case study

New York Botanical Garden

With strategic planning and innovative upgrades, NYBG cut emissions by 53% per area square foot while nearly doubling the size of the Garden's facilities.

Enid A. Haupt Conservatory, courtesy NYBG © Robert Benson Photography

beex
building energy exchange

NYC Citywide Administrative Services | Energy Management

project overview

Project Type
Energy Efficiency Master Plan
Location
Bronx, NY
Year Project(s) Completed
1993–Ongoing
Year Base Buildings Completed
1840– 2018
Project Size
38 buildings (780,000 sq. ft.), 250-acre campus
Building Type(s)
Cultural Institution: Botanical Garden (Conservatory; Library; Offices; Academic Spaces; Research Labs; Visitor Services)

project team

Project Owners/ Managers
NYBG; NYC DCLA; NYC DDC; NYC DCAS DEM; NYC Council; NYS Parks
Oversight, Energy Management, & Planning Services
NYBG Facilities
Grant Providers
NYC DCAS DEM; NYPA; Con Ed

primary energy figures

Total DCAS Grant Funding (since 1999)
$3.0 million
Simple Payback
10.2 years
Annual Savings
$300,000 (avg.)

Energy Reduction per area sq. ft. (2005–2017)

- Before
- After

Carbon Reduction per area sq. ft. (2005–2017)

- Before
- After

strategies at-a-glance

The New York Botanical Garden's (NYBG) commitment to conservation, research, and education is reflected in nearly all aspects of their work. For over a decade, NYBG has conducted strategic energy efficiency capital planning for their 250-acre, 38-building campus in the Bronx. The Garden uses annual carbon audits and ongoing energy monitoring to identify upgrade opportunities and measure progress towards their goal of reducing emissions 80% by 2050. Efficiency upgrades to date have been wide-reaching and included pilots of innovative technologies and strategies. As a leading educational institution, NYBG has shared lessons learned with other institutions, City agencies, community groups, and visitors. Highlights include:

Heating, Cooling, & Ventilation

- Converted primary heating fuel from oil to natural gas, halving emissions.
- Upgraded AC equipment in five buildings to reduce cooling loads. Work included installing new scroll chillers, variable frequency drives (VFDs), and controls.
- Piloted use of nanotech additives for chillers to improve heat exchange rates in four buildings.
- Installed Variable Air Volume (VAV) controls to reduce air handling unit (AHU) energy use; installed heat recovery units and adjusted louvers to reduce heat loss in one building.
- Piloted component-by-component refurbishment of one building's AHUs (incl. new return fans, dampers, digital motor actuators, VFDs, controls, and steam-to-hot-water converter) to save energy.
- Converted four buildings from steam heating to higher efficiency hydronic.

Domestic Water

- Installed VFDs on 60% of pumps & motors to modulate energy use.
- Piloted installation of SmartValves in one building to reduce standby heat losses.
- Upgraded to efficient condensing boilers in four buildings.

Lighting

- Upgraded interior and exterior lamps to LEDs campus-wide.

Monitoring & Controls

- Upgraded from stand-alone Building Management System (BMS) to networked BMS and integrated it with new equipment to increase reliability and control.
- Real-time energy monitoring to fine tune systems and identify preventative maintenance needs.

Additional Measures

- Demand management with a commitment to reduce loads up to 25% during peak periods.
- Alternative energy development, including solar PV installations at two buildings; conversion to EV and CNG fleet; and installation of CNG and EV charging stations
- Carbon sequestration through organic gardening, new plantings, mature tree care, and restoration.
- Education & outreach for visitors, students, community groups, and City agencies to inspire environmental stewardship.

benefits at-a-glance

- Energy use and peak demand reduction
- Reduced utility & operating costs
- Reduced carbon footprint
- Improved ability to coordinate, schedule, and budget for projects using multiyear strategic plan
- Proof-of-concept for innovative measures through tech pilots
- Reduced pollution and stormwater runoff
- Support for NYBG's mission to protect natural resources for current and future generations

Image courtesy of The New York Botanical Garden

project description

"We want to lead the charge for energy efficiency, sustainability, and climate action. When we learn about a good idea, we go for it."
– Mark Cupkovic, VP for Site Operations & Chief Sustainability Officer

Since 1891 The New York Botanical Garden (NYBG) has been a world leader in environmental conservation. A National Historic Landmark, NYBG's 250-acre campus features a wide variety of plant collections, landscapes, and buildings. Over the past decade, NYBG has transformed its facilities into a 21st-century model of sustainability. By implementing annual carbon accounting, integrating energy efficiency into capital planning, and piloting innovative solutions, NYBG has reduced energy use by 21% and emissions by 53% per area sq. ft. since 2005, saving nearly $300,000 each year.

