for parking helps match parking supply to parking demand and avoids situations in which drivers cruise endlessly for available parking spots, which contribute to congestion. San Francisco (SFPark) and Los Angeles (LAExpresspark) already have such programs in place, and New York City is conducting pilots in Greenwich Village, Park Slope, Jackson Heights, and Atlantic/Smith/Court Streets as part of the PARK Smart program. Depending on the results of the pilots, the program could be expanded further, making parking in the city more efficient.

Pay as you drive insurance

As its name suggests, "pay as you drive" insurance (PAYD) allows drivers to pay for insurance based on the amount of miles they drive. Newly available thanks to simple devices that car owners can install to share driving data with their insurance companies, PAYD rewards drivers for driving less, thereby contributing to reductions in the number of miles traveled. Two insurance companies began offering PAYD insurance in New York in early 2013; in the longer term, if the experience proves successful, a 50 percent switch to PAYD insurance could abate as much as 0.5 MtCO2e.

Selectively Improving Air and Freight

Air travel and the movement of freight are two large sources of emissions not counted in the City inventory. Although large-scale changes to either are often beyond the purview of the City and its partners, targeted opportunities for improvement do exist.

Assisted airplane towing

% n/a	
1.2	million tons
-$640	per ton

Airplanes produce most of their emissions while airborne, but a surprisingly high share takes place on the ground, where planes use their jet engines for taxiing during takeoff and landing. Precise amounts differ depending on the level of airport congestion, but a 2007 study from MIT[16] estimated that a short/medium range A320 jet could expend up to 5-10 percent of its fuel on the ground. Assisted towing – moving planes to takeoff positions using either diesel tugs or electric in-wheel engines – would allow planes to run their engines less, resulting in net on-the-ground CO2 emissions reductions that the MIT study put at 70-77 percent depending on airport.

None of the three airports in the New York City area use towing yet; nor do any of the airlines that fly into them. Diesel tugs present operational and safety challenges that arise any time that additional equipment is added to the airfield, and airplane manufacturers do not yet guarantee that their everyday use would not damage the planes; in-wheel tugs are still being tested. Yet the potential for reducing emissions, 0.7 million tons if 80 percent of flights out of the city's three airports relied on assisted towing, is comparable to the potential of large-scale vehicle electrification. Thanks to the fuel savings, the cost of abatement would be deeply negative, at -$640/ton. In the coming years, pilot projects could help establish whether assisted towing could be an option for the area's airports.

Improved freight operations

% n/a	
2.7	million tons
$ n/a	

Decades ago, most freight arrived in New York City by rail and by sea. The piers from those days are mostly gone, but their numbering – say, Pier 71, indicates just how many of them used to accept goods coming into the city. Today, most freight comes into the city by truck – but trucking, at 0.37 pounds of CO2 per ton-mile, is far more carbon intensive than rail freight, at 0.22 pounds, let alone seaborne shipments, at 0.09 pounds. Carbon intensity of trucking will decrease as fuel economy improves and as new technologies appear. Shifting 70 percent of inbound freight away from trucks or to low emitting technologies could result in carbon emissions savings of between 1.6 and 3.7 MtCO2e. Because the exact amount is difficult to estimate this potential was not counted together with other 80 by 50 levers. PortNYC, a program of the New York City Economic Development Corporation (NYCEDC), has been working for years to boost the volumes of traffic coming in by sea and by rail, including through reopening the Staten Island Railroad, improving rail facilities at the Hunts Point Food Market, and upgrading the capacity of South Brooklyn Marine Terminal to allow transloading of sea cargo onto trains. Future PortNYC projects will continue to improve non-truck freight options available.

Credit: John H. Lee, NYC Mayor's Office

DSNY Garage, East Harlem

Solid Waste

Every year, New York City generates enough solid waste to fill up the Empire State Building twenty-one times over. Some of this waste is recycled or converted to energy, but most is sent by truck to landfills as far as Virginia, where it releases methane as it decomposes. The resulting emissions add up to over 2 million tons a year – 4 percent of the city's total. Emissions have decreased 22 percent since 2005 as New Yorkers generated less waste and as some of the waste transport shifted to rail and barge – but potential exists to reduce emissions in the waste system dramatically by focusing on waste prevention, scaling up the processing of organic waste, improving recycling, and utilizing energy produced from waste and organics processing technologies. Achieving such deep reductions would require changing behaviors through education and incentives, strengthening regulations, investing in new infrastructure, and working closely with the city's waste producing sectors – all of which will be challenging, yet possible.

Overview

Credit: Edward Reed

Mayor Bloomberg Announces Start of Expanded Recycling Program

On the city's sidewalks, black bags pile up at night; by morning, they disappear into the bellies of garbage trucks. Leftover food and old clothes, used paper cups and coffee shop grinds, wood and metal and concrete debris all add up to 10 million tons of waste a year — enough to fill the Empire State Building 21 times over, or to load up more than 3,000 large trucks every day. Around 15 percent of this material ends up at recycling plants; another 10 to 15 percent is converted to energy at facilities in New Jersey; less than 1 percent becomes compost; and the remainder travels as far away as Virginia and South Carolina to end up in landfills. City taxpayers fund the residential part of the system, spending more than $100 for every ton that goes to landfills, but earning back up to $20 for every ton that is recycled, for a net expenditure of more than $300 million a year for the export of waste. Collection costs run an additional $700 million. Commercial waste is paid for by businesses directly.

Annual emissions from waste amount to 2.1 million metric tons — most from paper and organic waste as they decompose in landfills, and the rest from waste-to-energy facilities and from the trucks and trains that move the waste within the city and away from it. Emissions fell more than 20 percent in recent years because New Yorkers generate less waste, and because some of the waste now travels by rail and barge instead of truck – but reductions consistent with an 80 by 50 goal would need to go far beyond that. On that pathway, the volumes of waste would have to drop, most recyclable waste would have to be recycled, most organic waste would need to be composted or turned into biogas, and the rest would be converted to energy with minimal environmental impact. Very little would be landfilled.

The potential does exist to achieve these outcomes – and nearly all of the individual measures to get there would lead to savings in the long term. Yet unlocking this potential will be challenging. New Yorkers would need to improve recycling habits, which will be aided by the recent simplification of rules and improved messaging. Waste processing infrastructure improved significantly this fall with the opening of the new Sims recycling facility in South Brooklyn – but the infrastructure to process organic waste would need to be expanded. Plants in New Jersey convert some of the waste-to-energy – but newer, cleaner, and more efficient plants are yet to be built.

These challenges are real, but they may be possible to overcome – and initiatives of the last years have already pushed New York City towards a more sustainable solid waste system. With the appropriate long-term commitment, emissions from solid waste could continue to drop and potentially even be neutralized.

Solid Waste Fundamentals

New York City's residents, workers, and visitors generate more than 10 million tons of waste every year. Approximately two-thirds of this waste is generated from everyday activities and typically left for pickup on the curb. The remaining third is debris from the construction and demolition of buildings (also called C&D waste). An additional 4.8 million tons of fill – essentially dirt from excavations – is generated each year but nearly all of it is reused within the city and thus is not a major source of exported waste or GHG emissions.

Uniformed City workers from the Department of Sanitation (DSNY) pick up waste from residents, City government buildings, and some large institutions like hospitals and universities. More than 200 commercial carters pick up waste from businesses. Residents are required to separate their waste into three streams: paper and cardboard, metal/glass/plastic, and all the rest.[17] Businesses are also required by law to recycle and some are now required to source separate organic waste. (See chart: *Residential Waste Composition*)

Once picked up, residential and commercial waste is typically transported to one of four types of destinations: recycling facilities, organic waste processing facilities, waste-to-energy facilities, or landfills. A small but potentially growing amount of organic waste is processed at the City's wastewater treatment plants; several hundred tons a year are also composted locally at neighborhood community gardens. In 2011, recycling rates for residential, commercial, and C&D waste were at 20 percent, 46 percent, and 45 percent, respectively. Between 8 and 19 percent of waste was converted to energy, one percent was composted, and the rest was sent to landfills. (See charts: *New York City Solid Waste by Source and Mode of Disposal* and *New York City Residential and Commercial Solid Waste Flows*)

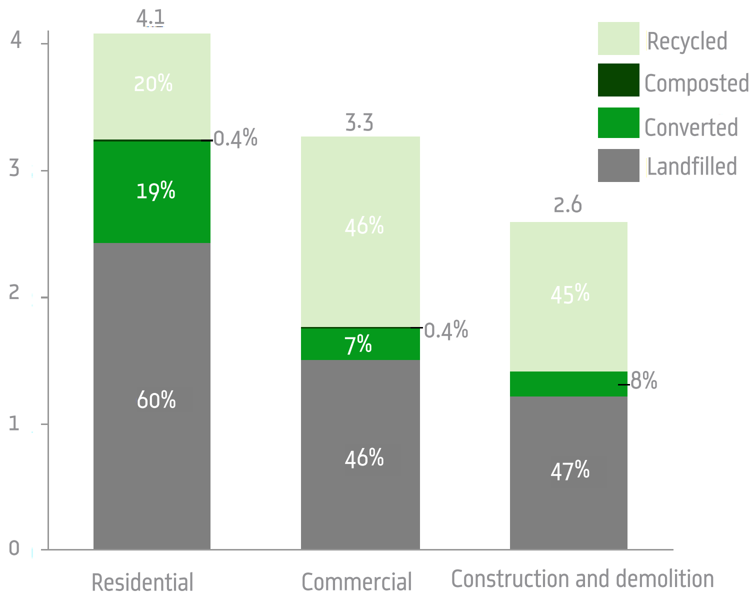
Solid waste transfer and processing facilities are spread throughout the city and far beyond it as well. The majority of DSNY's recyclable content is managed at the new Sims facility in South Brooklyn; composting is taken to locations in Staten Island, Rikers Island, and most recently, to the Newtown Creek Wastewater Treatment Plant; and everything left over is taken to waste-to energy facilities outside of the city or to transfer stations in the city that coordinate delivery to landfills as far away as Virginia and South Carolina. In the case of commercial carters, recyclables are taken to a variety of private processing facilities; compostable waste mostly travels to a facility in Delaware — though large commercial facilities are now under development closer by; and the remaining waste either goes directly to waste-to-energy facilities or is offloaded at a network of private transfer stations in and around the city and exported to remote landfills, mostly by truck. (See chart: *New York City's Solid Waste Infrastructure*)

The costs of managing the city's waste are substantial. DSNY spends more than $700 million a year to collect the waste, and more than $300 million to export it, paying on the order of $100/ton for landfill exports, around $60/ton to recycle metal, glass, and plastic, and earning $20/ton on paper recycling. Businesses spend comparable amounts.

The system has evolved over the years. In the first half of the twentieth century, building-based incineration was common, and disposal in local landfills was the standard until municipal landfills started closing, culminating in the closure of Fresh Kills Landfill on Staten Island in 2001. In 2006, the City's Comprehensive Solid Waste Management Plan (SWMP) addressed the issues of geographic equity in the siting of waste transfer infrastructure. Historically the Bronx and Staten Island hosted a disproportionate part of the city's waste infrastructure. The SWMP sought to minimize in-city waste truck traffic by committing to construct a network of marine transfer stations throughout the city, where waste would be loaded onto barges and then taken to transfer stations outside the city, in order to be put into rail cars and trucks and exported to landfills. Each borough would manage the waste it generates at facilities located within the borough. The City is in the process of signing long-term export contracts with landfills in the Northeast; five marine transfer stations are under construction and are scheduled to become operational in 2018.

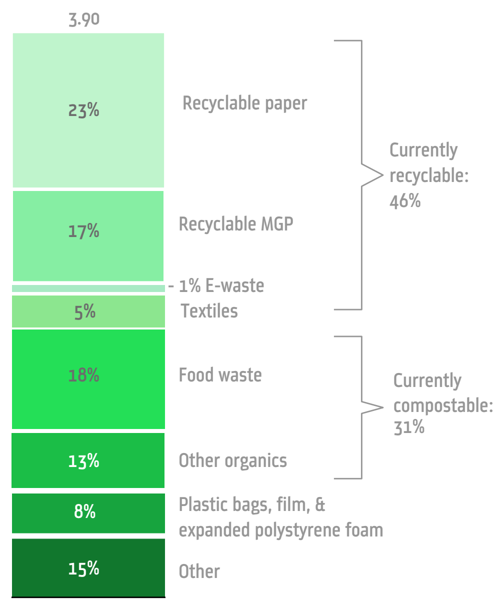
Approaches to managing waste are also evolving: in the 2011 update to PlaNYC, the City committed to diverting 75 percent of solid waste from landfills by 2030 (the number includes fill). In 2013, the City also undertook the largest expansion of the recycling program in its 25 year history by accepting all rigid plastics for recycling for the first time.

