EXTREME HEAT
CHAPTER 4.5

Extreme heat causes more fatalities annually than any other extreme weather event in the United States. New York City is particularly susceptible to this hazard due to its dense urban environment, which absorbs and traps the heat. Prolonged periods of this heat accompanied by high humidity create a dangerous situation for vulnerable populations while straining the city's utilities and infrastructure. Climate scientists expect extreme heat events to worsen as a result of climate change.

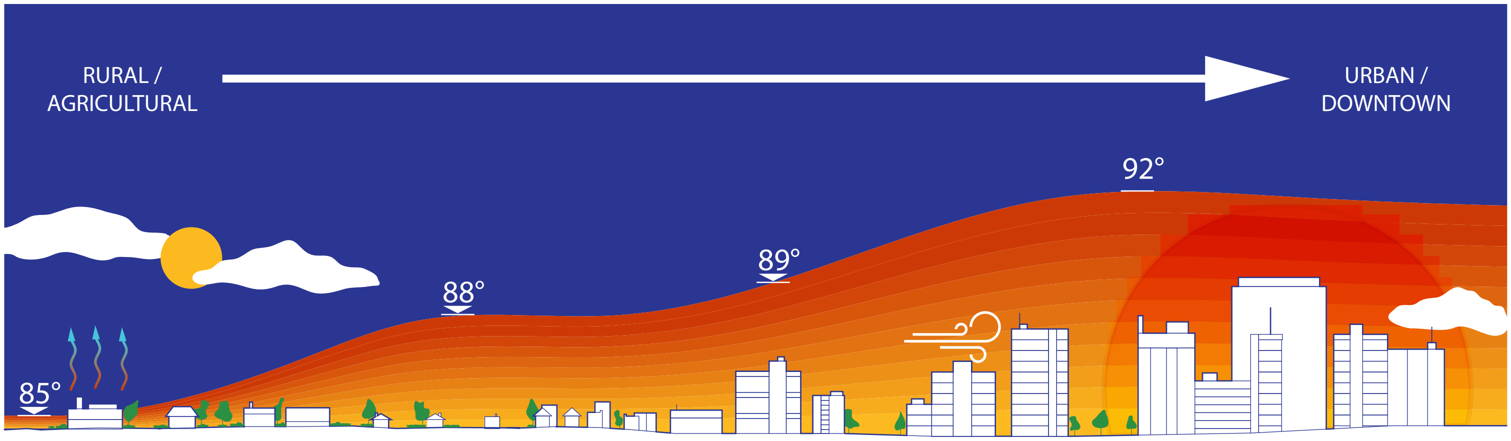
WHAT IS THE HAZARD?

During the summer, New York City usually experiences one or more periods of extreme heat. Heat is not just uncomfortable; it can be dangerous – causing dehydration, heat exhaustion, heat stroke, and in extreme cases, death. It can also cause power outages that produce a cascade of impacts throughout the city.

Extreme heat events are most likely to occur between June and August, but they may also occur in May or September. Between 1971 and 2000, Central Park averaged 18 days a year with temperatures of 90°F or higher.

The effects of extreme heat are worsened by high levels of humidity – the amount of moisture in the air. The higher the temperature, the more moisture the air can hold. High humidity impairs the body's ability to cool itself and can make the temperature feel hotter than it actually is. The combined effect of temperature and humidity – what the temperature "feels like" – is known as the heat index. Another effect of extreme heat is poor air quality, which can occur in New York City during summer months, when stagnant atmospheric conditions trap humid air and pollutants, such as ozone, near the ground.

In New York City, extreme heat events are defined as periods when the heat index is 100°F or higher for one or more days, or when the heat index is 95°F or higher for two or more consecutive days. The longer a heat wave lasts and the hotter the temperature is, the greater the risk of adverse impacts on human health and the city's infrastructure. Climate change is likely to bring us hotter temperatures, more hot days, and more frequent and longer heat waves.



URBAN HEAT ISLAND TRANSECT

KEY HEAT FACTS

Heat causes more fatalities annually than any other extreme weather event.

