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Green Retrofitting in Battery Park City

"Green Retrofitting & Environmental Efficiency Now"

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Executive Summary

Battery Park City (BPC) is the only recently planned community in New York City with a unique commitment to developing environmentally responsible, or "green," buildings. While new construction presided over by the Battery Park City Authority (BPCA) in the past five years has led to the successful implementation of green building practices, existing residential buildings in the neighborhood have yet to become green. The next step in progressing the BPCA's mission to foster an environmentally responsible community in Battery Park City is to retrofit existing buildings so that they too are more green.

Green retrofitting refers to the process of modernizing or renovating existing buildings to minimize their environmental impact, subsequently improving building efficiency, improving the quality of life for building tenants, and saving money in operation costs over the long-term. Although green retrofitting is a growing field, it faces two major challenges: 1) the continued lack of green building practices in construction and renovation projects, and 2) the continued lack of commitment from building owners to invest in green renovations.

The purpose of this report is to identify functional tools BPCA can employ to promote the green retrofitting of existing buildings in Battery Park City. The report uses five environmental and efficiency target areas for multi-story residential buildings, as identified in BPCA's Residential Guidelines, as a basis for its findings:

- Energy efficiency
- Indoor environmental quality
- Conservation of materials and resources
- Operations and maintenance
- Water conservation

The first segment of the report, Green Building Technologies, identifies the most feasible and effective green technologies and practices available and applicable to green retrofitting. A few simple examples include: the installation of energy-efficient light emitting diode (LED) emergency exit signs and Energy Recovery Ventilators (ERV) which improve air quality, the installation of recycled glass and ceramic tiling, the development and implementation of an annual O&M plan and the installation of efficient water fixtures.

The second segment of the report is a cost-benefit analysis which identifies available green technologies as outlined in the green technologies section and determines the benefits – environmental, human health, monetary savings and other – against the costs in terms of dollars and time invested. For example, in the case of LED exit signs, the report shows that their original cost is slightly higher than conventional exit signs but that they consume only 25% as much electricity and, if purchased in bulk, have a two-year payback period that compares favorably to their average 10-year life span.

The third section of this report outlines powerful drivers for green retrofitting. Governmental policies play a critical role in the field by mandating building standards and environmental standards, as well as offering financial incentives for green building. Institutions like the United States Green Building Council (USGBC) and BPCA have played an important role in furthering green building by establishing guidelines like the Leadership in Energy and Environmental Design (LEED) Rating System for Existing Buildings and BPCA Residential Environmental Guidelines. Insurance companies also drive green building through standards and requirements related to specific environmental risks associated with buildings and the potential for litigation. In addition, strategic communications promote green building by educating the public about the benefits of green building and green practices that they can adopt.

The final section of the report outlines recommendations that may be employed by BPCA. A few of the recommended actions call for BPCA to:

- Develop a comprehensive strategy that is specific to green retrofitting
- Coordinate with local and state government to help individuals optimize the use of green retrofitting incentives
- Use green energy pricing programs available in New York City through Con Edison
- Sponsor the green retrofitting of an existing building in Battery Park as a model to demonstrate the feasibility and desirability of green retrofitting
- Develop educational programs to expose building owners, managers and residents to green retrofitting in general and give them tools to participate

Two key points of our comprehensive findings are that 1) green retrofitting is feasible, and 2) many green improvements can be accomplished rapidly. While green retrofitting involves challenges beyond those of new green building construction, there are numerous direct and indirect benefits of green retrofitting. Improvements in every target area – energy efficiency, indoor environmental quality, conservation of resources and materials, operations and maintenance, and water conservation – can be implemented in existing residential high-rise buildings. Implementing such improvements result in resource efficiency, reduced environmental impact, and improved human health. Additionally, these improvements can provide cost savings and embody indirect benefits such as risk mitigation and competitive advantage. In such cases, the dual objective of profitability and environmental responsibility can be achieved through green improvements to existing buildings.

List of Acronyms

A/C	Air Conditioning
AFUE	Annual Fuel Utilization Efficiency
AL	Air Leakage
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ATM	Atmospheric
BOC	Building Operations Certification
BPCA	Batter Park City Authority
BTU	British Thermal Unit
CFCs	Chlorofluorocarbons
CFL	Compact Fluorescent Light
CI	Cast iron
CO	Carbon Monoxide
CO_2	Carbon Dioxide
ConEd	Consolidated Edison
CRI	Carpet and Rug Institute
DDC	NYC Department of Design and Construction
EER	Energy Efficiency Ratio
ERV	Energy Recovery Ventilator
FIE	Fire Insurance Exchange
FSC	Forest Stewardship Council
GHGs	Greenhouse Gases
HEPA	High-Efficiency Particulate Air (filters)
HID	High-Intensity Discharge
HRV	Heat Recovery Ventilator
HVAC	Heating, Ventilation, and Air Conditioning
IEQ	Indoor Environmental Quality
ISO	Independent System Operator
kWh	Kilowatt hour
LED	Light Emitting Diodes
LEED	Leadership in Energy and Environmental Design
LEED-EB	Leadership in Energy and Environmental Design for Existing Buildings
LIFE	Low-Income Forum on Energy
MCFC	Molten Carbonate Fuel Cell
MWh	Megawatt Hour
NAIMA	North American Insulation Manufacturers Association
NEEP	Northeast Energy Partnership
NFRC	National Fenestration Rating Council
NOx	Nitrous Oxide
NYDDC	New York Department of Design and Construction
NYSEG	New York State Electric and Gas Corporation
NYSERDA	New York Energy Research and Development Authority
O&M	Operations and Maintenance
PAFC	Phosphoric Acid Fuel Cell
PCBs	Polychlorinated Biphenyls
PET	Polyethylene Terephthalate
PG&E	Pacific Gas and Electric
PM10	Particulate Matter up to 10 micrometers
PM2.5	Particulate Matter less than 2.5 micrometers
PPMV	Parts Per Million by Volume
PSC	Public Service Commission
PV	Photovoltaic
PWR	Power
RAP	Return Air Pathway
SBC	System Benefits Charge
SFT	Steel-fired tube
SHGC	Solar Heat Gain Coefficient
THC	Total Hydrocarbons
TVOC	Total Volatile Organic Compounds
USEPA	United States Environmental Protection Agency
USGBC	United States Green Building Council
UV	Ultra Violet
UVGI	Ultraviolet Germicidal Irradiation
VAV	Variable Air Volume
VOC	Volatile Organic Compounds
VT	Visible Transmittance

Introduction

Battery Park City is located at the southwest tip of Manhattan, adjacent to New York City's downtown financial district. The Hugh L. Carey Battery Park City Authority (BPCA) is a New York State public benefit corporation that was established in 1968 to oversee the development of the 92-acre site, which was created using landfill material excavated from the foundation for the World Trade Center in the 1970s.

The mission of BPCA is to plan, create, co-ordinate and maintain a balanced community of commercial, residential, retail, and park space within its designated 92-acre site on the lower west side of Manhattan.[a] The BPCA mission has four components: public private partnerships, balance and aesthetics, environmental responsibility and public benefit. Under the umbrella of environmental responsibility, the development and maintenance of green buildings within Battery Park is a key objective so that the site may serve as a model for high-rise residential construction in New York City and elsewhere.[b]

In accordance with BPCA's mission, developers looking to construct new residential buildings in the area must comply with the Residential Environmental Guidelines issued by the BPCA, which mandate a high standard of environmental accountability. Battery Park City is the only recently planned community in New York City with a unique commitment to developing environmentally responsible buildings. While new construction in the past five years has led to the successful implementation of new green building practices, existing residential buildings in the neighborhood have yet to become "green." The next practical step in progressing BPCA's mission is to foster an environmentally responsible community by promoting the retrofit of existing buildings to reap the benefits of improved building performance.

Given BPCA's leadership in the new construction of green high-rise residential buildings, it is feasible for BPCA to take a prominent role in promoting green retrofitting to existing buildings. In order to put policy into practice, BPCA must garner the support of area stakeholders for existing green building guidelines and the establishment of comprehensive green retrofitting guidelines. Despite the challenges of implementation, the benefits from green building and retrofitting policy incentives are numerous and include resource efficiency, protection of the natural environment, and healthier indoor environments.

This report presents feasible conservation strategies, technology solutions, and policy measures that BPCA can employ to advance the organization's green building goals for existing buildings.

[a] "Mission." Hugh L. Carey Battery Park City Authority website – http://www.batteryparkcity.org/About/mission.htm
[b] "South Residential Neighborhood: Site 3; Request for Proposals." Hugh L. Carey Battery Park City Authority. 2004.

Methodology

In dialogue with BPCA, the Columbia University workshop consulting team identified target areas and challenges of green retrofitting for Battery Park City. The team established a project control plan to articulate a strategic approach to formulating green retrofitting recommendations. An initial literature review of key resources and existing institutions created the foundation for further research. Next, the team compared the existing Residential Environmental Guidelines of BPCA with other green building guidelines such as LEED-EB (Existing Buildings) and New York City's High Performance Building Guidelines, with a focus on the implications for retrofitting.

The team based its research areas on the framework present in existing guidelines, addressing the same set of target areas throughout the analysis: energy efficiency, indoor environmental quality, materials and recycling, operations and maintenance, and water conservation. Using the five subject areas as a rubric, the team gathered information about existing technologies, identified exemplary case studies, and tabulated both quantitative and qualitative costs and benefits. The team also examined policy incentives for green building and identified various policy strategies BPCA can use to improve the implementation of green retrofitting within the target areas.

The consulting team additionally sought the expertise of individuals working within the fields of both green building and general building management. To better understand the perspectives of the many stakeholders involved in green retrofitting, team members interviewed current building management within Battery Park residential buildings, consulted with non-profit organizations that specialize in green building, and attended a conference on green building which featured a range of technology and policy experts within the field.

In order to customize research findings, the team selected the existing Gateway Plaza in Battery Park City to exemplify existing conditions within conventional residential buildings in the neighborhood. The team profiled the Gateway using management information, utility data, and an on-site tour to identify the most relevant areas of concern for green retrofitting opportunities. From this profile, the team developed a case-based cost-benefit assessment and retrofitting recommendations for the Gateway buildings. Final recommendations are based on a combination of the broad knowledge of available technology and policy solutions and apply directly to the unique conditions of Battery Park City.

The research culminated in two separate deliverables: a client presentation delivered on April 22, 2005, and this report.

Green Building and Green Retrofitting

Green building, as defined by the Office of the Federal Environmental Executive, means:

- Increasing the efficiency with which buildings and their sites use energy, water, and materials
- Reducing building impacts on human health and the environment through better siting, design, construction, operation, maintenance, and removal of waste.[1]

The following sections describe existing guidelines for green building and retrofitting.

Established Green Building Guidelines

Leadership in Energy and Environmental Design (LEED)

The United States Green Building Council (USGBC) is generally regarded as the preeminent authority on green building. USGBC's mission is to "promote the design and constructing of buildings that are environmentally responsible, profitable, and healthy places to live and work."[2] In 1999, the USGBC developed green building guidelines called *Leadership in Energy and Environmental Design* (LEED) that address several key energy and environmental areas impacted by buildings. The key areas addressed by LEED are:

- Sustainable siting
- Water efficiency
- Energy & atmosphere
- Materials & resources
- Indoor environmental quality (IEQ)
- Innovation in operation
- Upgrades and maintenance

The LEED guidelines are nationally recognized, as is the rating system that LEED applies to green building design. The USGBC has recently published a set of guidelines explicitly for existing buildings called LEED-EB, which will be discussed in a later section.

Battery Park City Authority Residential Environmental Guidelines

In order to adopt green building guidelines for new commercial and residential buildings in Battery Park City, BPCA developed new innovative guidelines to address multi-story residential buildings, as LEED had not yet addressed these structures. The *Battery Park City Authority Residential Environmental Guidelines* outline the essential environmental and efficiency target areas of green multi-story residential buildings including:

- Energy efficiency
- Indoor environmental quality (IEQ)
- Conservation of materials and resources
- Operations and maintenance
- Water conservation

These guidelines were embodied in the construction of the Solaire, a residential high-rise which opened in June 2003 and has since won international acclaim for its progressive design and performance.

High Performance Building Guidelines

The Office of Sustainable Design at the New York City Department of Design and Construction (DDC) developed a document entitled High Performance Building Guidelines "as a means of introducing sustainable design to DDC project teams"[3] DDC's guidelines detail information pertaining to the following areas:

- City process
- Design process
- Site design and planning
- Building energy use
- Indoor environment
- Material and product selection
- Water management
- Construction administration
- Commissioning
- Operations and maintenance

This is a comprehensive document that addresses the specific challenges and opportunities for buildings within the urban environment. It has been recognized by an international audience as a reference for a high-performance building.

Definition of Green Retrofitting

"Green retrofitting" refers to the process of modernizing or renovating existing buildings to improve their efficiency, reduce resource consumption, and create a healthier indoor environment. Green retrofitting is a nascent field. This is evidenced by USGBC's October 2004 release of specific guidelines for existing buildings (LEED-EB). Ideally, green retrofitting encompasses improvements in each environmental target area; however, green retrofitting may result in incremental green improvements according to the cost, implication, and feasibility of the improvement.

Battery Park City has some available space for new buildings, although most of New York City does not. Embracing green retrofitting opportunities is appropriate for BPCA as well as New York (City and State) as pioneers and advocates of green building. By championing the importance of green retrofitting in Battery Park City, the Authority can offer both concrete examples and lessons learned to the surrounding city, the state, and the nation.

The two greatest challenges of green retrofitting are 1) adapting existing green building practices to existing structures, and 2) initiating investment into green building renovations. This study addresses challenges to green retrofitting and recommends strategies for BPCA to promote a wave of green retrofitting within its jurisdiction.

The Importance of Green Building and Green Retrofitting

Popular environmental awareness is mounting as evidence of anthropogenic, or human induced, environmental degradation becomes prevalent in the media. Concerns include diminished air quality, water scarcity, waste management challenges, and global climate change.

Cities and buildings play a decisive role in protecting the environment and human health within the United States. As energy consumption in the United States continues to rise, energy efficiency is imperative. Buildings currently represent 65.2% of total U.S. electricity consumption and 39% of primary energy use.[4] The following chart illustrates primary energy consumption of buildings as compared to other sectors as well as a projection through 2025:

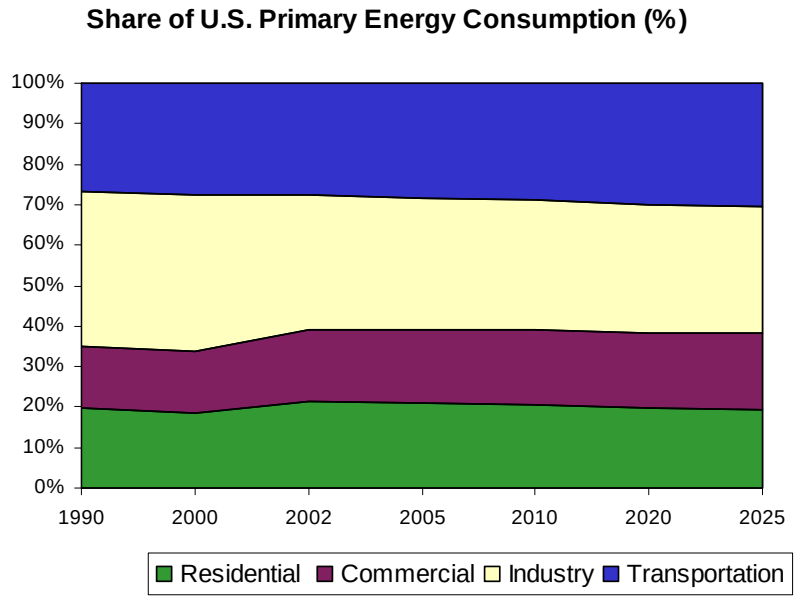


Figure 1

Source: U.S. EPA Buildings Energy Databook (2004)

Energy consumption in the U.S. is currently growing at a rate of approximately 2%, which is faster than the current population growth of approximately 1.5% per year.[5] The majority of this electricity is produced through fossil fuel combustion, creating pollution such as particulate matter and mercury that lead to human health problems and environmental degradation.

Electricity production also generates significant amounts of greenhouse gases (GHGs), particularly carbon dioxide (CO_2). Scientists in the international scientific community are aligned in asserting that the release of GHG emissions into the atmosphere is causing climate change on a global scale.[6] The electricity that buildings consume comprises a significant proportion of these emissions; the following chart illustrates building contributions to U.S. CO_2 emissions to be 23%.

Carbon Dioxide Emissions in the Developed World

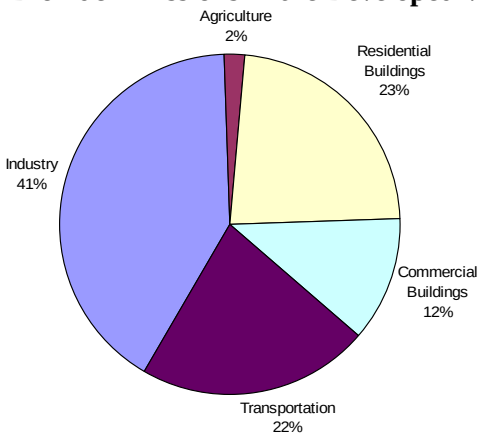


Figure 2
Source: IPCC 2001[7]

Excess waste from building construction in the U.S. is also an environmental concern. In the U.S. alone, approximately 136 million tons of construction and demolition waste is generated annually, which corresponds to 30% of the total waste generated. Buildings also represent 30% of raw material use and 12% of potable water consumption.[8] Urban environments like New York City are further plagued with complex environmental problems such as the "urban heat island effect"[a] and storm water runoff from impervious surfaces which can lead to combined sewage overflow.[b] Furthermore, New York City faces numerous waste disposal challenges, intensified by the closing of Fresh Kills Landfill in 2002, and is forced to export its waste to nearby states.

By employing sustainable building practices, many of the negative impacts of construction can be mitigated or reduced. Green building can reduce environmental degradation, improve air and water quality, and advance the quality of life of building occupants. Green building achieves resource efficiency through a diversity of measures, including but not limited to:

- Integrating energy- and water-efficient systems
- Installing high-quality insulation
- Utilizing energy-efficient appliances
- Employing renewable energy co-generation technologies
- Using recycled materials
- Developing storm water run-off catch systems, and
- Implementing operation and maintenance procedures

Adapting effective green building practices for implementation in existing buildings can dramatically improve environmental and human health conditions in residential buildings. Retrofitting existing buildings rather than replacing them with new green construction also achieves a minimization of environmental impacts by preventing excessive demolition waste.

[a] Urban heat island effect occurs when ambient temperatures in urban areas are higher (between 2 and 10ºF) than surrounding areas. For more information, see "Heat Island Effect" at U.S. EPA – http://www.epa.gov/heatisland/
[b] With average rainfall, 27 million gallons of untreated sewage flow into New York City's water bodies each year – www.riverkeeper.org

[1] "White Paper on Sustainability; A Report on the Green Building Movement," Building Design & Construction November 2003. Building Design & Construction Magazine. 29 Jan, 2005. <www.bdcmag.com/newstrends/BDCWhitePaperR2.pdf>
[2] "An Introduction to the U.S. Green Building Council and the LEED Green Building Rating System," *U.S. Green Building Council* December 2004. U.S. Green Building Council. 29 Jan, 2005. www.usgbc.org/Docs/Resources.usgbc/intro_ppt.
[3] "High Performance Building Guidelines. *New York City Department of Design and Construction.* April 1999. http://www.nyc.gov/html/ddc/html/ddcgreen/
[4] "An Introduction to the U.S. Green Building Council and the LEED Green Building Rating System," *U.S. Green Building Council* December 2004. U.S. Green Building Council. 29 Jan, 2005. www.usgbc.org/Docs/Resources.usgbc/intro_ppt.
[5] Ried Jr., 2004
[6] Watson, R.T. & Core Writing Team. (2001). "Climate Change 2001: Synthesis Report." *Intergovernmental Panel on Climate Change. http://www.ipcc.ch/pub/reports.htm*
[7] Metz, B. and Intergovernmental Panel on Climate Change. Working Group III., Climate change 2001: mitigation. 2001, Cambridge; New York: Published for the Intergovernmental Panel on Climate Change by Cambridge University Press. x, 752.
[8] "An Introduction to the U.S. Green Building Council and the LEED Green Building Rating System," *U.S. Green Building Council* December 2004. U.S. Green Building Council. 29 Jan, 2005. www.usgbc.org/Docs/Resources.usgbc/intro_ppt.

Green Guidelines by Category

Battery Park City Authority has identified five target areas where environmental solutions can be achieved. Furthermore, as presented in the previous section, the U.S. Green Building Council has developed the LEED-EB guidelines to address retrofitting options and New York City's High Performance Building Guidelines also offer insight into requirements for buildings classified as "high performance." There are strong similarities among the guidelines for each of these sources; the research team used all of these resources as references for the chosen technologies for each target area.

The following section describes the BPCA, LEED-EB, and NYC High Performance Building guidelines for each of the five target areas. The next section focuses on specific technologies that aim to provide green retrofitting solutions in each of these areas.

Energy Efficiency

According to the U.S. Department of Energy's 2004 Building Energy Databook, buildings consume nearly 40% of U.S. primary energy, with residential buildings contributing 21% of that figure.[1] Since the majority of electric power is generated by polluting fossil fuels, it follows that the less energy consumed by a building, the better for the environment. These technologies often improve the quality of living spaces and also lead to significant financial savings.

Battery Park City Guidelines
Battery Park City's Guidelines aim to maximize energy efficiency, model for energy performance, and utilize renewable energy and green power sources in their new building developments, relying on best available technology to achieve these goals.

