New York City's Roadmap to 80 X 50

The City of New York
Mayor Bill de Blasio

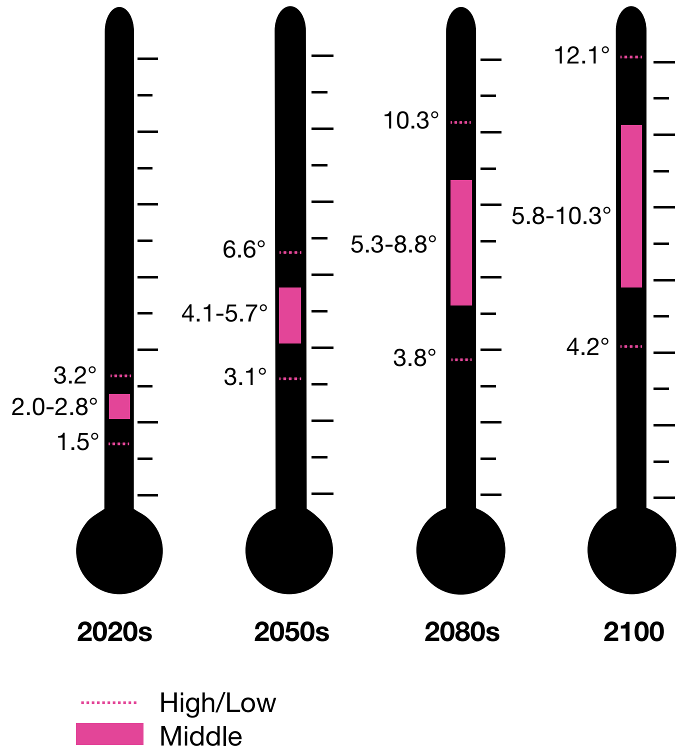
Anthony Shorris
First Deputy Mayor

#ONENYC

Climate change is an existential threat to our city, our country, and our planet. With the signing of the Paris Agreement in December 2015, 195 nations under the United Nations Framework Convention on Climate Change, agreed to limit global temperature increase to no more than two degrees Celsius above pre-industrial levels. The Agreement also recognizes the need to curb warming even further, and urges nations to increase efforts to limit global temperature increase to no more than 1.5 degrees Celsius above pre-industrial levels. To reach these ambitious but necessary targets, developed countries will have to reduce greenhouse gas (GHG) emissions, the harmful gases that are the cause of global climate change, by at least 80 percent by 2050 (80 x 50).

In September 2014, New York City committed itself to 80 x 50, with an interim target to reduce GHG emissions 40 percent by 2030 (40 x 30), and took immediate steps to achieve that goal. We committed billions of dollars to reduce our own carbon footprint with investments in energy efficiency for municipal buildings. We followed that up with the release of *One New York: The Plan for a Strong and Just City* (*OneNYC*) in April 2015, laying the blueprint for inclusive climate action that works for all New Yorkers across four key visions of Growth, Equity, Sustainability, and Resiliency. In *OneNYC*, we expanded our commitment to 80 x 50 with new investments in renewable energy, electric vehicles, and solid waste management that are improving air quality across the city and catalyzing an important shift away from fossil fuel-based sources of energy. With *New York City's Roadmap to 80 x 50,* the City is laying out a comprehensive report, based on the best available science and state-of-the-art GHG emissions modeling, to assess what will be necessary to reach 80 x 50, and to promote economic opportunities that come from the investments that will be required.

Expected Temperature Increases in NYC through the End of the Century (°F)
Temperature - Mean Annual Changes
Baseline (1971 - 2000) 54°F



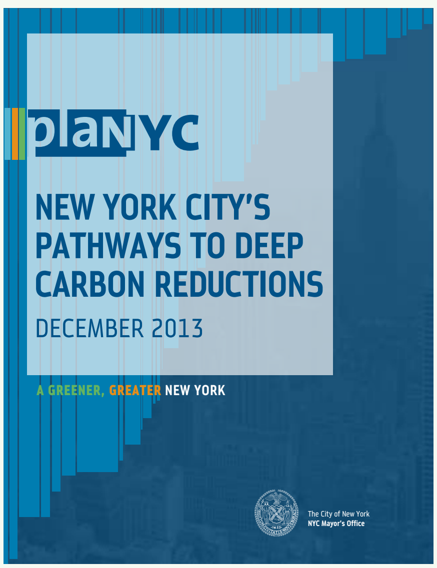
The low estimate (10th percentile), middle range (25th percentile to 75th percentile), and high estimate (90th percentile).

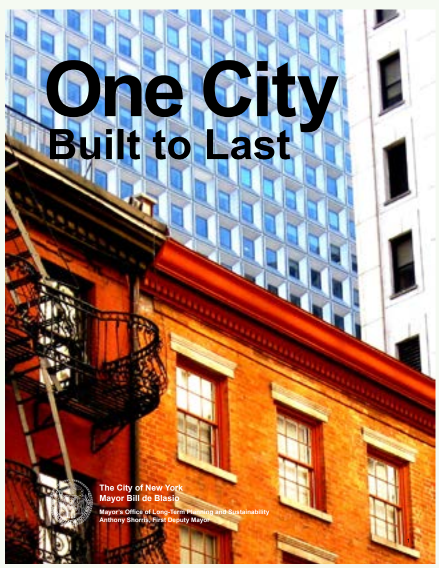
The Roadmap to 80 x 50

We now know what it takes to achieve 80 x 50. The City must accelerate efforts to make buildings and vehicles significantly more energy efficient, replace many fossil fuel-based heating and hot water systems in buildings with renewable or high efficiency electric systems, transition towards a renewables-based electric grid, significantly reduce the number of miles driven while transitioning remaining vehicle trips to electric and clean fuel vehicles, and achieve the goal of Zero Waste to landfills. The technologies necessary to shift away from fossil fuels and reduce waste-related emissions exist today. However, bold action is necessary from all levels of government and the private sector to make the investments, develop new regulatory frameworks, and drive institutional and societal changes necessary to achieve 80 x 50.

Benefits of 80 x 50 for all New Yorkers

On the path to 80 x 50, the city will take major steps that can improve the quality of life for New Yorkers and develop new industries that have significant potential for new job creation. Retrofits to buildings will improve the quality of housing, and the energy efficiency gained will help to keep homes affordable over the long-term. Shifts towards transportation options that are cleaner and multi-modal will improve air quality and public health outcomes in our communities, while also providing access to more transportation options to New Yorkers that currently lack them. An expansion of renewable energy across the city will provide communities with more choice, and will enhance the resiliency of critical services in neighborhoods that are currently vulnerable to outages and weather impacts. In the end, we know that this path is necessary and comes with a moral imperative that we pass on a stronger and more just world to the next generation.





December 2013
PlaNYC: New York City's Pathways to Deep Carbon Reductions, Evaluation of the technical potential of 80 x 50

September 2014
One City Built to Last, 10-year plan to reduce emissions from NYC buildings

NYC committed to 80 x 50

February 2015
Buildings Technical Working Group kickoff

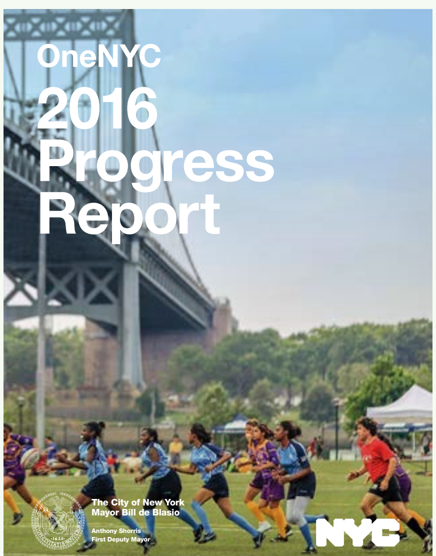
April 2015
One New York: The Plan for a Strong and Just City, NYC's comprehensive plan for a strong, sustainable, resilient, and equitable city

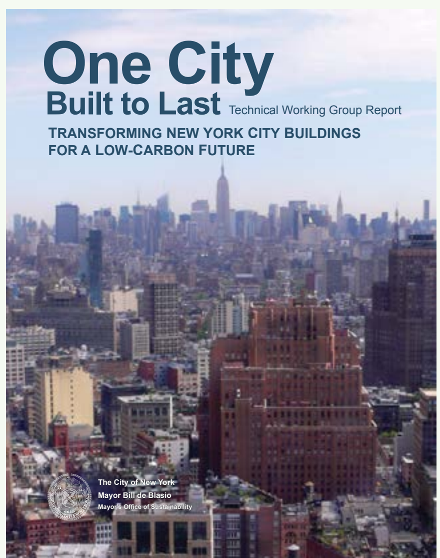
New York City already has one of the lowest levels of GHG emissions per resident among major national and global cities. In fact, the city's GHG emissions per capita are just one-third the U.S. average. In 2007, New York City committed to a first-ever goal of reducing greenhouse gas emissions 30 percent by 2030. Since that time, the threat of climate change has intensified; rising sea levels, increasing temperatures and precipitation, and the likelihood of more frequent and intense storms that leave our neighborhoods and infrastructure more vulnerable, while exacerbating many underlying social and economic inequalities. That is why we committed ourselves to enacting policies that achieve even deeper reductions in GHG emissions.

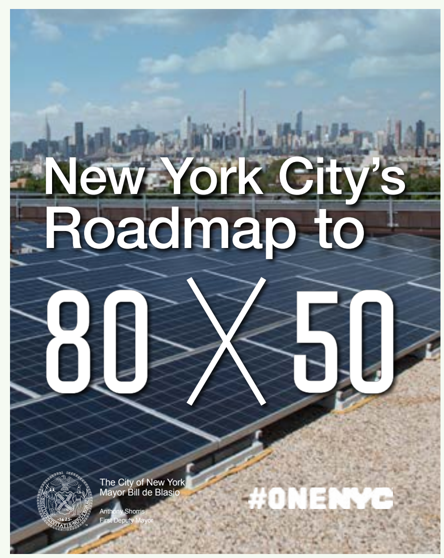
We are already on the path to 40 x 30

With the commitments in *OneNYC* and related efforts, the City is already implementing policies and programs that will significantly reduce GHG emissions. These initiatives, once fully realized, along with existing state and federal level policies and market trends, put us on track to achieve an interim target of a 40 percent reduction by 2030 (40 x 30). The City's analysis shows that the projected impact of these efforts will make it possible to bend the curve on GHG emissions. Our analysis also shows, however, that these efforts alone are not enough to reach 80 x 50. We must continue to do more to reduce emissions in New York City and lead progress across the globe if we are all to avoid the worst impacts of climate change.

In each sector—buildings, energy, transportation, and waste—the City has made progress toward 40 x 30, putting us on the trajectory necessary for 80 x 50. *New York City's Roadmap to 80 x 50* analysis has shown a feasible potential pathway to build on this progress with an integrated set of strategies to achieve 80 x 50.