In New York City, most people who die from heat stress are exposed in homes without air conditioning.

An estimated one in four New Yorkers (25 percent of our population) either do not have or use air conditioning regularly during hot weather.

EXCESS DEATHS

Heat can cause an excess of natural cause deaths (or "excess mortality.") This occurs when chronic conditions are exacerbated by heat and result in death, but heat is not recognized as a contributing cause on the death certificate.

Excess mortality is estimated using statistical models to determine whether more people died during a heat wave than expected compared with normal summer conditions.

WHAT IS THE RISK?

THE ROLE OF THE URBAN ENVIRONMENT

Our city's massive, dense, built environment creates a phenomenon known as the "urban heat island effect." Heat islands develop in urban areas where natural surfaces that were once permeable are paved with asphalt or covered by buildings and other structures. Incoming radiation from the sun is absorbed by these surfaces during the day and re-radiated at night, raising ambient temperatures. Waste heat from air conditioners, vehicles, and other equipment also contributes to the urban heat island effect. The effect is most pronounced during summer nights, when New York City is, on average, about 7°F warmer than surrounding suburban areas. Under certain nighttime conditions, the city can be as much as 10-20°F warmer than its surroundings.

The severity of an extreme heat event is typically measured by how the temperature and humidity affect people's health. To describe health effects, the National Weather Service developed the heat index chart. The National Weather Service also issues heat advisories, watches, and warnings for New York City. These advisories are based on analyses of the relationship between weather conditions and mortality, conducted by the New York City Department of Health and Mental Hygiene (DOHMH).

While extreme heat affects all of our city, the air temperature varies from location to location within the city. For example, areas with high concentrations of heat-trapping materials and less vegetative cover can be warmer than areas with more vegetative cover, or areas cooled by ocean breezes. Across the city, surface temperatures (the temperature of the ground and of surfaces in the built environment) are typically even more variable than air temperatures on hot days.

Since the late 19th century, the number of days with temperatures of 90 F or higher has been on the rise. Climate scientists predict that by the 2050s the city could have as many 90 F days as Birmingham, Alabama does today - more than triple the 18 days we have now.

PEOPLE AT RISK

Extreme heat can be lethal. Prolonged exposure to extreme heat can take a serious toll on the body and lead to dehydration and heat exhaustion. In extreme cases, heat stroke may occur when the body is no longer able to regulate its internal temperature, causing permanent damage to the brain and other vital organs, and, if not treated immediately, death. Heat exposure can also exacerbate chronic health problems such as heart and respiratory conditions.

In New York City, most deaths and serious illnesses from extreme heat occur from exposure in homes without air conditioning. Most at risk are people who fall into one or more of these categories:

Are aged 65 years or older

- Have chronic health conditions (e.g. heart disease or diabetes)
- Have dementia or serious mental illness that impairs their judgment
- Take certain medications
- Abuse drugs or alcohol
- Are obese
- Are socially isolated or homebound and unable to care for themselves

People who work outdoors or otherwise engage in vigorous outdoor activities are also at risk.

Between 2001 and 2011, an annual average of 450 emergency department visits and 150 hospital admissions due to heat-related illness were reported in New York City, along with an annual average of 13 heat stroke deaths.

In addition to directly causing deaths, heat can produce an excess of natural-cause deaths. This occurs when chronic conditions are exacerbated by heat and result in death, but heat is not recognized as a contributing cause of death on the death certificate. DOHMH estimates that between 1997 and 2013, an average of approximately 100 excess natural-cause deaths per year were associated with heat waves in New York City.

As our population ages and climate change brings more extreme heat events, rates of heat-related impairments and deaths may rise. A 2013 study based in Manhattan projects that the number of heat-related deaths will increase sharply throughout the 21st Century.

CONSEQUENCES FOR THE BUILT ENVIRONMENT

Buildings – internal temperatures

During an extreme heat event, the temperature can rise rapidly in buildings that lack air conditioning, or in which air conditioners are not working properly. A building's age and construction materials can affect internal temperatures, because older buildings were not built to Construction Code standards that require better-insulated windows and walls.