New York City Solid Waste by Source and Mode of Disposal
Millions of tons of waste; %, 2011



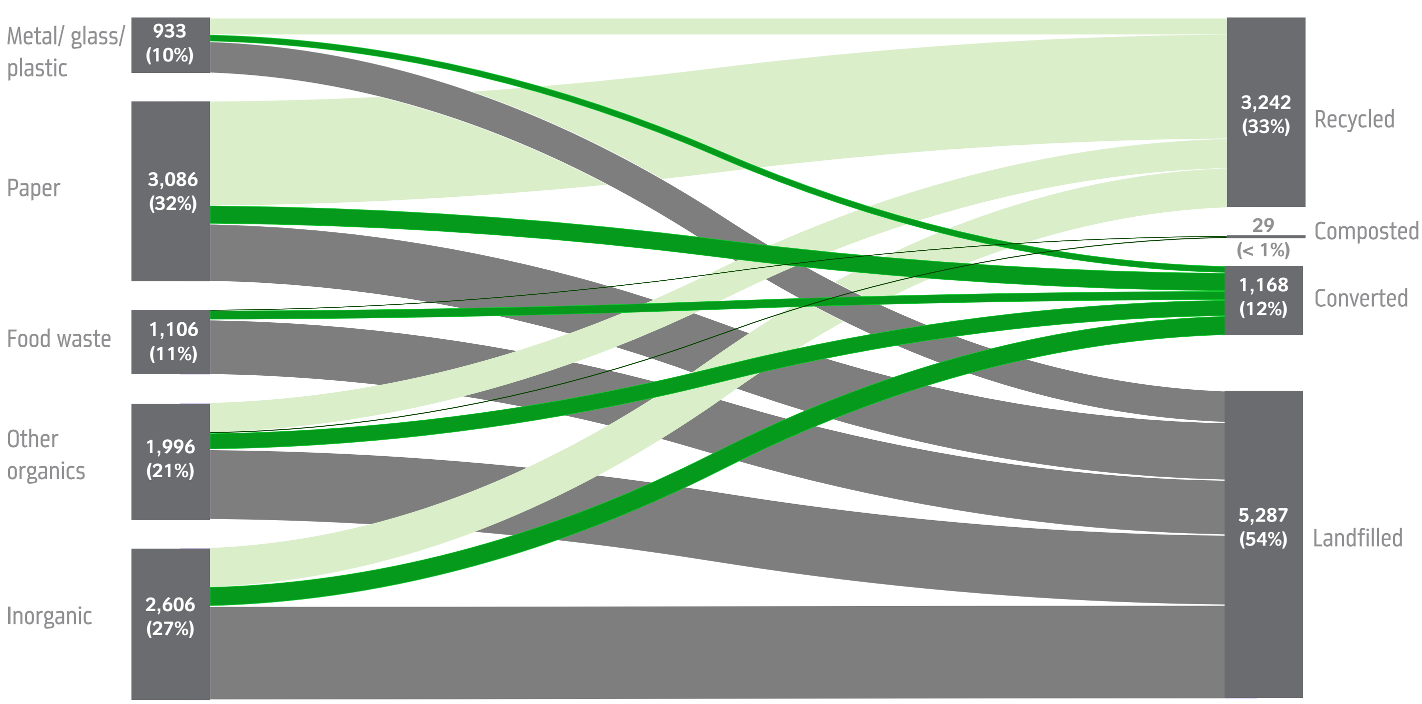
Source: NYC Mayor's Office

Residential Waste by Composition
Millions short tons; % of total; 2004-2005



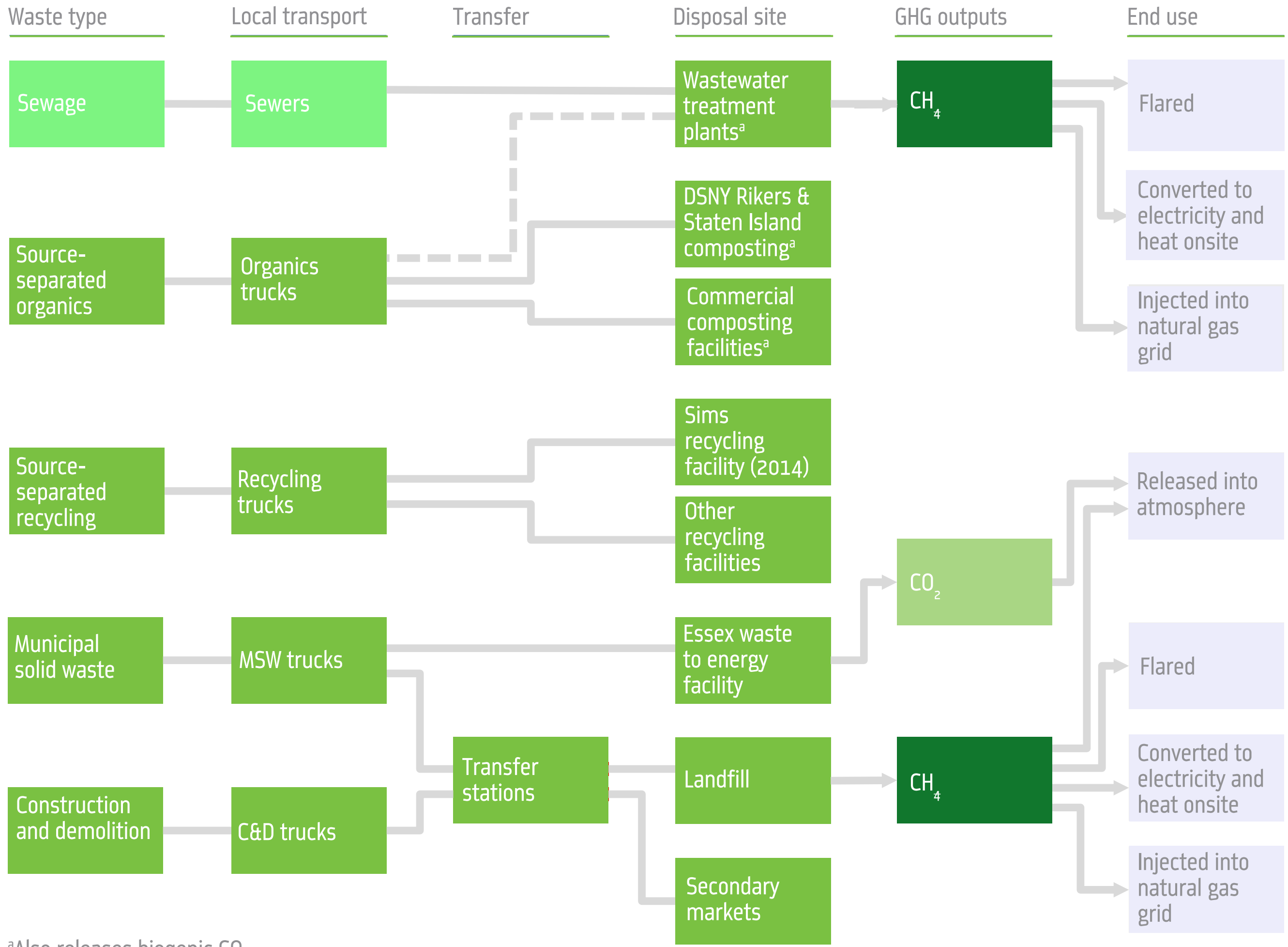
Source: NYC Mayor's Office

New York City Residential and Commercial Solid Waste Flows[18]
Thousands of tons; 2011



Source: NYC Mayor's Office

New York City's Solid Waste Infrastructure
As of 2013



[a]Also releases biogenic CO_2

Source: NYC Mayor's Office

Most recently, the processing of organic waste has come to the fore as the City is beginning to pilot curbside composting pickup in several neighborhoods in all five boroughs. In addition, working with the restaurant sector on a Food Waste Challenge requires participants to commit to diverting at least 50 percent of their food waste from landfill, and most recently, passing a requirement that large generators of organic waste source separate that content, beginning in 2015, in order to divert it from landfills. The City is also working with a waste management company to process food waste collected from Public Schools into a slurry and then use spare anaerobic digester capacity at the Newtown Creek Wastewater Treatment Plant to turn the food waste into biogas that can then be fed back into the utility grid.

Sources of GHG Emissions

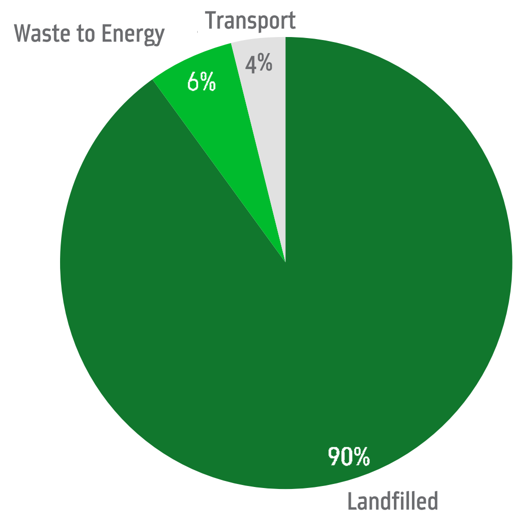
New York City's solid waste emissions come from three sources – landfill methane, waste-to-energy, and transportation – that in 2011 added up to more than 2.1 million tons.

Landfill methane is by far the biggest source: it is responsible for 89 percent of all solid waste emissions (See chart: *Solid Waste GHG Emissions by Source*). The methane is generated when paper and organic waste decompose in landfills without oxygen (if oxygen were present, the decomposition would produce CO2 instead). Most landfills install equipment that captures up to 90-95 percent of the leaking methane and either flares it, produces electricity with it, or cleans it and feeds it into the gas grid. However, because the global warming effect of methane is 25 times as high as that of CO2, even the relatively small amounts of fugitive emissions should be avoided.

Emissions from processing waste at waste-to-energy facilities are the second, but far smaller, source of emissions, with a 6 percent overall share. Transportation represents an even smaller share of the overall emissions, but has been a source of emissions reductions in recent years as export of municipal solid waste has shifted from truck-based to rail- or barge-based transportation.

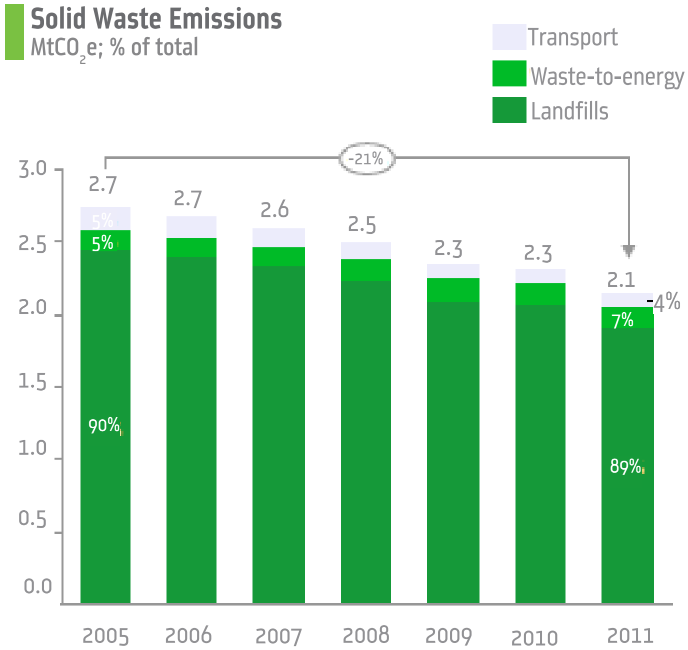
The relative composition of these three components has remained relatively unchanged since 2005, but the total fell by 21 percent, mostly because New Yorkers began to generate less waste per capita and because of the aforementioned mode shift. Exact reasons for the decline will not be known until DSNY completes a new waste characterization study (the previous one dates from 2005), but the technology-related decline in paper use and newsprint circulation might offer a partial explanation.