January 2016
Energy, Transportation, and Waste sectors begin 80 x 50 planning

April 2016
OneNYC 2016 Progress Report, NYC's progress in delivering on the *OneNYC* commitments

One City: Built to Last, Technical Working Group Report, Comprehensive analysis of energy use in NYC's buildings and next steps to place buildings on a pathway to 80 x 50

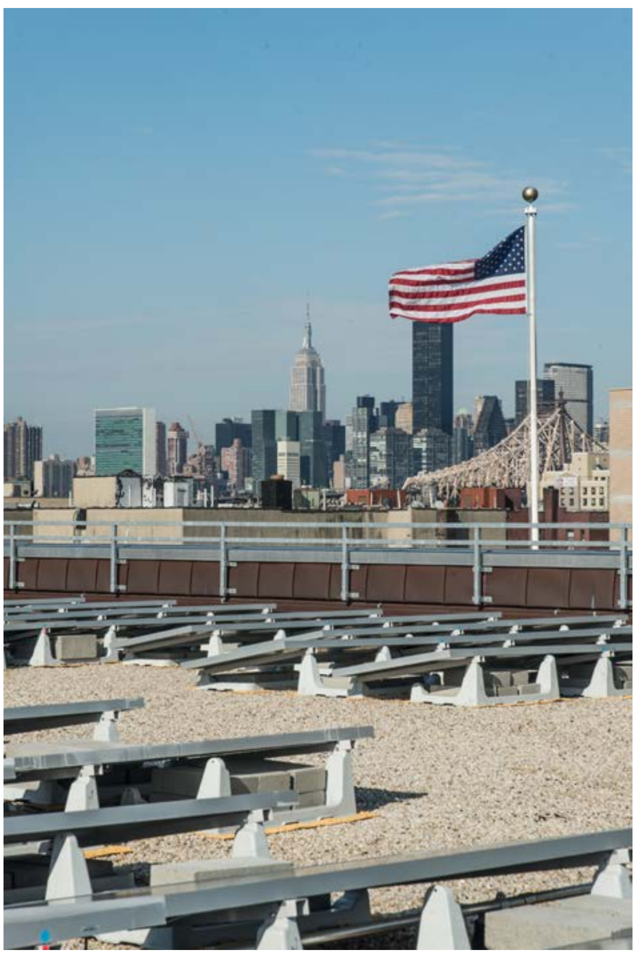
September 2016
New York City's Roadmap to 80 x 50

Energy

The biggest driver of GHG emission reductions in New York City, to date, has been changes to our electricity supply. Since 2005, the baseline year for our GHG accounting, New York City's electric grid has become cleaner due a switch in power plant fuel sources from oil and coal to natural gas, which emits fewer GHG emissions when burned, as well as an increase in the efficiency of operations and the construction of new, highly efficient power plants. Efforts at the state level, most notably the Clean Energy Standard's mandate that New York's utilities meet 50 percent of electricity consumption with renewable energy by 2030, are expected to further reduce the carbon intensity of the grid.

The City is also making great progress increasing local renewable electricity generation through solar photovoltaic (PV) installations. Since 2014 alone, citywide solar energy installations have nearly quadrupled. This progress reflects the City's commitment to become an even friendlier market for solar power, invest in solar on our own buildings, and facilitate the adoption of systems on private property through group purchasing and community-shared solar PV projects.

Rooftop solar panels
Photo credit: NYC Department of Citywide Administrative Services



Buildings

More than 68 percent of citywide GHG emissions can be attributed to the energy used to power, heat, and cool buildings—which includes the emissions from burning fossil fuels to generate electricity. While our city's population and economy grew, citywide GHG emissions were reduced largely due to reductions in GHG emissions from the electricity supply, the conversion from heaving heating oils to cleaner fuels in buildings and modest improvements in energy efficiency. The majority of GHG emissions in buildings are from the use of natural gas and oil for heat and hot water, followed by use of electricity from the central grid.

The City is currently leading by example to reduce GHG emissions from municipal buildings and are on track to achieve a 35 percent reduction in our own City buildings by 2025. The City is retrofitting every City-owned building to reduce energy consumption and installing 100 MW of solar energy on these properties. Beginning in 2017, all new City-owned properties will be designed to consume at least 50 percent less energy than current standards.

The City has implemented policies to encourage or require private building owners and decision-makers to invest in energy efficiency and switch to cleaner sources of energy. The City's efforts help ensure building owners and decision-makers have access to their energy use information and require improvements to the energy performance in New York City's largest buildings. To date, these policies have helped large buildings that consistently benchmark achieve an eight percent reduction in GHG emissions.

The City also phased out the use of No. 6 fuel oil. Nearly 6,000 buildings have converted to cleaner fuels, many with assistance provided through the City's NYC Clean Heat program. As these buildings have switched to a cleaner burning fuel, New York City's air quality has improved, preventing approximately 210 premature deaths and 540 hospitalizations annually. Neighborhoods with the highest density of boiler conversions—such as northern Manhattan, northern Queens, and the South Bronx—saw the greatest improvement in air quality, with the greatest proportion of health benefits occurring in vulnerable, high poverty areas.

The City launched multiple new or expanded programs as part of its *One City: Built to Last* plan, which include the NYC Retrofit Accelerator, Community Retrofit NYC, the NYC Benchmarking Help Center, and the NYC Carbon Challenge. Together, these programs are working with owners and decision-makers of nearly 4,000 properties, representing almost ten percent of the built square footage across New York City, to undertake energy efficiency projects and improve operations and maintenance. The associated reductions in utility of operational costs is helping, in part, to keep residential and commercial spaces affordable.

The City has continuously updated its local building codes to include more stringent energy efficiency and sustainability requirements, most recently with its 2016 update to the New York City Energy Conservation Code. The update will lead to an eight and a half percent reduction in energy use in new commercial buildings and a 25 percent reduction in new residential buildings.

Transportation

New York is home to the most extensive public transportation system in the country, and with it the highest percentage of public transit commuters. Still, over 90 percent of transportation-related GHG emissions come from on-road vehicles, and a majority of these emissions come from personal vehicles.

The City has been working to make more sustainable modes of transportation (public transportation, bicycling, and walking) more accessible options for New Yorkers to get around the city. The City has partnered with New York State to increase bus speed levels through the Select Bus Service and support the expansion of the transit system. This includes investments into the second phase of the Second Avenue Subway, the Penn Station Access project to bring Metro North trains into Penn Station, and the expansion of communications-based train control, to enable more frequent subway service. The City has also been working to make walking and bicycling safer and more enjoyable, pursuing investments in pedestrian plazas and enforcement efforts outlined in Vision Zero to make our streets safer for pedestrians. The City also continues to expand the citywide protected bike lane network and other bicycling infrastructure to double the number of cyclists by 2020. Together these efforts are helping more New Yorkers choose more sustainable transportation options over single-occupancy vehicles to move around the city.

Community Retrofit NYC launch event
Photo credit: NYC Mayor's Office

The City is helping to spur the market for electric vehicles and the use of renewable fuels for those trips that require vehicles. With the launch of the NYC Clean Fleet initiative, New York City set out to create the largest electric vehicle fleet of any U.S. city to date and reduce on-road emissions. The City has purchased over 500 electric vehicles since the program launched in December 2015.

The City has furthered this commitment to a more sustainable transportation sector with the release of the New York City Department of Transportation (DOT) *Strategic Plan 2016: Safe·Green·Smart·Equitable*. The strategic plan articulates how DOT will improve traffic safety and public health; expand travel choices for all New Yorkers; encourage New Yorkers to shift to lower carbon modes of transportation, including walking, biking and public transit; and maintain streets and bridges in a state of good repair. Greater use of technology will support data-driven parking and freight management programs.

Waste

Methane emissions from landfilled waste—especially from food and other organic material—and the processing of wastewater at the city's 14 wastewater treatment plants are responsible for four percent of citywide GHG emissions. As a leader on waste reduction initiatives, New York City is one of the largest cities in the world to make a commitment to Zero Waste. The City committed to meeting Zero Waste through a unique combination of waste reduction, reuse, and recycling programs and diversion of organic waste from landfills to wastewater treatment plants for digestion and beneficial reuse. All of which reduce GHG emissions. The City's Zero Waste program relies far less on conventional waste-to-energy processing, and instead emphasizes highest and best use of commodities and materials in the waste stream. To date, the City has expanded curbside organics collection to more than 700,000 New Yorkers, launched the NYCHA recycling program in more than 1,600 public housing buildings, updated city regulations to make it easier for businesses to recycle, and through our public engagement program, GreeNYC, empowered New Yorkers to opt out of unwanted mail and reduce waste from single-use shopping bags, coffee cups, and water bottles.

Our groundbreaking methodology and strategies to achieve 80 x 50

New York City's Roadmap to 80 x 50 builds on the initiatives launched by the City to date as well as analysis done for the *Pathways to Deep Carbon Reductions* report, published by the Bloomberg administration in 2013. We know achieving 80 x 50 in New York City is feasible using existing technologies and strategies, although it will require significant social, economic, and regulatory changes. A key challenge will be moving away from our current dependency on fossil fuels to the greatest extent possible, which currently provide us with the vast majority of energy we use for power, heat, cooling, and mobility.

The City conducted an in-depth, integrated analysis to understand potential strategies to make this transition and achieve 80 x 50 in New York City. The study found that the 80 x 50 roadmap requires an integrated approach looking across sectors—buildings, energy, transportation and waste. It also requires actions to reduce GHG emissions at the individual, buildings, community, city, and regional levels. The benefits to New Yorkers are real: strategies to reduce the carbon intensity of the electric grid reduce emissions from vehicles and buildings and improve air quality; small-scale and on-site energy sources can improve the efficiency of buildings and reduce the likelihood of power outages to enhance resiliency; and the latent energy available from solid waste and wastewater can be used as a renewable energy source and this use mitigates the exposure to methane, and other pollutants.

Designated electric vehicle parking spaces
Photo credit: NYC Department of Citywide Administrative Services

Curbside organics collection
Photo credit: NYC Department of Sanitation

These strategies also advance the cause of social and environmental considerations that are key components of the administration's equity agenda. When fully implemented, the results will be improved air quality and associated health outcomes in vulnerable communities; the emergence of new jobs and industries, as well as training programs to ensure that New Yorkers are prepared to fill these positions; and more affordable energy for residents and startup businesses alike. Equity and environmental conditions are inexorably linked, and this plan considers the environmental impediments to economic opportunity, as well as disparities in health outcomes related to environmental hazards.

The City's analysis shows that we must continue to move forward aggressively on all fronts to achieve 80 x 50. A renewables-based electric grid alone will not be sufficient to reach this goal, and neither will building retrofits alone. We need to pursue both, along with promoting distributed renewable community-scale electric, heating, and cooling networks; reductions in the number of miles people drive; a shift to electric vehicles and renewable fuels for remaining automobiles; and achievement of Zero Waste and net-zero energy at in-city wastewater treatment plants.