Factors that most affect internal temperature in hot weather are the type of windows and their size, the amount of air that escapes from the building through cracks and leaks in walls, and the amount of insulation in walls and roofs.

Windows matter for the same reason that greenhouses are made of glass: glass transmits heat far more readily than materials like brick, masonry, and wood. Thus, on a hot day, windows cause an internal greenhouse effect. During an extreme heat event, single-family homes that are exposed on all four sides and all-glass buildings tend to heat up the most, while row houses that share

Heat Index (Apparent Temperature)

AIR TEMPERATURE (F°)

RELATIVE HUMIDITY (PERCENT)

0	70	75	80	85	90	95	100	105	110	115	120	125	130	135	
5	64	69	73	78	83	87	91	95	99	103	107	111	117	120	125
10	64	69	74	79	84	88	93	97	102	107	111	116	122	128	
15	65	70	75	80	85	90	95	100	105	111	116	123	131		
20	65	71	76	81	86	91	97	102	108	115	123	131			
25	66	72	77	82	87	93	99	105	112	120	130	141			
30	66	72	77	83	88	94	101	109	117	127	139				
35	67	73	78	84	90	96	104	113	123	135	148				
40	67	73	79	85	91	98	107	118	130	143					
45	68	74	79	86	93	101	110	123	137	151					
50	68	74	80	87	95	104	115	129	143						
55	69	75	81	88	96	107	120	135	150						
60	69	75	81	89	98	110	126	142							
65	70	76	82	90	100	114	132	149							
70	70	76	83	91	102	119	138								
75	70	77	85	93	106	124	144								
80	70	77	86	95	109	130									
85	71	78	86	97	113	136									
90	71	78	87	99	117										
95	71	79	88	102	122										
100	71	79	89	105											
	72	80	91	108											

FATIGUE POSSIBLE WITH PROLONGED EXPOSURE AND/OR PHYSICAL ACTIVITY.

SUNSTROKE, HEAT CRAMPS AND HEAT EXHAUSTION POSSIBLE WITH PROLONGED EXPOSURE AND/OR PHYSICAL ACTIVITY.

SUNSTROKE, HEAT CRAMPS OR HEAT EXHAUSTION LIKELY, AND HEATSTROKE POSSIBLE WITH PROLONGED EXPOSURE AND/OR PHYSICAL ACTIVITY.

HEAT/SUNSTROKE HIGHLY LIKELY WITH CONTINUED EXPOSURE.

National Weather Service Heat-Related Products

Heat Advisory Issued within 24 hours prior to onset of any of the following conditions:

- Heat index of 100°F-104°F for any period
- Heat index of 95°F-99°F or greater for two consecutive days