LEED-EB Guidelines
LEED-EB seeks to "verify that fundamental building systems and assemblies are performing as intended to meet current needs and sustainability requirements" with particular focus on proper system calibration and efficiency.[2]

High Performance Building Guidelines
New York City's High Performance Building Guidelines promote the benefits of energy efficiency such as reducing building's heating and cooling lodes and optimizing a building's integrated systems. They call this the "practice of design integration" and highlight both greenhouse gas emission reductions and returns on investment.[3]

Indoor Environmental Quality (IEQ)

High indoor environmental quality is important for human health and quality of life. According to the Environmental Protection Agency (EPA), most people spend more than 90% of their time indoors, and indoor air is anywhere from 2 to 10 times more hazardous than outdoor air. The EPA warns that the indoor air quality is the United States' number one environmental health problem.[4] In 1992, The First Annual Air Quality Convention sponsored by EPA found that 20% of all employees have a major illness related to indoor air pollution such as allergies, asthma, and autoimmune diseases. The World Health Organization estimates that 40% of all buildings pose a serious health hazard due to indoor air pollution.[5] Green retrofitting mitigates these problems by improving air quality, thermal comfort, lighting, vibration, and acoustics. The majority of indoor air quality problems can be mitigated through improvements to Heating Ventilation and Air Conditioning (HVAC) Systems. Green retrofitting technologies improve

ventilation, air quality, lighting and controllability of systems. Overall, green retrofitting can vastly improve the quality of living spaces and also lead to significant financial savings.

Battery Park City Guidelines
Battery Park City's Guidelines aim to improve overall indoor air quality, to encourage the selection of low-emitting materials, increase controllability of systems, maximize access to daylight, control indoor pests, and prevent indoor air quality problems resulting from the renovation process. They rely on best available technology to achieve these goals.

LEED-EB Guidelines
LEED-EB seeks to "verify that fundamental building systems and assemblies are performing as intended to meet current needs and sustainability requirements" with particular focus on proper calibration and efficiency.[6]

High Performance Building Guidelines
The High Performance Buildings Guidelines stress the importance of supportive ambient conditions and outlines its major components: thermal comfort, indoor air quality, visual comfort, and appropriate acoustical quality. They provide detailed technical strategies, performance goals and tools/references to achieve these objectives. Increased attention to these environmental features can result in avoidance of "sick-building syndrome," reduced occupant complaints, lower rates of absenteeism, improved occupant health, and potentially improved occupant performance.[7]

Resources and Materials

Green retrofitting requires that materials used in the retrofitting process be as "clean" as possible. As the demand for green products increases, so too does the array of products available for purchase. In addition to using green materials, buildings must have comprehensive recycling programs in place to promote this practice. Conservation of Resources and Materials will frequently coincide with Indoor Environmental Quality (IEQ) and Operations and Maintenance.

Battery Park City Guidelines
Battery Park City Guidelines dedicate a section to the conservation of resources and materials. This section encourages "waste reduction, preservation of natural resources, and minimal external environmental impact." In addition, the guidelines seek "to protect the environment from biodiversity loss, air quality impacts and further depletion of resources by seeking out rapidly renewable resources and eliminating the use of chlorofluorocarbons (CFCs)."[8]

LEED-EB Guidelines
In addition to the incorporation of many BPCA guidelines on IEQ, LEED-EB also requires buildings to perform a waste stream audit and reduce mercury in light bulbs. The criteria principally advocate optimizing the use of less harmful products in the building environment.

High Performance Building Guidelines
The High Performance Building Guidelines specify a need for environmental and health considerations when choosing appropriate materials to build a high-performance building. Cost, performance, durability, and aesthetics are also mentioned as the traditional factors that should be taken into consideration. These ideals would be similarly reflected in a green retrofitting project.

Operations & Maintenance

Green building and retrofitting requires both short- and long-term maintenance to ensure that the structure continues to operate every aspect of its physical design efficiently, including actively minimizing waste and promoting responsible water and electricity use. Building O&M also addresses hazardous materials use (including cleaning supplies). O&M services can be employed to educate building employees and tenants about efficient and environmentally sound practices.

Battery Park City Guidelines
Battery Park City's Guidelines aim to "provide proper construction, maintenance, and controls so that building systems operate as designed in order to achieve and maintain energy performance and IEQ requirements."[9]

LEED-EB Guidelines
LEED-EB seeks to "provide building operation, design teams and projects the opportunity to be awarded points for exceptional performance above the requirements set by the LEED-EB Rating System and/or innovative performance in Green Building categories not specifically addressed by the LEED-EB Rating System."

High Performance Building Guidelines
The High Performance Building Guidelines focus on technical Strategies to improve operations and maintenance efficiency. This includes tools for implementation and considers environmental as well as well as human health concerns.

Water Conservation

The objective of water use reduction is to maximize potable water efficiency within buildings. This reduces the burden on municipal water supplies, wastewater systems and the surrounding environment. According to the U.S. Geological Survey, public water supply, including that which goes to residential buildings, accounts for roughly 13% of all U.S. water consumption. New York, California and Texas—the three most populated states—account for 30% of the nation's publicly supplied water use.[10] Green building can aid in conserving the nation's limited water supplies through innovative water use reduction technologies and efficient landscaping.

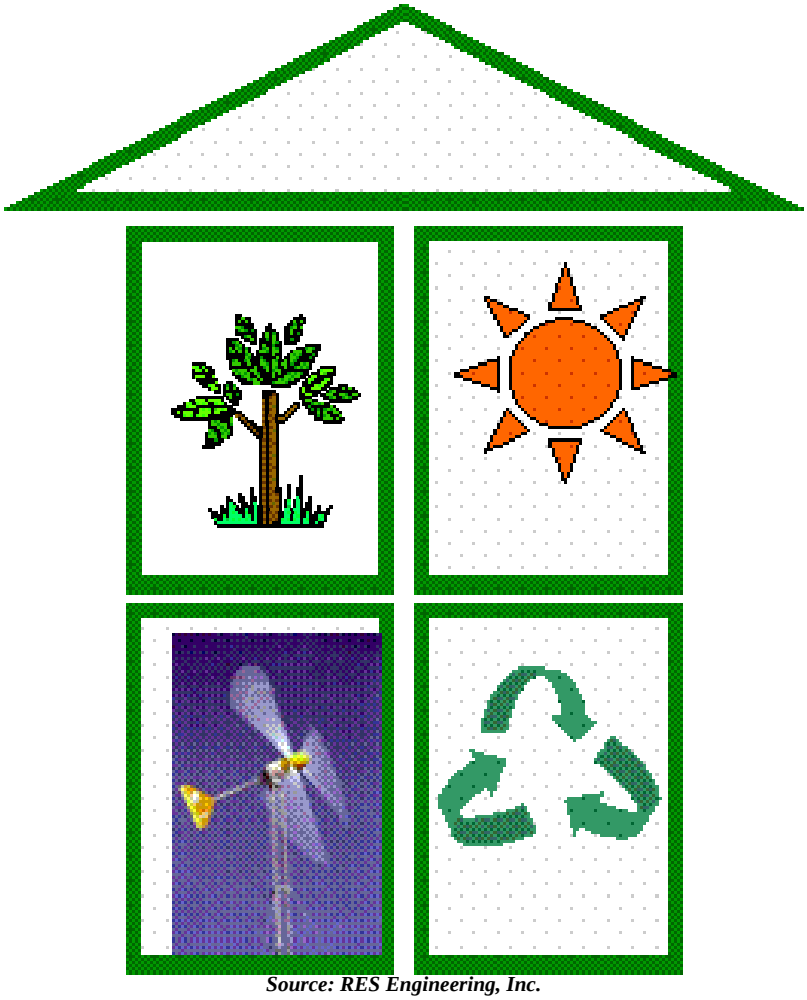
Battery Park City Guidelines
BPCA current Residential Environmental Guidelines regarding water use aim to "minimize water consumption by simultaneously reducing the inflow of city-supplied portable water and the outflow of waste water" and "conserve portable water by reducing demands for landscaping, irrigation, and other non-potable uses."[11]

LEED-EB Guidelines
LEED-EB encourages maximum use of water-efficient fixtures within buildings to protect and reduce the burden on potable water supply, wastewater systems, and natural habitats. LEED-EB further emphasizes the use of high-efficiency irrigation technologies, and planting climate-tolerating plant species.

High Performance Building Guidelines
The High Performance Building Guidelines highlight water dependencies that span multiple categories (e.g., reduction of hot water use decreases building energy consumption). They also provide tools for improving water conservation, related regulations, and additional references.

Available Green Building Technologies

The following sections examine available green building technologies that can be appropriate for green retrofitting initiatives. These are divided into each of the target areas: energy efficiency, indoor environmental quality, materials and resources, building operations and maintenance, and water conservation.



Source: RES Engineering, Inc.

Energy Efficiency

Energy solutions encompass both efficiency improvements and technological innovations that pertain to high energy-use applications. Many of these entail replacing older, inefficient equipment while others require improving building components such as insulation or windows. Sometimes, simply utilizing existing equipment in an efficient manner can lead to energy and cost savings. "Green energy" is also available, which entails utilizing, where possible, renewable energy sources rather than fossil fuels.

Renovations designed to increase energy efficiency in common areas and individual units in residential buildings range from minor lighting changes to replacement of the heating, venting and air conditioning (HVAC) system. As on-site power generation opportunities become more economically feasible, these technologies may also become a part of an energy retrofit package. This section examines energy efficiency options in the area of lighting, HVAC components, including ventilation, geothermal power and heating options, and distributed generation technologies.

Residential Energy End-Uses in 2002

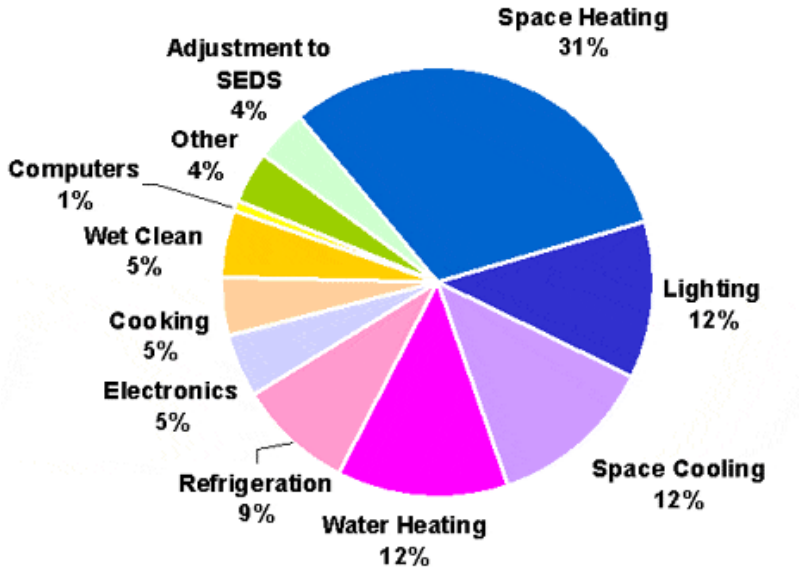


Figure 1
Source: 2004 Buildings Energy Sourcebook

Energy Efficiency Opportunities

HVAC

The majority of energy consumption in buildings is for climate conditioning – heating and cooling. In Northern Climate Zones, most energy is consumed by heating, while in Southern regions, more energy is consumed for air conditioning. HVAC refers to a building's heating, ventilation and air conditioning equipment. As such, it can be one of the most complex systems in a residential building, yet it also represents a source of significant energy use and potential savings. Some HVAC components can be replaced without modifying the entire system. Others, such as the layout of ventilation ducts, are often impossible to modify without a complete overhaul of the building.

Technology Solutions

Boilers: Modern boilers can operate at 90% efficiency. Boilers are currently used in medium and large buildings throughout the country to generate hot water, provide steam heat, and run commercial/industrial processes. Currently, more efficient multiple boiler systems are beginning to replace single-boiler operations. This can reduce distributive heat loss and allows for flexibility in meeting heat demands. Some new models can fit through standard-sized doorways, allowing for ease of installation in existing buildings. Boilers can also run via digital controls, providing real-time data to optimize the fuel/air mixture, sample flue-gas, and manage combustion.[12]

Desiccant Dehumidification: Desiccant materials attract and retain airborne moisture. This technology dries air as it enters a building, before it is cooled by the existing air conditioning system. These systems can be installed as additions to HVAC systems. Desiccant systems can be classified as "passive" or "active." Passive systems use dry air (usually building exhaust); active desiccants use heated air. They can dry air continuously in all weather.[13]

Chiller: A chiller uses cooled water to reduce ambient air temperatures. After chilling, the cooled water is distributed by pipes throughout a building. Water-cooled and air cooled technologies are available. HVAC chillers can account for 35% of a building's electricity use, and new technologies have an efficiency of 0.5 kW/ton, saving 0.15 to 0.30 kW/ton over older models. This translates to a 30-40% efficiency improvement. Additionally, older chillers use expensive and ozone-depleting CFCs.[14]

Evaporative Cooling: Evaporative cooling reduces temperatures by using temperature-reducing evaporation of water sprayed on the building's roof. This technology is only suitable for areas with low humidity and is of limited use in New York City.[15]

Air Venting: Ventilation fans for HVAC systems can use more electricity than any other system component, due to their year-round operation. While changing the air ventilation configuration can result in large energy savings, it is also expensive and appropriate for major renovations only. An upgraded ventilation system may include a variable air volume (VAV) system which provides only the required amount of air; VAV diffusers which allows for temperature control in individual rooms.[16]

Duct Sealing: Properly sealed HVAC ducts can reduce energy costs and improve indoor air quality for residents. Duct sealing should be done with an aerosol sealant or mastic, metal-backed tape. Standard duct tape does not provide an adequate seal, nor does it last a reasonable amount of time.[17] Rather than duct tape, aerosol-based duct sealing injects a cloud of aerosolized sealant particles into a pressurized duct system. If the system is pressurized and duct grilles sealed, the aerosol will flow to and seal existing leaks. This method seals leaks that are physically inaccessible or difficult to see, and it less costly and time-consuming than traditional methods. Sealing ducts in this manner can reduce energy use by up to 30%.[18]

Geothermal: Geothermal energy uses naturally-occurring reservoirs of low-to-moderate temperature water (68° to 302°F) for building heating and other applications. This is known as a "direct use" system, and requires three components: 1) a well or other structure to bring hot water to the surface, 2) a mechanical system to delver the heat, and 3) a water disposal system, often an injection well or storage pond.[19] Energy is supplied via a geothermal of ground source heat pump. It can be used for space heating and cooling, as well as water heating. Because of the constant temperature of subsurface water, geothermal energy can provide wintertime source of heat and a

summertime source of coolness.[20] Existing water resources under New York City have temperatures suitable for geothermal use.[21]

Daylighting

Daylighting is the process of using natural light where possible, which saves significantly on daytime artificial illumination. Daylighting options are restricted by building design, and are highly specific to the quantity and location of windows and other clear façades.

Artificial Lighting

Lighting often comprises a large portion of a building's energy use. Most buildings rely on incandescent bulbs which are less expensive to purchase, but more expensive to operate than newer technologies. These light bulbs are inefficient because up to 90% of the electricity consumed is lost as "waste" heat, causing higher energy utilization. Higher efficiency light bulbs and light fixtures are readily-available solutions which reduce energy use and thus energy bills. Many lighting options exist for residential apartment retrofits. Since bulbs can be replaced on an as-needed basis, lighting upgrades represent an easy and fairly inexpensive way to reduce a building's energy demand. The four lighting technologies discussed below are listed in order from least to highest cost, representing the least to most efficient light sources.

ENERGY STAR® makes the following recommendation in its "Change a Light, Change the World" campaign: Replace light bulbs and light fixtures with higher efficiency items. ENERGY STAR® recommends changing out the 5 most frequently used lights in the residence. This "5-light change" is anticipated to return a savings of more than $60 in annual energy costs, and also significantly reduce greenhouse gas emissions.[22]

Technology Solutions

High Performance (Tungsten-Halogen) Incandescent: These are the least efficient light sources, especially for hallway and public space lighting. Such bulbs are most appropriate for light sources that are continually turned off and on.[23]

High-intensity discharge (HID): HID lighting technology utilizes a gas capsule in lieu of a filament to produce light. They use various gases, including metal-halide, high pressure sodium, low-pressure sodium, and mercury vapor. These produce significantly more light output and last between three and five times longer than a typical halogen bulb.[24] Furthermore, their light approaches the "whiteness" of natural daylight, thus making them good candidates for indoor gardening.[25] These are frequently used in diving lamps and bicycle lights, but have residential applications as well.

Compact Fluorescent Lights (CFL): ENERGY STAR®[c] certified CFL use 66% less energy than a standard incandescent and can last up to ten times longer. Replacing a 100-watt incandescent with a 32-watt CFL can save $30 in energy costs over the bulb's life. Despite the listed wattage difference, a 32-watt CFL will have the same brightness (measured in lumens) as a 100 watt incandescent. CFLs also emit far less heat than halogen lights (100 degrees F vs. 1,000 degrees F), thus reducing fire risk. While more expensive to purchase, payback time from energy savings is approximately 0.2 years. Today's fluorescent lights also closely match the color quality of

[c] ENERGY STAR® is a government-backed program helping businesses and individuals protect the environment through superior energy efficiency – www.energystar.gov

traditional incandescent light; light quality is measured by the color rendition index (CRI). Incandescent bulbs have CRI's of 100; comparable fluorescent bulbs should have a CRI of 95.[26]

Light Emitting Diodes (LED): LED lights consume less than 25% of the electricity of fluorescent lighting, and can last ten times as long. While prices have historically been higher than other lighting forms, costs are beginning to come down. LEDs can run on 120 volt AC, and may be compatible with existing lamps; however, their small size makes them well-suited for lighting strips and ambient applications. Color indices are near 85, and unlike fluorescents, LED lights do not flicker, nor do they not interfere with household television and radio signals.[27]

- LED Exit Signs: Illuminated exit signs have become one of the first appliances to use LED technology. ENERGY STAR® exit signs use 5 watts or less to operate compared with 40 watts for operation of a conventional exit sign. Signs can last up to 10 years before a replacement is needed. Payback for the purchase of 100 signs is estimated to be 1.8 years.[28]

System Control Devices: System controls such as sensors and timers can regulate lighting systems to save energy. Sensors can detect either motion or daylight. Motion sensors, also called passive infrared sensors, detect movement and enable lights to automatically turn on and off when people enter and leave rooms. Daylight sensors or photocells detect a reduction in daylight and turn on lights when it becomes dark; these are most commonly used in exterior lighting.[29] Timers can be set for lights to be turned on and off at specific times of day. And dimmer switches enable the operator to adjust the amount of illumination to the task required and extend the life of the light bulbs.[30]

Windows

Windows are important both for their light admittance and their climate control capabilities. Inefficient windows allow a higher-than-preferred penetration of UV light, and allow indoor air to escape to the outdoors. Daylight made available through well-placed windows reduces the necessity of daytime artificial lighting, and with proper UV protection reduced fading of indoor wallpaper, carpets, and upholstery. Further, an increase in window insulation can lead to heating and cooling savings, reduced condensation, and improved comfort. The National Fenestration Rating Council (NFRC) offers further information as well as labeling to guide buyers of energy-efficient windows.

Technology Solutions

Efficiency improvements improve any combination of various factors:[31]

U-Factor: U-factor indicates the rate of heat loss caused by the window. It is the inverse of the window's R-factor, which measures insulation capabilities. A lower U-factor indicates a window's greater resistance to heat flow, therefore improving its insulating value. Windows in northern climates should have a U-factor of 0.35 or lower.[32]

Visible Transmittance (VT): VT indicates the amount of visible light transmitted through the window. A high VT is desirable to maximize daylight and reduce artificial illumination.

Solar Heat Gain Coefficient (SHGC): The SHGC is the fraction of incident solar radiation admitted through a window. When a window has a lower SHGC, it transmits less solar heat, thereby reducing the amount of energy expended via air conditioning for cooling.

*Air Leakage (AL):*This figure determines the amount of air passing through cracks in the window façade. When a window has a lower AL, less air will pass through cracks in the assembly.

Windows utilize various glazes and coatings in a variety of levels to address UV, VT, SHGC, and AL factors.

Glazing: Sunlight emits both visible light and heat. Proper glazing allows for the visible light to be transmitted while blocking the heat and harmful UV rays. Varieties include single-glass glazing, double glass glazing, triple glass glazing, and quadruple glass glazing. These levels refer to the amount of energy absorbed, and can be either tinted or reflective. Tinted glazes are found in green, bronze, gray, or blue tints.

Spaces/Insulation: The space between double-paned windows allows for better insulation when filled with a gas. Spaces are filled with air, argon, or krypton, each with increasing levels of insulation.

Applied Films: These films are "multilayer assemblies of coatings and polyester films"[33] applied to the window with an adhesive, and are typically used for retrofits.

Appliances

Appliances contribute about 25% of the energy use of a building. Appliances can be analyzed individually, based on the amount of electricity they use. Appliances that can be replaced or upgraded include refrigerators, freezers, dishwashers, clothes washers and dryers, water heaters, furnaces & boilers, and room air conditioners. Savings are incurred over the life of the appliances, and there is often little difference in purchase price between these and less energy-efficient items. Many of these actually have energy published efficiency ratings. Various energy-saving strategies can enhance the energy-savings of these appliances.

Technology Solutions

Refrigerators: According to U.S. EPA's ENERGY STAR® fact sheet, "Refrigerators are the single biggest energy consumer in most households. Replacing a refrigerator bought in 1990 with a new ENERGY STAR® qualified model would save enough energy to light the average household for more than four and a half months."[34] Other measures that can be taken to ensure the efficiency of a refrigerator include placing it away from heat-emitting appliances and vents, vacuuming the coils frequently (every 3 months is recommended) to eliminate dirt build-up, preventing door gasket leaks, and defrosting the freezer when more than one-quarter inch of ice builds up. Old units should be recycled rather moved to another area of the home to achieve all available savings from a new high-efficiency refrigerator.[35]

Dishwashers: The majority of the energy consumed by dishwashers is used for heating the water for dishwashing. An efficient dishwasher therefore uses less water than a less efficient model. As for other appliances and systems that use heated water, reducing the temperature of the home water heater to 120° F will further energy savings, as nearly all dishwashers have a component that further heats the water supplied. Additional tips include scraping dishes prior to dishwashing rather than pre-rinsing and using the "energy saver" setting.[36]

Ovens & Stoves: Energy-efficient cooking options include using convection ovens over conventional ovens and ensuring proper ventilation for stoves. Electric ignitions on gas ranges do not waste energy like pilot lights.[37]

Clothes Washers: According to EPA's ENERGY STAR® data, replacing a clothes washer model manufactured before 1994 with an ENERGY STAR® clothes washer save up to $110 per year.[38] Like in dishwashers, the energy consumed by the clothes washer is primarily for heating the water. Higher efficiency clothes washers will use less water per cycle per cubic-foot. Front-loading machines can also be more energy-efficient.[39] Again, the water-heater can be pre-set to 120ºF.