Solid Waste GHG Emissions by Source
% of total; 2012



Source: NYC Mayor's Office

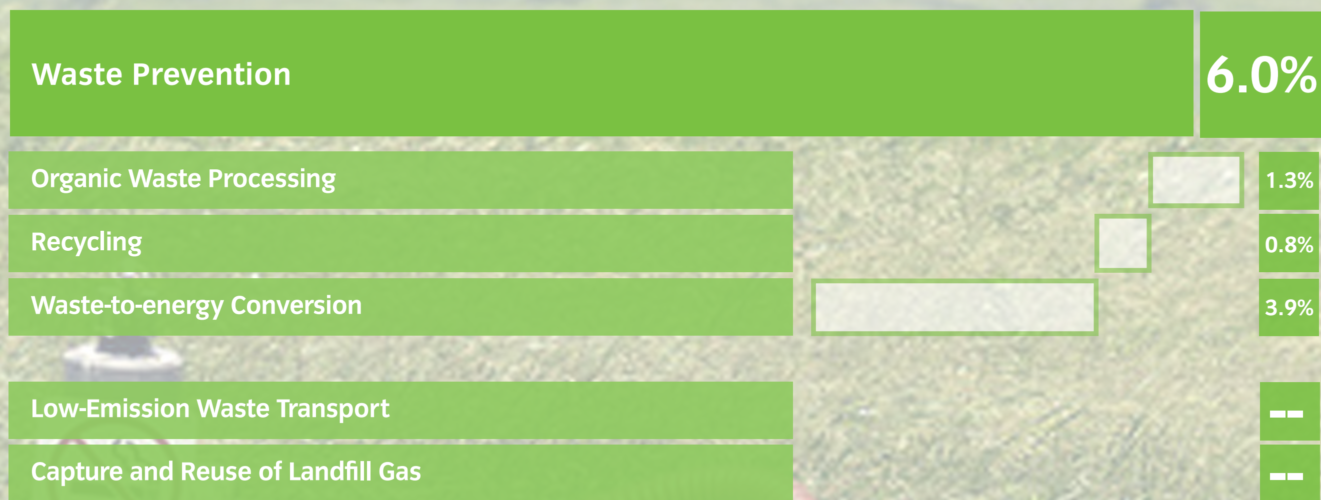
Solid Waste Emissions
$MtCO_2e$; % of total



Source: NYC Mayor's Office

Technical Potential of GHG Reduction Measures

As % of total 2005 emissions



Credit: Mike Di Paola, Bloomberg

Emissions Abatement Potential

The "three R's" of solid waste management – reduce, reuse, recycle – are also a strong framework for limiting greenhouse gas emissions from the sector. On the 80 by 50 pathway, volumes of waste would need to drop as consumers use fewer disposables and manufacturers of goods pay greater attention to packaging. Nearly all organic waste would need to be composted or processed in anaerobic digesters within the region; nearly all recyclable material would need to be recycled; and most of what remains would need to be turned into to energy at state-of-the-art, low-emission conversion facilities. Only a very small portion of remaining waste would be sent to landfills, which would lead to savings both for businesses and residents. The sector that produces more than 2.1 million tons of emissions today would need to be nearly carbon free to reach 80 by 50.

Waste prevention

The best way to reduce carbon emissions from waste is not to generate it in the first place. Volumes of waste generated per capita usually go hand in hand with prosperity. The wealthier a city, the more its residents tend to consume, and the less they tend to reuse. For example, New York City residents generate nearly 1,800 pounds of waste per year on average, while residents of the average city in China generate nearly half that — a reflection of higher consumption and income levels in the U.S. compared to China.

In recent years though, New York City's waste generation volumes have been falling. Since 2005 they have fallen by more than 20 percent. While the reasons behind the decline are not entirely clear — explanations include lighter packaging, a decline in paper use because of computerization, and a shift in consumption patterns away from goods and towards services), they mirror the national trends: solid waste generation in the U.S. stood at 980 pounds per year back in 1960, climbed to 1,730 in 2000, and has since declined to 1,606 — a drop of more than 7 percent.

Still, potential exists to reduce the volumes of waste further – for example, another 20 percent reduction would eliminate 0.4 million tons of emissions. For example, reducing the use of disposable paper and plastic bags by 75 percent — the kinds of reductions that cities like Washington DC and Dublin that introduced bag fees or bans are seeing — could reduce emissions by almost 20,000 tCO_2e. In another example, reducing the use of plastic foodservice packaging by 55 percent could reduce emissions by 11,000 tons. These numbers are highly understated given that they only capture local emissions and not the upstream emissions embedded in these disposables — a factor that is important to consider in any discussions of the impact of better solid waste management. This study however assumed, conservatively, that per capita generation rates will remain flat.

Organic waste processing

1.3%[a]
0.8 million tons[b]
-$60 per ton[c]

Organic waste makes up about 35 percent of the city's waste stream but less than one percent of that amount is composted or otherwise processed. The rest goes to landfills, including over 1.2 million tons of discarded food waste alone. Organic waste is the greatest contributor to New York City's solid waste emissions because the decomposition of organic materials in landfills in the absence of oxygen produces methane — a greenhouse gas that is 25 times stronger than carbon dioxide. While modern landfills can capture as much as 90 percent of their methane — which they either flare, feed back into the natural gas grid, or convert to electricity onsite — older landfills may emit methane at higher rates. Two favorable alternatives to landfilling organic waste can help to reduce emissions.

The first alternative, composting, involves the decomposition of organic waste in the presence of oxygen at either small-scale facilities in backyards or community gardens, or at a larger scale in windrows. Because the decomposition is aerobic, organic compounds break down into CO2 instead of methane — and because these materials (plants, for example) originally captured CO2 from the air, the net impact on global emissions is zero (such emissions are also called biogenic).

The second option, anaerobic digestion (AD), involves the accelerated decomposition of organics without the presence of oxygen in the same process that sewage undergoes at wastewater treatment plants after it received initial treatment. Digesters break down the waste into water, methane, and sludge. The sludge is then exported

[a] Percentage sector wide reduction
[b] Amount of CO_2e abated
[c] Cost to abate carbon

to specialized landfills or turned into fertilizer, while the methane is captured and, just as with landfill methane, is either flared, burned to produce heat and energy, or cleaned and returned into the natural gas distribution grid, as will be the case at the City's Newtown Creek Wastewater Treatment facility.

Of the two options, scaling up of anaerobic digestion holds the greatest carbon reduction potential. Initiatives like backyard and community garden composting are important, particularly to build public awareness, but regular composting fails to capture all of the energy embedded in organic waste (which is why composting heaps heat up), whereas AD captures most of it. Anaerobic digestion also makes economic sense. Societal cost of carbon reductions is on the order of negative $60/ton in 2030 because processing waste locally and turning it into energy is far cheaper than sending it to landfills by truck. The GHG reduction potential from it amounts to at least 0.8 MtCO2e in 2050.

Of the two options, scaling up of anaerobic digestion holds the greatest carbon reduction potential. Initiatives like backyard and community garden composting are important, particularly to build public awareness, but regular composting fails to capture all of the energy embedded in organic waste (which is why composting heaps heat up), whereas AD captures most of it. It also makes economic sense: societal cost of carbon reductions is on the order of negative $60/ton in 2030 because processing waste locally and turning it into energy is far cheaper than sending it to landfills by truck. The GHG reduction potential from it amounts to at least 0.8 MtCO2e in 2050.

Recycling

0.8%

0.5 million tons

-$130 per ton

Non-organic recyclables that end up in landfills contribute less to the City's Scope 2 emissions than organics do. This is because of the recyclables that New York City collects, only paper decomposes, while metal, glass, and plastic only contribute to transportation emissions. That said, the real benefit of recycling comes from reducing upstream emissions by tempering demand for virgin materials like paper and aluminum that require large amounts of energy to produce (aluminum smelters require so much energy that they are usually sited based on proximity to cheap electricity). The avoided emissions from recycling far outweigh those emissions that New York City's current carbon inventory would capture.

Just like anaerobic digestion, recycling is also attractive economically: the City is currently paying around $60/ton to process metal, glass, and plastic – an almost 50 percent reduction from the cost of landfilling, and it is actually earning up to $20/ton for paper. As a result, improving recycling rates can offer cost-negative reductions at a cost of around -$130 per ton of carbon.

The city's current recycling rate is relatively low compared to other major cities which is why such aggressive efforts are underway to increase participation. Only about 20 percent of residential waste is recycled. Recycling rates in the commercial sector are higher — around 46 percent, in part because much of it is paper, which is a valuable commodity. If recycling rates were to increase to 30 percent on the residential side — which is the City's current 2020 goal — and, very conservatively, stay at least unchanged on the commercial side, the city could reduce annual GHG emissions by at least 0.5 MtCO2e by 2050.

Waste-to-energy conversion

3.9%

2.5 million tons

-$100 per ton

Approximately 19 percent of the city's non-recycled residential waste and 7 percent of its non-recycled commercial waste travels to conversion facilities in Essex County, New Jersey rather than to landfills. These facilities utilize high temperatures to combust waste and then use the heat from the combustion to produce steam, which then powers the turbines that generate electricity.

A newer technology called plasma gasification is beginning to emerge as a viable alternative: in gasification facilities, waste is not combusted, but is rather heated up to such a high temperature that it breaks down into basic molecules that form synthetic gas (syngas) which is then used to produce electricity – a cleaner and more efficient way of turning waste into energy. The technology is not yet available in or around New York City, but the plants are clean enough and can be small enough to potentially site them in or near the city and connect them to either the local district heating systems or even potentially the steam system. Plasma gasification facilities could also be retooled to turn syngas into methane and then export it to the grid or to turn it into liquid fuels.

Several pilots have already been constructed around the U.S. and globally and the technology is becoming more promising. Although the siting of waste-to-energy facilities within or close to the city could be met with opposition from local residents, other cities — most notably Copenhagen — have successfully integrated small scale waste-to-energy facilities into their district heating systems, ultimately gaining public acceptance for the idea of processing waste closer to where it is generated.

The total potential carbon abatement from plasma gasification is 2.5 MtCO2e by 2050, which would enable the waste sector overall to become a carbon sink — i.e. it would create a net reduction in the city's overall emissions inventory. It is important to note, however, that although waste conversion using plasma gasification may be attractive from a carbon accounting point of view, it should not become a replacement for waste prevention, recycling, and composting, all of which are preferable from an overall environmental standpoint. As with organics processing and recycling, the cost per ton of carbon abated would be negative — around -$100/ton in 2030.

Low-emission waste transport

Waste transport accounts for just 4 percent of the city's solid waste emissions. A small share comes from the trucks that collect waste within the city; the majority is from larger long-distance export trucks that travel hundreds of miles to landfills out of state because landfilling is cheaper where land values are lower. The City's 2006 Solid Waste Management Plan called for transitioning to rail and barges for exporting waste as an alternative to trucks and implementation of the plan has already reduced emissions by 50,000 tons. Transport emissions could be reduced further through additional mode-shifting or through using more efficient vehicles and cleaner fuels for the long-haul export trucks. Because of the small size of the impact of mode-shifting, the exact potential was not quantified.

Capture and reuse of landfill gas

All landfills to which the city exports its waste capture fugitive methane, which they flare, turn to energy, or sell into the natural gas. The average landfill capture rate is around 85 percent. At landfills within the city, all of which are now capped, generation of methane is declining and methane capture is improving, which in recent years contributed to a 30,000 tCO2e reduction in emissions. While small additional improvements may be possible with better technology, further analysis was not conducted.

Challenges

The solid waste system could one day be nearly carbon-free — but three challenges stand in the way, having to do with choices, incentives, and infrastructure.

The right choice is not always the easy choice within the existing system

Every day, eight million New Yorkers make decisions about waste — whether to reuse, or recycle, or to compost, or to send something into a landfill. These decisions compete with hundreds of others — and if it comes to a choice between putting a water bottle in the trash, recycling it, or not buying it in the first place, the simplest option will often win. Recycling is available, but can be complicated; composting is thought of as an option for only the most environmentally minded. And even environmentalists can be frustrated by resource choices and packaging decisions that are made upstream, where the consumer has little influence. As a result, most waste ends up in landfills – even if the people who send it there would prefer that it did not.

Many residents and businesses are not concerned and have no incentive to be

Some New Yorkers pay enough attention to recycling and composting that they will begin to recycle new types of waste on the first day a new option is announced. But others will express little or know interest in learning new rules or changing behavior. They might benefit from having more information — but that may not stop them from feeling that "green" options are too varied or inconvenient. They might choose to modify their behavior if they had the incentive — but with waste pickup included in the tax bill, they have few reasons to do so.

Infrastructure to support new waste handling methods is unavailable locally

New York City exports most of its waste, and local facilities for processing it are in limited supply. The situation improved this fall with the opening of the Sims Recycling Facility in South Brooklyn, but more infrastructure is needed, particularly for organic waste processing. Small-scale, community- based composting programs are spreading to Greenmarkets and neighborhood facilities throughout the city thanks to a partnership between GrowNYC and the NYC Department of Parks and Recreation, but these sites do not offer sufficient processing capacity for a city-wide organic composting effort. Additional processing infrastructure is expected to come online now that the City passed legislation that will require large generators to divert organic waste from landfills by 2015.