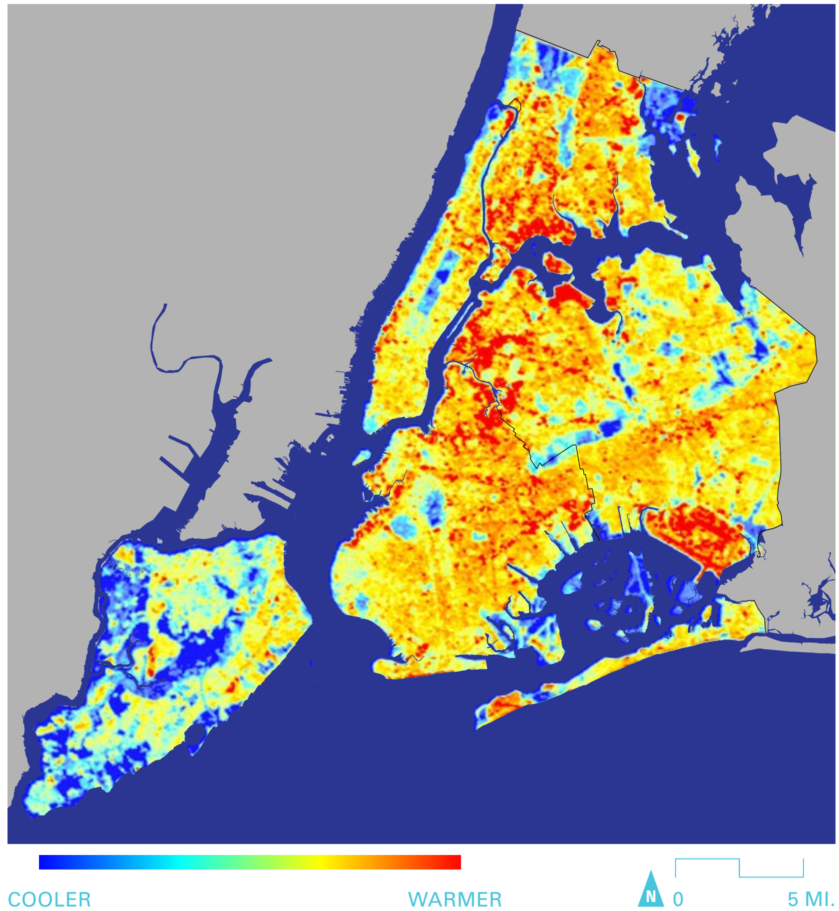
Excessive Heat Watch Issued 24-48 hours prior to onset of the following condition:

- Heat index of at least 105°F for at least two consecutive hours

Excessive Heat Warning Issued within 24 hours of onset of the following condition:

- Heat index of at least 105°F for at least two consecutive hours

SOURCE: NATIONAL WEATHER SERVICE, 2013



THERMAL IMAGERY

SOURCE: LANDSAT THERMAL DATA 08/18/09. NYC DOHMH

walls with their neighbors and masonry buildings with thicker walls are typically at an advantage.

The grid – power outages

Extreme heat drives the use of air conditioning, and thus demand for electricity. When demand threatens to outstrip the grid's capacity to supply electricity, utility providers must take precautions to reduce strain on the system. When capacity is exceeded, blackouts may occur.

Heat can also damage the electric system physically, stressing electrical generation, transmission, and distribution infrastructure. Power lines can overheat and short circuit, in some cases causing power outages. These systems are also affected when more electricity flows through them to meet higher demand, stressing electrical generation, transmission, and distribution infrastructure, which increases the likelihood of failure. The heat can also cause overhead electric and telecommunications lines to sag. If they sag onto trees, they may short circuit and cause an outage.

Outages can have pervasive and severe impacts on people and the built environment. They can shut down air conditioning, fans, elevators, electric pumps that distribute water to the upper floors of high-rise buildings, refrigerators, freezers, computers, and everything else that is plugged into the grid and lacks a source of backup power, including life-sustaining medical equipment. Impacts are greatest on vulnerable populations such as people dependent on oxygen concentrators, motorized wheel chairs that must be recharged, and medications that must be refrigerated.

A citywide power outage that occurred in August 2003 on a normal summer day - not during a heat wave - produced approximately 90 excess deaths. A widespread outage during a heat wave could cause even more deaths.

Power outages can also have significant consequences on communication. If the power is out, cell phones cannot be recharged and internet connections may be lost, and with them access to vital information or assistance in the case of an emergency.

Among other services that are potentially vulnerable in the case of a power outage are healthcare, our food supply system, and wastewater treatment.

Transportation

Extreme heat poses a risk to ground transportation infrastructure. For instance, high temperatures can cause railroad tracks and wires, and pavement and joints on roads and bridges to crack, buckle, or sag, resulting in service disruptions, potentially hazardous travel conditions, and the need for costly repairs. Along with this come problems with the opening and closing of movable bridges and the softening of asphalt roads. Power outages can also disable rail operations that are dependent on electricity.

THE SUMMER 2006 HEAT WAVES AND LONG ISLAND CITY NETWORK POWER OUTAGE

The summer of 2006 featured two severe heat waves. The first lasted from July 16 through July 18; the second from July 27 through August 5. Combined, the two directly caused 46 heat stroke deaths, most of which occurred during the second heat wave. The second heat wave also contributed to an estimated 100 excess deaths from natural causes. The majority of fatalities were among seniors and people with preexisting medical conditions.