Room Air conditioning: Single-unit room air conditioners are rated by their energy efficiency ratio (EER), which measures the amount of cooling provided (output) divided by the amount of power consumed by the device.[40] A higher EER indicates a more efficient air conditioner.

Renewable Energy

Renewable energy consists of non-fossil-fuel based sources of energy. These include wind power, solar heating and solar electricity generation, biomass, geothermal, and tidal energy. Currently, renewable fuel sources comprise less than 3% of total U.S. energy production.[41] The following graph illustrates the current electricity resource mix in the United States.

Fuel Mix for U.S. Electricity Generation

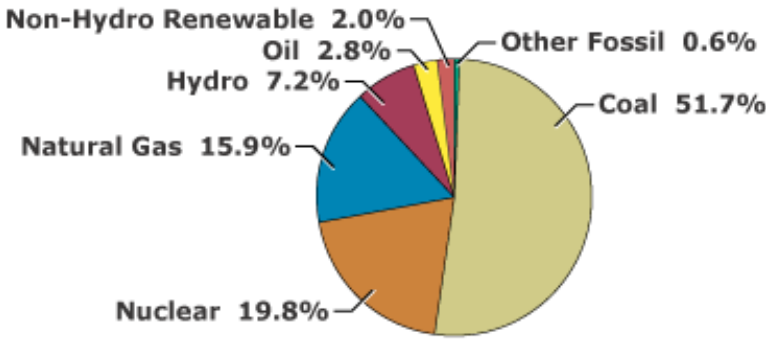


Figure 2
Source: U.S. Environmental Protection Agency

The contribution of renewable resources to the national energy mix is small but increasing, making these sources more readily available. A building can employ renewable technology either through directly generating its own power or by purchasing power only from a company that utilizes renewable technologies for power generation.

On-Site Power Generation

Some buildings have the opportunity to generate their own power on-site as a contribution to their overall electricity use. The Solaire for instance, generates 5% of the building's electricity from solar energy using photovoltaic panels affixed to the building façade. On-site generation alternatives for urban buildings include wind, solar power, microturbines, and fuel cells.

Technology Solutions

Wind: Wind technology consists of installing wind turbines on the building. Homes use approximately 9,400 (kWh) of electricity per year (about 780 kWh per month) – this would differ for a residential complex. Depending upon the average wind speed in the area, a wind turbine

rated in the range of 5 to 15 kilowatts would be required to make a significant contribution to meet this demand. Wind power could not provide all power required by a residential building; power purchased from the local utility would supplement wind power generation.[42]

Solar: Solar power can be applied in two ways. The first is through solar thermal systems (or solar heating), which consists generally of using the sun's energy to heat water. This water is then incorporated into a building's space conditioning systems.[43] However, building code restrictions in some cities make such application difficult. The second is solar electric generation through photovoltaic cells that convert solar energy into electric energy. Researchers are still working toward a consistent single technology, though various types of PVs are currently available. These include crystalline silicon solar cells, amorphous silicon solar cells, copper indium diselenide and related materials, and cadmium telluride solar cells.

Microturbine: These small electric generators burn gas and liquid fuels to produce power. This relatively new technology became commercially viable in 2000. Each turbine produces between 30 to 350 kW, and can be used for either electric power only or as part of a combined heat-and-power (cogeneration) systems. Microturbines can run on a variety of fuels such as natural gas, sour gas, gasoline, kerosene and others[17] and are ideal for distributed power generation, as they can be stacked in parallel for larger buildings. Most building applications are 30-100 kW. They can also be useful for combined heat and power applications and these turbines have extremely low emissions.[18]

Fuel Cells: Most fuel cells operate with a natural gas feedstock, which is converted into hydrogen fuel by the cell. Several kinds of fuel cells exist; two kinds are commercially available. One is a 200kW PAFC unit; another is a 250 kW MCFC unit. The PAFC unit is used in a New York City Police station and almost 200 other locations. Widespread commercial availability may be several years away.

Sourcing Offsite Green Power

It is possible to "request" power from an electricity provider that comes exclusively from "green" power sources. While Consolidated Edison (Con Edison) is the primary electricity provider in NYC, there are various utilities from whom Con Edison can purchase this electricity. Thru Con Edison 's Power Your Way program (www.poweryourway.com),Con Edison Solutions® offers green power alternatives that residents and business owners may choose.

Indoor Environmental Quality (IEQ)

Indoor Environmental Quality (IEQ) solutions encompass heating, ventilation and air conditioning (HVAC) system improvements as well as technological innovations that control contaminants in the buildings. Solutions include:

- Ventilation improvements
- Moisture control
- Air ventilation and treatment
- System controllability, and
- Use of green cleaning supplies

IEQ Improvement Opportunities

Ventilation Improvements

Poor ventilation can lead to high contaminant levels, poor air quality, which can lead to significant health problems. Energy recovery systems and air exchangers are readily-available solutions which reduce energy costs as mentioned in the previous section, but also improve ventilation.

Technology Solutions

Air-to-air recovery units: These units are designed to capture heat energy from building ventilation exhaust. The recovery units then transfer this heat to the ambient air being used for ventilation. This approach requires less heat energy to bring outside air up to a comfortable indoor air temperature.[44] Air-to-air recovery units can be added to existing HVAC systems and reduce electricity costs.

Energy-Recovery Ventilation System: These systems are designed to cool and dehumidify (precondition) outside air. To reduce operating costs, they make use of the heat present in the building's return air.[45] They can be readily retrofitted to packaged air conditioning (A/C) units without a major change to the building. Energy-recovery ventilation systems can more than double air exchange rates, thus minimizing exposure to tobacco-related contaminants, reducing Volatile Organic Compounds (VOCs) and chemicals from cleaning products.

Heat Recovery Ventilator (HRV): These systems are designed for cooler climates; they transfer heat, help reduce window condensation, and include a defrost mechanism. It provides users with more control over the fresh air flow as opposed to letting air seep out and drawn in. The units retain energy used to heat or cool the home, saving the homeowner money on utility bills.[46]

The following case study highlights improvements to air quality made by ventilation upgrades:

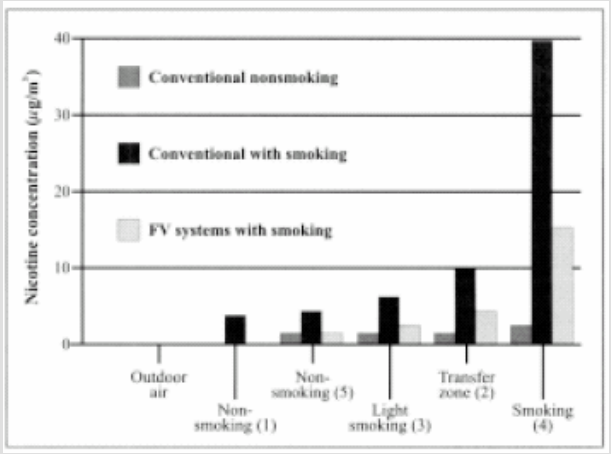
<u>Case Study 1</u> - ***Addressing Indoor Air Quality with Ventilation: A Case Study of an Energy-Recovery System***[47]

To improve the indoor air quality for the majority of America's workers, cost-effective solutions such as energy-recovery systems can be applied. President of Redi-Floor Inc. in Marietta, GA, Peter Brookner was facing indoor air quality problems related to tobacco smoke and volatile organic compounds (VOCs) emitted by new carpeting and flooring materials. He received complaints from two of his workers who were hypersensitive to smoke and chemicals and established a no-smoking policy. The no-smoking policy caused an increased outdoor smoke breaks, resulting in a major decrease in worker productivity.

Peter Brookner was looking for alternative solution to improve indoor air quality. He decided to install a ***total energy-recovery system****, designed to bring in more outside air without increasing the humidity level indoors. The units were easily installed into existing HVAC systems and packaged air conditioning units, with out a major change to the building. Specifically, Redi-Floor Inc. installed two energy-recovery systems from SEMCO, Inc. to the building's two electric air conditioning gas heating units.*

To measure the effect of increased ventilation and pressure balancing on Redi-Floors' indoor air quality, Georgia Tech Research Institute collected air samples in three different scenarios: the original ventilation system without smoking, the original system with smoking and the new energy recovery system with smoking. Georgia Tech measured levels of tobacco-related contaminants, VOCs, carbon monoxide, carbon dioxide, temperature and relative humidity.

According to the test results, the energy recovery system more than doubled the air exchange rate, from 0.8 to 2.1 changes per air. This increase was particular significant because it was achieved without increasing heating or air conditioning capacity or compromising indoor comfort conditions. Nicotine levels were 60% lower with the new system. According to the report, carbon monoxide levels never exceeded 2.25 parts per million by volume (ppmv) when the energy-recovery system was operating as opposed to original ventilation systems with levels of 16.3 ppmv in a smoking building. The energy-recovery system, as reduced the average concentration of VOCs by 30% to 36%.



Source: Engineered Systems, 1998

The bar chart above illustrates nicotine levels at six test sites in Redi-Floor's headquarters. Black bars show ambient nicotine levels using original ventilation system, when smoking was allowed. Dark gray bars show how much was recorded with original system when smoking was prohibited. Light gray bars show levels recorded with the newest ventilation system in place, with smoking permitted.

Moisture Control

Moisture control is extremely important in maintaining comfortable living conditions.

Technology Solutions

Dehumidification systems: Dehumidification systems are available to reduce excess moisture to a tolerable level, thus reducing the load on the A/C system.[48] Such systems also reduce humidity levels without cooling, providing better comfort control, and they improve indoor air quality by lowering the chance of mold, mildew, and bacteria.[49] Dehumidifiers can reduce energy consumption as well by reducing the load on the A/C system. Installation of such technology also saves money by reducing the size of cooling equipment.[50]

Mechanical refrigeration technology: In this technology, moist outside air passes over a coil cooled by refrigerant, where the moisture in the air condenses and is removed. The heat energy recovered during the dehumidification process can be placed back into the air stream when conditions call for heat or be removed to the outside as waste heat during cooling cycles. The dry, pretreated air then passes through the building's standard heating/cooling system.[51]

Humidifiers: Humidifiers replenish the much-needed moisture in the air inside the home. Dry winter air in the home can cause dry skin, nose and throat discomfort and static electricity. It also can cause wood floors and trim to shrink, walls to crack and wood instruments to warp. When a furnace runs in the winter, it constantly dries the air. Moisture levels may be replenished by installing a whole-house humidifier.[52] This is important because warm, dry air absorbs moisture from everything around it, and breathing this air can cause discomfort.[53]

Air Cleaners

Air cleaners offer an effective way to remove up to 94 % of the particles (dust, pollens, pet dander, plant spores, fungi, bacteria, tobacco smoke, etc.) from the air that passes through the home.[54]

Technology Solutions

Flat Mechanical Filters: These filters generally consist either of a low packing density of coarse glass fibers, animal hair, vegetable fibers, or synthetic fibers often coated with a viscous substance to act as an adhesive for particulate material, or slit and expanded aluminum. They may be installed in ducts in homes with central heating and/or air-conditioning or may be used in portable devices which contain a fan to force air through the filter. Flat filters may efficiently collect large particles, but remove only a small percentage of the particles we breathe.[55]

Pleated Mechanical Filters: The pleats in these filters create greater surface area, which allows the use of smaller fibers and an increase in packing density of the filter without a large drop in air flow rate. These may be installed in ducts in homes with central heating and/or air-conditioning or may be used in portable devices which contain a fan to force air through the filter. Pleated mechanical filters generally attain greater efficiency for capture of respirable particles than flat filters. [56]

Electronic Filters: These filters use an electrical field to trap charged particles. They can use electrostatic precipitators, in which particles are collected on a series of flat plates, or less common charged-media filter devices in which the particles are collected on the fibers in a filter. Like mechanical filters, they may be installed in central heating and/or air-conditioning system ducts or may be portable units with fans. In most electrostatic precipitators and some charged-

media filters, the particles are deliberately ionized before the collection process, resulting in higher collection efficiency.[57]

Ion Generators: Ion generation technology uses static charges to remove particles from indoor air. They act by charging the particles in a room, so they are attracted to walls, floors, table tops, draperies, occupants, etc. In some cases, these devices contain a collector to attract the charged particles back to the unit.[58] These devices come in portable units only, and are effective at collecting particles from the air.

Chemical Filtration Systems: These systems operate by passing the building's air supply through a chemical medium such as activated charcoal and potassium permanganate. The filtration medium is mixed precisely for the type of gas to be removed, and the condition of the filtration material is continuously monitored for its effectiveness. A chemical filtration system can be included as part of the building's HVAC during new construction, or it can be retrofitted into existing systems when an air deficiency problem is detected. Stand-alone units can also be installed in individual areas if the problem is localized or if retrofitting the building's entire HVAC system is economically unfeasible.[59] These systems are the preferred method of gaseous contaminant control because they remove rather than mask the offending problem.

Air Treatment

Boilers are currently in use in medium and large buildings to generate hot water, provide steam heat, and run commercial/industrial processes. Boiler technology has advanced and now contributes to air quality improvement.

Technology Solutions

Ultraviolet Air Treatment Systems: Photocatalysis[d] and photolysis[e] are used to remove VOCs and ultraviolet germicidal irradiation (UVGI) is to destroy bacteria, viruses and fungi.[60] These systems are particularly designed to prevent mold spore growth on A/C coils. This technology has been used for decades in water treatment, and helps reduce allergic reactions to mold while enhancing overall air quality.[61]

Controllability of Systems

Many conventional boilers and HVAC systems used in medium and large buildings do not have automated control capabilities installed. These technologies can improve the efficiency of the heating, hot water generation, and air conditioning systems to generate hot water, provide steam heat, and run commercial/industrial processes.

Technology Solutions

Sensors: Sensors monitor temperature, relative humidity, pressure, occupancy, fire and smoke. This information is then used to control building function particularly the HVAC system. Sensors can monitor individual pollutants including CO, CO2, PM10, PM2.5, ozone and TVOC as well as pollen and mold. They can be combined with other components such as local wireless data transfer, remote web accessibility, and artificial intelligence software to create total IEQ management systems.[62] Sensor information is very effective in preventing a buildings environment from becoming unhealthy.

[d] Photocatalysis is the acceleration of a chemical reaction by radiant energy (as light) acting either directly or by exciting a substance that in turn catalyzes the main reaction – www.dictionary.com

[e] Photolysis is chemical decomposition induced by light or other radiant energy – www.dictionary.com

Programmable Thermostat: The goal of a programmable, or "setback," thermostat is to regulate the HVAC system to maintain a desired comfort level when the home is occupied and then enter an economizing mode when the house is unoccupied. A "double adjustment" thermostat can be set to adjust during work hours and sleep hours and will result in the greatest energy savings in the summer and winter. A "single adjustment" thermostat can be set to an economizing mode each day and also contributes significant savings.[63] This is installed as a component of the HVAC system. It responds to your choices and schedule for optimal comfort and energy savings of up to 33%. It can play a major role in the energy efficiency of the HVAC system.[64]

Return Air Pathway (RAP): A RAP provides a passive pressure balancing system for central return HVAC systems, reducing the problems of light and noise transmission. These are designed for either new construction or retrofit applications, and reduce problems of light and noise transmission.

Lighting and Views

Increased lighting and improved views improve the atmosphere of a building, thereby enhancing the quality of life of building occupants.

Technology Solution

Glazing Low-E Windows: High-performance, energy-efficient window and glazing systems not only improve indoor environmental quality, they dramatically cut energy consumption and pollution sources. They have lower heat loss, less air leakage, and warmer window surfaces that improve comfort and minimize condensation. These high-performance windows feature double or triple glazing, specialized transparent coatings, insulating gas sandwiched between panes, and improved frames. All of these features reduce heat transfer, thereby cutting the energy lost through windows.[65]

Green Cleaning

Preventing pollutants from entering the building is very important in improving indoor environmental quality.

Technology Solutions

Entryway systems: The use of grills, grates, and mats can be used to reduce the amount of dirt, dust, pollen, and other particles entering the building, and for the use of cleaning strategies to maintain entryways and exterior walkways.[66] These solutions, which serve as pre-emptive measures to prevent pollutants from entering the building, reduce the need for removing them later on.

Low impact cleaning systems/products: The use of sustainable cleaning systems, sustainable cleaning products, chemical concentrates and dilution systems, programs for the proper training of maintenance personnel, hand soaps not containing antimicrobial agents (except where required by code), and cleaning equipment reduces impacts on indoor air quality.[67] Green products reduce pollutants such as harmful chemicals in the building atmosphere and thereby improve air quality. Implementation requires the commitment of building management to enforce such procedures.

Isolation of Janitorial Closets: Isolating janitorial closet prevents pollutants from entering buildings and keeps the air healthy. Isolation measures include deck-to-deck partitions with

separate exhausting, no air re-circulation, negative pressure in all closets, and hot and cold water and drains plumbed for appropriate disposal of liquid wastes. [68] Implementation may require the renovation of existing structures.

Environmental Impact of Pest Management: Development and implementation of an integrated indoor pest management policy that minimizes the use of toxic pesticides also helps to improve IEQ.[69] Green pest management also prevents toxic pesticides from entering the building environment and also requires the commitment of building management.

Materials and Resources

Conventional building materials contribute substantially to the overall environmental burden of buildings. Nearly every point in a material's life cycle somehow affects human and environmental health. For instance, the extraction of raw materials consumes energy, degrades water quality, and can damage ecosystems. Manufacturing produces waste and pollution, and installed materials contain, and in some cases emit, toxic compounds which may detrimentally affect occupant health. Even cleaning and maintenance processes may cause health risks and toxic waste exposure. Eventual disposal of these materials wastes recoverable resources, consumes landfill space, and often degrades groundwater.[70]

However, not all materials are equal. Some materials have alternative qualities which make them environmentally preferable or "green." Executive Order 13101 was issued September 14, 1998 for New York City and defines environmentally preferable materials as:

> [P]roducts that have a lesser or reduced effect on human health and the environment when compared with competing products or services that serve the same purpose. This comparison may consider materials acquisition, production, manufacturing, packaging, distribution, reuse, operation, maintenance, or disposal of the product or service. [71]

The implementation of recycling and conservation programs during the green retrofit of a building can dramatically reduce the volume of waste generated. Replacing old items with "environmentally friendly" materials can improve the quality of life for residents and other building occupants. Furthermore, many green products are created in an environmentally-conscious fashion which minimizes detrimental impacts to the environment.

This section examines options for recycling materials while retrofitting an existing building and also suggests materials that may be used in "greening" the building.

Materials and Resources Opportunities

Recycling Materials

Building conservation of resources and materials focuses on reducing waste by recycling components which would otherwise be discarded in the retrofitting process.

> ***Technology Solutions***
> Appliance Recycling: On average, 55 million appliances are removed from service each year. Older appliances can contain environmentally harmful materials such as mercury and polychlorinated biphenyls (PCBs), which are dangerous to human health.[72] These substances must be removed and managed properly before recycling an appliance. Retrofitting residential areas requires careful attention to the proper disposal and recycling of appliances.[73] Moreover, All NYC residents are required by law to arrange for the recovery of CFC/Freon when discarding freezers, refrigerators, air conditioners, water coolers, or dehumidifiers.[74]
>
> Carpet: According to the Minnesota Office of Environmental Assistance, "the amount of carpet reaching the end of its useful life and entering the waste stream is ever-increasing: estimated total discards for 2002 are 4.7 billion pounds."[75] Land disposal is by far the most common disposal method. National concerns about disposal capacity, combined with carpet's bulk (which makes it difficult and expensive to handle), have contributed to the search for alternative means for carpet

disposal.[76] Old carpeting can go through a few different chemical or mechanical breakdowns to recover nylon fibers which can be reused in new carpet fibers or backing.[77] While most of the components that make up carpet are recyclable or reusable, on average only 4% of waste carpet is recycled. Increasing recycling and reuse would reduce waste and recover valuable resources.[78]

Concrete: Recycling concrete is a relatively simple process. It involves breaking, removing, and crushing existing concrete into a material with a specified size and quality.[79] According to the Concrete Network, in large scale projects, "recycling concrete can result in considerable savings since it saves the costs of transporting concrete to the landfill (as much as $0.25 per ton/mile), and eliminates the cost of disposal (as high as $100 per ton)."[80] Recycled concrete can be used to generate new concrete pavements, sidewalks or curbs.

Glass: Glass is 100% recyclable in that it can be melted repeatedly to produce the same product. The technology for recycling glass is relatively simple and well established.[81] All windows, computer screens, TV screens, and other specialized glasses can be recycled but must be handled by separate facilities.[82] Still, there are some challenges to recycling glass. Although glass can be melted and changed from one form into another with ease, a problem arises in separating the glass from other materials in a product. Stray metal, ceramics, or other material that is often near glass when demolished can pose threats to the quality of the next generation of the recycled glass.[83] Transportation costs to deliver glass to the appropriate facilities are also deterrents to recycling.