Capturing the Potential

Strategy 1
Making it Easier to Compost and Recycle

Recycling in the public realm

New Yorkers can recycle at home and at work—but until recently their only option on most city streets was to toss their recyclables in garbage cans. In March 2013, Mayor Bloomberg launched the city's first public space recycling pilot, inaugurating 30 BigBelly solar-powered recycling compactors in Times Square that will serve more than 500,000 people who pass through the area every day. Conventional recycling containers are on the way as well: by the end of 2013, the City will place more than 1,000 of them around New York. Future efforts to encourage recycling would have to continue expanding the availability of public recycling options.

Recycling in apartment buildings

Many of the city's apartment dwellers may want to recycle but may not know enough about their options or may lack room for separate recycling bins in their buildings. To expand the availability of space for recycling in apartment buildings, the Green Codes Task Force—a group of more than 200 design and real estate professionals that were convened by the Urban Green Council at the request of Mayor Bloomberg and New York City Council Speaker Christine Quinn—recommended that new and fully renovated buildings with more than 12 units include a designated waste and recycling room. This proposal was enacted into law.

Existing buildings without dedicated recycling rooms can still benefit from better information and simpler recycling rules. To this end, DSNY recently expanded the recycling program to include for the first time the recycling of all rigid plastics, including toys, hangers, shampoo bottles, coffee cups and food containers, which will reduce confusion about which plastic types are recyclable and which are not. The City also simplified its information materials and messaging about recycling to educate New Yorkers about these changes.

Composting options

In 2013, DSNY started collecting organic waste from several neighborhoods in Staten Island, Queens and Brooklyn, picking it up from single- and multi-family homes several times a month and delivering it to transfer stations, from where it is sent onward to composting and anaerobic digestion facilities. The program has proven successful and is now being expanded to other neighborhoods and building types.

Strategy 2
Changing Behaviors through Education, Challenges and Incentives

Improving marketing and education

Individual actions can have a huge impact in changing the marketplace. New Yorkers are certainly open to the idea of changing their behaviors: a recent study by GreeNYC, PlaNYC's public education arm, found that the city's residents were collectively willing to take simple actions that could reduce up to 200,000 tons of paper, textile, and food waste per year—2 percent of the city's waste stream. Converting this willingness into real reductions will be challenging. Collection for commercial and residential waste streams operates entirely independently and this can cause confusion and frustration. To address the issue, the City is already working to improve its educational tools and is working with the commercial waste sector to achieve consistent messaging; the work will need to continue.

Food waste challenges

Mayoral Challenges, where several organizations within an industry are asked to commit to sustainable goals on a voluntary basis have worked well for greenhouse gas emissions – and the model can be expanded to solid waste. The Mayor's Food Waste Challenge, a voluntary challenge to the private sector to commit to divert from landfills at least 50 percent of the food waste that they generate is doing just that. The program requires participants to conduct a baseline waste generation audit and then use simple tracking techniques to measure diverted waste on an ongoing basis. It will also be complemented by a professionally branded, "consumer facing" campaign that could engage diners and the public to build awareness and support for organic waste composting. A high-profile group of participants and a successful program could prove that organic waste diversion is feasible, affordable, and good for business.

Price signals

Waste collection and export may cost the City hundreds of millions of dollars annually, but most New Yorkers would not notice since they are not billed directly but rather indirectly through their tax bills. As a result, households have no monetary incentives – other than fines for non-compliance – to either recycle more or to reduce the amount of waste they generate. Cities across the country have developed creative solutions to setting price signals that incentivize waste reduction. For example, the City of Philadelphia and others have partnered with private companies to incentivize recycling by providing discounts and gift certificates at leading retailers. Other cities have set direct price signals through Pay-As-You-Throw programs in which homes are charged for non-recyclable waste they generate, which becomes an incentive to produce less waste. In New York City, implementing these programs in multifamily housing could be challenging; one and two-family homes could present less of an obstacle.

Strategy 3
Spurring Action through Mandates and Enforcement

Targeted waste reduction measures

According to the City's 2005 Waste Characterization Study, paper and plastic bags represent 3.4 percent of the city's residential waste stream, or 120,000 tons a year. Cities like Dublin and Washington DC have already launched targeted campaigns to reduce disposable bag use – one program to impose small bag fees succeeded in reducing their volume by as much as 90 percent and significantly reduced pollution in rivers and water bodies. In New York City, similar measures to manage bag use could divert large amounts of waste from landfills at a negligible consumer cost.

Organics collection from the largest generators

The top 10 percent of food waste generators — large hotels, banquet halls, cafeterias, and food wholesalers — produce approximately 40 percent of organic waste. Policies and programs to introduce organics collection for at least these largest generators — including through mandates–would help jumpstart organics processing. To this end, the City recently passed into law a requirement that large generators of organic waste — those that generate at least one ton per week — divert it from landfills through source separation. When fully enacted in 2015, the law could result in up to 30 percent of the city's organic waste being diverted from landfills while only affecting less than 5 percent of businesses that generate organic waste and less than 0.5 percent of businesses overall.

Diversion of construction and demolition waste

Construction and demolition accounts for more than a quarter of the city's waste. The City is already addressing the issue through the Green Codes process: a recently passed local law requires at least 30 percent recycled asphalt in new streets, which will divert up to than 300,000 tons of asphalt away from landfills every year. Two more proposals are moving through City Council: one establishes requirements to recycle C&D waste from construction sites; the other requires a minimum percentage of recycled concrete in certain types of building materials. The proposals are expected to be introduced in the first half of 2014.

Packaging waste reduction

Governments, corporations and institutions across the country have begun to implement "Extended Producer Responsibility" (EPR) programs that allow large purchasing entities to use their buying power to encourage product suppliers to reduce packaging waste and end of life disposal costs without imposing an explicit tax. These programs allow producers to find the most efficient means of reducing waste, which can include reuse, buyback, or recycling, often with the assistance of a third party. These typically occur at the level of states – California's EPR programs have achieved significant reduction in the types and volume of packaging that end up in the waste stream, for example – but city-level measures could be just as viable.

Recycling enforcement

In 2010, Mayor Bloomberg signed legislation to raise the penalties for failing to recycle for the first time in over a decade. The new system created tiered penalties depending on building size; the penalties increase with building size. As new recycling programs come into effect, strong and effective enforcement will be crucial.

Strategy 4
Developing New Infrastructure to Support Better Waste Disposal

For years, New York City's waste processing infrastructure was focused on sending waste to landfills quickly and efficiently – first locally, in places like Fresh Kills, and then to other nearby states. Recycling infrastructure is beginning to catch up, but modern waste-to-energy and anaerobic digestion facilities would still need to be constructed if the city is to achieve its diversion goals and support the processing of higher volumes of waste diverted from landfills as education and incentives begin to take effect.

Recycling

The city's recycling infrastructure is improving: working in partnership with Sims Metal Management, the City is now constructing a state-of-the-art recycling facility at the South Brooklyn Marine Terminal that will process metal, glass, and an expanded variety of plastics. Another facility key to increasing the diversion rate is the Gansevoort Marine Transfer Station, located on the Hudson River in downtown Manhattan. The station, now under construction, will accept metal, glass, and plastic, along with paper from residential and commercial sources, and will become Manhattan's primary recycling marine transfer station, connecting by barge to the Sims facility and the Visy paper mill in Staten Island. Not only will this allow Manhattan to collect and transport its own recyclables for the first time, it will also eliminate nearly 14,000 truck trips per year to the Bronx and New Jersey.

Construction of the Gansevoort Station will also allow the City to convert Manhattan's West 59th Street Marine Transfer Station to the borough's only construction and demolition transfer facility. This will make it possible for C&D waste to leave Manhattan by barge instead of by truck, which is how the 400,000 tons of waste generated by construction activities in Manhattan leave the borough today.

Anaerobic digestion

Anaerobic digestion would have to play a major role in capturing the abatement potential of organic waste – but no dedicated facilities are yet available anywhere near New York City. The closest major organics processing facility is located in Delaware – but it uses the aerated windrow method, which ensures that the waste releases CO2 instead of methane as it decomposes but does not capture its full energy potential. A pilot AD facility in or near the city could help improve the economics of composting, make it more attractive to local businesses, and begin to solve the self-reinforcing problem of constrained processing capacity preventing the takeoff of demand, and vice versa.

Organics processing at wastewater plants

If food waste challenges and, down the road, a potential organics mandate succeed in generating high enough food waste volumes, the private sector will inevitably step in to offer processing solutions. Yet the necessary AD infrastructure might take several years to permit and build – and in the meantime, processing capacity is readily available within the city. Of the city's 14 wastewater treatment plants, 4 have spare capacity to process up to 560 tons a day of organics, of which 500 tons are at Newtown Creek, the city's newest plant. There, the Department of Environmental Protection (DEP) is partnering with a private company called Waste Management to process up to 60 tons of food waste a day, increasing to 250 tons by 2017 as long as all technical challenges are resolved. DEP will also launch a study to examine the economic and technical feasibility of repairing the digesters that are currently out of service or even potentially building new ones to handle higher volumes of organic waste.

Onsite food waste processing

Large-scale AD facilities are central to processing the city's organic waste, but not all of the waste needs to be picked up for processing. Where enough of it is generated in one place, it can be processed locally. Technologies to do so are available and large waste generators like produce markets could be possible candidates for piloting on-site processing of food waste.

Waste conversion

Fully capturing the abatement potential of waste conversion through plasma gasification or other comparable technologies would require constructing a network of facilities throughout the city – but a pilot would have to be developed first. A small-scale advanced conversion technology facility could serve as a proof concept for New York City, making it possible to test the economics of the project, potentially integrate it into local heating systems, and develop it into a blueprint that could later be used citywide.

Strategy 5
Improving Solid Waste Transportation

Transportation only represents a small proportion of solid waste emissions, but opportunities to improve it do exist for both municipal and commercial fleets.

Biofuel use in City waste fleets

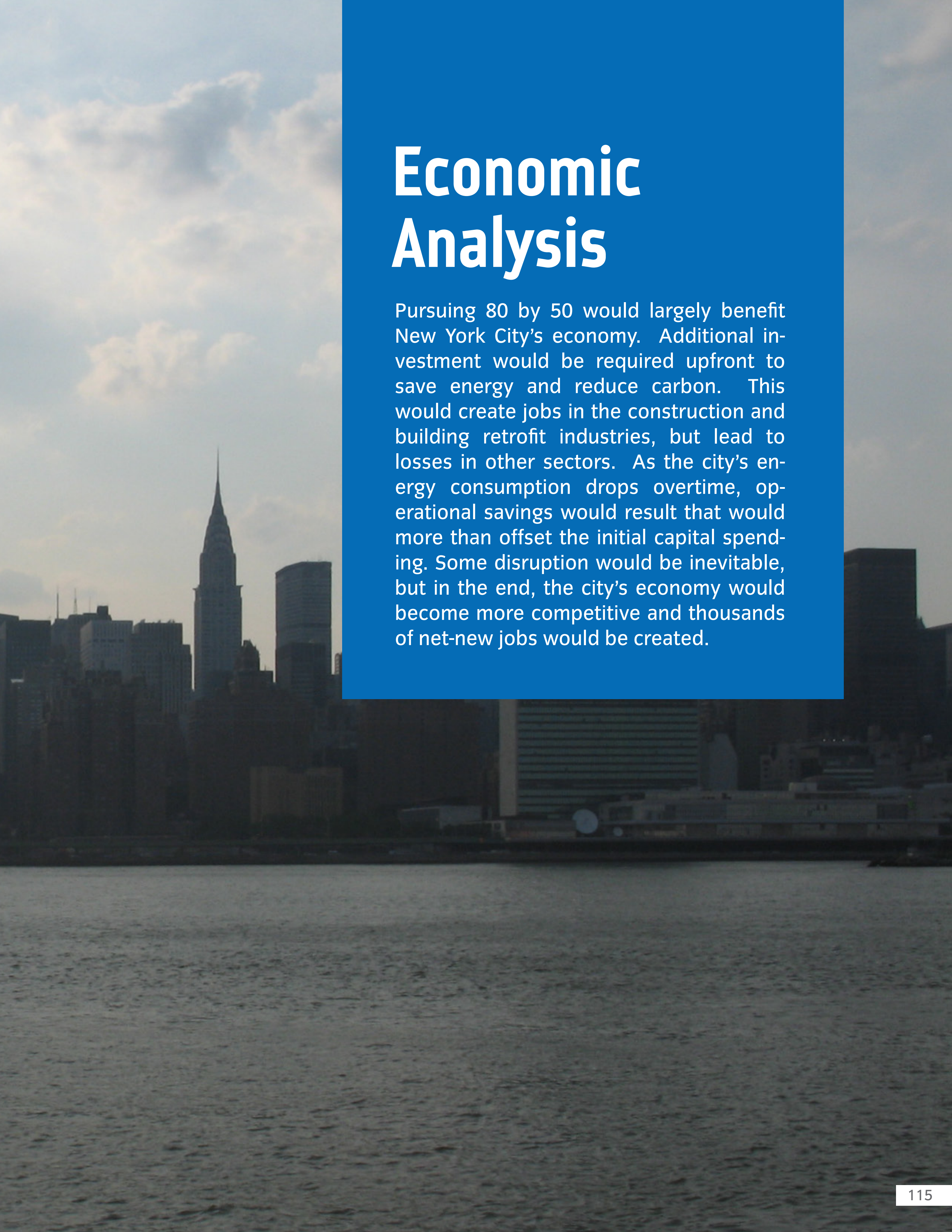
The Department of Sanitation has pioneered the use of biodiesel in its fleets and over time this practice has been adopted across agencies. All diesel-powered City vehicles now utilize a 5 percent blend of biodiesel (B5) and as of 2016, these vehicles will be required to use B20 between the months of April and November. Expanding to higher concentrations of biodiesel in City fleets would present an opportunity to "close the loop" in solid waste management because biodiesel can be processed from waste cooking oil and agricultural by-products at local facilities.