While the first heat wave was shorter and caused far fewer fatalities, record power usage during its first 2 days resulted in a major power outage in northwestern Queens that started on July 17 and lasted for 9 straight days. This unprecedented event was the longest single power outage in New York City's history.

Equipment failures in Con Edison's Long Island City network exacerbated the outage, which affected 174,000 residents in the Queens neighborhoods of Astoria, Long Island City, Sunnyside, and Woodside. Local businesses lost an estimated $111 million in revenue and inventory such as spoiled food. The outage also caused traffic congestion: traffic lights didn't work, and police officers had to direct traffic. Total outage-related costs were estimated at $188 million.

The extensive impacts of the outage drove home dramatically the need to protect electric utility networks from extreme heat events. Con Edison subsequently increased its operational capacity, strengthened its communication procedures, and improved its ability to track customer outages. These measures now help limit service disruptions.

CONSEQUENCES FOR THE NATURAL ENVIRONMENT

Poor air quality can occur during a heat wave, when stagnant atmospheric conditions trap pollutants in urban areas. Ozone, a major component of smog, is created in the presence of sunlight by reactions of chemicals in gasoline vapors from vehicles and industrial smoke stacks. Hot weather can increase ozone levels. High ozone levels often cause or worsen respiratory problems.

The U.S. Environmental Protection Agency monitors ozone levels and issues daily air quality forecasts. Its Air Quality Index (AQI) was created to correlate levels of different pollutants to one scale. The higher the AQI value, the greater the health concern. When levels of ozone and/or fine particles are expected to exceed an AQI value of 100, an Air Quality Health Advisory is issued alerting sensitive groups to take necessary precautions. When ozone levels in the unhealthy range are expected, people are advised to limit vigorous outdoor physical activity during the afternoon and early evening hours.

HOW DO WE MANAGE THE RISK?

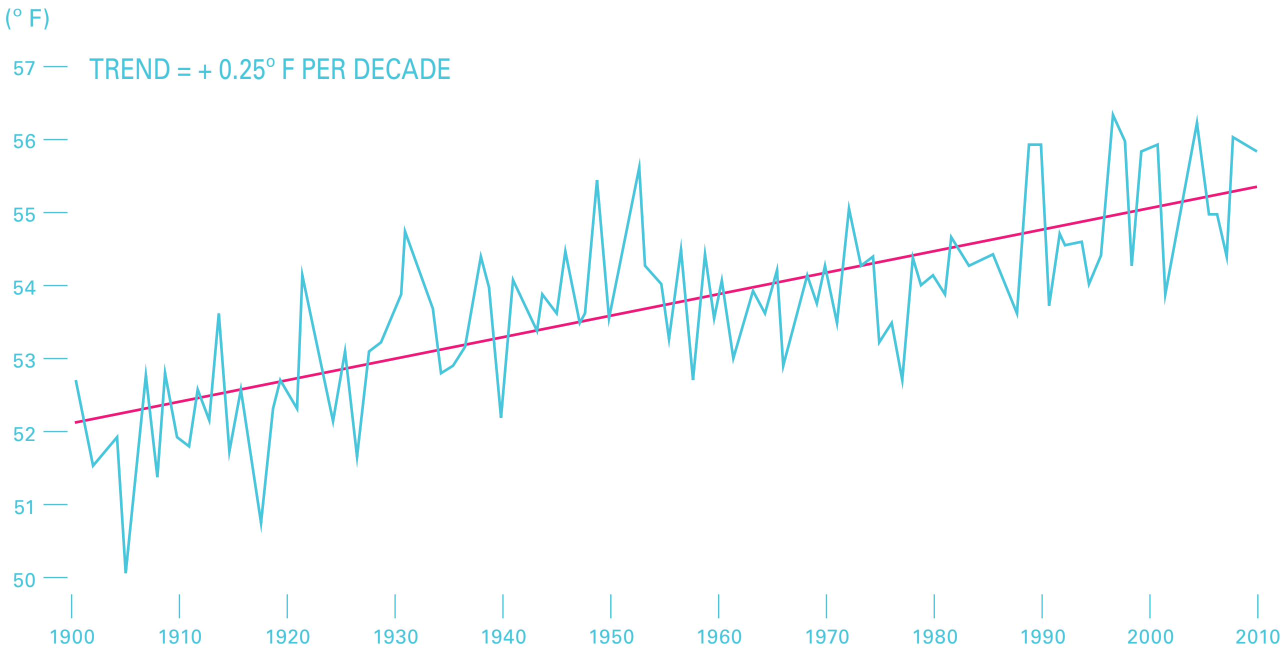
Extreme heat can have significant consequences for vulnerable populations and infrastructure, and the fact that these events are becoming more frequent and severe calls for more comprehensive risk management strategies. Those strategies begin with efforts to inform vulnerable populations about health risks and include measures to protect infrastructure, keep internal building temperatures cool, and reduce the urban heat island effect. What follows is a sampling of strategies.