Gypsum board (drywall): Gypsum board is a heavily used building material for drywall walls in most residences.[84] About 10% of all new cement is composed of gypsum. Tests using recycled gypsum in cement production have demonstrated that it can assist with the setting time. The biggest challenge to using recycled gypsum board in cement is the transportation cost.[85] It can be recycled in a variety of ways including: cement production, stucco additive sludge drying, water treatment, salty soil treatment, manure treatment, animal bedding, flea powder, grease absorption, and athletic field marking.

Wood: Wood waste created from renovation and demolition can be recycled for a number of uses. Often, wood fixtures that were initially used in homes can be turned into engineered wood products and composites.[86] Recycled wood can be used for mulch and energy. Additionally, hundreds of products ranging from adhesives to pet litter can be created from recycled wood.[87] Using recycled wood materials helps to preserve forests and encourages technological innovation to find additional uses for recycled wood.

Replacement Materials and Products

Conservation of Resources and Materials urges retrofitters to renovate using sound materials and to engage in the use of environmentally friendly products. Identifying proper sources for certain materials can be aided by recognizing certification systems.

Technology Solutions

Bamboo Flooring: Bamboo flooring is an alternative to hardwood flooring. Bamboo grass grows quickly and can be harvested in three to five years. Unlike traditional hardwoods, when harvested, bamboo does not require replanting.[88] Bamboo is a durable flooring option.

Carpet: Using polyethylene terephthalate (PET), the main component of plastic beverage bottles, carpet fibers can be produced from 25-100% of this recycled material as well as for the carpet backing.[89]

Cleaning Products: As described previously, hundreds of chemical contaminants are contained in cleaning products. Though designed to clean, these products can actually reduce indoor air quality.[90] An array of eco-friendly cleaning products have been developed and tested to ensure both low toxicity and high effectiveness.

Gypsum Wallboard: A new process in coal-fired power plants produces a product called desulphogypsum, which can be used in place of raw natural gypsum to create new wallboard. Many new gypsum wallboard manufacturing facilities are retrofitting to be able to produce wallboard specifically from this source. Green retrofitting requiring new drywall can request that the manufacturer uses desuplhogypsum board.[91]

Green Roofs: Vegetated green roof systems can significantly reduce heating and cooling costs.[92] The number of layers and the layer placement vary from system to system, but at the very least all green roofs include a single to multi-ply waterproofing layer, drainage, growing media and the plants, covering the entire roof deck surface.[93]

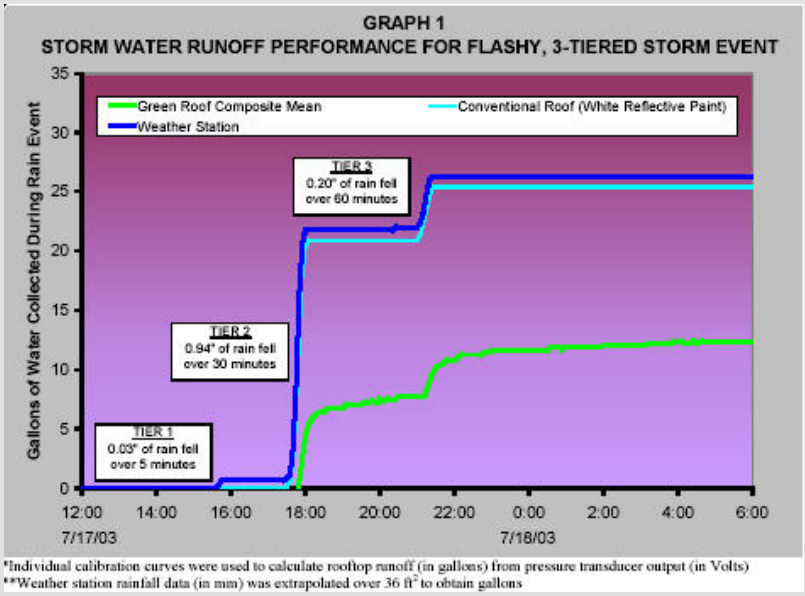
The following case study illustrates the technology and benefits of green roofs in greater detail:

Case Study 2: *Innovative Design – Green Roofs*

Architects and policymakers alike are becoming increasingly aware of the numerous environmental benefits that green roofs have to offer. Conventional black tar roofs have been known to reach temperatures as high as 175 °F during the summer.[94] Updrafts of hot air – and the tiny particles suspended within it – leaving conventional roofs, contribute to higher city temperatures and air pollution. In contrast, green roofs' peak temperatures do not exceed 77 °F. Therefore, numerous green roofs have the potential to dramatically impact a city's environmental quality and mitigate the "Urban Heat Island Effect"[95]. Another frequently sited benefit of green roofs is their ability to absorb water during precipitation events and minimize storm water runoff. In cities like New York, storm water runoff from impervious surfaces can cause environmental degradation to waterways in the form of combined sewage overflow. In addition to the direct environmental benefits that green roofs provide, they can also reduce air conditioning needs by up to 10 percent by shading, insulating and performing evaporative cooling for buildings.[96]

Traditionally, green roofs are built on newly constructed buildings designed to support their extra load. Intensive green roofs – planned and landscaped for tenant enjoyment and aesthetic virtues – require a minimum soil depth of 8", elaborate drainage and irrigation systems, as well as substantial maintenance. Recently, however, the emergence of eco-roofs, or extensive green roofs, makes adding green roofs to existing buildings possible. Extensive green roofs commonly weigh no more than gravel roofs, have a soil depth of only 1-4" and entail minimal maintenance. Aside from their inaccessibility to tenants, extensive green roofs offer the same environmental benefits that intensive green roofs do. In addition, both types of green roofs last up to three times longer than standard roofs, thereby reducing the replacement costs and the use of hazardous materials in conventional tar roofs. Extensive green roofs can be adapted for most existing buildings and earn one LEED-EB point so long as they cover at least 50 percent of the roof area.

The City of Chicago's Department of Environment performed a Green Roof Test Plot Project in 2003 to quantify the environmental benefits of green roofs compared to conventional roofs. The Chicago DOE used an extensive green roof design to measured six extensive green roof test plots against black tar, stone gravel and white reflective paint roof test plots. As the graph below shows, the Chicago DOE found that extensive green roofs significantly reduced the total storm water runoff and decreased peak runoff flows compared to conventional roofing materials. They also observed that extensive green roofs maintained the narrowest range of daily temperatures and demonstrated the lowest maximum daily temperature.



Source: City of Chicago Department of the Environment, 2003

Installing an extensive green roof as part of green renovation initiative offers benefits in numerous guideline areas including, but not limited to: water conservation, energy efficiency and conservation, outdoor air quality and construction material conservation. Furthermore, the installation of an extensive green roof is an accessible green improvement that can be achieved while a building is fully occupied and can be timed to replace a conventional roof at the end of its lifespan.

Insulation: According to the EPA, formaldehyde is a known carcinogen. It has also identified as a cause of respiratory damage.[97] Recycled-Content, fiberglass insulation with no added formaldehyde can be installed exactly as traditional fiberglass. Formaldehyde-free binders reduce indoor air quality problems and insulation contains up to 30% recycled glass.[98]

Paint: Most paints, both gloss and emulsion, contain solvents and volatile organic compounds (VOCs) which can be detrimental to indoor environmental quality. Some paint manufacturers have eliminated VOCs from their products, making them ideal for green retrofitting.[99]

Paint Caulking, Mastics, Glues: Numerous non-toxic and non-flammable caulks, mastics, and glues are available through eco-friendly construction products distributors.[100] These final products would be necessary in fitting and sealing in place all the new green materials used in residence.

Recycled Content Ceramic Tile: Originally developed for high traffic commercial conditions, recycled content tiles are very durable and wear well in residential applications. Some recycled-content ceramic tile is very dense, which significantly reduces the amount of moisture and stains that are absorbed into the tile, making it more durable and easier to maintain. Recycled-content ceramic tile can contain up to 70% recycled glass.[101]

Wood Products: Retrofitting of residential units in a building will likely involve removing or replacing wood fixtures that are common in residential settings, finding and identifying wood products that are green for the retrofitting process is important. The Forest Certification Resource Center lists four Forest Certification systems in North America including: American Tree Farm System, CSA International, Forest Stewardship Council and Sustainable Forestry Initiative.[102]

Building Operations and Maintenance

Building operations and maintenance plays an integral role in a building's longevity and efficiency over time through continued efforts to improve and maximize the structure's performance. The rising cost of energy, especially for heating and cooling, is a significant motivating factor in the development and implementation of a green operations and maintenance (O&M) master plan that will reduce high variable utilities costs for tenants and management alike. Advanced O&M planning plays an integral role in reducing immediate utility costs, but is also important for retaining and attracting new residents. Tenants are accustomed to nominal annual rate increases, but the rapid increase of costs is widening the margin between inefficient buildings and their more efficient counterparts. When given the choice, tenants are more likely to opt for efficient apartments rather than absorbing the high variable costs of buildings with inefficient utilities.

Building Operations and Maintenance Opportunities

Master Plan Development

Retrofitted buildings can develop a custom-made operations and maintenance manual or master plan to ensure issues are addressed for the short and long-term operations of the structure. The master plan requires the input and approval of building operator, management, and building owner and should be updated periodically. A master plan typically addresses the following issues:

- Building commissioning
- Buildings system monitoring
- Standard cleaning products
- Integrated communications strategy
- Procedures for renovations/new technologies
- Performance management benchmarking

Building Commissioning

The purpose of commissioning is to match a building's performance with the building owners' operational needs.[103] Commissioning may entail establishing criteria for measuring both current performance and in the future.

Solutions

Building Commissioning is a process usually undertaken by a private service provider whereby a building owner assesses the existing performance of the building systems. For optimal results, commissioning should be scheduled annually.

Maintenance Accountability

All levels of building employees can be given guidelines and held accountable to best maintain an efficiently operating building and continually improve performance.

Solutions

Ongoing Building Systems Monitoring: Automated systems produce interim reports on the performance of water systems, electricity usage and other metrics. In the absence of an automated system, building managers compile this data and make temporal comparisons.

Training & Certification: The building operator, management, landscapers, janitorial staff and building owner may receive regular training and maintain specialist credentials (such as the Northeast Energy Partnership's (NEEP) Building Operations & Maintenance Certification (BOC) Program) to continue to learn about and implement the latest green building technologies. Although funding is needed for regular training, it ensures continued efficiency and improvements to building operations.

Chemical Use Reduction and Substitution

Building personnel responsible for O&M and green retrofitting can also reduce the amount of chemicals used in daily operations by replacing hazardous cleaning and maintenance products with more benign but effective materials.

Solutions

As discussed in previous sections, current products can be replaced with more environmentally sound brands. Greater details regarding product types and recommendations are included in the cost/benefit section.

Recycling

The nine million residents of New York City consume an incredible amount of resources. This high consumption rate generates approximately 12,000 tons of garbage daily.[104] Recycling can help reduce the amount of waste that enters landfills and incinerators. New York City publishes lists identifying both recyclable and non-recyclable items. These can be found on the Department of Sanitation webpage of Residential Information, "What to Recycle," web address: http://www.nyc.gov/html/dos/html/bw_resid/index.html.

The strategy for incorporating recycling into building operations involves four simple steps:

1. Make recycling bins accessible to all building tenants
2. Designate and clearly label storage bins for each medium
3. Post signs in the building to remind tenants about the importance of recycling
4. Ensure there is a well ventilated holding area where maintenance crews can sort and prepare the recycling for pick up by the Department of Sanitation

Education/Communication

Building tenants play an integral role in ensuring the efficiency of a building. Building operators and management are responsible for educating and communicating with building tenants and support staff such as landscapers and janitors, on how to help operate and maintain a green building.

Tenant education is the most effective mechanism to reduce a building's solid waste contribution. For the Canterra Tower in Calgary, a commercial office building, tenant education yielded a 62% reduction in solid waste reaching the landfill, and only needs to be transported once every two weeks. Additionally, this resulted in a $0.05/sq. ft. reduction in operating costs since 1998. The food court waste was significantly mitigated through vermiculture composting methods, which used red worms to compost organic garbage.[105] Successful education strategies include more than a one-way line of communication from management to tenants.

Solutions

Employee Communications: Regular staff meetings can be held for information sharing and education purposes. By keeping support staff, including cleaning and grounds crews, abreast of operation and maintenance procedures, building managers can continually improve performance and maintenance efficiency.

Tenant Communications: Regular communications between management and tenants can educate and inspire tenants to change consumption habits, particularly for water and energy consumption. Education initiatives may require the establishment of a building website, a regular newsletter or bulletin, and related forms of internal collaboration. A building education coordinator or building manager can incorporate communications responsibilities into the position. Over the long-term, well-established communications ensure that tenants are prepared for modifications to their dwellings (retrofitting or the like), understand the impact of their behavior and modify their consumption based on these experiences.

Water Conservation

Various control initiatives and technologies have been developed to reduce water consumption in residential buildings; these can have a significant impact in water use reduction. The following chart illustrates water use, showing the primary areas of domestic water consumption. Clearly, toilets comprise the bulk of domestic water consumption:

Domestic Water Use

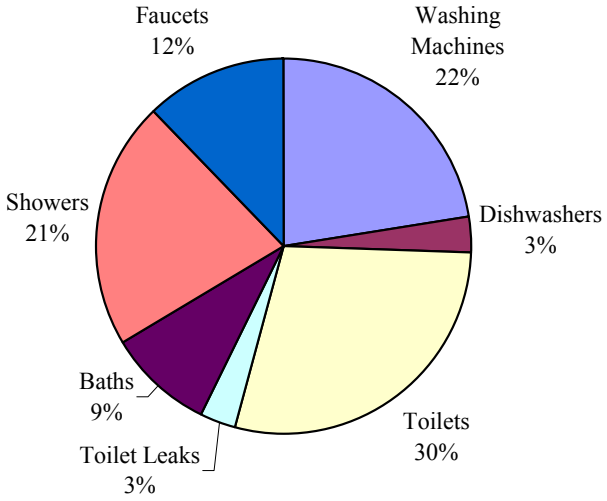


Figure 3
Source: Water Conservation Coalition[106]

Depending upon the technology, conservation solutions may be implemented on building-wide and individual tenant levels and range from the simple, such as changing plumbing fixtures, to the complex, such as installing an on-site wastewater treatment system.

The use of water efficient technologies often leads to cost savings in other areas as well. For example, water efficient appliances and fixtures require less heated water to accomplish the same task as their less efficient counterparts. This means that less energy is spent on heating water. This section examines various technologies available for water savings in buildings, including: water efficient fixtures, control technologies, water efficient landscaping, and innovative wastewater technologies.

Water Conservation Opportunities

Maintenance

Regular inspection and maintenance is an important first step to overall water efficiency. Unidentified and unaddressed problems often reduce the effectiveness of water-saving measures and compromise overall building efficiency. Leaks are a common water-related building maintenance problem as they result in unnecessary expenditures on water, and may also compromise building structural integrity and safety.

Technology Solution

Water Distribution System Audit: Knowing how much water is coming into a building and the relative proportions used by different activities can help to identify areas that need improvements. In some cases where leaks are large in size or number, an audit can alert building owners of their existence. Depending upon the information available, water distribution system audits may be extremely detailed or rough in their calculations. At the very least, a good audit should allow buildings to determine a baseline for water consumption and allow the establishment of reduction goals.

Water-Saving Fixtures

The Energy Policy Act of 1992 established benchmark minimum efficiency standards for buildings to achieve. Most green building guidelines state that the installation of new water fixtures should aim to reduce water use to (or below) the water usage requirements specified in this act, which include the following fixtures measured at a flowing water pressure of 80 pounds per square inch:[107]

Water Flow Rates

Lavatory faucets	2.5 gallons per minute
Lavatory replacement aerators	2.5 gallons per minute
Kitchen faucets	2.5 gallons per minute
Kitchen replacement aerators	2.5 gallons per minute
Metering faucets	0.25 gallons per cycle

Figure 4

The most common way to achieve these standards is to install low-flow plumbing fixtures such as showerheads and faucets.

Technology Solution

Showerheads: Showers account for about 20 percent of total indoor water use. The EPA reports that by replacing standard 4.5-gallon-per-minute showerheads with 2.5-gallon-per-minute heads, a family of four can save approximately 20,000 gallons of water per year. Furthermore, this simple action can lower the estimated per capita indoor water use by 6.4 percent.[108]

Faucets: The efficiency of faucets can be greatly improved by using aerators, which break the flowing water into fine droplets and increase the air content of the flow. Aerators are inexpensive and can be installed in sinks to reduce water use by as much as 60 percent while still delivering a strong flow. While many typical faucets are designed to deliver water at a rate of 3 to 5 gallons per minute, some of the newer and more efficient kitchen and bathroom faucets use only 2 gallons of water per minute.[109]

Water Efficient Landscaping

The objective of water efficient landscaping is to limit or eliminate the use of potable water for landscape irrigation. On a national level, lawn care accounts for approximately 32 percent of the total residential water use.[110] This number is smaller in urban settings where the average person devotes far less space to lawn and gardens than someone in suburban areas. However, substantial water use reductions can still be achieved by maintaining efficient landscaping.

Technology Solutions

Water Efficient Plantings

One way water use can be reduced for landscaping is through water efficient plantings. This method saves not only water, but fertilizers as well.[111] Furthermore, it can rely upon native plant varieties that do not pose a threat to surrounding ecosystems.

Efficient Irrigation Technologies and Practices

Modifying irrigation systems and practices can also help to reduce total water usage. Drip irrigation, soak hoses and subterranean irrigation systems all deliver the water to the plants more efficiently, but may be quite expensive to install.[112] Irrigating based upon need and setting timers to deliver water in the early morning when evaporation will be lowest can also achieve reductions when drip systems are not available.

Innovative Water Technologies

The objective of employing innovative water technologies is to reduce the generation of wastewater and potable water demand. Common technologies that address these issues include low flow toilets and package wastewater treatment technologies. In fact, the Energy Policy Act of 1992 also requires that all new toilets produced for home use must operate on 1.6 gallons per flush or less.[113] Reducing total water consumption using these methods can be quite effective once the proper technology is in place. However, in the case of making the decision to treat wastewater onsite using a package wastewater treatment system, capital costs will be quite high.

Technology Solutions

Water Efficient Conveyance Technologies

Low flow toilets: Recent estimates indicate that low flow toilets can save 33% of bathroom water use.[114f] Until recently, toilets commonly used 4.5 gallons per flush. Some newer models use only 1.6 gallons while maintaining excellent performance. Replacing toilets usually requires little capital investment and few ongoing maintenance costs, especially when compared with other options for reducing the burden of a building on local sewerage systems.

Graywater Reclamation System: Graywater is water that has been used in showers, sinks, and clothes washers which can be collected and reused for irrigation in some circumstances.[115] Graywater reclamation systems can be designed and installed by licensed engineering firms. Case studies of buildings with these systems reveal good performance and few long-term difficulties if maintenance is properly conducted.[116] However, installing these systems into existing buildings is difficult because extensive plumbing work must be undertaken.

Package Wastewater Treatment Plants: These plants are selected with the help of engineering firms that work with a technology provider to design and install the system. These plants can meet reuse standards and the resulting effluent can be used as flush water for toilets and to irrigate landscaping. The US EPA has extensive web resources on a variety of technologies suitable for urban wastewater treatment.[117] This approach to reducing wastewater generation and recouping water for irrigation and toilets should be studied closely as capital costs and ongoing maintenance requirements are high.

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Cost-Benefit Analysis of Green Retrofitting

The viability of retrofitting a building to achieve maximum operations efficiency and performance must be assessed in terms of quantitative or economic costs and benefits as well as qualitative factors. Four types of green strategies may be used to assess the costs and benefits of green retrofitting:

1. Some green technologies have a relatively short payback period and can recover the initial capital investment through dollar savings in less than five years.
2. Other technologies have longer payback periods, but also produce direct and indirect benefits, making investment in such capital expenditures a good business strategy. Benefits of such technologies include:
    - Human Health Benefits
        - Improved indoor air quality
        - Improved quality of life
    - Environmental Benefits
        - Resource efficiency
        - Waste reduction
    - Improved Quality of Life
        - Increased tenant loyalty and reduction in vacancies
    - Monetary Savings
        - Decrease in operations costs
        - Improved productivity among employees of commercial buildings
3. Some green technologies and high performance strategies may only be achieved at a premium, yet there is a specific audience willing to pay for this. These green technologies are purchased as a strategic business decision to serve a specific demographic.
4. Finally, some green technologies are adopted to prevent undesirable externalities. These technologies mitigate harm, reduce risks associated with liabilities, and expedite regulatory compliance.[1]

All four types of green strategies and corresponding valuation can add value to a high-performance building and should be employed when appropriate with specific business goals in mind.

The following section presents a cost-benefit analysis for the five target areas of this report: Energy Efficiency, Indoor Environmental Quality, Materials and Resources, Operations and Maintenance, and Water Conservation. Recommendations are then made based on these results, using the Gateway complex in Battery Park City to represent a multi-story residential building that could undergo green retrofitting.

Energy Efficiency

Simple energy efficiency measures can be taken to both reduce electricity consumption and save money on electric costs. Categories of energy efficiency measures include illumination, windows, appliances, climate control, on-site power generation, and "green" pricing.

Where applicable, and unless otherwise noted, electricity and gas rates are drawn from the information in the graph below to more easily compare projected energy savings among various technologies.

Electricity *
Rate Used: ConEd Winter Rate[2] (January 1, 2004) @ under 250kWh: .1526
ConEd Summer Rate[3] (July 1, 2004) @ under 250kWh: .1675
ConEd Average Rate (.1526 +.1675)/2 = .1601 kWh

Natural Gas*
Rate Used ConEd Rate as of 3/1/05[4]
Gas Cost Fact 76.4197
Firms Sales (1.3057)
Firm Transportation (3.7057)
Estimated Rate 71.4081/therm

**General service rates, calculated without applicable NYC taxes*

Figure 1
Source: Consolidated Edison (2005)

Illumination

Daylighting
Using natural light to illuminate space can substantially reduce energy expenditures, depending upon available window lighting and hours of available daylight. Common lobby areas and exterior rooms can often be lit sufficiently from outdoor light entering windows.