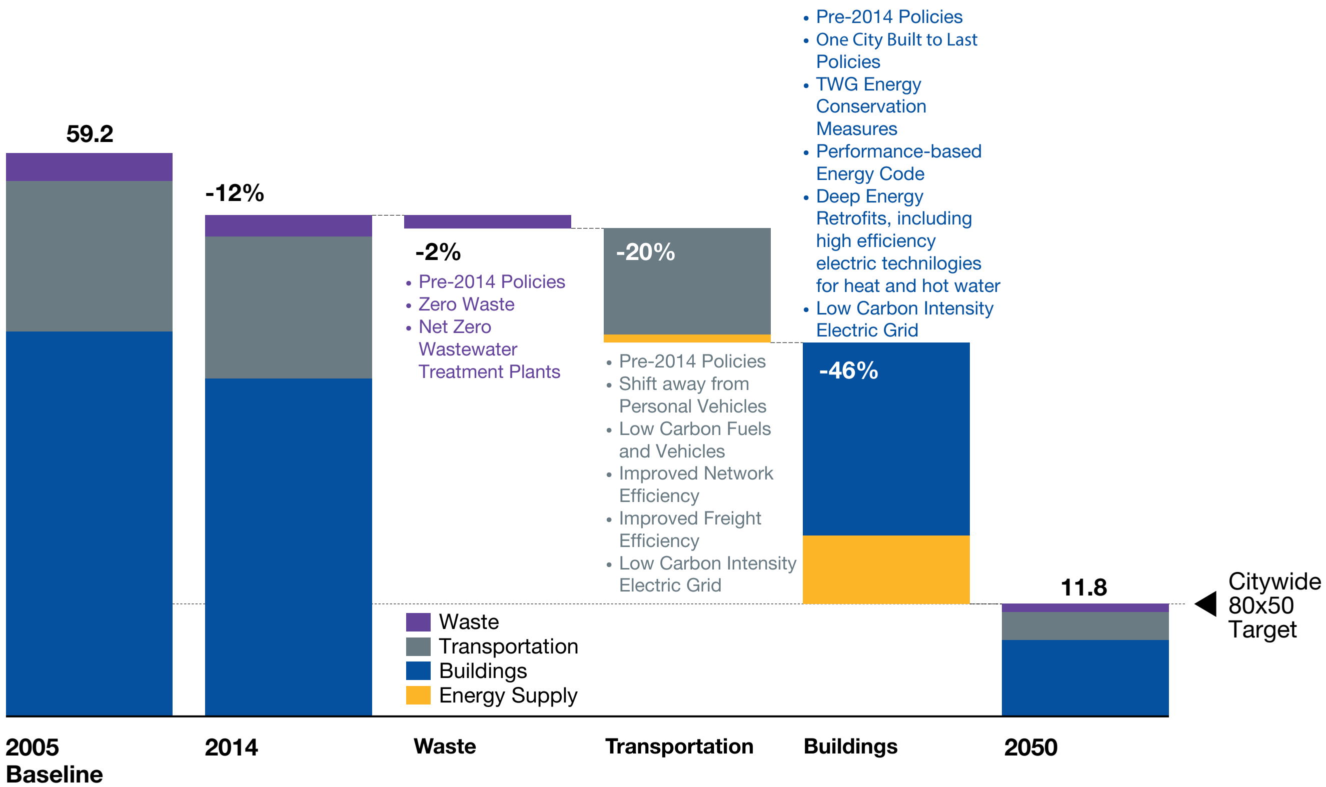
The City will use this analysis as a springboard to engage in an on-going implementation process that takes into account experience from existing, new, and future climate initiatives; the state of evolving technologies; and updated climate projections. The City is already taking numerous steps to reduce both municipal and citywide emissions, but there is plenty more that we New Yorkers need to and can do together.

We will have to transform New York City to achieve 80 x 50

Incremental steps can reduce emissions, but the level of reduction necessary for 80 x 50 requires transforming the financial, operational, and regulatory systems on which New York City depends. We know technologically this is feasible; turning this vision into a reality is a matter of guiding the essential social, economic, and regulatory changes.

The strategies laid out in this report, and the actions that will follow, are the product of a leading-edge analysis that covers critical sectors with an integrated approach. Reaching 80 x 50 is contingent on technological innovation, strong political will, and social and behavioral changes on multiple scales. At the same time, this research has illuminated the path to 80 x 50 in specific and actionable ways. While the responsibilities are dispersed among different levels of government, the private sector, and individual households, we must act together and lead the world by example. **Our city, and indeed our planet, requires nothing less.**

A Roadmap to 80 x 50, in Million Metric Tons of Carbon Dioxide Equivalent ($MtCO_2e$)



*All percent reductions are relative to the 2005 citywide baseline

Strategy Matrix

	Strategy	Energy	Buildings	Transportation	Waste
Energy	Increase direct and indirect investments in large-scale renewable energy and energy storage	●			
Energy	Increase efficiency and emissions requirements for in-city generators	●			
Energy	Make an unprecedented commitment to promote clean, distributed energy resources	●	●	●	●
Buildings	Implement cost-effective upgrades in existing build-ings to improve energy efficiency in the near-term		●		
Buildings	Scale up deep energy retrofits that holistically ad-dress heating systems, cooling systems, and building envelopes and transition buildings away from fossil fuels	●	●		
Buildings	Expand distributed solar energy and install 1,000 MW of solar capacity by 2030	●	●		
Buildings	Ensure building decision-makers have access to building energy use information		●		
Buildings	Provide assistance to the private sector to accelerate adoption of energy efficiency and clean energy	●	●		
Buildings	Streamline regulatory processes for building energy efficiency and clean energy	●	●		
Buildings	Ensure building owners can finance energy efficiency projects	●	●		
Buildings	Achieve exceptional energy performance for new buildings and substantial renovations		●		
Buildings	Lead by example in City-owned buildings	●	●	●	●
Buildings	Prepare New York City's workforce to deliver high performance buildings		●		
Buildings	Position New York City as a global hub for energy efficiency and clean energy technology	●	●	●	●

		Energy	Buildings	Transportation	Waste
Transportation	Modernize, expand, and reduce crowding on the city's transit system			●	
	Make walking and biking safer, more convenient options for all New Yorkers			●	
	Ensure that the City's policies prioritize walking, biking, and transit			●	
	Leverage technology and data to expand travel options and optimize the transportation network			●	
	Better manage and price parking to encourage efficient travel choices			●	
	Support new mobility options that reduce GHG emissions and prepare for autonomous vehicles			●	
	Accelerate purchases of zero-emission vehicles	●	●	●	
	Encourage the use of renewable and low-carbon fuels where electric vehicles are not an option	●		●	●
	Encourage increased efficiency of local and "last-mile" freight delivery			●	
	Invest in rail, maritime, and other infrastructure to increase the efficiency of freight movement			●	●
Waste	Engage all New Yorkers in reducing waste disposal to landfills				●
	Minimize waste generated by all City agencies				●
	Launch outreach campaigns to reduce food waste				●
	Implement proven incentive-based systems to minimize waste generation				●
	Support increasing citywide reuse and donation				●
	Accelerate diversion of recyclable materials from landfills				●
	Capture organics and ensure sufficient capacity to facilitate beneficial reuse in both the residential and commercial sectors	●			●
	Expand energy recovery from wastewater processing operations	●			●
	Reduce emissions from the collection and disposal of commercial waste			●	●

Energy

In 2050...

We envision that New York City's energy supply will have undergone a transformation. New York State will have a prevalent supply of large-scale renewable energy from sources outside of New York City. New transmission lines will connect New York City to those resources and will provide an added level of reliability to our energy system. Natural gas will continue to be an important resource, but will shift to a supporting role in the overall electricity mix by providing fuel diversity and supporting reliability. Distributed energy resources will be prevalent and deliver clean, affordable, and resilient energy to neighborhoods throughout the five boroughs, including to low- and moderate-income communities, which will allow New York City residents and communities to enjoy their benefits. We will have the technologies and market conditions to seamlessly manage demand and supply, from individual buildings to the electric grid, while consumers of energy will play a more informed and active role in how they use, manage, and even generate energy.

Achieving 80 x 50: Energy

The path towards 80 x 50 requires strong partnerships across all levels of government, and it requires working closely with utilities to ensure that our climate mitigation and adaptation goals guide infrastructure investment decisions. Achieving significant greenhouse gas (GHG) emissions reductions for buildings, transportation, and waste is contingent upon a transition towards a renewable energy-based electric grid. Since the City does not directly regulate energy supply, we will need to continue advocating for regulatory changes and infrastructure improvements that will allow renewable sources of energy to flow into the five boroughs. The City can leverage its purchasing power to help support this investment, as the City's municipal operations consume one-tenth of all electricity in New York City.

Within the city, existing power plants must improve efficiencies and reduce emissions in the near term. In the long term, the fleet of in-city power plants will need to transition towards more flexible sources of power that can be quickly ramped up or ramped down to help balance a renewables-based grid that will have more intermittent sources of power from solar and wind. In addition, the infrastructure needed to transmit and distribute electricity across the city will need to integrate technologies that improve efficiency and flexibility.

Distributed energy resources (DERs)—which include customer-owned renewable energy sources, energy efficient technologies and strategies, and energy storage—will need to be aggregated to meet electric demand or the needs of the electricity system as a whole. These resources will need to be scaled up at both the building and community levels, and new regulatory and financial structures will need to evolve to support the deployment of DERs in order to achieve the 80 x 50 vision of a clean, affordable, and resilient energy supply. The adoption of promising new emerging technologies must also be facilitated by pilot projects to demonstrate their performance and cost-effectiveness – a place where the City can play a key role.

Drivers of GHG Emissions

New York City's energy supply is primarily comprised of electricity that comes from the regional grid, which is used to power buildings and our electrified transportation networks; natural gas and petroleum used to power vehicles and provide heating, cooling, and hot water in buildings; and district steam from Con Edison that is also used for heating and cooling in buildings.

Approximately 30 percent of citywide GHG emissions are attributable to the power plants that generate electricity both within and outside of New York City. While most of those plants generate electricity by combusting fossil fuels, a significant portion also comes from zero-carbon nuclear generation.

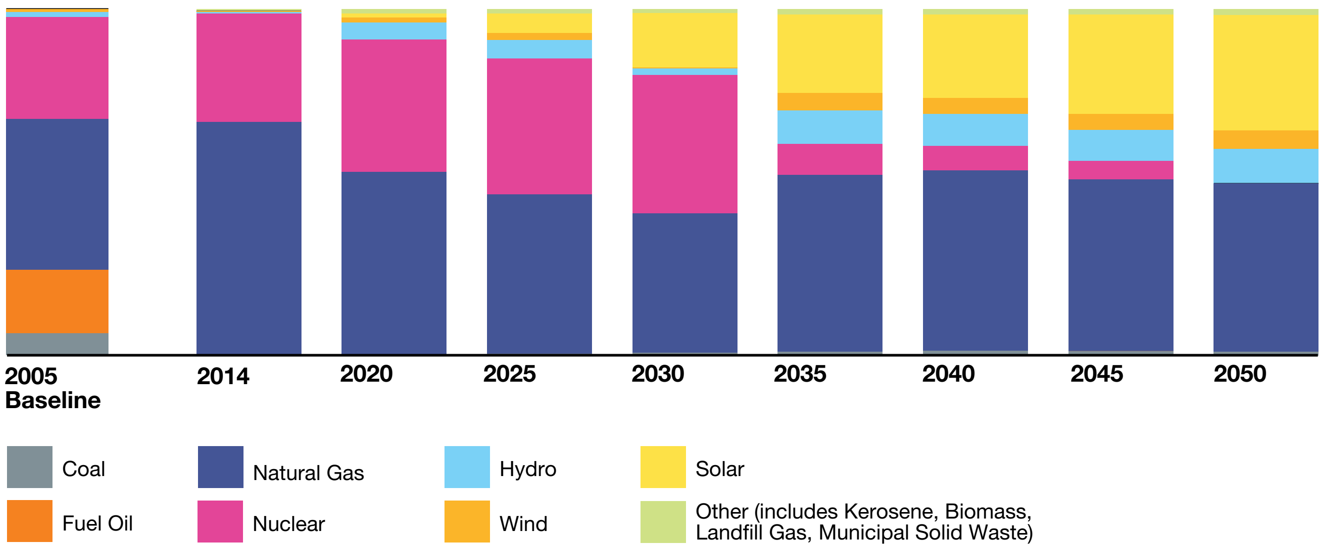
The 24 in-city power plants that directly serve New York City have a combined capacity of approximately 10,000 MW—enough to meet over 80 percent of the city's peak demand, which meets the reliability requirement of the New York State Reliability Council (NYSRC). On an annual basis, generation from these power plants provides approximately 50 percent of the electricity consumed in New York City. A majority of the balance originates from less expensive and cleaner sources elsewhere in New York State and surrounding regions.