summary

A champion of conservation for over a century, NYBG has extended this commitment to their own facilities. In 2007, NYBG pledged to reduce carbon emissions 30% below 2005 levels by 2017 to align their efforts with New York City's climate action plans. The Garden implemented annual carbon and energy auditing to identify ways to meet and track progress to their goal. With buy-in from NYBG leadership and support from the City, the Garden integrated energy efficiency into long-term capital planning. Since 2007, NYBG has implemented a wide array of energy conservation measures across their campus, quickly surpassing their initial goal. Now on track to reduce emissions 80% by 2050, NYBG is sharing data and lessons learned with other organizations to help accelerate NYC's progress toward a more sustainable future.

NYBG welcomes more than one million visitors to the Garden each year. In addition to delivering visitor services, educational programs, and cultural events, NYBG supports leading-edge plant science research. In NYBG's labs and in field research around the globe, staff observe the impacts of climate change first-hand. To tackle this challenge at home and lead by example, NYBG has committed to making their Bronx campus a model of sustainability.

In 1993, with help from the City, NYBG implemented the Efficient Lighting Project, their first multi-year, comprehensive energy improvement project. By 2007, both the City and the Garden decided that it was time to take bolder action. That year, NYBG launched a sustainability campaign, conducted their first annual carbon audit, and held the first of what would become an annual forum on climate research and action. The following year, the City released PlaNYC, which set forth detailed climate goals for the City and ushered in a new era of environmental awareness. As an active City partner and participant since the first PlaNYC meeting, NYBG quickly aligned their own climate action goals with those of the City.

Guided by a decade of energy audit data and an organizational commitment to long-term sustainability and efficiency planning, NYBG has since cut its carbon footprint roughly in half. Funding from the City, particularly the Department of Citywide Administrative Services' Division of Energy Management (DCAS DEM), has enabled NYBG to implement a wide array of energy efficiency capital upgrades and operational improvements. Upgrades have touched many major building systems, including heating, cooling, ventilation, domestic water, and controls.

Additionally, NYBG has embedded sustainability into its horticulture, public education, and community outreach endeavors. Despite a building campaign that increased the Garden's built square footage by 90% and a near equal increase in visitor attendance, from 2005 to 2017, NYBG reduced energy use by 21% per area sq. ft. and emissions by 53% per area sq. ft. (or by 47% per visitor), saving nearly $300,000 each year.

existing conditions

NYBG's 250-acre campus features 50 gardens and plant collections, 50 acres of old-growth forest, and 780,000 sq. ft. of built space with 38 structures of diverse age, type, and use.

Facilities Overview: NYBG's buildings range from a historic 1840s-era Stone Mill, turn-of-the-century Beaux-Arts library and Victorian-style conservatory, post-war educational facilities, visitor center, and greenhouses, to more recently constructed comfort stations and research labs. Multiple natural-gas and dual-fuel boiler and chiller plants provide the majority of the campus' heating and cooling. Some plants serve a single building, others serve a cluster.

Organizational Overview: NYBG is one of 33 entities that make up the NYC Cultural Institutions Group (CIG). As a CIG on City-owned property, NYBG provides cultural services for New Yorkers and in return receives 10% of its operating funds from the City, including the cost of energy. The other 90% of operating costs are funded by private contributions, earned revenue, and endowment income. Over three decades, more than $350M has been invested in the Garden's buildings and grounds, of which about 40% was provided by the City. The balance was funded primarily by private sources, including individuals, foundations, and corporations.

For energy efficiency projects, the bulk of funding comes through three programs of the NYC Department of Citywide Administrative Services' Division of Energy Management (DCAS DEM): Accelerated Conservation and Efficiency (ACE), Expenses for Conservation and Efficiency Leadership (ExCEL), and Innovative Demonstrations for Energy Adaptability (IDEA). Additional funding has also been provided by Con Edison and the New York Power Authority (NYPA).