Benefits:

+ Reduction in the use of electricity to power indoor lighting in the daytime

Costs:

– Installation of prisms to refract existing daylight
– Installation of additional windows or skylights, but these also save on electricity expenditures. Actual financial benefits are dependent upon available window lighting and the length of day these can be used

Automatic Control Lighting
Time-based, occupancy-based (motion sensors), and lighting-level controls are simple ways to reduce the electricity "wasted" by lighting. Costs depend on the type of light being adjusted and the complexity of the control itself. For instance, dimmer features include toggle, rotary, slide, and rocker varieties and some have remote capabilities.[5]

Benefits:

+ Extends life of light bulb
+ Saves electricity costs
+ Motion sensors and timers can also add security
+ Tenant self-installation possible

Costs:

– Small investment required to purchase device
– Timers can cost between $25 and $200 depending on electric lode capacity
– Dimmers can range from $5 to $70 depending primarily on wattage
– Motion sensors range between $50 and $100

Compact Fluorescent Light (CFL) Bulbs

Compact Fluorescent Light (CFL) bulbs can easily be substituted for incandescent bulbs as the latter ones burn out. Assuming a unit has four two-bulb light fixtures, that unit will require eight light bulbs, excluding lamps, recessed lighting, vanity lighting or other features. This analysis assumes that each bulb is used four hours per day. [6]

Light Bulb Comparison

	Compact Fluorescent ($)	Conventional Incandescent ($)	Savings ($)
Life cycle costs	136	795	659
Installed price	23	4	-24
TOTAL	**164**	**799**	***$635***

Figure 2

Fluorescent lights offer the most practical replacement value for a retrofitting scenario. The following table illustrates the comparative efficiency of these and other efficient lights:

Characteristics of Common Light Sources

Light Source	Efficiency (Lumens/Watt)	Average Lamp Life (Hours)
Standard Incandescent	**5-20**	**750-1000**
Tungsten Halogen	**15-25**	**2000-4000**
Compact Fluorescent	**20-55**	**10,000**
Tublar Fluorescent	**60-100**	**15,000-24,000**
Mercury Vapor	**25-50**	**Up to 24,000**
Metal Halide	**45-100**	**10,000-20,000**
High Pressure Sodium	**45-110**	**Up to 24,000**

Figure 3

Source: Lighting Fundamentals Handbook, EPRI 1992

Benefits:

+ Saves $54 annually in maintenance
+ Saves $127 annually in operating costs
+ Saves 3,151 kWh of electricity over the lifetime of eight CFL bulbs. This is equivalent to removing 4,506 pounds of CO_2 from the air, the same amount produced 0.39 cars or the amount filtered by 0.61 acres of forest in a single year

+ Each compact fluorescent bulb is projected to last 6,000 hours, compared to only 750 hours for a standard incandescent

Costs:

– Compact fluorescents cost approximately $3.50 per bulb, as opposed to $0.50 for incandescents
– Replacing eight bulbs in a given Gateway unit would cost $28, versus $4 for eight incandescents

Lighting Fixtures

Lighting fixtures, while often overlooked, consume energy in tandem with a light bulb. Cost savings can be realized from changing both a bulb and its fixture. Even a one-bedroom unit will likely have four overhead fixtures—two in the living area, one in the kitchen and one in the bedroom. Over the lifetime of these four fixtures, total operating costs can amount to $664 for energy-saving fixtures, compared to $2,080 for conventional ones, a savings of $1,147. Average payback of these fixtures is 2.3 years.

Lighting Fixtures Comparison

	ENERGY STAR® Fixture ($)	Conventional Fixture ($)	Savings ($)
Life cycle costs	664	2,080	1,147
Installed price	240	80	-160
TOTAL	**904**	**2,160**	***$1,257***

Figure 4

Benefits:

+ Saves 9,811 kWh of electricity over a 20-year lifespan, preventing the release of 14,030 pounds of CO_2. This is equivalent to removing 1.21 cars from the road or planting 1.91 acres of forest
+ Saves $79 annually in operating costs
+ Saves $26 annually in maintenance costs

Costs:

– Installation of the recommended ENERGY STAR® fixture is $60 (approximately $40 more than the estimated $20 charge for standard 120W fixtures)

Emergency Exit Signs

Exit signs are federally required in buildings throughout the country. Every floor of an apartment building should have at least one exit sign. Many buildings will have more than one per floor. Signs illuminated by light emitting diodes (LEDs) are beginning to replace those illuminated with traditional bulbs.[7] LEDs signs analyzed here use batteries for back-up power.

Exit Sign Comparison

	ENERGY STAR® Sign ($)	Conventional Sign ($)	Savings ($)
Life cycle costs	46	680	634
Installed price	165	75	-90
TOTAL	**211**	**755**	***$544***

Figure 5

Benefits:

+ Saves $78 annually in maintenance and requires no bulb replacement
+ Saves $50 annually in operating costs
+ Saves $634 annually over a projected 10-year lifetime
+ Saves $544 total, and has a payback of 1.2 years

Costs:

– Initial investments for LED exit signs total $165 per unit, as compared to $75 per conventional unit

Recommendations for Gateway and comparable multi-story residential buildings

1. As Gateway tenants are responsible for changing their own light bulbs, we recommend that Gateway management either provides high efficiency fluorescent bulbs to tenants, or provides educational materials that encourage tenant use of high efficiency lighting.
2. Increasing day-lighting is infeasible due to the poured concrete façade of the building.
3. Install dimmers to reduce hallway light during late-night hours when corridors are infrequently used. Dimmers can also be used to reduce artificial light in rooms that receive a substantial amount of natural light at some point in the day.
4. As LED exit signs recuperate their costs quite rapidly and offer substantial savings thereafter, we recommend that Gateway replace their numerous exit signs with LED signs.

Windows

Residential windows consume a sizable portion of all U.S. energy use; taking steps to make windows more efficient can dramatically reduce this energy consumption. Savings potential is difficult to calculate because HVAC, heating, cooling, and illumination costs are all impacted.

The RESFEN computer program allows the user to calculate heating and cooling impacts of windows in residential buildings for various climate conditions.

Benefits:

+ Improves the indoor environment by improving the thermal comfort of buildings in both heating and cooling seasons
+ Gas fillers for inner-glazing window cavity maintain energy saving benefits for more than 20 years, although efficiency decreases over time
    - Argon: less expensive
    - Krypton: better insulator
+ Low e-coatings:
    - Pay for themselves in 5-10 years, despite a higher initial investment
    - Protect interior furniture, upholstery, carpets, wallpapers, and artwork from UV damage

Costs:

– Gas fillers, particularly krypton, can be much more expensive than air as an insulator
– Low-e coatings:
    - Cost 10-15% more than plain, insulated glass
– Applied films:
    - Cost $1 to $5 per square foot, depending on film quality

Recommendations

1. Coat existing windows with a low-e film to realize energy and heating bill savings at a low cost.
2. Replace existing single-paned windows with double-paned, low-e versions as tenants vacate their units.

Appliances

Refrigerators

According to the Environmental Protection Agency, refrigerators consume more energy than any other household appliance. Replacing (and recycling) refrigerators in all building units can save energy and dollars.

Refrigerator Comparison*

	ENERGY STAR® Refrigerator ($)	Conventional Refrigerator ($)	Savings ($)
Lifecycle costs	1,011,865	1,190,214	17,882
Purchase price	800	600	-200
TOTAL	**1,012,665**	**1,191,030**	***$178,364***

*Figures for 1,712 refrigerators, one per unit

Figure 6

Benefits:

+ Saves almost 10 million kWh of energy and reduces nearly 14 million pounds of CO_2 after all building units have been replaced and recycled. This is equivalent to removing 2,000 cars from the road
+ Saves an estimated $200,000 in savings over the life of the appliances if installed in all units.
+ Uses up to 15% less energy by design

Costs:

– Roughly $200 more to purchase. For example, a conventional GE 17.9 cubic foot refrigerator will cost roughly $600 while an ENERGY STAR® compliant Black Kenmore 18.8 cu. ft. Top Mount Refrigerator will sell at around $800
– Expected payback in excess of 19 years may make this an economically unfeasible alternative

Dishwashers

Although dishwashers that operate more efficiently save comparatively less energy than other appliances, the combined energy and water savings still enhance conservation in each unit.

Dishwasher Comparison

	ENERGY STAR® Dishwasher ($)	Conventional Dishwasher ($)	Savings ($)
Life cycle costs	548	735	187
Purchase price	500	450	-50
TOTAL	**1,048**	**1,185**	***$137***

Figure 7

Benefits:

+ Uses 25 to 50% less energy
+ Uses 50% less water per load
+ Anticipated payback time is 2.5 years

Costs:

– Current models of top brands (Maytag, GE, Amana, Whirlpool) are all ENERGY STAR® rated.[8] Prices range from $350 to more than $1000 depending on capacity and features, making them a cost-competitive alternative to less efficient models

Clothes Washers

Clothes washers utilize electricity and water, both of which can be conserved with more energy-efficient models. These models cost more than conventional ones, but result in substantial energy savings. Anticipated payback time is 3.4 years when examining 25 clothes washers in the building:

Clothes Washer Comparison

	ENERGY STAR® Clothes Washer ($)	Conventional Clothes Washer ($)	Savings ($)
Life cycle costs	16,751	37,196	20,445
Purchase price (25 units)	18,750	11,250	-7,500
TOTAL	**35,501**	**48,446**	**12,945**

Figure 8

Benefits:

+ Net lifecycle savings per washer are estimated at $818
+ Anticipated payback time is 3.4 years
+ Each unit reduces CO_2 emissions by more than 3 tons

Costs:

– ENERGY STAR® models cost about $200 more than conventional clothes washers

Recommendations

Replace existing appliances at the end of their useful life

- Dishwashers have the shortest payback time, followed by clothes washers.
- Refrigerators have the longest payback time

Climate Control

A building's heating, ventilation and air conditioning (HVAC) system regulates indoor temperatures, air circulation and sometimes, domestic hot water. Many residential apartment buildings use a central system where warm or cold air is circulated to all units; others use separate heating and cooling units for each unit. HVAC systems can be retrofitted as whole unit; due to the complexity of these systems, however, upgrading individual components is often most feasible.

Window Air Conditioners

While most modern buildings have a central air conditioning system, many older units depend on window air conditioning. This analysis examines both a qualified ENERGY STAR® unit versus a typical conventional air conditioning unit[9], both with a cooling capacity of 10,000 Btu/hr. A typical unit in New York City is expected to operate at peak capacity for 1,089 hours per year.

Air Conditioner Comparison

	ENERGY STAR® A/C ($)	Conventional A/C ($)	Savings ($)
Life cycle costs	812	896	84
Installed price Per Unit	500	470	-30
TOTAL	**1,312**	**1,366**	**54**

Figure 9

Benefits:

+ Saves $9 annually in operation costs
+ Saves $84 over its 12-year lifespan
+ Saves about 1,259 kWh of electricity in its lifetime, thus preventing 1,800 pounds of CO_2 emissions

+ Anticipated payback time is 3.4 years

Costs:

– Estimated retail price for the ENERGY STAR® unit is $500, compared to $470 for a conventional one

Electric Heating and Cooling Units

Electric in-unit heating and cooling units are relatively inefficient, particularly in colder climates. Often, installing a central heating and cooling system in buildings designed without such systems is cost prohibitive. The following examines the costs and benefits of replacing an in-unit electric heating system with a direct-vent gas-fired room heater.

Electric Heating Comparison

	Electric Unit ($)	Direct Vent Gas Unit ($)	Savings
Five-year energy costs	8,810	1,720	7,090
Installed price	850	2,900	-2,050
TOTAL	**9,660**	**4,620**	**5040**

Figure 10

Annual energy costs, projected at an electricity rate of $.11/kWh and a gas rate of $0.51/thermal unit, was estimated at $1,762 with electric heating and $344 with gas heating.

It is important to remember that the direct vent gas unit, unlike the electric unit, does not provide air conditioning in the summer. Based on the information presented for ENERGY STAR® air conditioning units, installing and operating a room A/C unit would cost about $1,312 per 10,000 BTU capacity. This would reduce total savings to $3,728.

Benefits:

+ Reduces annualized electricity usage for heating purposes from 16,011 kWh to 0
+ Depending on prices, natural gas heating is often less expensive than electric heating

Costs:

– The total cost of gas heaters, including installation of piping and other associated costs, ranged from $1,800 to $2,900[10] compared to $799-$850 for electric heating systems[11-12]
– Raises annualized gas usage for heating from 0 to 674 kWh

Recommendations

1. At Gateway, cooling and heating are provided by the same unit; though some savings would accrue with separate high-efficiency heating and cooling systems, such a modification would be impractical because it would require the installation of both gas lines and additional air conditioning units.
2. We recommend, therefore, that no changes to climate conditioning be made.

Boilers

Gas or oil-fired boilers are used to provide heat for many multifamily buildings in New York City. Because of the wide variety of boilers, it is difficult to directly compare cost-benefit information

surrounding potential upgrades.[13] The first analysis[g] looks at retrofits for central steam heating systems.[14] The second section looks at hydronic systems which distribute heated water through a series of pipes to warm a building. These systems can provide domestic hot water but are not compatible with air filtering or central air conditioning.[15] Domestic hot water systems operate using boilers separate from the primary heating system.

The three tables in Appendix B examine the cost and benefits of retrofitting central steam heat boilers (Table 1), central hydronic heating (Table 2), and domestic hot water (Table 3).

Because central steam and central hydronic systems are widely used, Appendix B provides information for these common New York City boiler configurations. The following table illustrates boiler retrofit technologies offering a payback period of three years or less; additional technologies are also provided in the appendix.

Benefits:

+ The retrofit options examined above may reduce between 78 to 4,800 thermal units annually
+ CO_2 savings would prevent the emission of 936-57,600 pounds of this greenhouse gas. This is the equivalent of removing .08 to 4.98 cars from the road every year, or planting 0.128 to 7.85 acres of forest[16]

Costs:

– Costs vary dramatically, depending both on the retrofit itself as well as building-specific requirements; some projects with very high costs may still have acceptable payback times
– The complexities of HVAC retrofitting may call for consultation with an HVAC specialist, itself an additional cost

Recommendations:

1. At the Gateway complex, only domestic hot water is provided by a boiler. Gateway's best retrofit option is to turn down the thermostat from 140º (the industry pre-set standard) to 120º.
2. Another option is to investigate retrofits for demand-based hot water control, such as those that automatically lower or raise the heat at specified times.

[g] Data is provided from a 1995 study of multifamily buildings in Minneapolis-St. Paul, Minnesota. Steam-heated buildings consumed approximately 86,300 Btu/ft^2/year, compared 70,200 Btu/ft^2/year for hydronic applications. A typical building used about 12,095 thermal units (therm) annually for space heating. Domestic hot water accounted for 3,530 therm. These results should be taken as a lower boundary of expected savings resulting from upgrades. The cost of natural gas per therm was not provided.

The following case study highlights specific benefits gained by the installation of energy efficient heating in New York:

Case Study 3 - *Energy Efficiency in Buffalo, NY*

This case examines the conversion of electric in-unit baseboard heaters to direct-vent gas heaters in three apartments in Buffalo, New York. This conversion took place in 2000. Electric heating is generally found to be a less efficient and cost-effective method of heating than natural gas; however, features common to buildings designed for electric heating, such as a lack of duct work or poured concrete, usually make conversion to gas heat cost-prohibitive. Like their electric counterparts, gas heaters feature built-in thermostats, air filters and require no duct work. Direct-vent gas heaters pose considerably less risk from both carbon dioxide and nitrogen oxide than unvented models.

Installation

Installation costs for direct-vent gas heaters tend to be higher than for electric models, as gas units require the installation of appropriate piping and cosmetic components, as well as the removal of the old unit. Total installed costs for the units examined here and others in upstate New York ranged from $1,800 to $2,900, or $2.35-$5.50 per square foot. Energy use dropped significantly after installation in all apartments. This reduction varied from an 80% reduction in heating costs in an all-gas apartment to an 18% reduction in an apartment that maintained electric heating in the bedroom. During the trial period, the electricity rate was $0.11 kWh, while gas cost $0.51 per thermal unit. The chart below details the annualized energy costs associated with the electric and gas heaters.

	Annualized Energy Costs Before	Annualized Energy Costs After	Annualized Electricity Use Before (kWh)	Annualized Electricity Use After (kWh)	Annualized Gas Use After (CCF)	Projected Payback Period
1-story apartment; convert all rooms	$1,762	$344	16,011	0	674	7.1 yr
1-story apartment; convert living room	$1,615	$1,328	14,683	11,482	136	7.0 yr
2-story apartment; convert living room	$1,289	$374	11,534	1,428	426	2.2 yr

Lessons

Energy savings varied widely between the units. Room configuration was cited as a major cause of this. First, units that installed a gas heater in one room while keeping electric heat in other rooms experienced considerably less savings than units with gas heaters in all rooms. Second, a townhouse unit occupying two floors registered greater savings than the one-floor units. This suggests that heat from the gas units rose to warm the upper floors, a feature that makes this application especially suitable for high-rise uses.

Cautions

Tested units were rated at higher BTU levels than often necessary for apartment heating. BTU output of the gas heaters was 21,500 to 38,000, as compared to 9,000-12,000 BTU for comparable electric units. As installations become more common, smaller units may become available. Metering issues pose additional hurdles to installation, as such meters cost $20 per apartment. One option is to use a single meter for the entire building, which could shift savings to the landlord but reduce tenants' incentives to conserve energy. As combustion units, gas heaters contain some risk of carbon monoxide and nitrogen oxide exposure, though this is substantially lower than with unvented heaters. Lastly, the heaters examined here do not have an air conditioning element, unlike some electric models. Installing an ENERGY STAR® air conditioning unit is an option, although the additional cost of this (typically around $500) must also be examined.

On-site Power Generation

Solar and Wind Power

There are high capital and installation costs to wind power and solar photovoltaic (PV) arrays. A 600 watt PV system that powers various lights and appliances (though not simultaneously) can cost $8,000 or more, though costs have begun to decrease in recent years. The economics of wind turbine installation are highly dependent on area wind speeds and tend to be most economical when average electricity costs exceed 15¢ per kWh.[17] Still, there are no fuel costs. Only solar power is currently eligible for net metering (selling excess power back to the grid) in New York State.[18]

Benefits:

+ Decreased use of electricity generated by polluting fossil-fuel fired power plants
+ Residential wind turbines can reduce home electricity costs, though these vary based on wind speeds and consistency
+ Potential to educate community about on-site power generation capabilities

Costs:

– Solar costs about $4.50 per watt, though costs are falling[19]
– Wind currently has no net-metering option, so electricity generated cannot be "sold back" to the grid. Installation costs are also involved
– The design of the New York City electricity grid makes net metering possible only along avenues; buildings located on cross streets cannot participate in net metering regardless of power generation technology

Microturbines, Gas Turbines, and Fuel Cells

Distributed power technologies generate electricity for the building through the combustion of natural gas, the cleanest of the fossil fuels. They can be set up for electricity generation, domestic hot water and space heating and cooling, or some combination of these.[20] Depending on need, such systems can provide back-up power in case of failure of the larger energy grid, base load power, and peak load. Several technologies exist, including gas turbines, microturbines and natural gas fuel cells.[21] Prices range considerably for all three modes; costs per energy unit usually drop with increasing size. Table 4 in Appendix B compares installed costs, maintenance costs, life expectancy and efficiency of these on-site power generation alternatives.

The three technologies also demonstrate varying levels of emissions. Selecting the cleanest available technology is especially important in distributed power applications, as the power generation unit is often located inside the building for which power is generated. Table 5 in Appendix B details measured pollutant emissions for nitrogen oxides (NOx), a pollutant that contributes to ozone formation, carbon monoxide (CO), a pollutant which inhibits respiration at high concentrations, total hydrocarbons (THC) and volatile organic compounds (VOC), which also contribute to ozone formation and carbon dioxide, (CO_2), a greenhouse gas and contributor to climate disruption.

Benefits:

+ Gas turbines:
    - Suitable for large residential complexes or commercial applications
    - Proven technology with long performance record

+ Microturbines:
    - Lowest installed price for residential applications
    - Lowest maintenance costs for residential applications

+ Fuel Cells:
  - Substantially lower emissions than either gas generators or microturbines

Costs:

– Gas Turbines:
  - Useful for large residential complexes and commercial applications only
  - Emitted pollution represents an abatement concern, especially when used in residential buildings
– Microturbines:
  - Lack of performance data makes projects of costs and reliability uncertain
– Fuel Cells:
  - PAFC is the sole model used in large-scale electricity applications
  - Lack of performance data makes cost and reliability projections uncertain
  - Highest installation costs

"Green" Power

In most areas of the nation, residents must pay slightly more to use green energy although rebate and other incentives exist to promote the use of cleaner energy use. For example, Con Edison offers a $25 rebate for customers who select green power. Green power in New York City is comprised of 25% wind power and 75% low-impact hydro power. The city government has set a precedent by selecting green power for major city-owned industrial centers. "Con Edison *Solutions* officials estimated that these purchases… deliver an environmental benefit equivalent to planting approximately 275,000 trees or reducing automobile usage by approximately 3.5 million miles per year."[22]

Benefits:

+ Reduced pollution from decreased use of power generated by fossil fuels

Costs:

– Premium of 1¢ to 7¢ more per kWh[23]

Recommendations:

- Upfront costs of installing wind turbines or solar panels may be prohibitive at present, therefore small microturbines may be the most feasible alternative for on-site power generation.
- The best alternative overall for the Gateway would be to purchase "green power" from Con Edison, as the utility is the current electricity provider for the area, and switching to Con Edison *Solutions* requires no new investment.

General Energy Efficiency Recommendations

1. Change light bulbs (simple, inexpensive, low-impact).
2. Install LED Exit Signs (rapid payback, significant electricity savings).
3. Install double-paned windows (improve insulation and comfort, reduce climate conditioning costs).
4. Replace appliances once they have reached the end of their useful life with ENERGY STAR®-compliant models (rapid payback, electricity savings for building and individual units).
5. Purchase Green power (minimal increase in kWH premium, descreased used of power generated by fossil fuels and subsequently less pollution).