Energy is imported into New York City from a regional system of high-voltage transmission lines. These amount to little more than a handful of lines that connect the city with approximately 6,000 MW of electricity supply from areas as close as the Hudson Valley and northern New Jersey, northern and western New York State, Pennsylvania, and New England. Each of these regions has a different fuel supply mix. In 2014, power transmitted into the city consisted primarily of natural gas (67%) and nuclear (31%), with less than 2 percent coming from landfill gas, hydropower, coal, wind, solar, and other fuel sources.

DERs are a small but growing source of energy for New York City. These include distributed generation (DG) technologies that provide energy to customers at the community scale or even the building scale, as opposed to the traditional model in which utilities centrally procure and distribute energy to customers. DG can include customer-owned renewable energy sources as well as fuel cells and combined heat and power (CHP) systems. CHP systems co-generate electricity and useful heat locally, which allows for greater efficiencies than a typical power plant. Depending on system size, the electric and thermal energy can be distributed to one or more buildings. To date, there is more than 300 MW of DG installed citywide. In addition, DERs such as energy efficiency and energy storage—spurred in part by local policies such as the City's Greener, Greater Buildings Plan (GGBP)—have contributed to a reduction in energy consumption in buildings since 2005.

Electricity was the city's largest source of GHG emissions prior to 2013, but has since been supplanted by petro-

Business as Usual Electric Grid Fuel Mix



leum, largely used for on-road transportation, which generates 34 percent of the city's GHG emissions. Natural gas burned on-site to provide heating and hot water in buildings generates 31 percent. GHG emissions from the city's electricity supply have decreased by roughly 40 percent since 2005, which is largely the result of conversion away from coal and oil in power plants towards cleaner-burning natural gas as well as the retirement of older, less efficient power plants. Operational improvements on the part of Consolidated Edison (Con Edison), the investor-owned electric utility that serves the majority of New York City residents and businesses, have further contributed to these reductions. At the same time, natural gas usage has been growing due to a combination of low natural gas prices and regulations enacted by the City in 2011 phasing out the use of No. 6 and No. 4 heavy heating oils by 2015 and 2030, respectively.

While natural gas burns cleaner than other fossil fuels such as oil or coal and has been the major driver of emissions reductions achieved since 2005, New York City will not meet its 80 x 50 commitment if we continue to consume natural gas at today's rate. In addition, with natural gas as the predominant fuel source for the city's power plants and for building heating and hot water, there is a need for the City to explore greater diversification of supply sources to enhance reliability and increase resiliency to potential supply interruptions.

Con Edison's district steam system is one of the largest district-scale heating and cooling network in the United States. District heating and cooling networks consist of pipes in the ground connected to an energy source that can provide heating and cooling to more than one building. The system has served New York City's buildings for over 130 years, and continues to serve close to 1,700 customers in Manhattan, including some of the city's most iconic skyscrapers. The district steam system contributes 2 percent of citywide GHG emissions and has been getting cleaner over time. District steam has experienced a 33 percent decrease in carbon intensity between 2005 and 2014, largely as a result of the transition to an increasing use of CHP units that generate electricity and steam in a single integrated system.

Business as usual findings

To understand what it will take to achieve 80 x 50, the City modeled projected GHG reductions under a business as usual (BAU) scenario for each sector through 2050. The BAU analysis for energy supply examines multiple potential trajectories for the New York City electric grid through 2050. The analysis takes into account expected changes in electric demand associated with population growth and economic development, as well as potential adoption of DERs. It also incorporates the expected impacts of existing state and federal policies and regulations by modeling electricity-related

Energy Policy in New York State

Reforming the Energy Vision

The New York State Public Service Commission (PSC), which regulates utility companies, initiated Reforming the Energy Vision (REV) in April 2014 to transform the State's electric distribution systems. Specifically, REV seeks to advance energy policies and markets to speed the adoption of energy efficiency and clean, locally produced power, as well as to modernize aging infrastructure and enhance the security and resiliency of the grid. This includes promoting smart grid technology and markets that enable greater efficiency and demand flexibility. Additionally, regulatory changes are expected to give customers new opportunities for energy savings as well as local power generation and enhanced reliability. These will result in safe, clean, and affordable electric service, empowering New Yorkers to make informed energy choices, creating new jobs, and reducing GHG emissions.

The City is supporting the REV objectives and is advocating for social, environmental, and physical considerations that are unique to the city to be integrated into the regulatory process. This includes the promotion of DER deployment to benefit all New York City communities.

Clean Energy Standard

The Clean Energy Standard (CES), adopted by the PSC in August 2016, was developed to lower GHG emissions and reduce air pollution from the state's energy generation resources and ensure a reliable and diverse energy supply. The CES is an enforceable mandate that will require 50 percent of New York's electricity to come from renewable energy sources by 2030.

Under the CES, utilities and other energy suppliers will be required to obtain Renewable Energy Credits through procurements of new renewable energy resources. The CES also includes directives regarding energy efficiency and additional renewable energy sources beyond land-based wind and solar. These include the evaluation of low-carbon heat sources such as geothermal heat pumps, a blueprint to advance offshore wind to be developed by the New York State Energy Research & Development Agency, and a commitment by the PSC to work with New York Independent System Operator and other stakeholders to ensure necessary investments are made in transmission, storage, and smart grid technologies to ensure the reliability of the grid. The CES also seeks to maintain zero-carbon nuclear power resources in the state by requiring investor-owned utilities to purchase Zero-Emission Credits.

renewable energy policies, including New York State's Clean Energy Standard (CES), the Regional Greenhouse Gas Initiative (RGGI), and the federal Clean Power Plan (CPP), as well as expected trends for electricity demand, natural gas prices, and renewable energy costs. The City sought expert opinions to assess the expected outcomes of policies that were in development at the time of analysis, such as the State's Clean Energy Standard (CES).

From this analysis, the City found that under the most likely scenario (the "BAU grid"), the carbon intensity of the city's electric supply—or the amount of GHG emissions per unit of energy—is projected to become 50-60 percent cleaner by 2030 relative to 2005 levels. The results of the analysis are driven by an increasing proportion of electricity from utility-scale solar photovoltaic (PV) systems and land-based wind turbines in the grid mix, consistent with the CES requirement to meet 50 percent of New York State's electricity with renewable energy sources by 2030 (see box above). Additionally, power plants within New York City are expected to continue to transition towards natural gas-fired combustion turbines, while older, less efficient power plants are expected to retire.

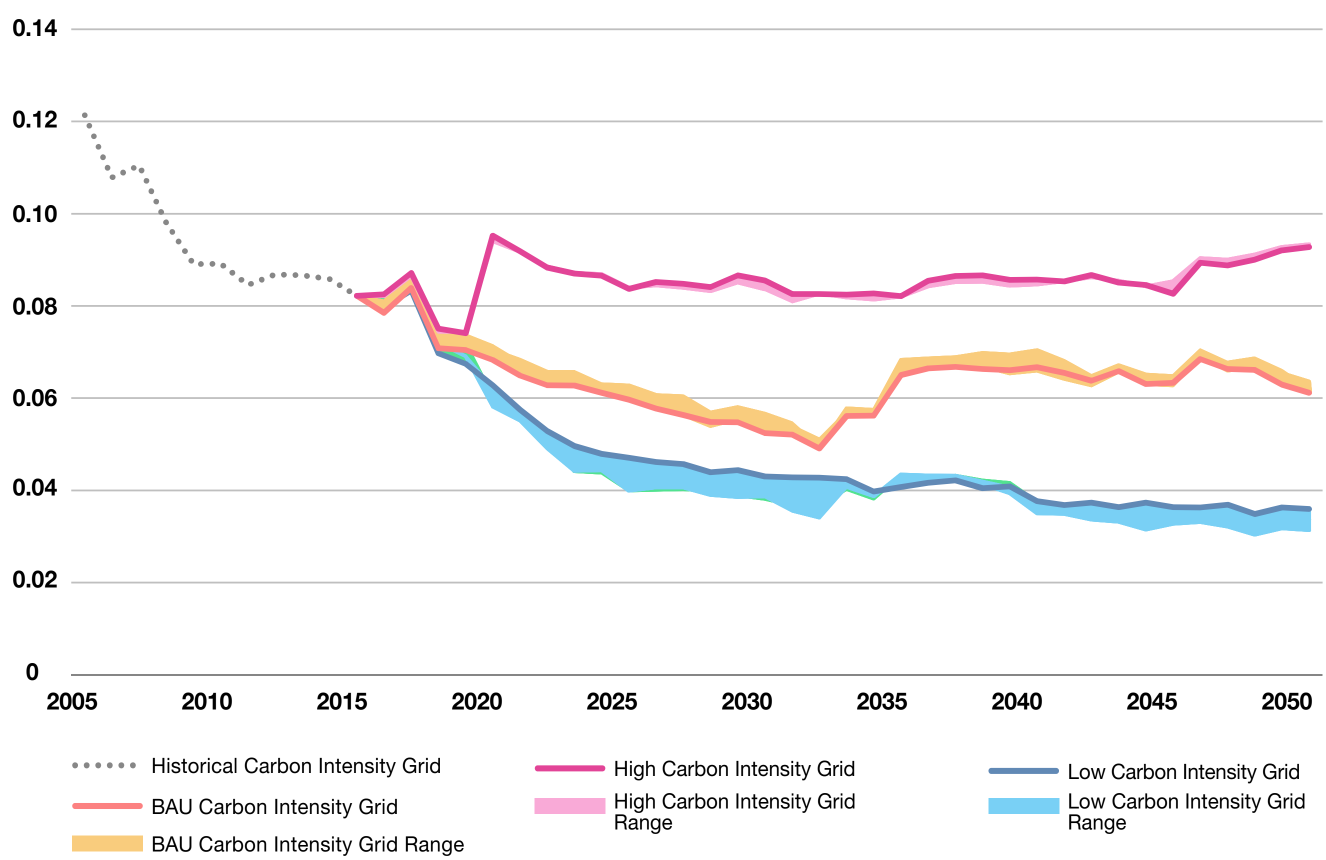
The carbon intensity of the grid is anticipated to begin to rise between 2030 and 2035 as existing nuclear power plants start to retire. Nuclear plants currently generate 31 percent of the city's electricity. When they retire, large-scale renewables such as wind and solar are expected to fill some but not all of the electricity gap. The remainder is projected to be met with natural gas capacity, which will lead to an increase in GHG emissions relative to zero-emission nuclear generation. As a result, the city's electricity supply is projected to be 50 percent less carbon intensive in 2050 relative to 2005 levels, and 23 percent less carbon intensive than today.

Generators will continue to exist within New York City to meet the NYSRC regulatory reliability requirement for sufficient in-city generation capacity, with the least efficient units replaced by fast-ramping combustion turbines by 2030. While in-city generators are expected to provide 40-50 percent of the city's electricity in the near term, in-city generators are projected to run for fewer hours each year as a greater proportion of electricity is delivered from outside New York City. Modeling results show they may provide less than 30 percent in 2050, facilitated by the addition of transmission across the state and into the city.

Given the level of uncertainty about how fuel prices and the capital costs of renewable energy generation will change over time, the City also modeled two "bookend" scenarios that reflect a "high carbon intensity grid" and a "low carbon intensity grid." The high carbon intensity (HCI) grid assumes natural gas prices will remain low and renewable energy costs stay comparatively high. The low carbon intensity (LCI) grid assumes the opposite, with gas prices rising and renewable generation costs falling, along with augmented transmission capacity throughout the state to facilitate the flow of renewable energy into the city. The City's modeling revealed that the carbon intensity of the low carbon intensity grid is expected to be more than 70 percent lower in 2050 than in 2005, with an estimated 70-75 percent renewables in the grid mix, while the high carbon intensity grid is expected to be roughly 25 percent lower, with roughly 50 percent renewables in the grid mix—the minimum needed for CES compliance.