NYC DCAS Energy Management (DCAS DEM)

As part of a suite of programs to help New York City government agencies advance their energy management efforts, the Department of Citywide Administrative Services' Division of Energy Management (DCAS DEM) provides competitive grant funding opportunities for energy retrofit projects and operations and maintenance measures. Since 2006, DCAS DEM has invested more than $900M in energy retrofit projects that advance the City's greenhouse gas reduction goals and deliver energy usage reductions, cost savings, and resiliency benefits. These projects represent investments in over 1,400 properties that cumulatively reduce the City's carbon emissions by more than 25% across 27 City agencies.

project details

Leveraging more than a decade of audit data, grant funding from DCAS DEM, support from the NYBG administration and Board of Trustees, and a spirit of innovation, the Garden has completed an impressive array of upgrades. Highlights include:

A **Heating, Cooling, & Ventilation:** NYBG's most significant energy and carbon savings have been achieved by optimizing heating, cooling, and ventilation (HVAC) equipment. Highlights include:

Fuel Conversion: In 1997, NYBG converted from heavily polluting #4 oil to cleaner natural gas as the primary fuel for the Garden's major heating plants, reducing fuel-related emissions 52%.

Cooling Upgrades: Since 2007, NYBG has upgraded AC equipment in five major buildings. Work included replacing reciprocating AC units with new scroll chillers, which alone improved cooling efficiency by 38%. NYBG also installed variable frequency drives (VFDs) on motors and advanced controls to manage new systems, further reducing cooling energy use by 40%.

Nanotech Additives: In 2015, NYBG piloted the use of MicroGuard, a catalyzed siloxane coating for AC unit coils that improves air flow and increases heat transfer efficiency by 16%, on average. The following year, NYBG applied Permafrost, a one-time additive to coat the interior pipes of its centrifugal chillers and prevent particulate build-up, improving chiller efficiency by an additional 18%. In 2017, NYBG piloted the use of HTF, an antifreeze-like additive that maintains consistent heat transfer in water and has been found to further improve chiller efficiency by 15%.

Ventilation Upgrades: Showing innovation not only in retrofit technologies but also processes, in 2014, NYBG completed a component-by-component refurbishment of one building's Air Handling Units (AHUs). The alternative – craning in a brand new model – would have been exponentially more expensive. AHU refurbishment included installing new return fans, dampers, digital motor actuators, VFD motors, Variable Air Volume (VAV) controllers, and a steam-to-hot-water converter. Additionally, NYBG replaced drafty louvers with fresh air supply units, reducing heating and cooling losses and energy needed for ventilation.

In 2017, NYBG completed ventilation improvements in one of their lab buildings, adjusting fume hood exhaust louvers, installing energy recovery units and VAVs, and programming nighttime setbacks to reduce excessively high air change rates to cut ventilation energy use by 12%.

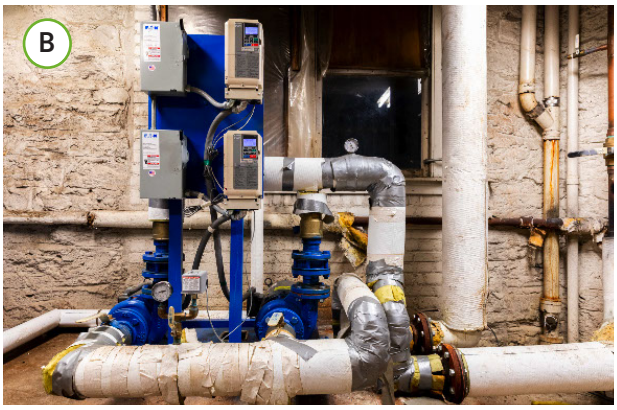
Heating Upgrades: In 2010, NYBG completed an extensive renovation of their historic 1840s-era Goldman Stone Mill. Work included converting the steam heating distribution system to high efficiency hydronic, which helped increase overall building efficiency by 11%. Following this success, NYBG completed steam-to-hydronic conversions in three additional buildings.

B **Domestic Hot Water (DHW):** Domestic water booster pumps across the Garden's property were originally designed to run on a continuous basis. In 2017, NYBG installed VFDs in five buildings so pumps run only as needed, increasing their efficiency by 50%. Based on the success of this measure, NYBG plans to install VFDs on all applicable pumps and motors moving forward. Also in 2017, NYBG piloted the installation of SmartValves to regulate DHW flows and reduce standby heating losses, cutting DHW energy use by 18%. Additionally, since 2010, NYBG has replaced DHW heaters in four buildings with condensing boilers that are 11% more efficient, on average.