Modernization of private waste fleets

Many of the city's more than 200 commercial carters operate trucks that are over 15 years old and inefficient compared to newer models. Carters will gradually replace their trucks with models that comply with recent federal fuel efficiency standards – but the process could be accelerated through a mixture of requirements and incentives, helping reduce not only carbon emissions, but also emissions of airborne pollutants, which would have a direct positive impact on public health.


Credit: John H. Lee; NYC Mayor's Office

Midtown Manhattan, view from Queens



Economic Analysis

Pursuing 80 by 50 would largely benefit New York City's economy. Additional investment would be required upfront to save energy and reduce carbon. This would create jobs in the construction and building retrofit industries, but lead to losses in other sectors. As the city's energy consumption drops overtime, operational savings would result that would more than offset the initial capital spending. Some disruption would be inevitable, but in the end, the city's economy would become more competitive and thousands of net-new jobs would be created.

Abatement Cost-Effectiveness

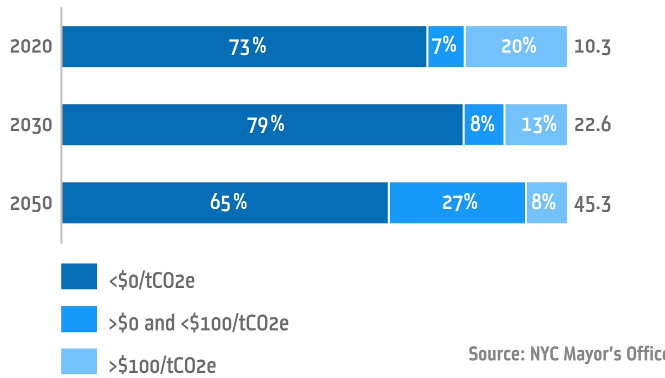
As described in the preceding chapters, reaching 80 by 50 would require a portfolio of actions to reduce carbon across all sectors, year in and year out. Many of these measures would come with an incremental cost or need for upfront investment. However, as long as measures are timed to coincide with natural replacement and retrofit cycles, the majority would more than pay for themselves because of savings in energy consumption, solid waste export fees or other operational expenditures. At a 4 percent discount rate, these measures would be beneficial from a societal standpoint or, in other words, they would have a "negative-cost."

In 2030, for example, nearly 80 percent of carbon abatement measures are estimated to be cost-negative. Another 8 percent of measures would cost less than $100/ton, and only 12 percent cost more than $100/ton. As 2050 approaches, more expensive measures would eventually need to be implemented to achieve an 80 percent reduction, but overall, two-thirds of measures would be cost-negative.

The cost effectiveness of abatement measures would vary significantly by sector. In the solid waste sector, for example, 100 percent of measures would be cost-negative because the fees that the City and private companies currently pay for waste export are so high and diverting waste to recycling and composting is nearly guaranteed to save money. Likewise, over 80 percent of abatement measures in buildings would be cost-negative because savings from reduced energy consumption would typically exceed upfront costs.

In the power sector, however, approximately 95 percent of measures would cost above $100/ton.[19] This does not include behind-the-meter technologies such as solar PV, which are assumed to enter the market on an economic basis (e.g. at grid parity). Large-scale renewables might reduce the need for fossil fuels in electricity production, but the amount of upfront capital investment they would require would exceed any savings over time. Nevertheless, achieving 80 by 50 without cleaning up the electric grid would be nearly impossible. But at the same time it is essential to reduce electricity demand as much as possible in order to reduce the amount of clean power generation that would need to be built and therefore to minimize costs. (See chart: *2030 Abatement Costs by Sector*)

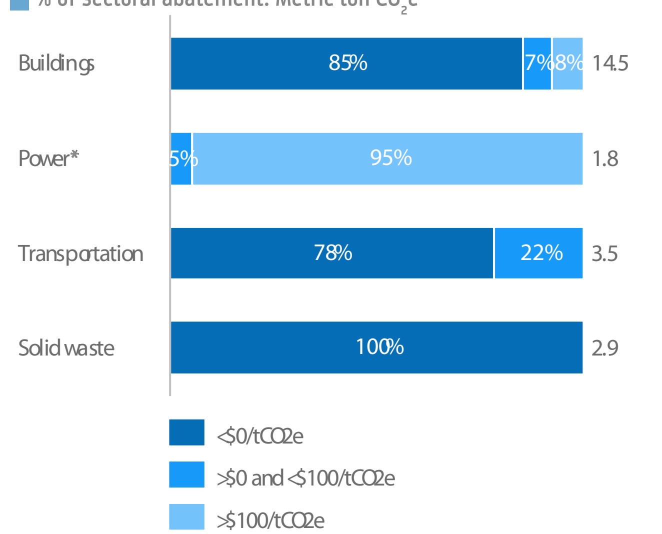
Abatement Potential by Cost per Ton
% of total; Metric tons Co_2e



Source: NYC Mayor's Office

Ranking abatement measures by their cost effectiveness on a marginal abatement cost curve demonstrates a theoretical pathway to reach 80 by 50. The lower cost abatement measures like plug load reduction and lighting upgrades—appearing on the left hand side of the abatement curve—are tapped first and consistently over time as more and more buildings replace their equipment on a natural time cycle. In contrast, more expensive measures like electrifying heating systems or building out large-scale renewable energy resources are delayed until later years when technology costs fall and other abatement options becomes scarce enough that capturing this potential becomes necessary. (See graphics: *Emissions Abatement Potential by Year*)

2030 Abatement Costs By Sector
% of sectoral abatement: Metric ton CO_2e

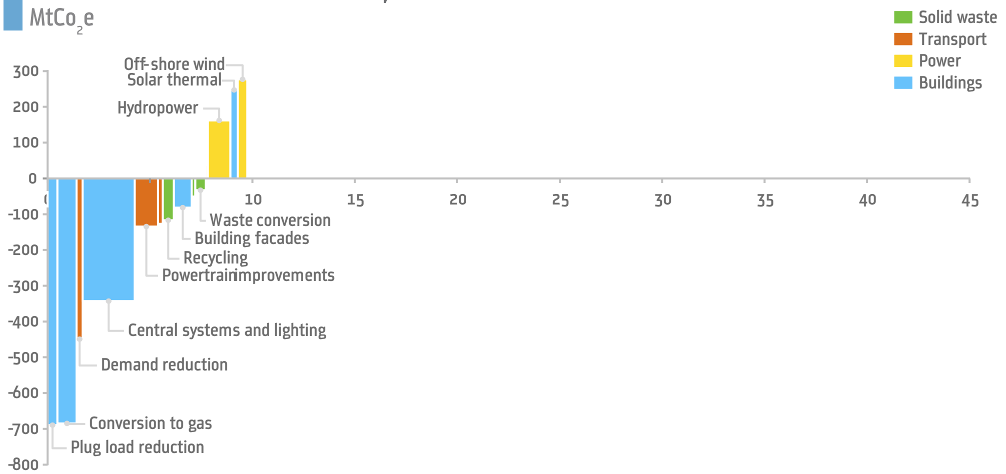


* does not include behind the meter technologies

Source: NYC Mayor's Office

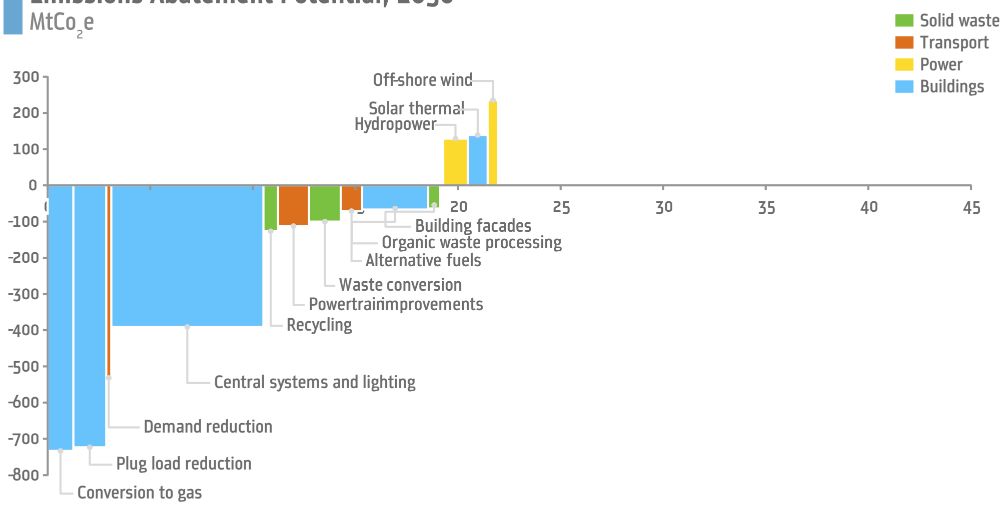
Emissions Abatement Potential; 2020

$MtCo_2e$



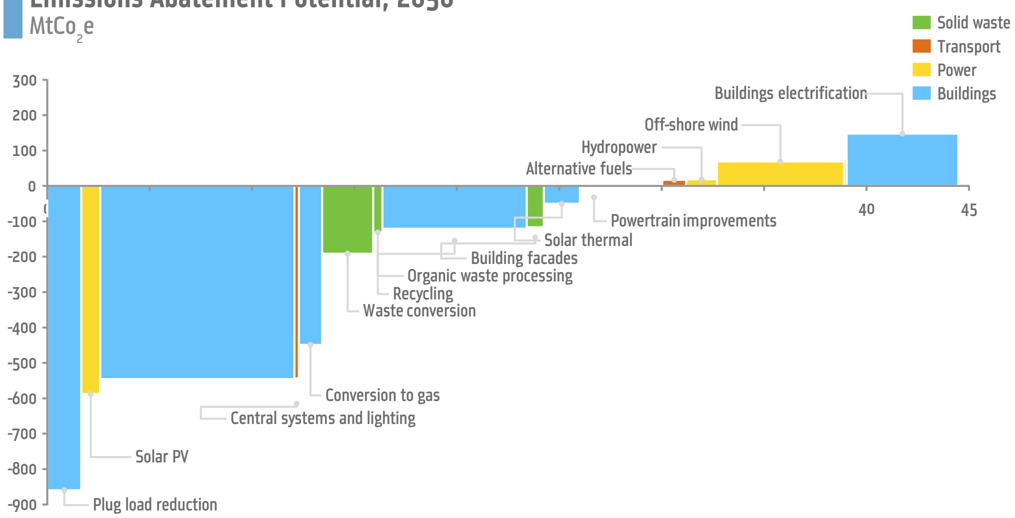
Emissions Abatement Potential; 2030

$MtCo_2e$



Emissions Abatement Potential; 2050

$MtCo_2e$



Source: NYC Mayor's Office

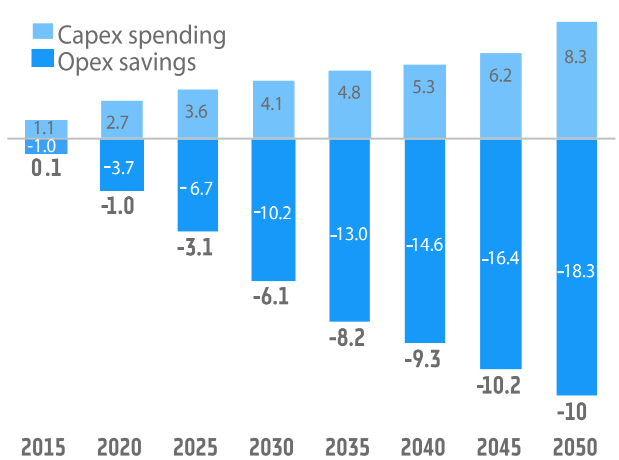
Changes to Capital and Operational Expenditure Flows

To achieve 80 by 50 would require billions of dollars of incremental capital investment. Over the next twenty years, the majority of this incremental investment would go towards energy efficiency retrofits in buildings. Investments in clean power would ramp up after 2030, while incremental spending on more efficient and less polluting transportation would be smaller but steady throughout the next several decades. The effect of these investments would be felt in the near term as buildings begin to utilize less electricity, natural gas and liquid fuels, and as vehicles become more efficient. As a result, annual savings on operational expenditures (opex) would exceed the required annual capital investments by 2020. By the 2030s, the annual savings would equal more than $6 billion a year. (See chart: *Changes in Annual Capital Spending and Opex*)

The amount of capital investments required – $1 billion a year in 2015 and scaling up to more than $4 billion a year by the 2030s – is comparable to the entire capital investment programs of Con Edison or the Department of Environmental Protection (DEP), the city's water and sewer utility. However, the number needs to be seen in the context of citywide investments that occur every year in the course of normal construction and activity. In 2012, for example, more than $30 billion was spent on construction in New York City; an additional $4 billion a year would represent 13 percent of this amount.