Based on the BAU analysis, the main external drivers of the electric grid's carbon intensity are fuel prices, capital costs of renewables, and state environmental policies. The City also investigated how New York City electricity demand affects the electricity supply. The City developed one scenario in which New York City's annual electricity use and peak demand each increase by roughly 10 percent due to widespread electrification of certain building systems and electric vehicle adoption. The City devel-

Modeled Future Carbon Intensity of Electric Grid and Ranges based on Changes to NYC Electric Demand
($tCO_2e/MMBtu$)



oped an alternate scenario in which annual electricity use and peak demand each decrease by 30-35 percent, due to the adoption of energy efficiency in buildings and community-scale DERs. When these scenarios were modeled on the BAU grid, low carbon intensity grid, and high carbon intensity grid, there was little change in the overall grid carbon intensity in any scenario.

Changes in New York City demand could have an impact on the amount of generation that would be constructed, but the analysis found that overall fuel mix and carbon intensity would not be influenced. In this analysis, increases in New York City demand were largely met by cleaner and less costly sources imported from outside of the city. This means that an increase in the number of electric vehicles and electrification of certain building systems could be effective means of reducing New York City's GHG emissions without generating significant unintended consequences for the carbon intensity of the electric grid.

Emerging Trends

The pace of innovation in sustainable energy has been accelerating. Advances in technologies including solar PV, energy storage, anaerobic digestion, and electric grid operations are allowing clean energy technologies to become more efficient, flexible, and cost-competitive with traditional sources of energy. These advancements, along with market growth and environmental policies, are resulting in lower costs and accordingly increasing demand for clean energy technologies.

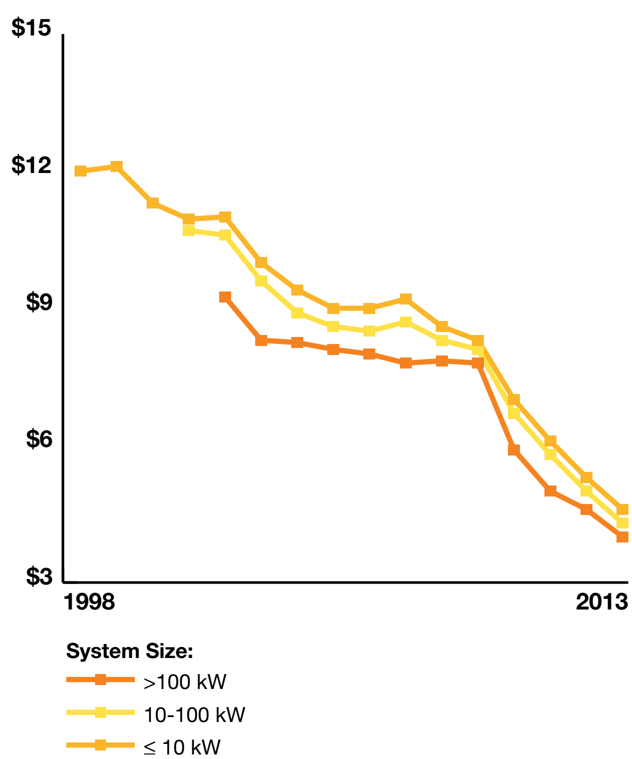
Solar PV. Renewable energy sources are becoming increasingly economically competitive with natural gas generation. The costs of solar PV have decreased dramatically, dropping more than 50 percent between 2002 and 2013, and are expected to continue their decline. According to the National Renewable Energy Laboratory (NREL), the capital cost of utility-scale solar is projected to decrease more than 40 percent between 2016 and 2030.[1]

Solar adoption is growing as a result of falling prices, as well as supportive policies like the federal investment tax credit and new financing mechanisms including solar loans and leases. In 2015, New York State installed 242 MW of solar electric capacity, a 65 percent increase over the previous year. While there are still financial and regulatory hurdles to solar adoption in New York City, there is currently 78 MW of installed solar in the city (private and public sector combined) and another 17 MW in the pipeline, compared to a total of 2 MW of installed solar in the city just ten years ago.

Various procurement and financing programs are helping to spur this growth. These include solar group purchasing programs, which pool demand to lower the cost of solar installations, and community shared solar policies, which allow multiple customers to purchase or subscribe to a portion of a common solar installation. With the enactment of community shared distributed generation (DG) in New York State just last year, multiple customers are now able to subscribe to shares of output from a common solar array, even if they live in another part of the city. This change has opened up the solar market to renters who until now have not been able to access the benefits of local solar energy.

Solar hardware is also rapidly evolving and reshaping the cityscape. The use of solar canopies in the city is rising and has the potential to grow. While space for solar PV installations has historically been limited to portions of rooftops due to competing infrastructure and fire safety requirements, solar canopies can help overcome this limitation by elevating solar panels nine or more feet above

Historical Prices of Solar PV Systems
(2014 US$/W)



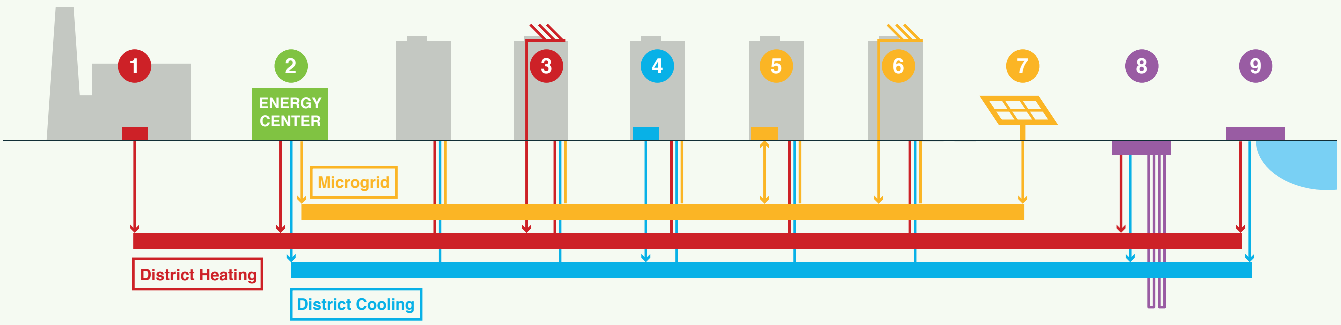
Solar canopy in Brooklyn
Photo credit: Situ Studio

building rooftops. As a result, solar canopies have the potential to enable two to three times as much solar PV capacity on a given roof relative to conventional designs.

Energy storage. Significant technological advancements have also occurred in the field of energy storage. Energy storage, through the use of technologies such as batteries, allows excess energy to be produced at one point in time and stored for later use. This helps overcome the problem of intermittency, which is common with renewable energy sources such as solar PV, in which energy cannot be produced at constant output due to the availability of natural resources such as sunlight or wind. Consequently, renewable energy production cannot always be matched to energy demand. Improvements to energy storage technologies such as lithium-ion and vanadium flux redox batteries are allowing for greater amounts of storage to be deployed at lower costs, which can allow for greater deployment of renewable energy sources.

Energy storage is another option to provide flexibility to balance energy demands and electric generation from the power grid. Energy storage has the potential to make both on-site and utility-scale renewable energy generation more useful, support microgrids, reduce peak demand, or shift demand to provide grid reliability and reduce electricity costs. At the utility scale, energy storage can provide flexibility to grid operators in managing the generation variability from intermittent renewable energy resources, which will become increasingly critical as New York City's electricity supply becomes more reliant on renewables.

One type of energy storage comes in the form of thermal energy storage (TES), which refers to technologies that make it possible to store heat or chilled water for use at a later time. For instance, a residential building with solar thermal collectors and TES can generate hot water over the course of the day and store it for use when residential heating demands are highest at night. Another example, sometimes referred to as "ice storage," is a cooling system used to generate and store chilled water mixed with glycol in tanks during off-peak hours, usually at night, when electricity is less expensive. TES can assist the transition to a renewables-based grid by balancing thermal energy demands between peak and off-peak hours, or even from season to season.



Community Energy Solutions

Microgrid

A microgrid is an electrical distribution network that is connected to two or more buildings in a local area. With the appropriate controls and design, microgrids can enter into 'island mode' and provide power when there is a grid outage.

District Heating and Cooling

District heating and cooling systems, also referred to jointly as "district energy," produce steam, hot water, or chilled water that is piped underground to multiple buildings. They can provide environmental, operational, and financial benefits by leveraging economies of scale.

Energy Sources

Heat Capture (1)

Heat capture refers to a suite of technologies that recover waste heat from commercial and industrial activities. Heat rejected from building cooling systems can also be captured and utilized for space heating.

Combined Heat and Power (CHP) (2)

Combined heat and power, also known as cogeneration, is the simultaneous production of two or more useful forms of energy from a single device. A CHP system will take fuel, most commonly natural gas, to generate electricity and heat. Combined cooling, heat and power also includes the production of cooling.

Solar Thermal (3)

Solar thermal systems utilize solar energy to generate hot water that can be used for domestic hot water and/or space heating in buildings. It is often paired with thermal energy storage.

Energy Storage (4) (5)

Energy storage technologies save generated energy and use it when demand is high. Energy storage includes electric systems such as batteries as well as thermal systems such as hot and cold water storage tanks. Energy storage can operate critical systems during outages.

Distributed Generation (2) (6) (7)

Distributed generation technologies allow customers to generate electricity onsite through solar photovoltaic (PV) systems, combined heat and power (CHP), and other technologies.

Community Shared Solar (7)

Community shared solar installations allow multiple customers to subscribe to shares of output from a solar PV array. The array can be connected to a microgrid or it can be located in another part of the city.

Geothermal Heat Pumps (8)

Geothermal heat pumps use onsite energy from underground temperature differentials to heat and cool buildings with rewarding reductions in energy use. They are also known as ground source heat pumps.

Water Source Heat Pumps (9)

Water source heat pumps extract or reject heat from large water bodies to heat and cool buildings. This term is also used for heat capture systems that utilize water loops within buildings and districts (see heat capture).

Community energy. Technological advancements have also improved the outlook for community-scale energy solutions, including microgrids and district heating and cooling networks. Microgrids are small-scale electric grids that connect more than one building to a power source and can integrate DERs—including renewables, fuel cells, and CHP units. When combined with energy storage and demand management strategies to reduce peak demand (see Buildings chapter), microgrids produce clean electricity that also improve the reliability of energy services for customers. Following the devastation of Hurricane Sandy, the City and State have supported the evaluation and installation of new microgrids in the city that can function independently from the central electric grid and can support critical loads in the event of a power outage. District heating and cooling networks provide similar benefits for buildings that are connected to a shared source of heating and cooling.

Prices have fallen for many DERs that can be deployed as part of a microgrid or a district heating and cooling network. The current low cost of natural gas in particular creates favorable economics for CHP deployment. Natural gas-fired CHP installations have increased over the last decade, with more than 230 MW of distributed CHP generation now installed in New York City. Based on the carbon intensity of today's grid, CHP units reduce GHG emissions relative to electricity from the grid due to their effective usage of waste heat. They can also serve as a reliable and cost-effective anchor for district heating and cooling networks (refer to box at left) and could be used to establish a platform for clean localized energy solutions in the future that integrate more renewable energy sources.