COST-BENEFIT OVERVIEW: ENERGY EFFICIENCY		
Technology	**Cost***	**Benefit**
Illumination		
Daylighting	+	▪ Emphasis on natural light brings aesthetic and environmental benefits.
Automatic Control Lighting	variable by product and quality desired	▪ Simple to install with less than 3 year payback.
Light Fixtures		▪ Reduces the need for greater fossil fuel emissions.
Compact Fluorescent Light Bulbs		▪ Decreases emissions of pollutants that contribute to asthma and smog.
Exit Signs		▪ Reduces the need for increased fossil fuel infrastructure.
Windows		
Low-e window film	+	▪ Reduces need for energy to heat and cool the unit. ▪ Protects furniture and upholstery from UV damage.
Double-paned windows		
Appliances		
Refrigerators		▪ Electricity savings reduce energy-related pollution.
Clothes Washer	–	▪ Clothes and dishwashers may also use less water than conventional models.
Dish Washer	+	
Climate Control		
In-Room Air Conditioning	+	▪ Minimizes electricity use. ▪ Filters may reduce pollution from outside air.
Direct Vent Gas Heater	–	▪ Natural gas combustion cleaner than some power plant generated electricity.
Boilers	=	▪ Can reduce use and combustion of fuel oil.
	Savings vary depending on retrofit.	▪ Improved heating control increases comfort to residents.
Power Generation		
Renewable Energy	+	▪ Energy produced is pollution-free and does not contribute to respiratory disease. ▪ Immune to fluctuating commodity prices.
Distributed Power		
Small Gas Turbine	–	▪ Reduces fossil fuel inputs into electricity production.
Microturbine		▪ On-site generation protects against power disruptions.
Fuel Cell	–	
Green Power Purchasing	+	▪ Uses existing pollution-free electricity resources. ▪ No equipment installation requirements.

LEGEND: Projected cost over the course of life in comparison to conventional technology or practices:
[+ indicates savings], [– indicates loss], [= comparable]

Figure 11

Indoor Environmental Quality

Poor indoor environmental quality (IEQ) can be detrimental to human health and reduce the quality of life for building occupants. This can result in unseen costs to individual in terms of health care as well as a loss of worker productivity. Improvements in IEQ produce considerable advantages by improving people's health, comfort, and overall living conditions. The majority of available IEQ technologies also result in significant cost savings by decreasing utility bills. IEQ technologies can be categorized as ventilation improvements, air cleaners, air treatment, controllability of systems and lighting/views.

Ventilation Improvements

Ventilation technologies are comprised of Energy Recovery Ventilators (ERV) and Heat Recovery Ventilators (HRV), which increase airflow, reduce pollutants, maintain humidity levels and increase energy efficiency.

Benefits:

+ Reduce loads by 75%, save 80% on annual operating costs over 3 years
+ *Energy Recovery Ventilators (ERV)*
    - Save $42 per month on the electricity bill and 80% annual operating costs in 3 years or less
    - Reduce heating, cooling and humidification loads by 75%[24]
+ *Heat Recovery Ventilators (HRV)*
    - Contribute $42/month savings on the electricity bill and recover 80% of heat energy[25]
    - Air exchangers can be used for up to 2,200 sq. ft. and significantly improve air flow which help prevents poor air quality and illness

Costs:

– HRV/ERV units cost between $904 and $1,173
– Including cost of installation, retrofitting HRV/ERV runs $1,000 to $2,500+ due to the difficulty of running ductwork to the source points[26]
– Required maintenance for ERV/HRV can be done by the homeowner:
    - Clean/replace air filters every 1-3 months
    - Clean/unblock outside hoods and screens every 13 months
    - Clean energy recovery core every 6 months
    - Clean condensate drain and pans every 6 months
    - Service fans every 3-6 months
    - Clean grills and inspect ductwork for any leaks or obstructions annually
– Hiring a professional to check the system and verify that the system is properly balanced annually represents an additional cost[27]

Air Cleaners

Air filters can significantly remove pollutants, which can reduce on allergies and improve overall health and worker productivity in office environments. Air cleaners include mechanical filters, electronic air cleaners, high-efficiency particulate air (HEPA) filters, media air cleaners, ion generators, and ultraviolet air treatments.

Benefits:

+ Mechanical filters
    - Can be applied to an entire residence

    - 75% effective for smaller particles
+ Electronic air cleaners
    - Can also be applied to entire residence
    - Are extremely effective
    - Trap 89% of pollutants[28]
+ High-Efficiency Particulate Air (HEPA) filters
    - Are exceptionally effective
    - Trap 99.97% of pollutants
+ Media air cleaner
    - Less expensive than HEPA filter
    - 40% more efficient than traditional filters
+ Ion generator
    - 85% efficient for dust
    - 15-20% efficient for particles smaller than 5 microns[29]
+ Ultraviolet air treatment
    - Unique and efficient technology
    - Kills 87% of airborne bacteria
    - Can be applied to entire residence

Costs:

— Mechanical filters
    - Initial costs of $335 to $480.
    - Maintenance costs of $38 to $45 per year
— Electronic air cleaners
    - Is a more expensive alternative
    - Initial costs of $620 to $95030
    - Filters must be washed every 60 days
— HEPA filters
    - Initial costs run between $2,000 and $2,800
    - Maintenance costs of $80 to $100
— Media filters
    - Are less expensive filter option
    - Filters must be replaced every 1 to 2 years[31]
— Ion generator
    - Least expensive options
    - Initial costs between $98 and $19532
    - Must be washed every 30 days
— Ultraviolet air treatment
    - Initial costs between $350 and $56033
    - Replacement bulbs run from $99 to $20034

Controllability of Systems

System controllability improves the comfort of individual inhabitants through managed temperature, humidity, lighting, and views. These systems also frequently result in energy and cost savings.

Benefits:

+ Ventilation control systems
    - Control the air that circulates within the household
+ Programmable thermostats
    - Excellent way to monitor entire residence

- Saves up to 33% on the utility bill[35]

+ Controllers
  - Can be incorporated into the HVAC system
  - Create optimal living conditions
+ Temperature sensor
  - A cheaper alternative to other control devices
  - Helps adapt the inside environment according to outside temperatures
+ Humidifiers/ Dehumidifiers
  - Effectively controls moisture levels
  - Dehumidifiers prevent the growth of mold and bacteria
  - Humidifiers keep the environment comfortable for its inhabitants[36]

Costs:

– Ventilation control systems
  - Costs about $181
– Programmable thermostats
  - Costs range from $60 to $150[37]
– Controllers
  - Are incorporated into the HVAC system
  - Costs vary between $205 and $1,020
– Temperature sensors
  - Costs between $3 and $50
  - A less expensive alternative
– Dehumidifiers
  - Are more expensive
  - Costs about $1,025
– Humidifiers
  - Run between $142 and $260[38]

General IEQ Recommendations

1. Add HRV/ERV to existing HVAC system (expensive, but extremely effective and results in substantial cost savings; simple payback of 3 years or less).
2. Install programmable thermostats (inexpensive, substantial comfort improvements).
3. Add controllers to HVAC system (wide range of costs and benefits).
4. Purchase air filters (can be done by tenant; significantly improves air quality).
5. Purchase humidifiers/dehumidifiers and create a comfortable level of humidity (improvements can be made by the tenant; devices prevent the growth of mold and bacteria).

COST-BENEFIT OVERVIEW: INDOOR ENVIRONMENTAL QUALITY		
Technology	**Cost***	**Benefit**
Ventilation		
Energy recovery ventilation system	+	▪ Increases air flow ▪ reduces pollutant concentrations in the air ▪ Controls humidity levels ▪ Reduces energy costs
Heat recovery ventilation system		▪ Reduce spread of illness and increase worker productivity
Air Cleaners		
Mechanical filter Electronic filter HEPA filter Media filter Ion generator Ultraviolet air treatment	–	▪ decreases problems with asthma, allergies and chemical sensitivites
Controllability of Systems		
Ventilation control systems	–	▪ improve overall comfort for individual inhabitants ▪ manage temperature, humidity, lighting and views

LEGEND: Projected cost over the course of life in comparison to conventional technology or practices:
[+ indicates savings], [– indicates loss], [= comparable]
*Estimate, **If applicable

Figure 12

Materials and Resources

The use of green materials for retrofitting can offer numerous benefits to both residents and the environment. Residents appreciate materials which have low toxicity, long life, and low maintenance. Similarly, environmental benefits are achieved by reducing raw material consumption and increasing salvage and recycling value.

Life-cycle assessment of construction materials and assemblies is complex and time-consuming. Fortunately, there are now several programs that rate certain products for their environmental performance and award "environmental" labels, certifications, or recommendations to those with merit. Some common retrofitting products and their certifying organizations are described in the following table:

Material Certifications and Standards

MATERIAL	CERTIFICATION	STANDARD
Carpets	Carpet and Rug Institute (CRI)	Defines maximum allowable emissions of total VOCs, formaldehyde, and other specific compounds for carpets, carpet adhesives, and carpet cushions
Cleaning Products, Paints, Sealants, Adhesives & Coatings	Green Seal	Defines toxicity, lifecycle, packaging requirements, VOC limits and chemical component limitations for interior and exterior chemical products.
Wood Products, Flooring	Forest Stewardship Council (FSC)	Monitors biodiversity and wildlife habitat of the forest where extraction occurs.

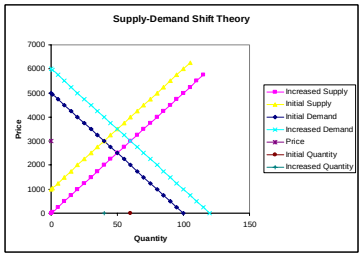
Figure 13

The following case study illustrates green building materials from an economic perspective:

Case Study 4 - ***The Economics of Green Building Materials***

Bill Hayward, president of Hayward Lumber, hired a consultant in 1997 to look at the demand for green materials in Monterey, California.[39] Like many in the industry, he was skeptical of consumers desire for green materials. To his surprise, the consultant found a substantial group of builders striving to create green projects. Their projects called for specific building materials, one of which was Forest Service Certified (FSC) lumber. Since no retailers sold this product locally, the builders had to order the lumber months ahead of time from sources outside their immediate area. Hayward determined that if he sold the FSC certified lumbar locally, he could dominate the market. In 1999 Hayward Lumber stocked the FSC certified lumber and earned $2,000,000 in sales in 2002 on FSC certified framing lumber alone.[40]

In this case, Hayward Lumber virtually monopolized the FSC certified lumber market in the area. However, access to healthy, durably and aesthetically pleasing materials has typically been worth a price premium to consumers. A national survey conducted by Cahners Residential Group in 2000 revealed 89% of homebuyers said they would pay more for green features if they improved the home's quality, durability and health. Over half would pay between $2,500 and $5,000, and 9.5% would pay $10,000 for a green package.[41] This finding has and will continue to persuade retailers to supply green products.



Applying basic economic theory, an increase in demand for green building materials will cause the supply of the product to increase. Other than proper knowledge about green products, there are no insurmountable obstacles to market entry. Thus, over time more stores will inevitably offer green products to acquire a share of the profitable market. Eventually this process will drive down the price for consumers.

This economic theory is taking shape in the New York City green building materials market. For example, in 2000 when the Battery Park City Authority commissioned developers to build a residential tower at 20 River Terrace in accordance with the Authority's Green Guidelines, finding the proper green materials was a challenge.[42] M. Scott Marks and Tim Button of Stedila Design faced the task of finding flooring, tile, cupboards, and countertops for the 27 stories, 400,000 square foot building.[43] While some local suppliers carried green products, none could meet the demand for a large multi-resident building. The project ended up costing $125 million which is slightly more than the average Manhattan high-rise. The owners of the Garden City-Based Albanese Development Corporation building attribute the higher cost of construction to the use of materials with low or no volatile organic chemicals, often found in household products such as paint and carpets, which can have negative health effects.

However, three years later the Albanese Development Corporation when embarked on a similar 24-story, 299,000-square foot building, located just east of The Solaire, the process was dramatically easier.[44] Local flooring companies that previously could only offer one tile option at a high price now had a selection of sixteen tiles at a reduced price. The total cost of this project has decrease substantially to $105 million. Essentially, as the demand for green building materials continues to rise, the supply will increase and the price will fall.

Caulks, Adhesives, Coatings

Below are conventional products that would be used in renovation and maintenance of materials within residential apartments, as well as some green alternatives:

Caulk, Adhesive, and Coatings Product Comparison

Conventional Product	Quantity	Cost	Source	Green Product[45]	Quantity	Cost	Source
DAP Caulk	10.1 oz.	16.49	Homedepot.com	Polyseamseal Tile and Tub Caulk (Low VOC)	10 oz	3.07	Lowes.com
Minwax Polyurethane Finish	8 oz.	7.75	Stockade-Supply.com	Natural Resin Floor Finish	0.75 liter (25 oz)	24.00	bioshield.com
HENRY 420 ClearPro Tile Adhesive	1 gal.	16.47	Homedepot.com	Safecoat 3 in 1 Tile Adhesive	1 gal.	42.14	homegreenhome.com

Figure 14

Benefits:

+ Low-VOC emissions
+ Reduced health risk to residents and maintenance staff

Costs:

– Similar in price to conventional products commonly used
– Requires extra research time to determine proper green replacements
– Will vary depending on quality and quantity desired

Cleaning Products

Since the demand and technology for green cleaning products is growing, in most cases green products are comparably priced with conventional products. The following table below compares common conventional cleaning products with environmental counterparts.

Cleaning Product Comparison

Conventional Product	Size	Cost	Source	Environmental Product	Size	Cost	Source
Rug Shampoo	1 gal	$19.54	parish-supply.com	Earth Friendly Products Rug Shampoo	40 fl oz	$8.00	drugstore.com
Clorox ® Bathroom Cleaner with Teflon	32 oz	$6.99	staples.com	One Bathroom Sanitizer/ Cleaner	32 oz	$5.20	cleaninggpro.com
Windex® Glass Cleaner	33 oz	$4.29	staples.com	Eco Glass Cleaner	32 oz	$4.85	cleaninggpro.com
Grout Haze Remover	32 oz	$19.15	wellspent.org	Not Available	-	-	-
Palmolive ® Ultra Dish Soap	25 oz	$4.19	staples.com	Method Upside Down Cucumber Dish Soap	25oz.	$3.99	lnt.com

Figure 15

Benefits:

+ Low-VOC emissions
+ Chemically safer alternatives to conventional products
+ Reduced health risk to residents and maintenance staff

Costs:

– Similar in price to conventional products commonly used
– Requires extra research time to determine proper green replacements
– Will vary depending on quality and quantity desired

Flooring

Wood Flooring (see Sustainable Wood Products)

Non-Wood Flooring

Recycled Glass/Ceramic Tile

The following table illustrates a comparison of tile prices:

Potential GSA Contract Prices[46]

Classic Series	Size	Carton Per Sq. Ft.	Pallet Per Sq. Ft.	Truckload Per Sq. Ft.
Tiles	4 x 4	$ 4.88	$ 4.39	$ 3.90
	4 x 8	$ 4.88	$ 4.39	$ 3.90
	6 x 6	$ 4.88	$ 4.39	$ 3.90
	8 x 8	$ 4.88	$ 4.39	$ 3.90
	12 x 12	$ 6.00	$ 5.40	$ 4.80
	8" Gothic	$ 6.00	$ 5.40	$ 4.80
	10" Octagonal	$ 6.00	$ 5.40	$ 4.80

Figure 16

Source: Government Sales Associates, Inc.

Benefits:

+ Strong, durable, scratch and stain resistant
+ Versatile – can be used for flooring as well as countertops and wall cover in kitchens and bathrooms
+ Reduced cleaning and maintenance costs
+ Aesthetically pleasing; unique designs, colors, and appearance
+ Reuses would-be landfill waste

Costs:

– Substantially higher cost than conventional ceramic tile

– Will vary depending on style and quantity desired; Terra Green Ceramics, sells their classic traffic tile at approximately $13.95 per square foot.[47] In comparison, BuildDirect.com offers wholesale ceramic tile flooring for around $1 per square foot.[48]

Carpeting

Benefits:

+ Low-VOC emissions
+ Reduced health risk to residents and maintenance staff
+ Diverts materials from landfill

Costs:

– Similar in price to conventional carpet; ranges from $1.32-$2.63, depending on the type of carpet fiber, weave, height of pile, and fiber count.[49]
– Requires extra research time to determine proper green replacements
– Will vary depending on style and quantity desired

Paints

Benefits:

+ Low-VOC emissions
+ No lingering paint smells
+ Reduced health risk to residents and maintenance staff
+ Sooner occupation time following repainting
+ Easier disposability

Costs:

– costs roughly 10%-20% more than conventional latex paints[50]
– Requires extra research time to determine proper green replacements
– Will vary depending on style and quantity desired

Recycling

Recycling programs can be implemented at minimal cost. New York City's Department of Sanitation provides materials including bins, posters and pamphlets for free. Furthermore, the Department of Sanitation picks up the recyclable materials at no additional cost.[51] In fact, all commercial residents, including those living in apartments, are legally required to recycle appropriate materials.

Benefits:

+ Reduced landfill input
+ Compliance with regulations

Costs:

– Similar to current costs; action is required by law

Sustainable Wood Products

Including furniture, flooring, cabinetry, and other fixtures, use of sustainable wood products is a benchmark of green building activities.

Benefits:

+ Contributes to sustainable harvesting market
+ Specifying certified lumber likely to add only a fraction to total project cost

Costs:

– Typically 0-15% more expensive than non-certified counterparts.[52]
– Requires extra research time to determine proper green replacements
– Will vary depending on style and quantity desired

Additional Alternative Materials

Numerous websites and organizations are dedicated to the pursuit of greening our living habitations. While retrofitting, it will be useful to take the time to investigate whether a certain product intended for use could have a greener counterpart. In making this decision, the internet serves as an excellent source of information. There are also printed catalogs, such as the GreenSpec® Guide to Residential Building Materials, which incorporate the majority of products. Additionally, the market for green products to use within residences is continually growing. In time, more traditional home improvement stores may provide green options among their standard lines of products.

Benefits:

+ Additional green improvements to residential areas

Costs:

– Requires extra research time to determine proper green alternatives
– Will vary depending on style and quantity desired

General Materials and Resources Recommendations

1. Use adhesives, sealants, coatings, finishes, and stains that have comparably-priced green alternatives. Most renovation activities can use these products with minimal cost increases.
2. Use comparably priced green cleaning alternatives. Maintenance staff can use these products in cleaning common residential areas. Additionally, these products could be offered by building – operations to tenants for use, and even marked up for a small profit.
3. Utilize alternative flooring options. These will generally be more costly than conventional floors, depending on wood type. Still, if funding is available these are an excellent green option. Recycled glass and ceramic tile also tend to be more expensive (depending on type and pattern), but reduced maintenance costs and durability make them good long-term investments.
4. Use carpet that is a comparably priced green alternative. Its benefit will be in decreased health costs to residents.
5. Use green paints for all repainting activities.

COST-BENEFIT OVERVIEW: MATERIALS AND RESOURCES		
Material	**Cost***	**Benefit**
Adhesives, Sealants, Coatings		
Caulk	=	▪ Minimized volatile organic compound emissions
Sealant	variable by product and quality desired	▪ Less potential resident health detriments
Epoxy		
Varnish		
Mastics		
Cleaning Products		
Bath/Kitchen Cleaners	=	▪ Minimized volatile organic compound emissions
Carpet Shampoo	variable by product and quality desired	▪ Minimized skin irritation, inadvertent poisoning
Soaps		▪ Minimized risk of fire or fatal gas production upon mixing
Stain Remover		▪ Potentially biodegradable ▪ Greater occupant and worker health
Flooring		
Wood	+	▪ Green Improvement
Bamboo		
Coconut Palm		
Urban Trees		
Non-Wood	+	▪ Green Improvement ▪ Increased durability, effective life ▪ Scratch, stain resistant
Recycled glass/ceramic tile		▪ Reduced cleaning costs
Carpet	=	▪ Minimized volatile organic compound emissions
	variable by fiber, weave, height of pile, and fiber count	▪ Diversion of landfill waste
Paints		
Latex Paint	+	▪ Minimized volatile organic compound emission ▪ Reduced irritation to body ▪ Easier disposability
Sustainable Wood Products		
Cabinets Wood Flooring Doors Molding Bases Furniture	+	▪ Sustainably harvested ▪ Green Improvement

LEGEND: Projected cost over the course of life in comparison to conventional technology or practices:
[+ indicates savings], [– indicates loss], [= comparable]
*Estimate, **If applicable

Figure 17

Operations & Maintenance

Measuring Green Operations & Maintenance Costs

A building's operations costs fall into the categories of insurance/liability, energy use, water use, waste removal costs, custodial practices, and maintenance costs. Qualitative O&M costs include improving air quality and aesthetic appeal and building management/tenant relations. Building managers have a fixed budget and must allocate resources to address the many quantitative and qualitative costs demanded for regular operations. While computerized systems have assisted many managers with such multi-faceted operations and management of commercial and residential buildings, it is still essential for the building manager to review, assess and revise operations regularly to achieve maximum efficiency and high performance. The following case study illustrates the "hidden" value of high-performance buildings:

Case Study 5 - *The Hidden Value in High-Performance Buildings*

In commercial buildings, business tenants are more likely to consider the operations costs of the building with regard to the bottom-line. For this reason, Fortune 500 companies often seek high-performance buildings as a component of their competitive strategy. These savvy companies have discovered that a high-performance building also equates to significant increases in employee productivity. Employee productivity is a measure of average output per worker. While sick days used due to building-induced illness clearly impacts productivity, other factors such as a worker's ability to exercise and shower while at their place of employment, or a pleasant working environment, contribute to employee happiness and the overall measure of productivity. The calculations in the table below illustrate that a minimal productivity increase of just 1% over 30 years is not insignificant.[53]

Analyzing One Percent Productivity	
(A) Average Campus Building Construction Cost	$80-150/SF
(B) Average Campus Building Size	100,000 SF
(C) Number of Employees per Average Building	500
(D) Average Fully-burdened Salary per Employee	$100,000
(E) Useful Life of Building	30+ years
(F) Labor Costs per SF Over Useful Live (C*D*E/B)	$15,000/SF
(G) Labor Cost per SF vs. Construction Cost per SF (F/A)	100 to 1
(H) 1% Productivity Improvement over 30 years (1%*C*D*E)	**$15 million**

This model estimates that a 1% increase in productivity results in cost savings of $15 million, and the link between high-performance buildings and increased productivity is even stronger. The U.S. Department of Energy suggests that high-performance buildings can increase employee productivity by as much as a 20%. In this model, that would amount to $300 million over 30 years. Businesses attempt to quantify these qualitative benefits because of the discrepancies in real costs. The model demonstrates that construction expenditures are only one hundredth of the labor expenditures that will occur within the building. Therefore, spending more on construction to achieve a high-performance building can yield returns in decreased labor costs for the duration of the building's lifespan.