EDUCATION, COMMUNICATION, AND OUTREACH

Before a heat wave strikes, the public – especially vulnerable populations – must understand the dangers posed by extreme heat, who is most at risk and why, and what practical measures they can take to protect themselves.

- **Education**: OEM's brochure "Beat the Heat" delivers important safety tips and information online and in print. DOHMH offers information about the health impacts of heat and heat illness prevention.

OBSERVED ANNUAL TEMPERATURE IN CENTRAL PARK (1900 - 2011)
Source: NPCC, 2013



- NYC Emergency Management closely monitors National Weather Service heat advisories, and excessive heat watches and warnings. When conditions warrant, OEM activates the City's Heat Emergency Plan, which it developed jointly with the National Weather Service, DOHMH, and many other partners.

- **Public alerts** offer safety tips during heat advisories through Notify NYC and organizations serving vulnerable populations through the Advanced Warning System. Alerts are also given to health care providers through the Health Alert Network and other DOHMH outreach.

- **Cooling centers** are opened at designated locations such as community centers, senior centers, and public libraries, to offer air conditioning to the public. Studies show that spending as few as 2 hours a day in air-conditioned spaces can significantly reduce the risk of heat-related illnesses. During the summer of 2014, the City had over 500 air-conditioned spaces available.

- **Outreach** to the homeless is extended when the heat index reaches 90°F or higher, especially during the sun's peak hours: between 11:00 a.m. and 5:00 p.m. Agencies in regular contact with vulnerable populations, including the homeless, can determine whether individuals may need further protection.

- The "Be a Buddy" campaign describes DOHMH's outreach to the general public advising them to check on neighbors, family, and friends who may be vulnerable during a heat wave. DOHMH includes these messages in all public communications including press releases and heat-health guidance.

PROTECTING INFRASTRUCTURE

Government agencies and private sector parties pursue many strategies to manage risks related to infrastructure. Some are short-term; some are long-term. Some long-term measures deliver the short-term benefit of reducing demand on the grid and thus the risk of power outages.

MAJOR HEAT WAVES THAT INFORMED OUTREACH STRATEGIES

Two of the most significant heat waves in recent memory occurred in Chicago in 1995 and across much of Europe in 2003. The Chicago heat wave lasted for 2 weeks during July. The heat index peaked at nearly 120°F, claiming over 700 lives. The European heat wave was even more dramatic. It affected France, Portugal, The Netherlands, Spain, Italy, Germany, Switzerland, the United Kingdom, and Ireland, and lasted for most of the summer (with the first half of August being hottest). Estimates of heat-related deaths range from 50,000 to 70,000, with nearly 15,000 of them in France. One reason impacts were so severe is that air conditioning is not widespread in Europe. Should a widespread power outage occur in New York City during an extended, severe heat wave, it could greatly increase the public health threat.