Changes in Annual Capital Spending and Opex

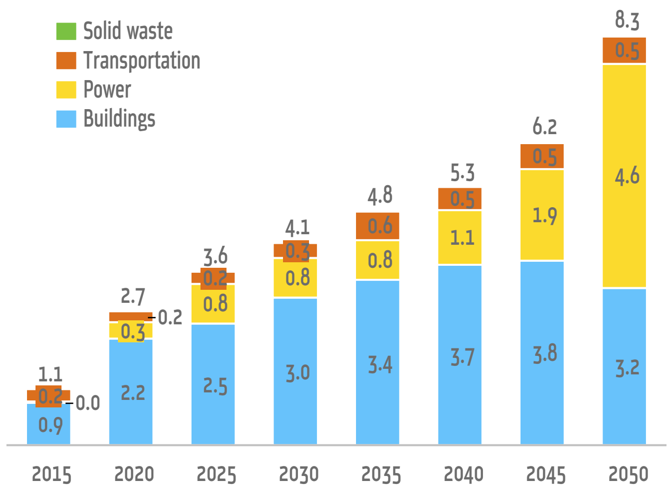
$ billions; net difference in bold



Source: NYC Mayor's Office

Changes to Annual Capital Investment Flows by Sector

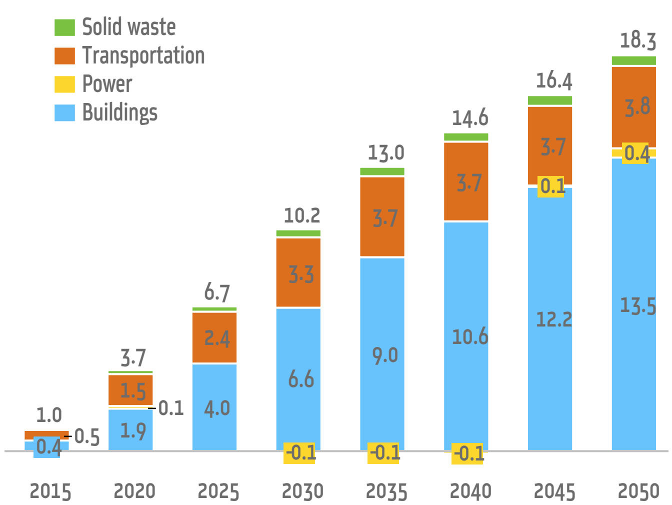
$ billions



Source: NYC Mayor's Office

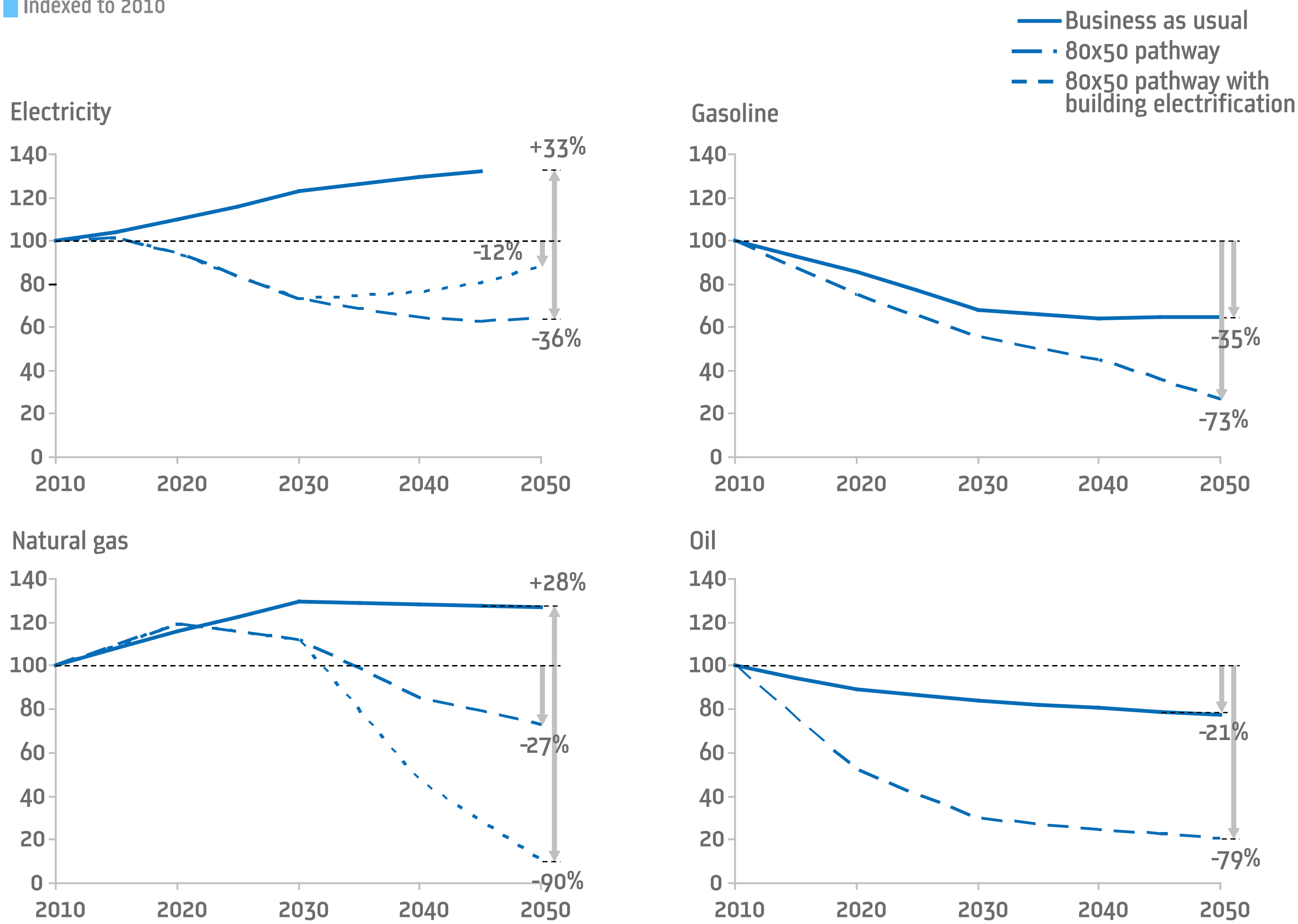
Changes to Annual Opex Flows by Sector under 80 by 50 BAU

$ billions



Source: NYC Mayor's Office

Changes to Energy Demand on the 80 by 50 Pathway vs. BAU
Indexed to 2010

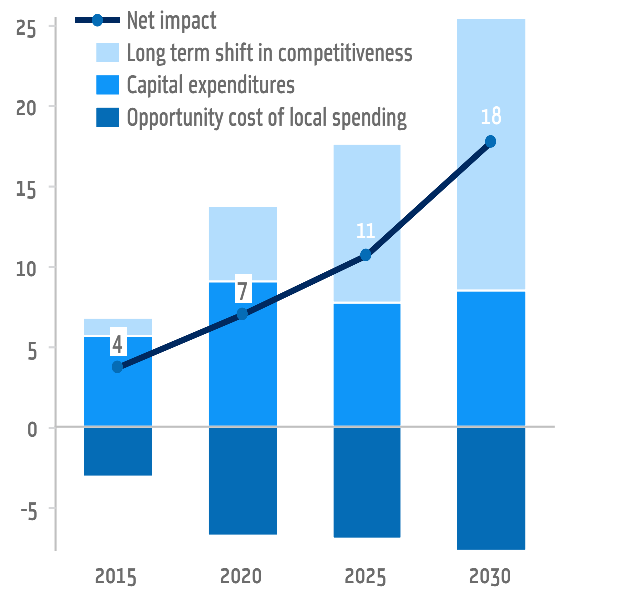


Source: NYC Mayor's Office

Changes to Energy Demand

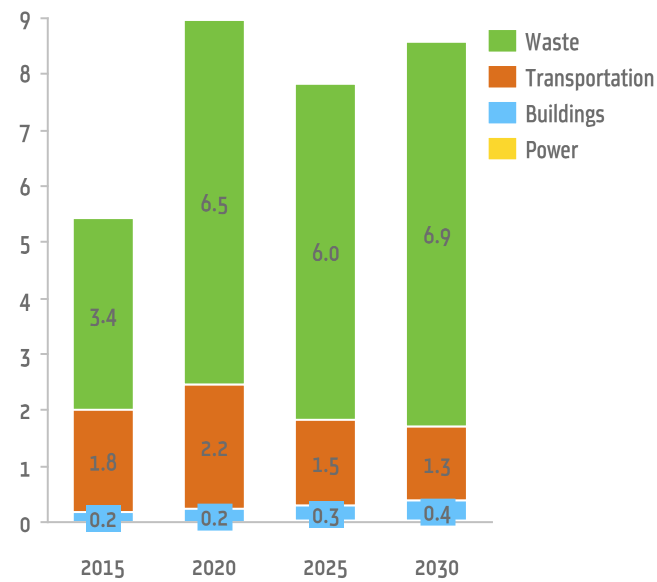
Reductions in energy demand would be the primary driver of operational savings in the economy. Electricity demand would initially drop as buildings become more efficient, but recover partially as vehicles (and potentially building heating systems) electrify. By 2050, electricity demand would be 12 to 36 percent below 2012 levels depending on how many buildings electrify. Gasoline demand is expected to drop even under the business as usual case because of aggressive federal standards to improve automobile efficiency—Corporate Average Fuel Economy or CAFE standards. On the 80 by 50 pathway, gasoline demand would decline even faster due to an accelerated switch to electric vehicles, reaching a 73 percent reduction from today's levels by 2050. Natural gas demand would first increase to accommodate buildings moving away from heavy fuel oils and then gradually drop as investment in energy efficiency grows. The extent of declining natural gas demand by 2050 would depend on how widespread electrification of buildings is, but it would exceed 25 percent and could be much higher. Demand for heating oil is also expected to drop in the business as usual (BAU) case because of the current pacing of oil-to-gas conversions, as well as the competitive economics of natural gas, but demand reductions could exceed 70 percent by 2050 on the abatement pathway. (See chart: *Changes to Energy Demand on the 80 by 50 pathway vs. BAU*)

Employment Impacts by Type
Thousands; by type of impact



Source: NYC Mayor's Office

Jobs Created Through Capital Expenditure, by Sector
Thousands



Source: NYC Mayor's Office

Impact on Local Economy

The changes to the patterns of capital investment and operational expenditures would impact the economy directly: jobs would be created in some sectors and lost in others, personal income would increase, and gross regional product would grow. The economic impact, only estimated through 2030 due to the level of uncertainty past that date, would occur via three main channels:

- **Direct impact of capital expenditures:** Capital investment directly creating jobs in construction and related sectors
- **Opportunity cost of local spending:** The diversion of spending from other sectors to pay for the investment in (1) leads to negative economic impacts in other sectors of the economy
- **Long-term shift in competitiveness:** Decrease in energy use resulting from capital investment helps to lower production costs and make the economy more competitive in the long term

The jobs impact from the combination of these three channels would be positive: by 2030, the 80 by 50 pathway could create up to 18,000 jobs — mainly because the economy would become more competitive. While the direct job creation spurred by capital investment would be offset by losses in other sectors, the resulting energy savings from capital investments would have enough of an impact on the economy's production costs to create thousands of net-new jobs over the next two decades. (See chart: *Employment Impacts by Type*)

Capital expenditures in buildings would play the most important role in the creation of jobs, contributing between 60 and 80 percent of all the new jobs. Power investments would account for most of the remaining job benefits, with solar PV installations contributing the most and offshore wind playing a role as well. The employment impact of transportation and solid waste measures would be negligible. (See chart: *Jobs Created Through Capital Expenditure, by Sector*)

Gross regional product (GRP) — or the measure of the strength of the region's economy — would benefit as well. By 2030, GRP would increase by nearly $1.9 billion a year. Investments in buildings, again, would provide the greatest contribution. Investments in cleaner power, on the other hand, would lead to losses because of its relatively higher costs. Personal income levels would experience similar effects, with cost savings from using less energy more than offsetting the higher prices consumers would pay for cleaner energy — leading to a net increase in income of $2.2 billion a year by 2030.