If we transfer this productivity model for commercial buildings to large-scale residential buildings, we are measuring quality of life along with residents' out-of-pocket expenses. Residents are happier to have lower utility bills, and they benefit from the decrease incidence of pulmonary disease, allergic reactions, and cancer to mitigate health care costs.

Creating an Operations & Maintenance Master Plan

The development of a master plan with involvement from building owners, staff, and tenants will lead to a successful implementation if each constituent has had an opportunity to give input and take ownership in the outcome, including cost savings and a better quality of life.

Benefits:

+ Formalizes goals and procedures for the specific needs of the building; must be actively implemented in order to yield benefit
+ Adherence to plan saves time and improves efficiency of operations

Costs:

– Staff time spent creating internal standard operating procedures or engaging many stakeholders in an interactive process
– Based on estimate of 40-80 hours at $20/hr, costs range between $800 and $1600

Implementation of the Master Plan

A master plan will only achieve its goals as far as it is supported and implemented by all related stakeholders, including the building managers, tenants, owners, employees, subcontractors, etc. Master plans will be customized to serve the specific building and stakeholder needs, thus the costs associated are variable.

Benefits:

+ Streamlined standard operating procedures can yield significant monetary benefits simply by enabling the green retrofitting process. Actual savings depend upon the bundle of strategies employed by the Master Plan

Costs:

– Costs of implementing a master plan have been estimated at $.11- .77 per square foot[h]
– Will be dependent of the combined components of staff and programs. To some extent, these costs represent sunk costs, which already fund certain positions and duties

Staff Development

Administrative Staff

All buildings should have someone on staff who manages building safety and health issues and who coordinates educational communications between building administration and tenants. The key responsibilities of these functions may also be incorporated into the responsibilities of current administrative staff, assuming each has time available to dedicate to such work.

Benefits:

+ Avoids fines by complying with local, state, and federal regulations
+ Energy and water savings accrued based on enhanced system maintenance
+ Decreased vacancy rate due to increased tenant satisfaction

[h] This is based on housekeeping and maintenance costs of $2.30 per square foot and efficiency improvements of 5-35% Ashkin, Stephen. “Green and Clean: The Designer’s Impact on Housekeeping and Maintenance.” Proceedings from The 21st Century Outlook Conference Technical Papers, American Institute of Architects, 1997.

+ Operational savings through extended life of equipment and materials, continued efficiency and performance improvement

Costs:

– Costs incurred only if new hires are required:
  - **Environmental ,Safety and Health Coordinator:** $55,000 - $80,000 (base salary); will be responsible for implementing the components of the communications plan
  - **Communications Coordinator:** $45,000 – $65,000 (base salary); should develop procedures for educating tenants and staff as well as documenting, tracking and responding to tenant complaints and regulatory violations of indoor environmental quality, utilities use, waste disposal and other related issues

General Staff

Custodial, grounds maintenance, and other general building staff play an important role in maintaining excellent indoor and outdoor environmental quality. A communications plan and O&M policies and procedures should be developed to ensure each staff member is held accountable in his/her individual area of expertise, including the following:

1. Inspection
2. Preventative Maintenance
3. Cleaning
4. Repair of mechanical systems

Benefits:

+ More efficient use of utilities such as water and electricity
+ Improved maintenance and safety with proper use of chemicals and materials

Costs:

– Staff person is an existing cost, but training programs and staff certification may require expenditure

Programs

<u>Communications</u>

Ongoing communication between building owners, managers, tenants, and others is essential to the long-term success of a green retrofit. The goal is to provide easy access to information, tailored to the concerns of target audiences, on comprehensive green building programs.

Benefits:

+ Timely and more widespread implementation of building green strategies
+ Sets expectations so tenants can easily take cooperative actions or avoid conflict or redundancy

Costs:

– Undergoing communications between building managers and tenants will have a minimal cost, based on staff time and type of communications media use

Recycling

Recycling is required by New York City for glass, plastic, aluminum, and steel. Optional recycling programs for items that are not recycled city-wide such as batteries and electronics (computers, cell phones, etc.) provide additional opportunities for tenants. Costs and benefits are discussed in Materials and Resources section above.

Training/Certification

Residential and commercial buildings are large, complex, and costly to maintain. All staff should be properly trained in their individual areas of expertise to remain up-to-date with building standards and regulations to reduce risks and maintain efficiency. O&M policies and procedures should be developed for the following:

1. Maintaining compliance with local, state and federal regulations
2. Documenting both compliance and violations (including corrective actions)
3. Ensuring proper qualifications to operate special equipment

Benefits:

+ Enables continuing high performance of building management and staff
+ Provides source of new strategies to managing green buildings

Costs:

– Minimal new costs associated with training if not currently in place

Operations Performance Review

Review of energy and water consumption should be conducted on a quarterly basis. Additionally, commissioning should be conducted annually.

Benefits:

+ Ability to estimate the success and shortcomings of a building's performance

Costs:

– Internal review will consume variable costs, depending upon the scale of the building and access to monitoring equipment that gauges performance. Building Commissioning is less frequent
– Computer monitoring systems can be installed to automatically tabulate information, thus reducing staff time needed for tracking and improving accuracy of results

General O&M Recommendations

1. If necessary, re-engineer the way funds are utilized to include comprehensive operations and maintenance plan. In some cases, green strategies will require an initial outlay of funds for specific tasks, such as building commissioning.
2. Implement computer automation of tasks where feasible.

COST-BENEFIT OVERVIEW: OPERATIONS AND MAINTENANCE		
Technology	**Cost***	**Benefit**
O&M Master Plan		
Development*	+	▪ Formalize building goals/procedures ▪ Operations efficiency ▪ Continued performance improvement ▪ Operational savings through extended life of equipment and materials ▪ Avoided fines by complying with local, state and federal regulations
Implementation*		▪ Savings accrued from proper system maintenance (including reduced use of water and energy)
Staff		
Administrative**	+	▪ Operations efficiency and continued performance improvement ▪ Decreased vacancy rate due to increased tenant satisfaction ▪ Other intangibles
General**		
Programs		
Communications**	+	▪ Continued operations performance ▪ Improved quality of life ▪ Improved quality of life for BPCA and NYC as a whole
Recycling**	+	▪ Avoided fines by complying with local, state and federal regulations ▪ Operations efficiency and continued performance improvement
Training/Certification		
Performance**	+	▪ Operations efficiency and continued performance improvement
Commissioning**	+	▪ Operations efficiency and continued performance improvement

LEGEND: Projected cost over the course of life in comparison to conventional technology or practices:
[+ indicates savings], [– indicates loss], [= comparable]
*Estimate, **If applicable

Figure 18

Water Conservation

Water-related improvements to a building's overall environmental performance often yield high returns for relatively low investments. Simple measures such as fixing leaks and replacing basic plumbing fixtures with more efficient models can greatly boost the building's water efficiency while maintaining the same level of service to users. The economics of increasing water efficiency in older buildings often provides for an initial level of improvement with relatively little initial capital outlay. Water related improvements include maintenance, water-saving fixtures, landscaping, and innovative wastewater technologies.

The New York City water rates in the table below illustrate cost differences between various technologies presented.

New York City Water Rates (Effective as of July 1, 2004)*

Volume Provided / Meter	Charge Levied
100 cubic feet (748 gallons)	$1.60

*Note: if 100 cubic feet of water is not reached per meter in any one month billing period, a minimum charge of $0.21 per day will be imposed.

Figure 19

Water-Related Maintenance

Before any water related improvements are made to a building, a water audit should be conducted. This is important because it allows building managers to establish a baseline from which they can assess the performance of any future measures. Additionally, it can reveal leaks and other inefficient uses of water that when corrected can result in large savings.

Water Audit:
The process of conducting a water audit consists of creating a balance sheet with incoming water estimates from the utility matched as closely as possible with a total water usage estimate for the building. The process is somewhat imprecise due to the inability to measure usage with great accuracy.

Benefits:

+ Can help to identify any large leaks or systems using water unnecessarily

Costs:

– Approximately 8 hours of time by a qualified building manager

Repairs to Existing Water Delivery System:
Based upon findings of the water audit, any leaks detected are fixed and associated repairs made.

Benefits:

+ Can save a building water usage costs
+ Preserves building integrity
+ Helps to prevent the growth of molds

Costs:

– Minimal or moderate, depending upon site conditions and severity of leaks

Recommendations

1. The Gateway and similar buildings should conduct water audits to determine if water in the building is being used unnecessarily.
2. The complex should also make an effort to fix any existing leaks, including small leaks in apartment sinks, showers and toilets.

Plumbing Fixtures

The most common types of plumbing fixtures are aerating flow restrictors, which may be used in sinks and showers. These devices can cost as little as $2 and fit a wide variety of existing fixtures. There are also many inexpensive low-flow toilet units that are simple to install.

Low-Flow Sink and Shower Fixtures

These fixtures reduce water flow for minimal cost.

Benefits:

+ Approximately 50% water use reductions over conventional fixtures

Costs:

– Minimal; aerators can be purchased as accessories to existing sink and shower fixtures and cost less than $5 per unit

Low-Flow Toilets

Low flow toilets use just 1.6 gallons per flush and provide a good opportunity for reducing total water usage without incurring excessively high installation costs.

Benefits:

+ Saves 35% compared to 4.5 gallon models

Costs:

– Low-flow models range in price from just over $100 to over $1000

Recommendations

1. Research the cost of purchasing in bulk aerators and distribute these to tenants at a reasonable cost.
2. Building management should begin a voluntary program of education and assistance to encourage tenants to replace their fixtures

Landscaping

Choosing appropriate landscaping is an important consideration in planning an appealing and efficient green space. There are many beautiful native plant species that protect the environment by not threatening surrounding ecosystems and by requiring modest amounts of water.[54]

Benefits:

+ Water efficient landscaping can cut irrigation costs by over 75%
+ Maintains aesthetic appeal if designed properly

Costs:

– Costs will vary greatly depending upon area and plants present

Recommendations

1. Establish a baseline of water used for irrigating outdoor plantings to determine if replacing existing plant species with native varieties (that consume less water) would reduce costs.

General Water Conservation Recommendations

1. Conduct a water audit.
2. Add aerators to all sinks and showers.
3. Install low flow toilets.
4. Plant native plant species.
5. Install an efficient landscape irrigation system.

COST-BENEFIT OVERVIEW: WATER CONSERVATION		
Technology	**Cost***	**Benefit**
Maintenance		
Water Audit	+	▪ Gives Building Owners a baseline from which to make improvements.
Fix Leaks	variable by quality	▪ Can detect large water consuming leaks. ▪ Can Help to prevent mold and structural damage to property.
Water Saving Fixtures		
Sinks and showers Toilets	+	▪ Maintains high quality water delivery. ▪ Conserves water and energy.
Landscaping		
Replace plantings with drought resistant native varieties	+	▪ Maintains an aesthetic appeal. ▪ Reduces water consumed on irrigation costs. ▪ Preserves local biodiversity.

LEGEND: Projected cost over the course of life in comparison to conventional technology or practices:
[+ indicates savings], [– indicates loss], [= comparable]
*Estimate, **If applicable

Figure 20

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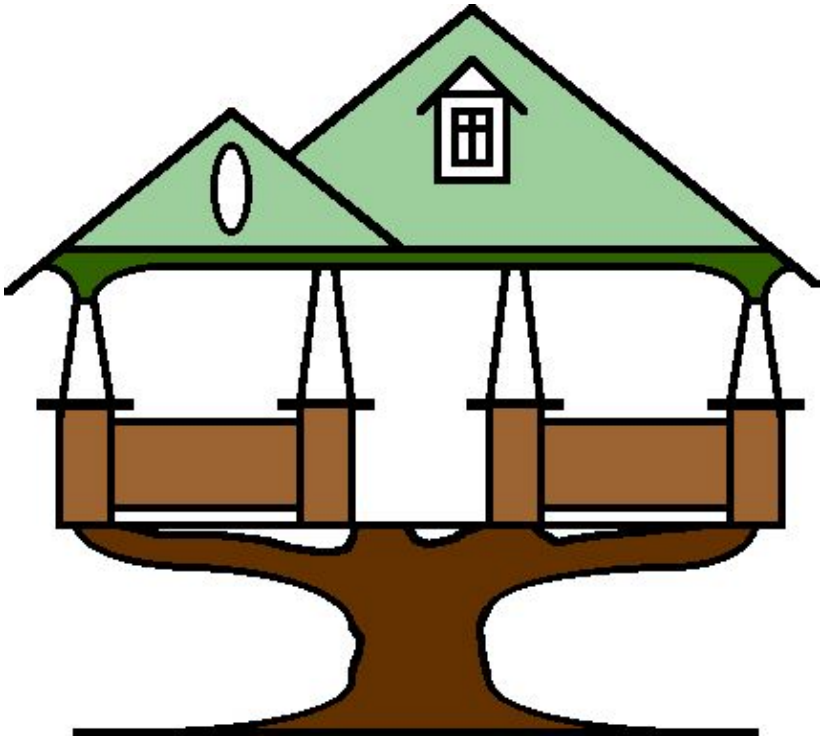
Drivers of Green Building

Policies and regulations, insurance restrictions and the threat of litigation, building industry standards, and educational campaigns provide the primary incentives for developers, property owners, and residents to participate in green building and retrofitting. Regulations and legislation play a critical role by mandating building and environmental standards, as well as offering financial incentives for green building. Institutions like the United States Green Building Council (USGBC) and the Battery Park City Authority (BPCA) can encourage green building by endorsing guidelines like LEED and LEED-EB, BPCA Residential Environmental Guidelines, and the New York City Department of Design and Construction's High-Performance Building Guidelines. Insurance companies also drive green building through standards and requisites related to specific environmental risks associated with buildings. Communications also plays a vital role in driving green building through educational campaigns about the benefits of green building and green practices that they can adopt.



Source: The EcoBuilders, Inc. (2005)

Policy

An important role of governmental green building policy is compensating for "market failures" that limit private investment in cost-effective efficiency measures and environmentally friendly technologies.[1] Each type of market failure should be addressed with tailored policy to address the unique circumstances of each. One reason for these market failures is that green technologies' initial purchasing costs can be significantly higher than their conventional counterparts even though they may be cost-effective over their full life cycle. Second, consumers tend to be risk-averse, resisting the adoption of new technologies or practices before they are widely accepted. Few consumers are "early adopters" who seek out opportunities to save money in the long run through efficiency. Third, green technologies and practices typically have less visibility in the marketplace, and green companies tend to spend less money on advertising than their mainstream competitors. Moreover, sales personnel are less familiar with green technologies because they have not been historically present in the market place. Finally, efficiency and green measures can be of low importance to customers who do not consider resource conservation to be a primary business objective.

Thus, it is essential to understand these market failures in order to create tailored policies that make green retrofitting more feasible and attractive. Federal, state and local government can employ various financial incentives like tax credits, reduced loan rates and rebates to accomplish green retrofitting goals.

Federal Policies

Federal policy is instrumental in facilitating large-scale capital projects such assisting traditional power companies to develop and implement renewable energy technologies, including fuel cells, bio-digesters, and wind turbines. The Federal Energy Management Program (under the U.S. Department of Energy, Energy Efficiency, and Renewable Energy) publishes a list of energy efficient product parameters and performance details, which can be used as guidelines or sources of information on energy efficient products.

New York State Policies

State governments have the capacity to design and implement effective green building policies and financial incentives that are tailored to their state's unique needs. The State of New York has designed such green building policies and incentives.

Executive Order No. 111

Governor Pataki passed *Executive Order No. 111*, a component of New York State's green building policy, mandating that all buildings owned, rented or operated by state agencies adopt conservation and environmentally friendly measures. In addition, the order requires that new state buildings be constructed in accordance with established green building guidelines or the LEED rating system. *Executive Order No. 111* also requires that all state agencies improve their energy efficiency by 35% from their 1990 baseline by 2010. Furthermore, new state buildings must achieve a 20% improvement in energy efficiency compared to the levels required by the state's Energy Conservation Construction Code.

The Green Buildings Tax Credit

New York was the first state to adopt an income tax credit for green buildings. It was developed by New York Energy Research and Development Authority (NYSERDA) and approved in 2000. The legislation offers an income tax credit between 5 and 8% of the total cost of a green construction or renovation of a building that is at least 20,000 sq. ft. in size. The legislation caps cumulative credits

available to owners and tenants of commercial and residential buildings at $25 million over 10 years. Additional incentives are available for buildings that employ fuel cells or photovoltaic panels for electricity generation. Fuel cells qualify for a 30% tax credit; building-integrated photovoltaics recover 100% of their costs, and non-building-integrated photovoltaics earn 25%.[2]

NYSERDA and New York Energy $mart

The New York Energy $mart program is "designed to continue energy efficiency, low-income services, research and development, and environmental protection programs during the State's transition to electric retail competition, and is a key element in the restructuring of New York's electric utility industry."[3] NYSERDA administers some 2,700 projects in 40 programs which are funded by a charge on the electricity transmitted and distributed by the State's investor-owned utilities.[4] The NYSERDA 2004 "Evaluation and Status Report for New York Energy $mart Program" found that the program has fostered and accelerated market development in the areas of energy efficiency, peak load reduction, and renewable energy that would not have occurred in the program's absence.[5] The following table outlines incentives administered by NYSERDA for the Energy $mart Program:

NEW YORK ENERGY $MART INCENTIVES ADMINISTERED BY NYSERDA	
For New York Residents	**For New York Building Owners**
Buildings Research and Development	Assisted Multifamily Program (those receiving State and local tax credits & subsidies)
Contractors & Vendors	Submetering for Multifamily Buildings (Advanced Meters)
Get Energy Smart Website	Comprehensive Energy Management Services Program (metering)
New York Energy $mart SM Loan Fund	Low-Income Forum on Energy (LIFE)
Residential Family 5+ Units	New Construction Program
Residential Low Income	New York Energy $mart SM Loan Fund (low-interest loans)
Residential Single-Family to Four-Family	Residential Technical Assistance (energy engineering services & audits)
Residential Vendor / Manufacturer	Smart Equipment Choices (energy-efficient equipment incentives)
Solar-Electric(PV) System Incentive Program	Solar-Electric (PV) System Incentive Program
	Cogeneration for Multifamily Buildings
	Energy $mart Communities (Energy-efficiency improvements in communities)

Figure 1

Source: New York Energy $mart[6]

Also through the New York Energy $mart program, residents investing in photovoltaics can earn cash incentives from the state. However, to qualify for funding under this program, the photovoltaic system must be connected to the electricity grid. As long as several additional conditions are met – like hiring eligible installers from NYSERDA's list – the photovoltaic panels earn at least $4 per watt once they are connected. Investments in photovoltaics are also eligible for reduced interest rate loans.

Small on-site wind generators qualify for state incentives as well. The cash incentives for wind power can help reduce installation costs by 15 to 70% overall. Incentive levels are calculated using the total installed wind capacity at the site, as outlined in the table below. Wind turbine installations, like photovoltaics, can also receive reduced rate loans.

		WIND INCENTIVE LEVELS* (based on percent of installed cost minus any other grants)		
		Sectors		
		Residences, Businesses, Institutional, Government	Commercial Farms**	Educational Institutions that Include Wind in Curriculum***
Installed Wind Capacity	500W - 10kW	50%	60%	70%
	10kW - 80kW	Incentive % = [rated capacity (kW) x (-0.5) + 55] (i.e., for a 50kW machine, [50 x (-0.5)] +55 = 30% incentive)	Incentive % = [rated capacity (kW) x (-0.643)] + 66.43	Incentive % = [rated capacity (kW) x (-0.786)] + 77.86
	over 80kW	15%		

Figure 2
Source: NYSERDA, 2004

In New York, HVAC systems also receive financial incentives and reduced rate loans under the energy-efficient equipment program at the state level. For existing buildings, incentives of 28.8¢ per annual kWh are given to projects that achieve cooling savings of approximately 18,000 kWh annually, but only to commercial, industrial, institutional and governmental sectors. However, all sectors are eligible to receive special loans for energy-efficiency improvements that can reduce interest rates by 4% for loans up to $5 million.