The Chicago and European heat waves exposed the vulnerabilities of certain population groups, particularly the elderly, who made up the majority of the victims, and people without air conditioning.

The 10-day heat wave in 2006 was one of New York City's worst extreme heat events in the past two decades. This event prompted expansions of the City's Heat Emergency Plan to increase outreach to vulnerable populations and to emphasize the importance of air conditioning in preventing heat illnesses.

An important dimension of outreach is the Check on Your Neighbor (DOHMH calls the campaign "Be a Buddy") strategy that asks citizens to share life-saving information about heat risks and safety measures with people they know who may require assistance, particularly those living alone.

Energy systems

Utilities employ "supply-side" strategies to reduce strain on the system and continue operations during extreme heat events:

- **System reinforcements** provide alternate or additional supplies of power to minimize the risk of disruption due to heat – for example, by increasing the number of power supply feeders, installing additional distribution transformers, building new substations, and redistributing electric loads among substations.
- **Improving system reliability** safeguards system components so that they are operational and available for service. This includes inspecting and maintaining equipment, upgrading components, and implementing improvements such as redesigning circuits to minimize the number of customers affected, and installing automated switches.
- **Operational readiness** involves measures to prepare system operations for summer conditions by conducting engineering analyses and studies to assess system conditions, implementing protective steps such as voltage reduction, conducting staff training and exercises on how to handle extreme heat scenarios, and confirming that power generators have adequate capacity.
- **Increased system redundancy** provides alternate power supplies if the main supply is disrupted due to heat.

The city's primary utility providers, Con Edison and PSEG, are strengthening their power sources and energy infrastructure by making utility systems more flexible and by diversifying energy sources to minimize impacts of extreme weather events.

- **Utility demand response programs** are short-term strategies that offer financial incentives to customers to avoid blackouts when demand for electricity soars. Con Edison runs aggressive demand-response programs in which commercial, industrial, and residential customers can enroll voluntarily. When demand for electricity soars, Con Edison pays those customers who *temporarily* reduce their consumption of electricity upon request.

Transportation systems

Transportation systems can be protected with measures such as these:

- Equipment upgrades to rail systems involve replacing or retrofitting trains, track signals and switches.

- Retrofits to roads and bridges employ heat-resistant materials to prevent cracking and buckling from thermal expansion.

The MTA has invested in measures to protect its systems and equipment from heat-related damage, such as new redundancy measures and structural improvements to trains, railroad tracks, and buses. The City's Department of Transportation is studying the use of permeable pavements in roads and bridges. While such pavements would primarily reduce impacts from heavy precipitation and snowmelt, it may also reduce impacts from extreme heat: this type of roadway surface would not get as hot as a typical roadway surface.

PROTECTING BUILDINGS

Long-term strategies aim at increasing energy efficiency and lowering indoor air temperatures. Reducing energy consumption over the long-term helps reduce the need for short-term strategies such as utility demand-response programs, and it reduces the risk of power outages.

As building codes have grown stricter over time, they have required better-insulated windows and walls. Many buildings are now being built to performance standards that are even higher than the minimum required in our Construction Codes. High-performance buildings use advanced design and materials such as windows that keep cool air from escaping during

BIOSWALE IN QUEENS BY NYC GREENSTREETS

summer, rigorous air sealing, and extensive insulation. The internal temperatures inside these high-performance buildings remain significantly lower.

Existing buildings can benefit from retrofits like these:

- Sealing and insulating buildings properly keeps them cooler by ensuring that cooled air does not leak out. This can be accomplished by caulking and sealing doors and windows that leak air, and caulking and sealing air leaks where plumbing, ducts, or electrical wiring comes through walls, floors, or ceilings. Making sure walls and attics are properly insulated helps, too, as insulation slows the transfer of heat into the building's interior.

- High-performance materials, such as multiple-paned windows with reflective coatings, help insulate buildings from extreme heat and keep cool air from escaping.

- Energy efficiency retrofits such as higher-efficiency mechanical systems and smart sensors can reduce energy demand, decreasing the strain on the electric grid.