However, as the electric grid continues to become cleaner, the GHG emissions associated with natural gas-fired CHP will eventually reach a "breakeven" point at which the electricity generated by CHP is no longer less carbon intensive than the grid. Globally, there are examples of CHP installations that incorporate renewable fuel sources, such as biomass and synthetic natural gas. Biomass is a fuel created from organic matter, such as food waste and construction and demolition (C&D) waste. The City has a long tradition of using biomass at its wastewater treatment plants by harnessing methane gas produced during the treatment process and using it to produce electricity and heat for use on-site. However, transitioning from natural gas to biomass throughout New York City would require a major new supply chain in the region. Anaerobic digestion is one option for expanding this supply, which has the potential to play an increasingly prominent role in helping to divert the landfilling of organic waste while also creating a low carbon source of energy (see Waste chapter).

Smart grids. Utilities are adapting to increased installations of DERs, but these resources create new technical and economic challenges. Utilities must rethink their business models and introduce a new set of technologies to enable the transition to an electric grid with greater penetration of DERs, including smart grid technologies. Smart grid technologies use communications, remote control, and automation software to enhance reliability and energy efficiency of the electric grid and to integrate a growing proportion of DERs. Smart grid technologies include smart meters, controls, computers, and equipment that enable utilities to quickly scale up or scale back power output to address real-time swings in electric supply and demand.[2] By providing two-way communication between the utility and its customers, this also allows customers to reduce energy use when it is most beneficial, such as during times of peak energy demand when prices are highest. The emergence of smart grid technologies helps grid operators to better match supply with demand and manage power quality, resulting in a more flexible, efficient, and reliable grid.

Another key to integrating renewable energy into the electric grid will be enhancing the flexibility of existing generators to meet changes in electric demand. Many fossil-fuel based generators have a minimum generation level and are unable to increase or decrease output quickly enough to match potentially rapid shifts in renewable generation. Fast-ramping natural gas generators, such as combustion turbines, are designed to start and stop quickly. Improving the efficiency of these generators and linking them with dispatchable renewable energy, energy storage, and smart grid technologies is a key component of a more flexible grid that can incorporate large-scale renewable energy sources and DERs.

80 x 50 Roadmap: Energy

Achieving 80 x 50 will require aggressive action on all fronts. Based on the City's analysis, the New York State electric generation mix will need to move beyond the BAU grid to become 70 to 80 percent renewable. This will include significant volumes of offshore wind, expansive land-side solar and wind installations, hydropower, and new transmission that will allow access to these renewable energy sources from outside the city.

Understanding and Prioritizing the Potential of Community Energy

New York City cannot reach 80 x 50 without community energy solutions. Deploying electricity and heating resources at a community scale also creates opportunities to advance growth, equity, sustainability, and resiliency. Specifically, the deployment of energy resources can create local jobs and strengthen local businesses, potentially reduce energy costs, contribute to cleaner air quality and reduced greenhouse gas emissions, and help communities and buildings keep the lights on during a power outage.

The City conducted a geospatial analysis to inform priority areas where the City can support the deployment of community energy resources. The study identified the feasibility of implementing a range of technologies to meet demand and reduce greenhouse gas emissions at the community scale, including combined heat and power (CHP), ground source heat pumps, water source heat pumps, combined cooling, heating and power (CCHP), wind, solar, and heat recovery.

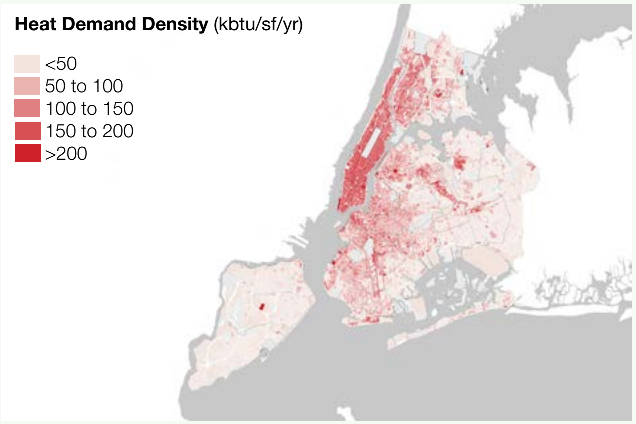
These technologies deliver power, heating and cooling to buildings through district heating and cooling networks and microgrids (Refer to Community Energy Solutions call out box). District heating and cooling networks consist of pipes in the ground connected to energy sources that can provide heating and cooling needs to more than one building. A microgrid connects more than one building to one or more power sources. With the appropriate controls and design, buildings connected to the microgrid can maintain power even when isolated from the utility grid. These platforms for energy delivery can reduce greenhouse gas emissions by taking advantage of renewable sources locally and avoid energy that is lost in the delivery of energy from large-scale centralized systems. The community energy analysis evaluated the technical potential of each technology and their potential to reduce greenhouse gas emissions.

To better understand which locations in the city would most benefit from these installations beyond greenhouse gas emission reductions, the City overlaid several other parameters to this analysis, including climate risks and environmental and economic factors at the community district level. This work is ongoing and additional data will be integrated into the analysis going forward.

Distributed energy resources can achieve goals that both mitigate emissions and advance objectives across growth, equity, sustainability and resiliency.

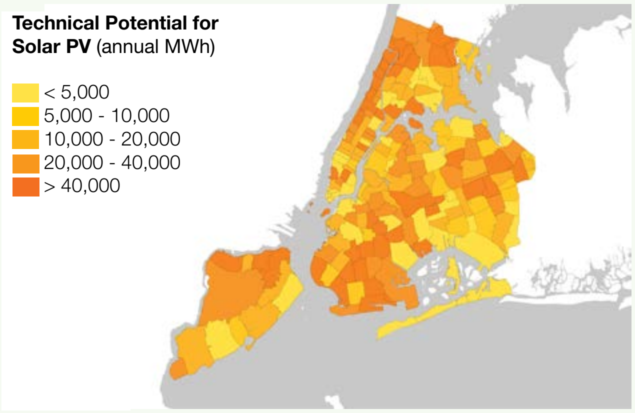
Approach and Sample Outputs

As a first step, the City mapped current demands for heating, cooling, and power across the city in



order to match up potential new supply with existing needs to identify opportunities for district heating and cooling systems that could capture economies and efficiencies of scale. This map shows heating demand at the block level across the City. The demand for heating, cooling, and power is greatest in areas of the city with a high density of buildings, which includes much of the Bronx, Brooklyn, and Manhattan. While building density provides assurance that there is sufficient energy and heating and cooling demand for a local district system (e.g., as described above and please also refer to Community Energy Solutions call out box), it leaves limited space for the installation of some distributed energy resources.

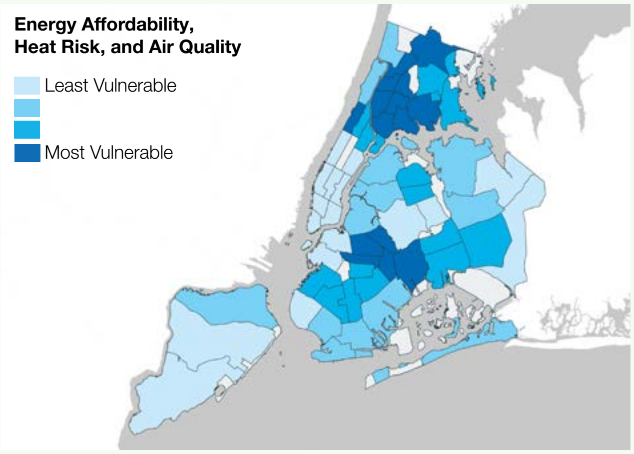
Once heating, cooling and power demand was examined, the analysis assessed the energy supply potential of different distributed heating, cooling and power technologies,



Data source: City University of New York - New York Solar Map

including solar PV, solar thermal, wind, combined heat and power systems, combined cooling, heating and power systems, and heat pumps (water source and ground source) at the block level. Technologies were prioritized based on their emissions reduction potential. The map above focuses on one type of technology—solar PV—and shows that there is clear potential for solar PV across the five boroughs.

In addition to assessing the technical supply potential, understanding which communities are most vulnerable to climate risks and high energy costs helps inform where the



deployment of community energy solutions can provide the broadest set of co-benefits in terms of equitable economic development, sustainability and resiliency. This map above shows the results—at a community district level—of a composite risk index made up of three different factors that community energy projects may help address: energy affordability, air quality, and heat risk. The City is also examining individual risk indicators and how they overlap with each other.[3] These analyses are ongoing and will help inform where the City will prioritize its facilitation efforts for community energy projects, including bringing together community non-profits, project developers, financing and funding entities and state and federal partners. This map shows that the east Bronx and central Brooklyn are priority areas for community energy.

The map above identifies potential critical facilities ranging from City-owned assets such as firehouses, police stations and schools, to community-based critical facilities such as cooling centers and shelters. Churches and community centers can also serve as community-defined critical facilities, by providing important services to vulnerable populations during an outage and/or serving as a designated place to shelter during an extreme weather or evacuation event. Community energy projects should seek to include alternate or backup power at these types of facilities if feasible. This map zooms in on neighborhoods in Central Brooklyn which host a variety of different potential critical facilities that could be candidates for inclusion in a potential community energy project.

Relevant Projects

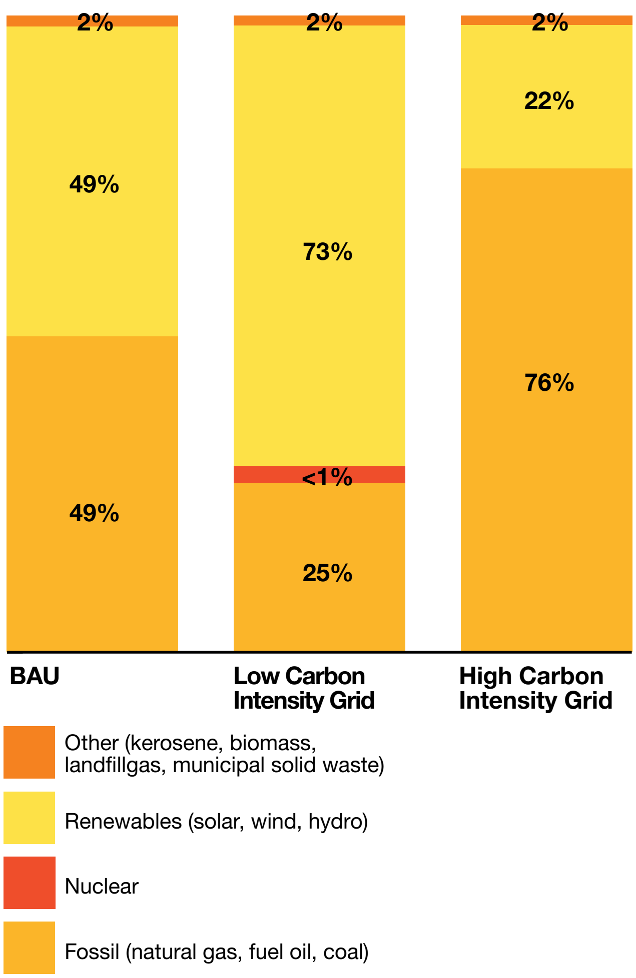
Developing a district heating system and microgrid for the NYCHA Red Hook East Houses and Red Hook West Houses. To meet heating needs and provide energy resiliency benefits to over 6,250 residents, many of whom are elderly, disabled, or children, across 28 buildings and 2,873 apartments, NYCHA issued an RFP in June 2016 for the development of a district heating system and resilient microgrid for its Red Hook Houses. The eight existing steam plants, which provide heat to these residents, were severely damaged by flooding from Sandy, and the buildings are currently receiving heat and hot water from temporary boilers. NYCHA hopes to enter contract negotiations by end of 2016.