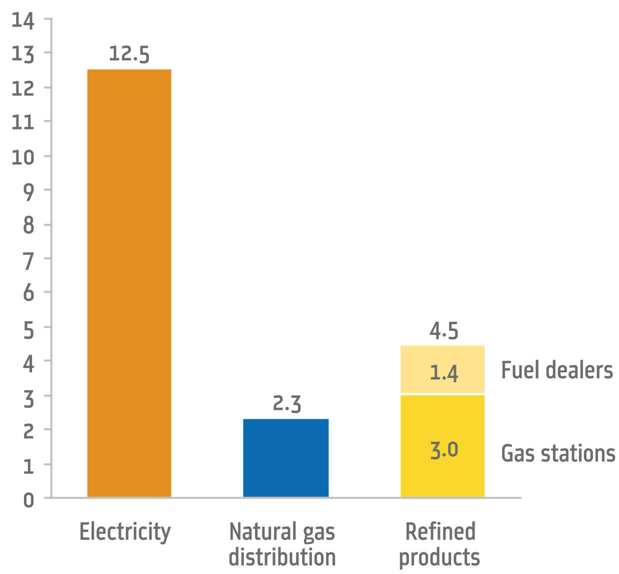
Economic Disruptions of Carbon Abatement

Impact on Energy Sector Jobs

Every year, New Yorkers spend almost $30 billion on energy – approximately $11 billion on electricity, $10 billion on natural gas and liquid fuels in buildings, and $8 billion on transportation fuels. Part of this spending goes towards the extraction and refining of fossil fuels, which takes place outside of New York City, but other parts support local jobs – 20,000 in total, or 0.2 percent of the city's total 2011 private sector employment of 3.1 million. More than half of these jobs are in electricity distribution (primarily Con Edison); the rest are in natural gas distribution, fuel distribution, and retail gasoline operations (See chart: *Energy Sector Employment in New York City*).

On the 80 by 50 pathway, the 12,500 jobs in power transmission and distribution would be relatively unaffected. The city would still have to maintain its electrical grid regardless of changes to either demand or the carbon intensity of electricity. The 500 jobs in power generation would be unaffected by 2030 – gas-fired power plants would still be playing a prominent role – but by 2050, the importance of gas-fired generation would decline, and at least some of those jobs would likely shift to other power generation technologies. The 2,300 jobs in natural gas distribution would remain relatively unaffected as well – just as with electricity, the city would still have to maintain its natural gas grid, though demand for natural gas would likely fall off because of energy efficiency and building electrification. Businesses serving the gasoline marketplace — 4,400 jobs in all — would likely feel the impact of decarbonization the most. Some of these businesses would reorient their services (gas stations, for example, could add EV charging); some would go out of business.

Energy Sector Employment in New York City
Thousands: based on NAICS-6 classification; 2011



Source: Bureau of Labor Statistics; NYC Mayor's Office

Impact on Lower Income Residents and Energy Intensive Businesses

Pursuing 80 by 50 could also have equity implications: total energy costs might drop for the city overall, but electricity prices would increase, affecting energy intensive manufacturing and residents who live on fixed income or low wages. Both cases would call for some form of assistance – and the necessary programs may already exist.

Manufacturing no longer accounts for as many New York City jobs as it used to – but industrial companies still employ tens of thousands of New Yorkers. These companies would stand to benefit less from energy efficiency than, for example, office buildings. Two existing programs administered by the New York City Economic Development Corporation, BIR (the Business Incentive Rate), and NYCPUS (the New York City Public Utility Service), have for years been providing discounts and rebates of up to 20 percent to local manufacturers. These and similar programs could be used to help energy intensive businesses mitigate the impacts of higher electricity prices related to decarbonization in order to maintain competitiveness of local manufacturing. As discussed previously, decarbonization would ideally occur at a national or at least regional scale in order to level the playing field, so that New York City's industries are not disproportionately impacted.

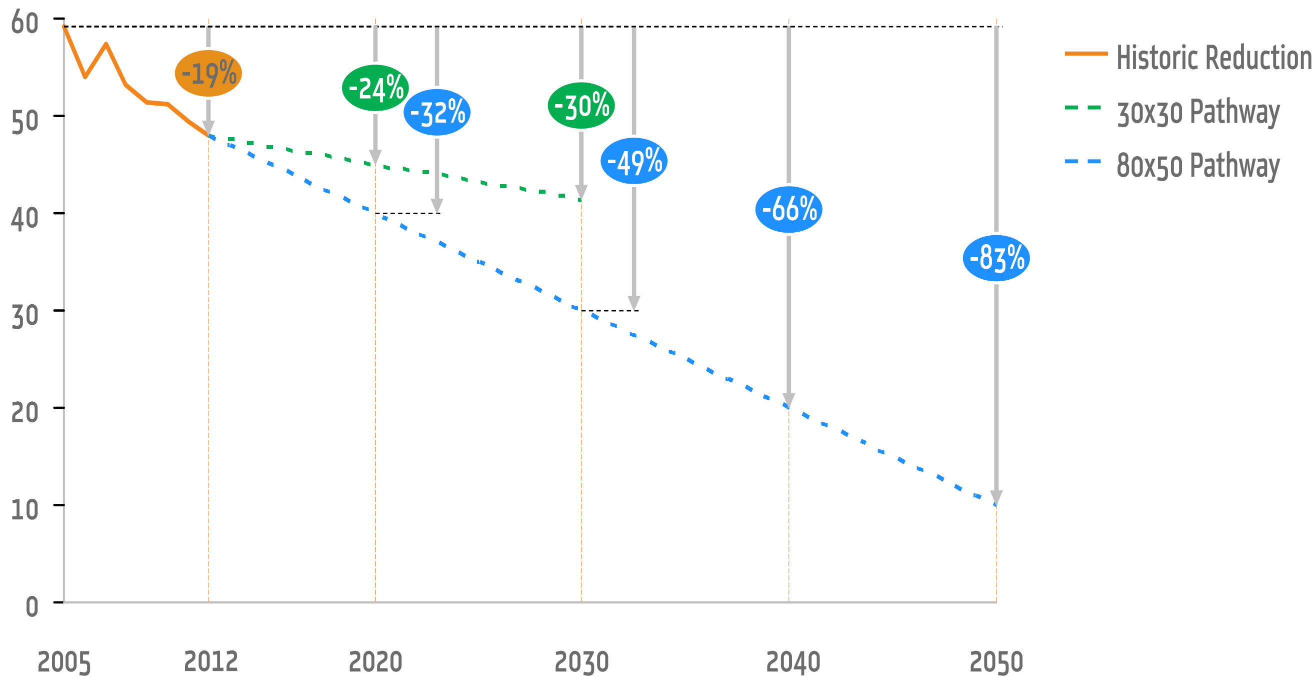
City residents that live on fixed incomes or low wages could benefit from energy efficiency measures if they were able to partake in them, but practical obstacles could limit uptake and help would be required to mitigate cost of living impacts. NYSERDA's EmPower New York program provides income-eligible New Yorkers with energy efficiency services for no cost, while the New York State Department of Housing and Community Renewal provides free and low-cost weatherization services through its network of contractors. The federally-funded Low Income Home Energy Assistance Program (LIHEAP) helps income-eligible residents to pay for the costs of home heating. These programs could be adapted to help residents cope with higher power prices that result from switching to a lower carbon grid.

Downtown Brooklyn

Credit: John H. Lee; NYC Mayor's Office

Next Steps

GHG Emissions Pathways
Metric tons Co_2e; % reduction vs. 2005 in a give year

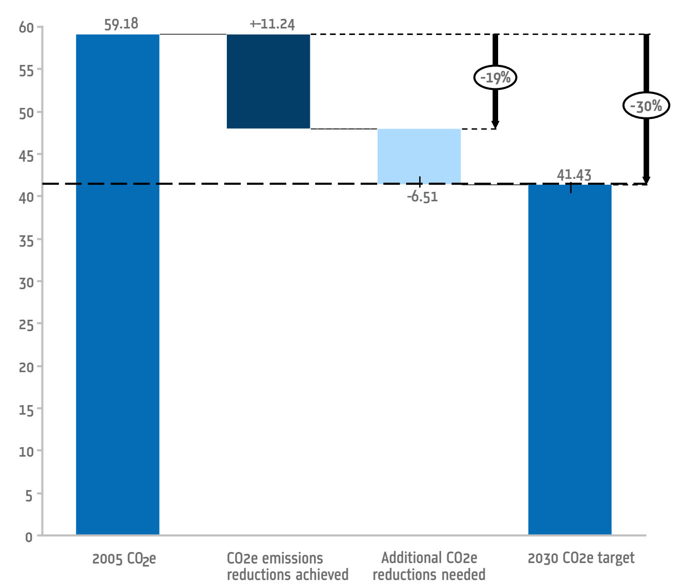


Source: NYC Mayor's Office

Even though the exact shape of a low-carbon city is uncertain today — and the 80 by 50 goal itself may well be too aggressive for a relatively efficient city like New York — the city has both the tools and the momentum to accelerate carbon reduction efforts this decade. As the city is now close to two-thirds of the way to the PlaNYC 30 percent greenhouse gas reduction goal, it could consider accelerating the target date for reaching the goal, from 2030 to 2020. Doing so could put New York City on a trajectory to achieve 80 by 50 while maintaining focus on what is achievable today.

To reach a 30 percent reduction, emissions would need to fall another 6.4 million tons below 2012 levels. If the City aggressively implements and strategically expands several existing initiatives it could achieve the 6.4 million ton reduction within this decade. These reduction actions are focused on the buildings, transportation and waste sectors. Given the long-lead times and expense of projects it is not assumed that any major abatements will accrue from the power sector. However, several promising near-term opportunities exist and could be pursued in tandem with the hope of providing an

Citywide CO_2e Emissions Reduction Summary
MtCO2e

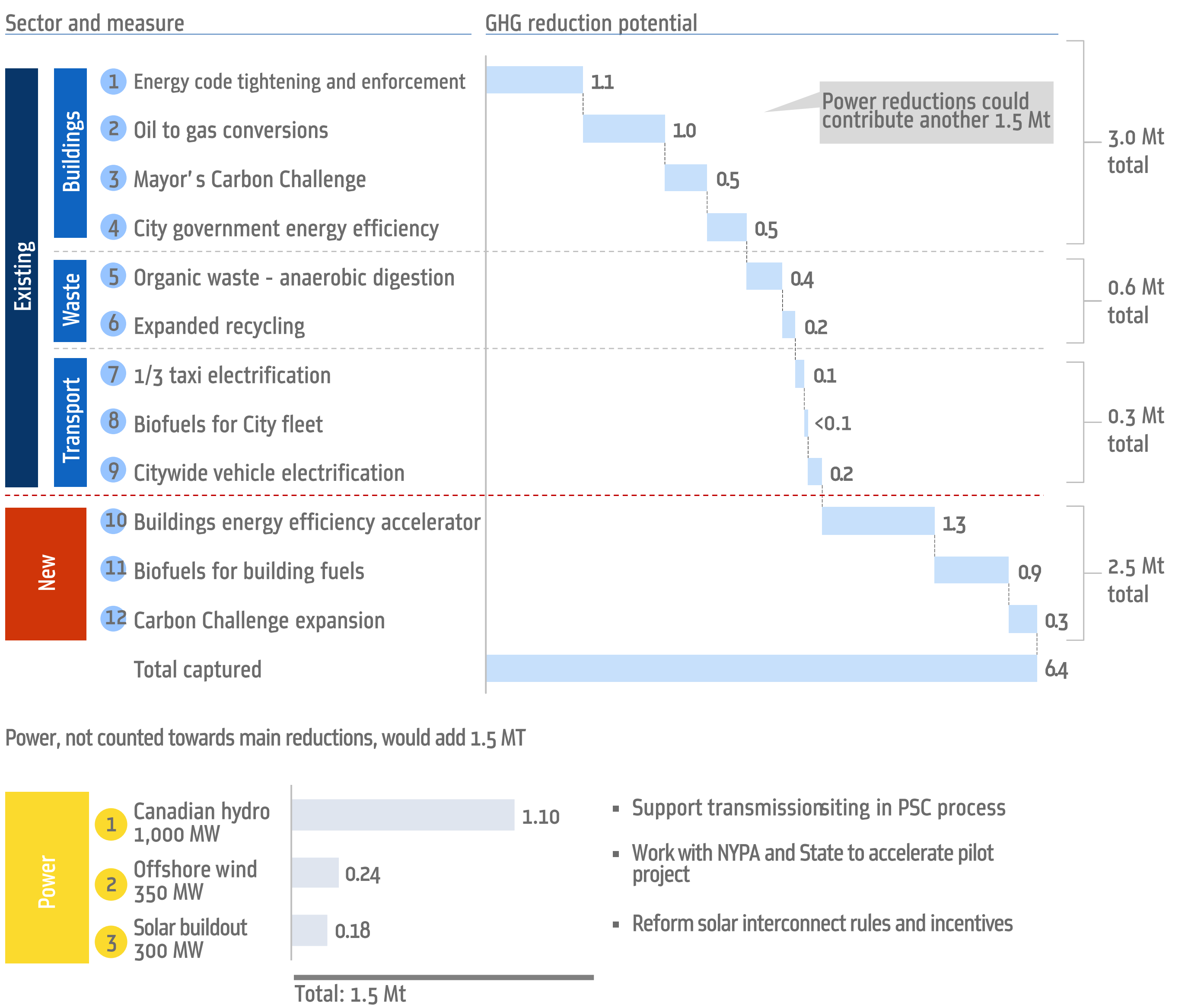


Source: NYC Mayor's Office

additional buffer to achieve 30 by 20. The following section briefly describes these possible efforts.