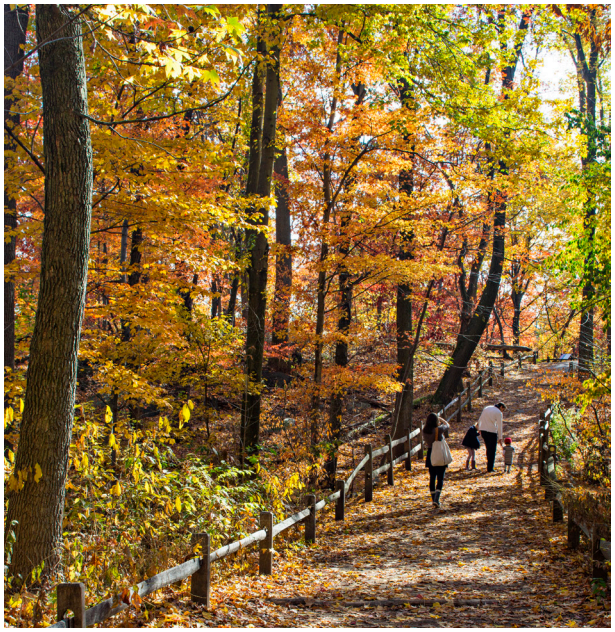
C **Lighting:** Lighting was the first energy system upgrade NYBG tackled, starting in 1993 with upgrades of interior fluorescent lighting fixtures from T-12 lamps to more efficient T-8s, incandescent lamps to CFLs, and exterior high-pressure sodium lamps to metal halide ones. Since initiating this Efficient Lighting Project, NYBG has continued to upgrade fixtures to the most efficient technologies available. Currently, NYBG is converting all interior and exterior fixtures to LEDs, with expected energy savings of 50%.

D **Controls and Sensors:** In 1997, NYBG piloted an early precursor to a Building Management System (BMS) in one of their buildings. In 2007, they installed their first modern BMS across multiple buildings. Since then, NYBG has upgraded pneumatic controls to direct digital ones and stand-alone BMS to a networked system, enabling greater reliability, control, and communication. Approximately 75% of NYBG's facilities are currently covered by the BMS – even the historic Goldman Stone Mill, which had sensors and controls installed during its 2010 renovation.

All connected equipment can be monitored online in real-time and adjusted by NYBG staff. This networked BMS has allowed NYBG to maintain the same number of engineers and facilities staff over the last decade, despite a 90% increase in the Garden's built area. It has also helped reduce operating costs and track performance of retrofits to date. By alerting staff to preventative maintenance needs, the BMS is also reducing maintenance costs and helping NYBG plan strategically for future equipment upgrades.



From Top: New scroll compressors for cooling; water booster pumps with VFDs; exterior LED lighting upgrades with historic casing intact; the historic Goldman Stone Mill, built circa 1840, which had cutting-edge energy sensors and controls installed as part of campus-wide BMS upgrades. (All images courtesy of The New York Botanical Garden)



From Top: Greening NYBG's fleet of vehicles; educating the next generation of environmental stewards at the Edible Academy; sequestering carbon through mature tree care in the Thain Family Forest. *(All images courtesy of The New York Botanical Garden)*

E Additional Measures

NYBG has integrated sustainability into nearly every facet of their operations. Additional measures taken to reduce the Garden's energy use and carbon footprint include:

Demand Management: NYBG participates in a citywide demand response program to reduce energy use up to 25% during times of peak demand on the electric grid. To achieve this reduction, NYBG turns off secondary pumps, motors, and equipment across the physical plant, and encourages staff to reduce unnecessary lighting and electricity use. NYBG joined the DCAS-run program in 2006, making it the first NYC cultural institution to do so. In summer 2017, NYBG received $80,000 for their participation.

Green Vehicles and Alternative Energy: NYBG installed one of the first Compressed Natural Gas (CNG) stations in NYC in 1997 and added Electric Vehicle (EV) stations in 2012. The Garden has since converted all visitor trams to CNG, reducing their emissions by 48% and is committed to purchasing additional EV and CNG-powered vehicles moving forward. NYBG has also installed solar PV arrays over four parking garage stair towers and over the Edible Academy's Solar Pavilion. DCAS DEM recently awarded NYBG funding to install innovative solar fabric tents made by Pvilion.

Carbon Sequestration and Garden Management: NYBG has achieved sequestration equivalent to 4% of its annual carbon emissions through restoration and management of existing trees, gardens, and turf, as well as through new plantings. NYBG's grounds and garden also staff use a variety of methods to reduce emissions and pollution, including organic gardening techniques like on-site composting, integrated pest management, and using natural alternatives to chemical pesticides and fertilizers. Since 1988, NYBG's Bronx Green-Up program has worked with local partners to establish over 200 community gardens, helping to green the broader Bronx community.