Piloting an energy resiliency project for Hunts Point in the southeast Bronx. Home to a strong residential community and a major industrial job hub for food distribution, Hunts Point is vulnerable to infrastructure outages and flooding. The Hunts Point Resiliency Project will result in the implementation of an energy pilot project that will enhance the resiliency of the area and decrease its vulnerability to extended power outages. Guided by an extensive stakeholder engagement process that includes over 45 local community organizations, businesses, residents, and elected officials, the project aims to build resiliency, strengthen the community, and provide workforce opportunities in the peninsula.

This is in line with the City's low carbon intensity grid scenario, and is increasingly feasible as renewable energy sources become more economically viable and as a result of both policy decisions and technological innovation. Deploying these resources for New York City's grid will also require adequate transmission capacity to the city.

Reducing demand on the electric grid by maximizing energy efficiency in buildings, scaling up distributed solar PV, and installing energy storage would increase the ability to meet energy demand with renewable energy sources. At the same time, we must also shift away from fossil fuels for heating, cooling, and hot water production in buildings. When combined with efficiency improvements, transitioning these systems to high efficiency electric technologies, such as air source or ground source heat pumps, could achieve significant GHG reductions by tapping into a clean future electric grid (see Buildings chapter). Similarly, transitioning to electric vehicles will contribute further GHG reductions by reducing the use of petroleum in on-road vehicles (see Transportation chapter).

2050 Electric Grid Fuel Mix by Scenario



The City can also deploy low-carbon district heating and cooling networks at strategic locations to reduce energy consumption and provide resiliency benefits by capturing wasted heat from power plants, substations, and building cooling systems and installing district-scale ground source and water source heat pumps.

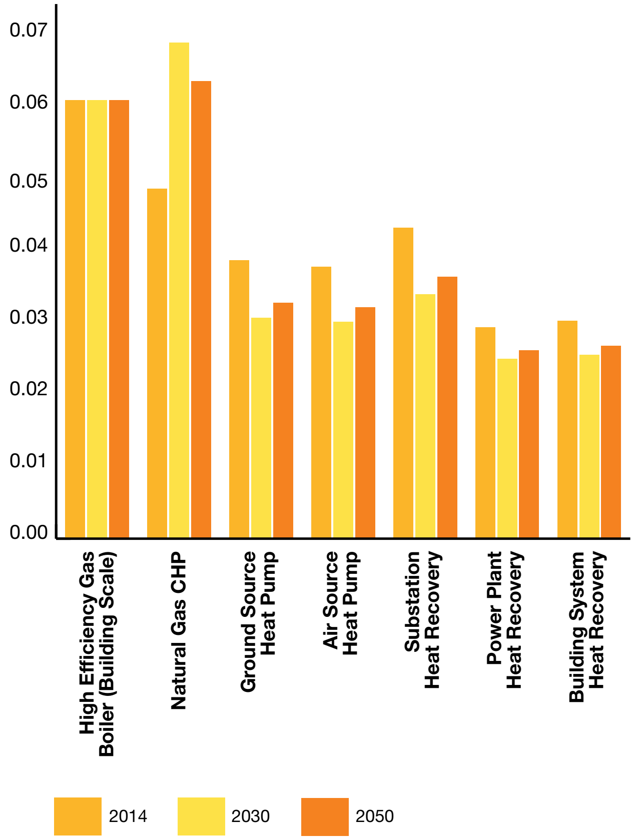
To better understand the opportunities for supplying local energy sources, the City is developing a Community Energy Map to analyze the technical potential of a range of distributed energy resources throughout all five boroughs of the city, block by block. The Community Energy Map will consider the current demands for heating, cooling, and power across different building typologies, the physical characteristics of each block, the technical potential for several technology types, and the business case for these technologies. The analysis will further prioritize opportunities based on their potential for GHG reductions and several geographically-based indicators of social vulnerability.

The analysis found that CHP is a promising technology for community energy today because its beneficial use of waste heat from electricity generation makes it economical and reduces GHG emissions relative to the current electric grid. However, when paired with the City's low carbon intensity grid scenario, natural gas-fired CHP will cease to provide a GHG reduction benefit. Still, CHP is an important part of the 80 x 50 roadmap because it can be the primary source of heat for district heating networks in the near term. In the long run, natural gas CHP could transition to renewable fuel sources or be phased out in favor of low-carbon heat sources such as biogas to reduce GHG emissions. This strategy allows CHP to play an important role in establishing district heating and cooling networks in New York City that will ultimately be necessary to achieve 80 x 50.

Challenges to address

While the adoption of DERs bears promise for the City's GHG reduction, air quality, and resiliency goals, high levels of DER adoption are hampered by regulatory, technical, and financial challenges. DERs are subject to various

Carbon Intensity of District Heating Sources
($tCO_2e/MMBtu$)



permitting and interconnection requirements that can add time and expense to project planning. Once completed, the value proposition for several types of DERs depends on factors such as the compensation received from utilities for energy that is not consumed on-site, but is rather exported to the grid (currently governed by a "net metering" tariff that allows on-site energy production to offset energy consumption) and the cost of maintaining utility service as a backup to the DER when it is out of service (known as a "standby tariff"). With State-level regulatory activities taking these tariffs under review as part of REV, there is an opportunity for the City and others to advocate for the more holistic valuation of the benefits DERs provide to the grid, the environment, and society. Failure to adjust these tariffs to recognize the full value they provide will continue to hinder significant DER uptake.

Given the above hurdles to DER adoption in addition to space constraints, the City will need to look beyond its own borders for the provision of large-scale renewables. While the high density of New York City's built environment is conducive to public transit and provides opportunities for community energy solutions, it also means that the city has little available land for large-scale renewables. With the exception of the Bronx, New York City is a city of islands, meaning that there are a limited number of transmission lines that connect the city to the regional electric grid, which has greater access to land and natural resources for large-scale renewables. Much like other infrastructure investments, adding new transmission capacity will require major capital investments and years to develop. Still, the City can engage the State and the New York Independent System Operator (NYISO) regarding the need for transmission investments to bring economic renewables from upstate into New York City.

Policies that are set at the state, regional, and federal level are the main drivers of future GHG reductions from the electric grid. Statewide policies are helping to increase the role of renewable energy in the grid mix, but additional regulatory changes are necessary to support market conditions for existing power plants to transition to cleaner, more flexible technologies that support a renewables-based grid. The lack of direct City control over its electricity supply makes it more critical for the City to leverage its purchasing power, where possible, to invest in renewable energy resources.

State and regional entities have also helped to address economic challenges to low-carbon electricity generation through RGGI, which is an interstate emissions trading scheme among northeastern states that places a cost on GHG emissions from power plants. Putting a price on carbon allows market forces to drive down demand for high-carbon fossil fuels and make renewable energy more economically competitive, although current prices still do not reflect the true cost to society from the environmental and public health impacts associated with GHG emissions and emissions of criteria pollutants, including particulate matter, ozone, carbon monoxide, sulfur oxides, nitrogen oxides, and lead, and as a result, have not had a significant impact on the market. Moreover, our modeling indicates that more electricity will be imported from outside the RGGI-participating states by 2050. Accordingly, the City must advocate for state, regional, and federal policies that better reflect the social costs of energy production to ensure future supplies come from clean and renewable sources.

The price of natural gas can also partly determine the feasibility of a sufficiently renewables-based grid to achieve 80 x 50. Natural gas prices have been relatively low in recent years due to an increase in supply explained in part by the widescale use of hydraulic fracturing, or "fracking," to extract natural gas from shale formations. Fracking is a controversial method of natural gas extraction, with opponents pointing to adverse effects on local water quality among other impacts. The transition from oil and coal to natural gas, which burns cleaner than other fossil fuels, has contributed to lower GHG emissions to date in power plants. However, sustained low natural gas prices could increase our reliance on gas and delay the uptake of large-scale renewables.

The transition to a renewables-based grid will also heighten challenges of intermittency. In order to provide reliable service, the grid will need to become increasingly flexible, incorporating energy from centralized or decentralized plants that can ramp up and down quickly. This will need to be combined with utility-scale storage to respond to the daily fluctuations of solar and wind generation. Making this transition will require technological solutions as well as price signals that provide incentives for supply balancing resources and load management.

Simultaneously, as building systems and vehicles shift from heating fuels and petroleum to efficient, electric-based technologies, increased electricity demand may affect grid performance and resiliency as we become more dependent on the grid to support more of our daily activities. An increased dependence on reliable electricity, coupled with increasingly intermittent supply to the electric grid, make it imperative that decisive steps are taken to develop the necessary market and regulatory environment to enable emerging grid management technologies to flourish.

Near-term actions to reduce GHG emissions

Increase direct and indirect investments in large-scale renewable energy and energy storage

New large-scale renewable energy systems are one of the most critical investments for achieving 80 x 50. The CES will build upon existing renewables in the state, realizing more of the potential for on-land wind turbines and large-scale solar farms upstate. New York City's ambitious 80 x 50 goal will require going beyond full implementation of the CES. This includes fostering a new regional market for offshore wind, similar to those along European coastlines.

To help catalyze the market for large-scale renewable energy, in July of 2015, the City issued a Request for Information to identify projects that would meet 100 percent of City government electricity needs from new renewable energy while maintaining reliability and affordability. After responses were received in September 2015, no single project met all of the requirements. The City has met with various respondents and other stakeholders, including project developers, regulatory agencies, utilities, and environmental advocates, to explore options in greater detail and to identify opportunities to further spur private-sector investment.

From these collaborations, the City has identified several near-term opportunities and continues to work with a broad base of stakeholders to accelerate and ensure longer-term opportunities have the greatest potential to be realized. The City is engaged in discussions with offshore wind developers on ways the City could facilitate the development of this resource around the metro area. This will signal the City's interest in offshore wind, help attract components of the supply chain to the local area and boost economic activity, and provide valuable lessons for larger offshore wind farms off of New York City that are further out on the horizon.

In addition, the City has been speaking with a number of developers who are looking to bring larger volumes of renewable energy from outside of New York City into the local system via high voltage direct current (HVDC) transmission lines. These types of projects have the ability to tap into numerous renewable energy technologies, including solar, land-based wind, and hydroelectric power, in locations that are more suitable to their development and transmit the energy long distances, often underground, with less energy lost along the way.

Along with GHG emission reductions, future offshore wind farms along with underground HVDC lines that connect directly into the local grid afford New York City an increased level of reliability and resiliency that will help keep the power on and restore it more quickly when there are major interruptions from natural or human induced events. They also bring the added benefit of reducing reliance on older, less efficient in-city generators, resulting in improved air quality and public health. The City will continue to assess how it can leverage its purchasing power and work with utilities, regulators, transmission owners, grid operators, generators, environmental advocates and developers to bring about legislative and rule changes that will facilitate the delivery of 70 to 80 percent of the citywide electrical load from renewable energy sources.

Increase efficiency and emissions requirements for in-city generators

The in-city generation stock is expected to transition from providing roughly 50 percent of generation today to less than one-third in 2050. It will need to play a supporting role to the renewables-based grid, shoring up the reliability of electricity supply within the five boroughs. The City will continue to support the repowering or replacement of the most inefficient power plants. Those remaining will need to be efficient natural gas turbines that can ramp up and down quickly to complement the ebb and flow of a grid highly reliant on intermittent renewable energy resources.

The City will work with the New York State Public Service Commission (PSC) to create a long-term vision for the future of the grid and will advocate for NYISO to develop standards that will guide this transition. One such example is the development of a ramping tariff that would allow NYISO to procure ramping capability to address the intermittency challenges associated with a renewables-based grid. The City will continue to play an active role in NYISO discussions that impact the investments in and operations of in-city generators. We will also advocate for investment in programs and products that improve grid flexibility and ensure power quality.