Achieving 30 by 20 will require tremendous effort and consistent reductions of 2 percent per year through the end of the decade. This will not be easy, but New Yorkers stand to gain along the way. Reducing energy consumption in buildings will lower operational expenses and create jobs. Converting to cleaner fuels in buildings and electrifying or using biodiesel in vehicles will improve air quality. And diverting waste from landfills will save city residents and businesses on waste export costs and could promote local industries. These and other measures could reinforce and strengthen New York City's global leadership in responding to climate change, while making the city more competitive, livable, and resilient.

GHG Reduction Potential of Existing and New Policies
Sector and GHG reduction potential



Source: NYC Mayor's Office

Emissions Abatement and Climate Resiliency

Even as the City works to reduce greenhouse gas emissions, the climate is still changing, and the climate risks that the city has always faced are becoming worse. However, the very strategies that help reduce emissions can also make the city more resilient.

Storm surges and heat waves are the two most important climate risks for New York City. Both struck in recent years, and both affected the city's energy infrastructure: Hurricane Sandy left 800,000 customers in the dark and devastated liquid fuels supply infrastructure in 2012, Hurricane Irene came close to shutting down the electric grid in 2011, and intense heat waves led to highest-ever periods of peak demand in the summers of 2012 and 2013 – though the electric grid held up relatively well in both cases.

These risks will intensify: according to the New York City Panel on Climate Change, a scientific advisory body that Mayor Bloomberg originally convened in 2008, by the 2050s, sea levels around New York City could rise by as much as 2.5 feet, and heat waves would become a far more regular occurrence, with more than 50 days every year above 90°F, compared to less than 20 today.

In this context, any strategy that reduces emissions by reducing energy demand and diversifying its sources can help make the city more resilient to storm surge and heat wave-related disruptions to energy supply infrastructure. Measures that advance building energy efficiency, promote distributed generation, and increase the penetration of electric vehicles help do just that.

Building energy efficiency measures reduce baseline electricity demand – and that alleviates the strain on the electric grid during periods of high demand that occur during heat waves. To mitigate the consequences of heat waves, utilities rely on programs that pay large customers to reduce their demand if necessary (called demand response), but an 8 percent reduction in citywide electricity demand achieved through energy efficiency would provide double the demand reduction available through demand response programs today and obviate the need for hundreds of millions of dollars in spending to upgrade the electric distribution system that would otherwise be required. An additional benefit of energy efficiency is that if outages do occur, more efficient buildings can remain comfortably habitable longer because it takes longer for them to heat up in summer or cool down in winter.

Distributed generation systems allow customers to produce their own electricity – including when the grid is down. Properly installed combined heat and power systems and fuel cells – both running on natural gas – can supply buildings with enough electricity to operate normally even if the electric grid is completely down. Smaller scale distributed generation systems – primarily rooftop-mounted solar panels – usually cannot cover a building's electricity needs during an outage, but if properly installed, they could provide enough energy to operate at least several lights and power outlets in a typical one or two-family home.

Electric vehicles lessen the city's dependence on liquid fuels for mobility at the cost of greater reliance on the electric grid – but the electric grid is generally more reliable in the face of storm surges than the liquid fuels infrastructure is. They also make it possible to provide power to one or two-family homes during power outages: a fully charged EV with a 26 kWh battery could power a one or two-family home for at least a day, as long as the home is pre-wired to be able to connect to the vehicle. In the next few years, once the necessary interconnection standards are developed, EVs might also be able to help shave peak load, feeding their stored energy back into the grid during periods of high demand.

These and other strategies are discussed in detail in the context of resiliency in PlaNYC: A Stronger, More Resilient New York, a 438-page report that Mayor Bloomberg launched in the aftermath of Sandy and released on June 11, 2013. The report puts forward more than 200 initiatives to protect New York City's residents, buildings, and infrastructure from climate threats today and in the future and is available online at nyc.gov/resiliency.

Credit: John H. Lee, Mayor's Office

Appendix: Assumptions

Assumptions used to evaluate the emissions reduction potential throughout this study include the following information below.

Population and economy

Population, employment, and GDP growth figures were taken from the New York Metropolitan Transportation Council (NYMTC) forecasts for 2010-2030 and 2031-2040. This information was proportionally adapted to forecast figures through 2050. On average: population growth increases at 0.4 percent annually; employment increases at 0.8 percent annually; and GDP grows at 3 percent annually.

Energy consumption

According to Consolidated Edison, Inc. Annual Energy Outlook, annual energy demand grows by 0.7 percent for electricity, 0.7 percent for natural gas, 0.1 percent a year for steam, and -0.8 percent a year for oil. 2031-2050 growth across energy sources is driven by growth in residential and nonresidential floor space, or residential compound annual growth (CAGR) of 0.3 percent and nonresidential CAGR of 0.4 percent.

Energy consumption figures for the report presumes no new energy efficiency policies, programs, nor use of current technologies. Additionally, GHG emissions reductions from the Greener, Greater Buildings Plan and the Green Codes Task Force were not taken into account.

Buildings

Population growth drove an increase in residential square footage from 3.6 billion sq ft in 2010, and is expected to rise to 3.9 billion sq ft in 2030. By holding the 2010 sq ft per capita figure constant, a 2050 square footage of 4.1 billion sq. ft. is projected. For nonresidential square footage, holding the 2010 figure of 1.8 billion sq ft constant, square footage for 2030 and 2050 is projected for increases of 1.9 billion and 2.1 billion sq ft, respectively.

Although building stock is divided into low and high rise categories, new growth was evenly allocated between the two groups. For low rise buildings, an additional impact of demolition is included; 0.6 percent of buildings are demolished annually, which translates into an average building lifetime of less than 150 years. With the occurrence of low rise demolitions, the 2050 share of high rise buildings increases.

Climate change

According to the New York City Panel on Climate Change, average temperatures may rise up to 3 degrees Fahrenheit by 2050.

Other

Other analysis includes the following assumptions:

- Waste per capita remains constant, according to the New York City Mayor's Office of Long-Term Planning and Sustainability (OLTPS).
- NYMTC forecasts also include an increase in vehicle miles traveled by 17 percent.
- All non-City measures currently in place take effect, such as Corporate Average Fuel Economy (CAFE) standards, electricity grid upgrades, and transit system upgrades from the NYMTC Regional Transportation Plan.

Endnotes

1. Compared to 2005 levels.
2. RCPs, or Representative Concentration Pathways, are an evolution of the IPCC's approach to forecasting emissions. Instead of trying to develop emissions scenarios from economic and social ones, the RCP approach develops carbon pathways first; from those, economic and social scenario combinations can be derived if necessary.
3. 2010, an EU nonprofit had already set a precedent for releasing a comprehensive study of this type: Roadmap 2050, a report funded by the European Climate Foundation, analyzed the technical potential and costs of deep union-wide emissions reductions, with a particular focus on the energy sector. In 2013, a study by Urban Green Council, the New York Chapter of the U.S. Green Buildings Council called "90x50" examined the technical potential for deep carbon reductions in New York City, focusing most heavily on buildings and finding that even with existing technology, such reductions indeed appear possible in the long term. Also in 2013, a study by the International Energy Agency drew renewed attention to the issue at the global level by suggesting that targeted energy efficiency measures, partial phase-out of coal-fired power plants, reduction in fugitive emissions from fossil fuel production, and a partial phase-out of fossil fuel subsidies could stop the growth in worldwide emissions by 2020 at no net cost to the global economy.

   "ROADMAP 2050." Roadmap 2050. N.p., n.d. Web. 31 Dec. 2013. <http://www.roadmap2050.eu/project/roadmap-2050#>.

   "90 By 50: NYC Can Reduce its Carbon Footprint 90% By 2050." Urban Green Council. Urban Green Council, 14 Feb. 2013. Web. 31 Dec. 2013. <http://www.urbangreencouncil.org/servlet/servlet.FileDownload?file=015U0000000nD3r>.

   "Redrawing the Energy-Climate Map." World Energy Outlook Special Report. N.p., 10 June 2013. Web. 31 Dec. 2013. <http://www.worldenergyoutlook.org/media/weowebsite/2013/energyclimatemap/RedrawingEnergyClimateMap.pdf>.
4. In the energy sector, fugitive emissions are mostly caused by methane escaping from gas pipelines and by sulfur hexafluoride (SF_6)—a highly potent GHG that utilities used for insulation in the past--leaking from electric equipment.
5. Scope 1 and 2 only.
6. Although it is possible to assess these impacts through 2050, the usefulness of this analysis is limited by the very long time horizon, which becomes more of a constraint in economic modeling than in the estimation of technical reduction potential.
7. Full abatement potential would be achieved by 2050, but unless otherwise noted cost per ton is for 2030 given greater cost uncertainty in the outer years.
8. Cost per ton value shown is for 2050, since heat pumps do not play a significant abatement role in 2050.
9. The potential for having GSHPs replace cooling loads was not estimated given the added costs of integrating them into building cooling systems – particularly if cooling is provided by packaged terminal air conditioners (PTACs) installed directly in windows and walls.
10. In the Bronx and in Manhattan, the forecast adoption rates could be 15 percent and 10 percent respectively, mostly from standing column systems serving low-rise buildings. In Staten Island, the rate could be higher: 25 percent served by open loop and standing column systems. In Queens and Brooklyn, the rates could be up to 35 percent and limited only by the need to balance heat extracted from the aquifer in winter and returned for cooling in summer.
11. Approximately 50 percent of New York City's buildings use steam radiators for heat, with the balance being hydronic, forced air, and electric window units. Air source heat pumps can integrate with most hydronic and forced air heating systems at a negligible cost. Integration with steam radiators is prohibitively expensive, but it can be bypassed at least in residential applications through replacing PTACs directly, where ASHPs – unlike GSHPs – could provide cooling as well for no added cost.
12. 2050 cost.

13. A 20 MW Goteborg Energi facility in Sweden is under construction, a 12 MW unit sponsored by the Energy Research Centre of the Netherlands is in planning, and a 200 MW plant by E.ON, also in Sweden, is targeted for a 2015 completion.
14. This number does not take into account the impact of shifting car passengers onto trains, which is was beyond the scope of this exercise.
15. "Congestion Pricing: A Primer." Federal Highway Administration Publications. U.S. Department of Transportation Federal Highway Administration, n.d. Web. 31 Dec. 2013. <http://ops.fhwa.dot.gov/publications/congestionpricing/congestionpricing.pdf>.
16. "Opportunities for Reducing Surface Emissions Through Surface Movement Optimization." Technical Report #: ICAT-2008-7. MIT International Center for Air Transportation (ICAT) Department of Aeronautics & Astronautics Massachusetts Institute of Technology, n.d. Web. 31 Dec. 2013. <http://dspace.mit.edu/bitstream/handle/1721.1/66491/Balakrishnan-ICAT-2008-07.pdf?sequence=1>.
17. Residential waste is at least 41 percent recyclable and 40 percent compostable
18. Excludes fill.
19. This does not include solar energy, which is considered a demand-side or building sector measure.

This page left blank intentionally.

Mayor's Office of Long-Term Planning & Sustainability
City Hall
New York, NY 10007
www.nyc.gov/PlaNYC