Outreach and Education: Through hands-on learning experiences at the Everett Children's Adventure Garden and the Edible Academy (recently awarded LEED Gold certification for its Classroom Building), NYBG serves 90,000 students annually, helping to train the next generation of environmental stewards. NYBG also offers comprehensive adult education programs in horticulture and plant science, serving more than 9,000 participants a year. Additionally, NYBG brings garden-based sustainability and science curricula to public schools across the Bronx, having trained over 52,000 teachers since 1995.

lessons learned

"The progress the Garden has made is due to sustainability in action – the foresight to set aside land and resources... for future generations."
– "Accounting for Our Carbon," NYBG

Strategic Planning: Building a Shared Vision

Generating staff buy-in is critical to the success of any long-term efficiency plan. In the case of NYBG, this has been relatively easy. Integrating a lens of energy and carbon reduction into the Garden's capital planning process supports their core mission of protecting natural resources. This mission is embraced not only by the NYBG administration and Board of Trustees, but by their entire community of staff and visitors. This shared vision helps drive and sustain NYBG's long-term commitment to efficiency planning and upgrades.

Making the Case: Monitoring and Analysis

To secure approval for specific energy conservation projects, NYBG facilities staff rely on data from the annual carbon audit, which identifies high-level areas of opportunity. They supplement this with regular energy audits and BMS data to zero in on priority measures. Finally, NYBG conducts a third party feasibility study to evaluate the potential costs and benefits of various upgrade and technology alternatives. While the financial viability of a project (e.g., estimated savings and payback period) is typically the top consideration, NYBG also prioritizes measures based on the magnitude of potential energy and carbon savings.

Implementation: Communicating with Partners

As a non-profit, quasi-governmental institution, NYBG must coordinate with many partners to complete their capital projects. Maintaining open lines of communication between partners has been essential to helping NYBG avoid delays and streamline the work process. Partner input also helps NYBG find new solutions to challenges and learn how to innovate and improve projects going forward. NYBG also works hard to keep staff, visitors, and the general public in the loop on their efficiency upgrades and progress toward climate goals. In addition to communicating via educational signage and newsletters, NYBG holds an annual "Sustainability Summit" that is open to all.

Getting It Right: Commissioning and Training

After completing a project, the technology provider commissions equipment to ensure that it performs as intended. They typically also train NYBG's facilities team on proper system operations and maintenance and help them integrate equipment with the BMS. NYBG's staff use the BMS to optimize system performance and to identify preventive maintenance needs before they turn into more serious problems. NYBG also shares real-time energy use data with the City University of New York's Building Performance Lab (CUNY BPL), which helps them analyze "micro-data" and adjust scheduling and tuning of systems at a level that pushes the boundaries of efficiency.

Scaling up Solutions: Sharing Results

To assess the impact of energy projects, especially innovative pilot measures, NYBG conducts thorough measurement and verification (M&V). When M&V data indicates positive outcomes, NYBG often rolls the measure out across their campus. For example, after seeing significant savings from the Goldman Stone Mill's hydronic heating conversion and condensing boiler upgrade, NYBG went on to implement these measures at three additional building plants.

As a leading educational institution, NYBG also shares results with peers and NYC agencies, particularly DCAS DEM, which relies on M&V data to determine which measures to scale up across the City's buildings. As result of seeing positive outcomes from some of NYBG's most innovative measures, such as nanotech additives for HVAC, DCAS DEM has introduced new technology to other institutions, helping to accelerate the adoption of new climate solutions across NYC. NYBG's facilities team also takes the initiative to learn from others, often visiting other institutions or bringing in experts to teach them about new technologies and operational best-practices. With research at the heart of NYBG's mission, Board and staff members also contribute to the facilities team's effort to identify cutting-edge solutions.

looking ahead

NYBG continues to seek out innovative energy solutions to support the City's climate action goals as well as their own mission of preserving resources for current and future generations.

NYBG's facilities team will continue conducting annual carbon audits and monitoring energy systems in real-time to identify even deeper energy saving opportunities for the future. NYBG plans to install submeters to enable more granular analysis and optimization of equipment (in most cases, the BMS currently only captures data at the level of each electric circuit).

In addition to energy projects, NYBG will continue to prioritize sustainability in horticultural practices. Research is focusing on the use of hardy, low-maintenance plants that require less water and fertilizer than traditional plants, preparing the Garden to serve visitors well into the future.

The Department of Citywide Administrative Services' (DCAS) Division of Energy Management (DEM) serves as the hub for energy management for New York City government operations, serving 80 agencies and more than 4,000 buildings. DEM is tasked with leading the City's efforts to reduce greenhouse gas emissions 80% by 2050 from a 2005 baseline, with a near-term goal to reduce emissions from government buildings 35% by 2025.

Visit nyc.gov/dem

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