The City will pursue the expansion of the transmission network that connects the city to the regional grid, in order to access clean regional resources and reduce the need for in-city generating capacity to satisfy the city's reliability requirement. In turn, this will facilitate the retirement of older, less efficient plants and reduce costs for ratepayers in the long run. The City will also support measures to expand the in-city transmission and distribution network to address acute stresses, such as local transmission constraints near load pockets, in order to further decrease reliance on in-city generators.

Make an unprecedented commitment to promote clean, distributed energy resources

DERs, including rooftop and community solar, energy efficiency, and energy storage, will play an important role in increasing the amount of clean energy in the city, especially in the near term. They also play a critical role in reducing demand on the grid and providing resiliency benefits. Therefore, building on efforts over the last few years, the City is bolstering its commitment to support their deployment.

Community energy solutions can support both climate mitigation and adaptation needs. The development of the Community Energy Map allows the City and project developers to identify which locations provide the opportunities to both reduce GHG emissions and enhance the resiliency of vulnerable neighborhoods with community energy systems.

In addition to evaluating the technical potential of different distributed generation sources, the Community Energy Map incorporates dimensions of climate change vulnerability—including energy affordability, air quality, heat risk, and flood risk—so that investments in clean, resilient energy investments can be prioritized to address these challenges. The findings from this analysis could facilitate potential partnerships for community energy projects. The City will explore developing the map into an online resource that will help communities and project developers identify potential sites for community energy projects.

The City can lead by example by deploying DERs on our own buildings and can leverage our own assets to foster community energy solutions. The City owns thousands of public facilities, including 14 wastewater treatment plants, throughout the five boroughs, and has committed to retrofit every municipal building with significant energy use to improve energy efficiency and to install 100 MW of distributed solar energy on City-owned property by 2025 (see Buildings chapter). NYCHA has an additional 328 developments and has committed to reduce energy intensity per square foot from these properties by 20 percent by 2025 though energy efficiency upgrades and the development of 25 MW of renewable energy capacity by the same year.

From hospitals and office buildings to neighborhood schools and libraries, larger public facilities offer an opportunity to serve as host sites or power and heating off-takers for community-scale energy projects. As densely developed as the city is, there are opportunities to consider brownfields, landfills, other open spaces, and public rights-of-way for community-scale energy resources. The Department of Citywide Administrative Services (DCAS) already identifies any City-owned properties that may be candidates for rooftop solar. DCAS is now exploring the expansion of this program to identify vacant City properties that could be used to host community shared solar arrays. The City will explore ways to facilitate the beneficial use of such sites through a variety of mechanisms, such as through low- or no-cost land leases.

To promote greater penetration of DERs, the City is working to address regulatory and market barriers to deployment. "Soft" costs due to permitting and interconnection requirements have impeded the growth of building- and community-scale DERs. The City is actively engaged in reviewing regulatory barriers and encouraging modifications to existing utility tariffs to support their more efficient deployment. For example, the City has continually advocated for changes to utility standby rates, which are designed to recover the utility's costs of "standing by" with a reliable supply of power in the event that a DG unit fails and the customer requires full electricity supply from the utility grid.

The City has successfully advocated for modifications to existing standby rates to make them more attractive for DG project developers. Examples include encouraging the PSC to create a "campus-style" standby rate that allows a customer to offset load at multiple buildings from a single DG unit. The City also successfully argued for an incentive for standby customers that rewards DG units for reliable performance and petitioned for modifications to the steam standby rates to reduce onerous steam standby charges that can make DG project economics challenging.

The City has also played a key role in shaping discussions around net metering, which has been a critical driver in smaller-scale DG development throughout the City. The City is actively participating in the statewide effort to develop a successor tariff to net metering with the objective of encouraging significant new investment in renewable energy over the next several years. In addition, the City has been a leading proponent for community DG, which, through projects such as community shared solar arrays, is designed to extend the benefits of smaller-scale DG to a much greater number of participants—particularly customer segments like low-to-moderate income customers that have been historically underserved by renewable energy development. The City recently joined a coalition of solar industry and environmental advocates in petitioning the PSC to remove, for certain building arrangements, the 10-member requirement currently in the community DG rules, with the goal of expanding opportunities for on-site community DG to the many smaller, multifamily buildings located throughout New York City.

Furthermore, the City has been an active voice in reforms to utility interconnection procedures, which are routinely cited as one of the largest barriers to increased DG deployment. As a result, the City advocated for changes to New York's standardized interconnection requirements that are designed to, among other things: (1) expedite the interconnection process for projects that will have minimal impact on the utility grid; (2) reduce the upfront costs that project developers are required to bear; and (3) expand the project size limit (from 2 MW to 5 MW) for eligibility under standardized interconnection treatment. In addition, the City is a participant in the PSC's ongoing Interconnection Policy Working Group, which is tasked with identifying and resolving major barriers to DG interconnection with the utility grid, such as uncertain allocation among developers of required utility upgrade costs. All of these efforts are designed to reduce the time and expense associated with utility interconnection, while ensuring that interconnections continue to be completed in a safe and reliable manner.

These measures serve to benefit various forms of clean DG and will support the City's ambitious solar deployment goals. In 2014, the City committed to install 100 MW of solar PV capacity on City-owned property by 2025 and to support the development of 250 MW of solar PV on private property by 2025, in part through group purchasing and community shared solar projects. The City is over a third of the way toward achieving its 250 MW private-sector solar target (combining the 69 MW in operation with the 17 MW in development) and on track to be a quarter of the way toward its 100 MW goal by the end of 2018.

As we continue progressing towards the OneNYC solar goal, the City is expanding the citywide installation target (for both private and publicly-owned properties) to 1,000 MW by 2030. The City's efforts to streamline the permitting and review process have reduced the average turnaround time for solar PV plan reviews at the Department of Buildings (DOB) to less than a day (see Buildings chapter) and provide significant support for this new stretch goal. In addition, this new target builds on the impressive recent growth of the city's solar market, which is projected to continue its upward trajectory, on the strength of emerging technologies and market structures. With over 2,700 solar jobs already in New York City, this expanded solar deployment target solidifies the city's position as a major clean energy jobs hub in the northeast.

Through the New York City Solar Partnership, a joint effort of the City University of New York (CUNY), the New York City Economic Development Corporation (NYCEDC), and the Mayor's Office of Sustainability, the City will support programs that accelerate rooftop solar installations and efforts to facilitate community shared solar installations. The Solar Partnership recently launched Solarize NYC, which supports community-led group purchasing campaigns that lower the costs of installing rooftop solar PV, as well as Shared Solar NYC, a program to match developers with rooftop owners that can host large "shared solar" installations. Under Shared Solar NYC, rooftop owners can offer subscriptions to shares of the project's energy output to renters and homeowners without suitable roofs. The City is taking additional policy measures to ensure that community shared solar can flourish in New York City, where its initial uptake has lagged relative to other areas of New York State with greater land availability for substantial solar installations. For instance, the City has submitted a joint petition with other stakeholders throughout the state to the PSC to enable small multifamily properties to structure their own community shared solar projects.

We are also establishing the city's first-ever energy storage deployment target—100 MWh by 2020. Energy storage can enhance the economic viability of solar PV installations while also helping to manage peak electricity demand and provide a resiliency benefit by providing backup power. Energy storage systems also power electric vehicles and can be used to help manage their electricity consumption from the grid in high-voltage charging applications.

Battery technology needs a streamlined pathway through regulatory agencies and into the marketplace. CUNY's Smart DG Hub Resilient Solar Project has been coordinating this process in partnership with City agencies and utilities. For example, fire safety is a key issue that must be addressed before certain types of energy storage systems, in particular lithium-ion batteries, can become widely deployed. The Fire Department of the City of New York (FDNY) is actively engaged in an energy storage testing study commissioned by Con Edison and the New York State Energy Research and Development Authority (NYSERDA) to assess safety and suppression measures required for various types of energy storage systems. This work will inform the development of improved permitting guidelines to streamline FDNY's review process for technologies deemed sufficiently safe in testing. In order to accelerate the safe deployment of emerging technologies, including energy storage systems, the City will make investments to reduce permitting times, develop standards for design and installation of safety measures, and continue to incorporate new technologies into the City's building and fire safety codes.

In addition to solar, the City is exploring opportunities to scale up the use of ground source heat pumps. The City is conducting a cost-benefit analysis that includes the social cost of carbon when comparing ground source heat pumps to traditional heating systems for City-owned buildings. The City is also developing a publicly available online screening tool to assess whether ground source heat pumps can be a cost-effective low-carbon solution for providing heating and cooling to both City-owned and private buildings (see Buildings chapter).

To encourage the further development and adoption of new and emerging technologies, the City, led by EDC, will continue its support for clean technologies and smart cities entrepreneurs and innovation through the Applied Sciences NYC initiative to build or expand world-class applied sciences and engineering campuses

Solar installation in NYC
Photo credit: NYC Deparment of Citywide Administrative Services

in New York City, and UrbanTech NYC—a comprehensive program offering incubation and step-out spaces, prototyping equipment and commercialization programming, demonstration opportunities, and shared resources to companies working to solve New York City's urban challenges.

Laying the Foundation for the Future

The challenge of achieving 80 x 50 goes beyond New York City. Regulatory action is needed at the state, regional, and federal levels to enable large-scale renewables to become the dominant sources in the electric grid. As technologies evolve and distributed energy resources become increasingly cost competitive, the institutional and regulatory framework must evolve to allow for these solutions to be integrated into the energy supply system and to allow for customers to have the ability to play a more active role in determining their energy supply. Public policy must also continue to guide decisions made in the private sector in order for the City to achieve its goals—namely, the City will continue to advocate at the NYISO and PSC for increased transmission that connects the city directly to other areas in the region that are near large-scale renewable energy production facilities.

Con Edison has implemented interconnection and other infrastructure improvements to support DER integration, enhance the resiliency of the grid, and reduce emissions from its steam system. The City will continue to look to Con Edison as a partner in achieving 80 x 50 and will also continue to advocate for utilities to build upon these improvements and accelerate the transformation necessary for a 2050 grid that is renewables-based, affordable, and reliable.

It takes time for new technologies and business models to mature and become competitive with existing systems. Researchers and project developers must also be able to test and refine the technologies in real-world settings to give them ample opportunity to mature. New York City will continue to foster and support innovation by offering public sites to test new technologies and strategies and encouraging private sites to host pilot projects, such as through the DCAS Innovative Demonstrations for Energy Adaptability (IDEA) program (see Buildings chapter). The City and NYCEDC will also continue to invest in emerging technologies and private sector innovation for DERs, DG, energy storage, and other opportunities through its joint initiatives.

The NYISO and the State will have to continue to lead the way in defining the vision for a renewables-based grid, ensuring the NYISO market structures result in the fleet of in-city generators, energy storage, and smart grid technologies necessary to help balance the grid and ensure reliable service. In terms of DERs, New York State's Reforming the Energy Vision (REV) is laying the groundwork for a transition to future energy systems that feature distributed energy resources more prominently, and the City will continue to advocate for utilities to implement REV in a way that allows clean energy to be prioritized based on a variety of social and environmental considerations without sacrificing energy reliability or resiliency.

Energy Strategies	Energy	Buildings	Transportation	Waste
Increase direct and indirect investments in large-scale renewable energy and energy storage	●			
Reduce greenhouse gas emissions of in-city energy systems	●			
Make an unprecedented commitment to promote clean, distributed energy resources	●	●	●	●