NYC GREEN ROOFS
SOURCE: NYC PARKS

- Utility demand reduction programs provide incentives to commercial and industrial building owners to permanently reduce their energy consumption. Con Edison offers a number of energy efficiency tools to encourage residential, small business, multifamily building, and commercial/industrial customers to reduce energy consumption.

The New York City Department of Housing Preservation and Development has developed *New York City Greenhouse*, a program to help building owners retrofit with higher-performance materials and to reduce the amount of energy and water their building operations consume. The program provides tax credits, rebates, and incentives that promote energy efficiency, as well as tips for lowering energy bills.

PlaNYC includes the *Greener Greater Buildings Plan*, a set of regulatory measures aimed at reducing the City's carbon footprint. As of 2013, the city had reduced its overall emissions by 19 percent since benchmarking first took place in 2005. The *New York City Carbon Challenge*, which commenced in 2007, calls specifically on private sector partners – including universities, hospitals, commercial offices, multifamily buildings, and Broadway theatres – to reduce their greenhouse gas emissions 30 percent by 2017.

While greenhouse gas reductions serve the long-term goal of slowing climate change, the gains in energy efficiency directly and immediately serve the near-term goal of avoiding power outages (while also reducing electricity bills).

ENVIRONMENTAL CONTROLS

Certain features of the natural environment can partially offset the impacts of extreme heat. The urban heat island effect is directly tied to the ratio of natural cover (trees and other vegetation) to artificial built surfaces. Trees and vegetation keep the surrounding environment cooler by releasing moisture into the air, while many built surfaces trap heat and keep the surrounding environment warmer. Risk management strategies focus on increasing vegetative cover to help lower air temperatures and reduce the urban heat island effect:

- Light surfaces reflect more light and heat than dark surfaces, which absorb and retain heat and worsen the urban heat island effect. Converting dark surfaces such as asphalt and blacktop to lighter materials can reduce local temperatures by several degrees. Replacing roofs with lighter materials ("cool roofs") can help lower a building's internal temperature, in addition to reducing surface and surrounding air temperatures.

NYC COOL ROOFS PROGRAM
SOURCE: DOB-SAMANTHA MODELL

- Planting trees and vegetation along streets and in open spaces – "ecological infrastructure" – can significantly reduce local air temperatures. Trees naturally cool the surrounding air by releasing moisture and absorbing carbon dioxide from the atmosphere. Replacing concrete, asphalt, or even grassy surfaces with trees can help reduce the air temperature by several degrees. Green roofs – roofs with vegetation planted on them – can reduce both outdoor and indoor air temperatures.

Through the NYC Cool Roofs Program – a collaboration between NYC Service (New York City's regional volunteer center) and the Department of Buildings – nearly 6 million square feet of roofs have been re-coated with lighter-colored materials, both reducing internal building temperatures and the local urban heat island effect.

The Department of Transportation has also begun to explore the use of lighter-colored pavement and to incorporate it into street resurfacing and reconstruction.

MillionTreesNYC is a public-private initiative which was launched in 2007 by New York Restoration Project and the Department of Parks and Recreation. It aims to plant and care for one million new trees citywide by 2015. The City will plant 70 percent of these trees in parks, along streets, and in other public spaces. The remainder will be planted by homeowners, businesses, and community organizations. Over 870,000 trees had been planted as of July 2014.

The City's *Green Infrastructure Program*, led by the Department of Environmental Protection, promotes a variety of sustainable green infrastructure practices such as green roofs, rain gardens, and right-of-way bioswales on City-owned property such as streets, sidewalks, schools, and public housing. While the program is primarily aimed at reducing the impacts of stormwater runoff and combined sewer overflows, several strategies, such as expanding the number of green roofs, help reduce urban heat island effects as well.

In the summer of 2013, the Mayor's Office of Long-term Planning and Sustainability formed an Urban Heat Island Working Group to explore further means of reducing heat-island effects. It includes policymakers, scientists, and subject matter experts from across the city and from leading academic institutions.