Benefit and Rebate Programs
New York's Public Service Commission created a multi-utility System Benefits Charge (SBC) for energy efficiency in 1998. The SBC was designed to fund energy efficiency and renewable energy programs that "might not immediately develop in the competitive market place"[7] and offers an average of $150 million in funding. These programs are available to customers of:

- Central Hudson
- Con Edison
- New York State Electric and Gas Corporation (NYSEG)
- Niagara Mohawk
- Orange and Rockland
- Rochester Gas and Electric

Independent of the SBC, the Long Island Power Authority and the New York Power Authority administer energy efficiency programs. Additionally, Pacific Gas and Electric (PG&E) Company offer the Multifamily Energy Efficiency Rebate Program to existing residential multifamily property owners and property managers. This program is available from January 1 – December 31, 2005 or until funds are depleted. Multifamily properties – apartment buildings, mobile home parks, and condominium complexes (with 5 or more units) – are eligible for up to a $1,500 rebate for installation of qualifying energy-efficient products in individual tenant units and in common areas. The following table summarizes rebates available for various products:[8]

PG&E Multifamily Energy Efficiency Rebate Program	
Qualified Energy-Efficient Products	***Rebate Amount***
I. Apartment and Common Area Products	
Screw-In Compact Fluorescent (CF) Reflector Bulbs	$10 each
High Performance Dual-Pane Windows	$1 square foot
ENERGY STAR® Labeled Ceiling Fans with ENERGY STAR® CFLs	$20 each
ENERGY STAR® Labeled Interior Hardwired Fluorescent Fixtures	$50 each
T-5 or T-8 Lamps with Electronic Ballasts	$32-$45 each
ENERGY STAR® Qualified Clothes Washers for tenant dwelling	$75-$100 unit
ENERGY STAR® Qualified Dishwashers	$50 each
Attic and/or Wall Insulation	$0.30 square foot
Low-Flow Showerheads	$5 each
Faucet Aerators	$1.25 each
Efficient Electric Storage Water Heaters	$40 each
ENERGY STAR® Labeled Exterior Hardwired Fluorescent Lights	$30 each
ENERGY STAR® High Efficiency Exit Signs	$25 each
Occupancy Sensors	$10 each
Photocells	$10 each
ENERGY STAR® Qualified Coin Operated Clothes Washers for common area	$150 each
II. Mechanical Products	
Energy-Efficient Package Terminal Air Conditioners and Heat Pumps	$100 each
ENERGY STAR® Central Natural Gas Furnaces – 90%AFUE	$200 each
Natural Gas Storage Water Heaters	$40 each
ENERGY STAR® Qualified Room Air Conditioners	$50 each
Central System Natural Gas Water Heaters	$550 each
Central System Natural Gas Boilers	$1,500 each
Natural Gas Water Heater and/or Boiler Controllers	$750-$1,500 each
III. High Efficiency and Cooling Products	
High Efficiency Air Conditioners	$200-$425
Energy-Efficient Central Heat Pumps	$275-$500

Figure 3
Source: Pacific Gas and Electric Company

Review of New York's Green Building Policies

New York State's green building incentives and mandates are more comprehensive than those of most other states in the U.S. The success of New York State's policies is evident in NYSERDA's 2004 Evaluation and Status Report for New York Energy $mart Program. However, issues of eligibility and coordination of policies statewide still need to be resolved. For instance, eligibility for the Green Building Tax Credit could be broadened to include a larger group of recipients. Furthermore, allowing O&M companies and contractors to receive the tax credits may result in a greater number of green improvements to existing buildings. Finally, some suggest that procedural problems still exist in the application process for green building tax credits, which can be time-consuming and complicated; if an application is not properly completed it is rejected without the option for corrections or appeal.[9]

Insurance

Insurance standards, requisites, and the threat of litigation indirectly promote green building practices. Obtaining insurance is often more difficult or costly for buildings with indoor environmental quality risks. Therefore, insurance drives green building in the form of environmental risk management. Building management has three primary concerns when approaching potential environmental quality risks:

1. Increasing insurance premiums,
2. Potential for litigation, and
3. Maintaining a competitive advantage to draw potential tenants by offering a more safe, appealing and affordable housing.

The two primary areas that are insured for residential buildings are related to human health and property. Building management may resolve insurance concerns as they relate to staff and tenant health as well as property protection in the long-term. Building managers can mitigate risks and maintain a healthy indoor environment by adopting a three-party strategy: educating tenants, capitalizing on green technologies, and leading by example, as shown by the chart below:

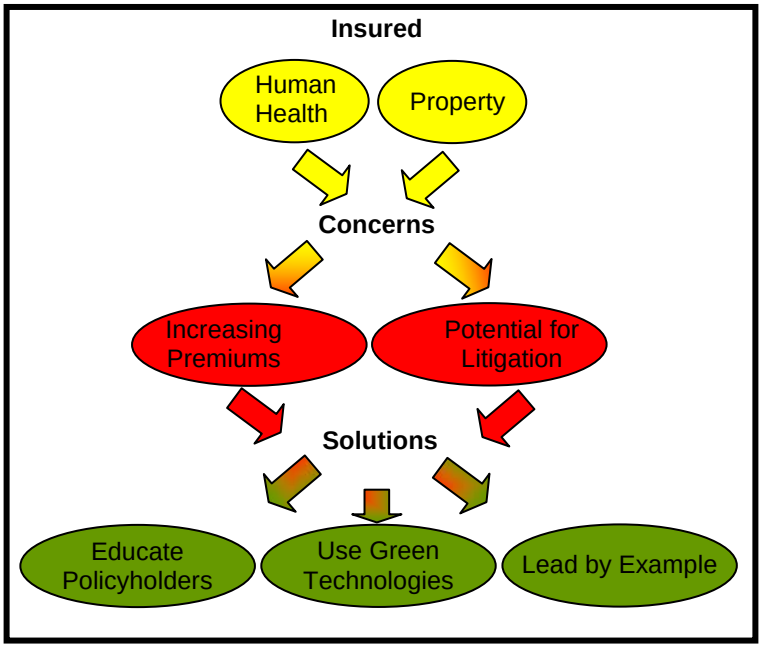
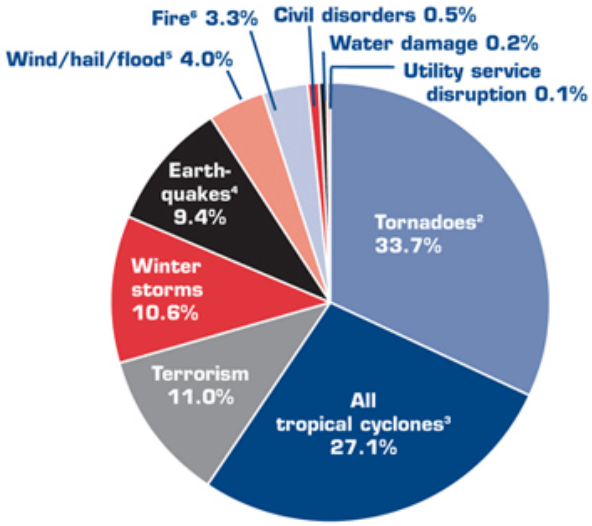


Figure 4

Increasing Premiums

Home and business owners alike in the United States utilize insurance policies to reduce their risk of loss. However, clients pay a premium for this risk management service, a premium whose rate has increased (in real terms) more in the last 15 years than in the 50 years previously. One decisive factor causing the heightened rates is the increase in the frequency and severity of natural catastrophes as depicted in Figure 5 below:

Inflation-Adjusted U.S. Catastrophe Losses by Cause of Loss
1984-2003[10]



(1) Catastrophes are all events causing direct insured losses to property of $25 million or more in 2003 dollars.
(2) Excludes snow.
(3) Includes hurricanes and tropical storms.
(4) Includes other geologic events such as volcanic eruptions and other earth movement.
(5) Does not include flood damage covered by the federally administered National Flood Insurance Program.
(6) Includes wildland fires.

Figure 5
Source: Insurance Information Institute

Insurers have paid more than $100 billion to victims in catastrophe-related losses, nearly $700 million per month since 1993. This is many times more than was ever paid in prior decades.[11] Scientific evidence shows that global climate change is caused by the increase of anthropogenic gases in the atmosphere and it threatens the global system through significant storm events – which are becoming increasingly common, – biodiversity loss, and rising sea levels. According to the United States EPA, there were three times as many natural catastrophes in the last decade as there were in the three prior decades. In short, natural catastrophes are occurring more frequently and at greater expense in the past 15 years, even after adjusting for inflation.[12]

Insurance holders confronting environmental risks are faced with higher premiums and greater liability. According to a 2002 *Planet Ark* interview with Carlos Joly, head of the insurance industry's environmental initiative: "[The insurance companies] will simply exclude paying out claims from events, such as flooding or windstorms, caused by global warming, leaving governments, businesses and individuals to pick up the bill themselves."[13]

To address these increased risks and regulatory barriers to compensation for environmental and human health damage, individuals and companies are taking environmental risk management measures. Similarly, insurers are implementing policies to address these risks. They are educating and informing consumers on energy saving measures and analyzing the costs of green technology investments. Insurers are also adopting incentive-based policies like property insurance credits for policyholders that invest in energy-efficient appliances or take courses on weatherization or home efficiency.

In addition, insurers recognize that environmentally-responsible building management can help mitigate risks and offer lower insurance premiums for compliant managers. Incentives are available for the implementation of communications programs aimed at educating tenants and staff on improving indoor environmental quality. Management can also invest in green technologies by installing low-flow toilets or retrofitting an existing building with green technologies. In the short-term, this leads to lower insurance premium rates; in the long term, this can result in cost savings, improved quality of life for tenants, and the potential reduction of environmental hazards both within and outside the building.

Potential for Litigation

The rising number of health and property suits is a driving factor in both insurance policy and building management practices. In fact, the fastest growing areas of tort litigation in the United States are in construction defect suits and litigation.[14] Asbestos and mold litigation are the most well-known cases in residential litigation because of the attention they have received in the media. The importance for building managers and owners to address indoor environmental quality issues, especially mold growth, is evident in the case study below.

Case Study 6 - ***Mitigating Insurance Risks: Residential Mold Growth***

In the last decade, U.S. insurance premiums have been rapidly increasing due to systemic conditions crippling the insurance sector. Specifically, the prominence of asbestos remediation and health-related claims, followed by a surge of "toxic mold" related claims, has caused a dramatic increase in related premiums. This case study examines how the surge in mold claims during the late 1990s and in the first few years of 2000s had enormous financial implications within the industry. This case will also review how the industry's quick response with policy and education curbed long-term damage to the industry and enabled the insurance sector's continued viability. Overall, the numerous mold claims, their subsequent litigation, and the industry's response provide an example of an effective proactive approach to mitigating environmental risks.

Arguably, the single most influential mold court case this century was Ballard V. Fire Insurance Exchange. The lawsuit, filed by homeowners Melinda Ballard and Ron Allison, alleged that Fire Insurance Exchange (FIE), a Farmers' subsidiary, mishandled their insurance claim after the family experienced a plumbing leak in a bathroom. Though the leak was discovered and repaired in 1998, the flooring began buckling several months later. According to suit allegations, a flooring contractor warned Farmers about the potential for dangerous mold growth in December 1998. Farmers refused to take action and blamed the buckling on foundation settling, which was not covered by Ballard's policy. Furthermore, the house was inspected by Farmers for plumbing leaks but none were found.

In early 1999, the floor buckling worsened and the walls, windows and doors were also damaged, as it was discovered, because the sub-floor was waterlogged. At that point, Farmers tried to settle the claim and offered a payout that the Ballard family considered insufficient to adequately repair the home. Concurrently, the family, Ballard, Allison and their young son Reese were experiencing unexplained health ailments, including coughing up blood.

A microbiologist, Dan Bridge, was sent by Farmers to inspect the home. He concluded that air space contained Stachbotrys spores –found in mold – however neither he nor Farmers informed the family of the spore presence at the time of its discovery. An independent study conducted by Texas Tech University at the Ballard family's request confirmed the presence of the toxic mold spores.[15] After the confirmation, the family moved out.

The family was initially awarded $32 million by a Travis Country District Court jury. According to Austin American Statesman, the family was awarded $6.2 million in actual damages, $12 million in punitive damages, $5 million for mental anguish and $8.9 million for lawyer's fees[16].

In 2001, mold claims in Texas cost the insurance sector more than $850 million, compared to almost nothing only a few years prior. Furthermore, the number of mold claims between 2000 and 2001 increased by roughly 1,300%.[17] *The insurance industry blames media for contributing to the increase in mold cases by hyping the issue and causing hysteria. Further, the hype is perpetuated by self-interested trial lawyers, mold remediators and other "experts" who were seeking to benefit financially from the scare. Despite the national attention given to the issue, the rising number of claims and subsequent premium increases, mold did not have the same lasting impact as asbestos did in the 1970s.* [18i]

Three key areas were identified in a 2004 Insurance Journal article as forces that kept the mold issue from becoming a "runaway problem" that could have seriously disabled or bankrupted the insurance sector. These forces were: 1) the aggressive public policy response to the mold crisis by insurers once the issue had been identified, 2) the issuance of sound, timely and consistent data provided the medical community for educational purposes 3) a common sense approach by legislators. Most importantly, insurers immediately addressed the problem by gathering facts and working to educate regulators, legislators and the public. The end result was a positive one. Instead of the continued economic drain that "toxic" mold could have become, insurers were able to move mold into the realm of a "controllable exposure" by getting the right facts to the public and legislators.

According to David Golden, director of commercial lines for Property Casualty Insurers Association of America, insurers must continue to use the proven methods of public policy advocates to maintain mitigate to individuals, businesses and the insurance sector itself. They should "gather all the facts, build strong coalitions of organizations and individuals that may be damaged by these unfounded claims and speak with one clear and unambiguous voice to legislators, regulators, the news media and consumers."[19]

In addition to managing risk and reducing liability, building owners and managers can achieve a competitive advantage by addressing their buildings' health and environmental impacts and mitigating them proactively. Remediating existing indoor environmental problems within a building, as well as educating tenants, will foster tenant loyalty. Increasing public awareness of indoor environmental quality and human health will make environmentally responsible buildings more attractive to potential tenants. A building's competitive advantage and retention of tenants are both components of achieving profitability and long-term viability.

[i] In the mid-1970s, asbestos, used in building construction among thousands of other applications, was linked to certain types of cancer and other serious health conditions. These findings prompted the discontinued use of asbestos insulation for almost all construction applications. As a result of the health and remediation liabilities associated with asbestos, U.S companies insurers have spent tens of billions of dollars in legal defense and lawsuit settlements.

Education

Education is an essential component to green building and the adoption of green practices within a community. Educational programs offered at different levels are critical to the success of green building. First, education and communication between building managers and tenants plays an integral role in ensuring the efficiency of a building. Building operators and management are responsible for educating and communicating with building tenants. Second, education at the neighborhood level can increase awareness and foster community simultaneously. Finally, city or statewide campaigns for educating consumers about conservation, green building and green products have been effective in California, as outlined in the case study below, as well as in El Paso, Texas (see Appendix).

Case Study 7 – *The California Energy Crisis and Energy Conservation Lessons*

In June 2000, California experienced its first blackout of the ensuing energy crisis. By January 2001, California consumers were paying an average of $313 per megawatt hour compared to $63 per megawatt hour in New York that same month while rolling blackouts continued.

In response to the California energy crisis, numerous utilities, state agencies and associations developed energy conservation campaigns to aid consumers in reducing their energy costs. Flex Your Power, a public outreach program sponsored by four of the state's utility companies, aimed to demonstrate to California consumers how to reduce energy prices by reducing overall demand, avoid shortages, and lower their monthly energy bills. Flex Your Power succeeded in making consumers partners in energy conservation through paid media and more than a dozen major initiatives, including partnerships with business, local governments, schools, and consumers. Possibly the most effective of the campaign was a collaborative effort between the state and the investor-owned utilities that focused on making consumers aware of how they could save energy and money through energy efficiency.[20]

Flex Your Power's aggressive television, radio, and newspaper media strategy, coupled with utility incentives in the form of credits, proved incredibly effective. In the summer of 2001, California reduced its overall energy consumption by at least 7%, reaching 14% during peak hours. In addition, 33% of residential customers and 27% of commercial customers reduced energy usage by 20% compared to previous years.[21] *In recognition of their efforts, the State of California, Southern California Edison, Pacific Gas and Electric Company, Sempra Energy Utilities and San Diego Gas & Electric were awarded the 2003 ENERGY STAR® award for Regional, State and Community Leadership in Energy Efficiency. The same utilities have also been leading the way in the construction of energy efficient homes that exceed state energy codes by 15% and greater, building almost 21,500 new ENERGY STAR® homes in 2002.*

Another program called Raise Your IQ (Insulation Quotient) – Simply Insulate was also launched in response to the energy crisis in California by the North American Insulation Manufacturers Association (NAIMA) in 2001. The central component of this outreach was an interactive website (www.simplyinsulate.com) where consumers could learn about upgrading their home insulation, compare average energy prices before and after insulation upgrades, and obtain information on local energy conservation programs like the California Energy Commission's Consumer Energy Center.[22]

Both the Raise Your IQ and Flex Your Power campaigns proved that energy conservation and efficiency campaigns are immediate and powerful weapons for reducing energy consumption. The campaigns also developed strategies and resources that could be employed throughout the country to reduce U.S. energy use overall.

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Recommendations

Battery Park City is a state authority that demonstrates leadership in enacting green building policy. Therefore, the GREEN team recommends that the Authority focus on promoting education, enhancing operations, and developing and implementing policy to promote green retrofitting in the neighborhood. Our recommendations are built from a thorough assessment of feasible technologies and successful drivers of green building.

Education

- Develop and distribute educational materials regularly to BPC residents, as well as building owners and managers, to explain the benefits of green building and how individuals can contribute to environmental sustainability. Potential topics can include, but are not limited to:
    - Energy and water conservation measures
    - Indoor air quality and asthma
    - Recycling
    - Green cleaning products

  Include product brochures from companies that provide environmental products to create synergies between the goals of BPCA and industry. This will promote public private partnerships to facilitate the development and distribution of educational material.
- Educate building owners and residents about federal and state financial incentives for green building and products for which they are eligible. Assign a staff or community member to assist residents in filing the necessary paperwork.
- Host community forums at which experts from both the green building and the health field can speak with BPC residents and raise awareness of the many important issues surrounding green building and conservation.
- Establish a community task force dedicated to promoting community dialogue about green building and quality of life issues, as well as other typical community interests and concerns.
- Coordinate with governmental and non-governmental organizations to design a city-wide and/or a state-wide comprehensive conservation and education campaign.

Operations

- Encourage the development of an O&M manual, as well as a yearly O&M plan, for every building in BPC.
    - Facilitate the creation and adoption of both an O&M manual and an annual plan through training workshops for building engineers and staff.
- Encourage building managers to engage tenants, learn about their concerns, and determine the areas in greatest need for improvement.
    - Managers should prioritize these by level of importance and involve tenants as key stakeholders in the design and implementation of strategic building operations and maintenance.
- Encourage the purchase and installation of HVAC systems that are more efficient.
- Establish a retail store in a convenient location within Battery Park City that sells (possibly subsidized) green household products to residents to encourage the use of green products.
    - Products can include air filters, humidifiers, cleaning supplies, and energy efficient light bulbs, among other regularly used green products.

- Facilitate the installation of lightweight extensive green roofs, or eco-roofs, on the existing buildings to mitigate storm water runoff, reduce the "heat island effect," decrease buildings' cooling costs, and beautify Battery Park City.
    - Install a model extensive green roof on an existing building in BPCA to generate green roof enthusiasm and confidence in building owners and managers as well as residents.

Policy

- Employ a two-pronged approach to green retrofitting in BPC:
    - Promote green building at Battery Park City. For example, sponsor the green retrofitting of common spaces (hallways, foyers, etc.) and one model apartment of an existing building. This will allow residents and building owners to observe the benefits and feasibility of green retrofitting.
    - Simultaneously, encourage improvements by facilitating the adoption and implementation of easy and inexpensive green measures, such as installing water-efficient fixtures, using non-toxic cleaning products, and using paint without VOCs for repainting.
- Develop a comprehensive procedural plan for addressing the green retrofitting of existing buildings for BPCA
    - The plan should standardize a green retrofitting methodology so that renovations of existing buildings can occur in an incremental manner within a specified timeframe.
- Encourage building owners and managers to provide new tenants the opportunity to move in to a retrofitted green apartment. This service can be provided at a premium and would achieve the objective of green retrofitting without the challenges associated with an occupied apartment.
- Purchase "green" power from Con Edison Solutions, and encourage other purchasers of electricity in Battery Park City to do the same. This modification currently costs less than 1¢ more per kilowatt hour than conventional power in New York, can be adopted immediately, and does not require any consumer adjustment.
- Coordinate with local, state and federal government to better utilize legislative incentives for green building and encourage the development of additional incentives.

Conclusion

Green retrofitting involves challenges beyond those of new green construction; however, there are numerous direct and indirect benefits of green retrofitting. Improvements in every target area – energy efficiency, indoor environmental quality, water conservation, materials & resources, and operations & maintenance – can be implemented in existing residential high-rise buildings. These improvements will foster resource efficiency, reduced environmental impact, and improved human health. Additionally, these improvements can provide cost savings and embody indirect benefits such as risk mitigation and competitive advantages. In such cases, the dual objective of profitability and environmental responsibility can be achieved through green improvements to existing buildings.

Tenants and building owners in New York State can also receive offsets for higher initial costs through government-sponsored financial incentives. The New York *Green Building Tax Credit* covers between 5 and 8% of the cost of environmentally responsible new construction and renovations, while New York State offers rebates for green products through the New York Energy $mart program, administered by NYSERDA.

Limited investment in green retrofitting to date is due primarily to a lack of information about green alternatives and their overall cost-effectiveness. Education at the building, local, and state levels can facilitate the growth of green markets that provide green technologies and practices for retrofitting initiatives. Moreover, simple actions such as distributing educational materials, hosting informational community forums, or opening a local green product retail store would foster an environmentally responsible building environment.

The purpose of this report has been to identify key areas where Battery Park City can be instrumental in incentivizing green building within its jurisdiction. It is important to note, however, that there are both continuing and future trends that should be investigated as Battery Park City moves forward with its green retrofitting objective. Further research should, for example, appraise the quality-of-life benefits and other priorities that draw tenants to green building.[j] Continuing research is especially important in the green building field, as rapid technology improvements can render relatively new upgrades obsolete while making cutting-edge new technologies cost-effective. Such information can lead building managers, architects, and engineers to adopt environmentally-friendly technologies without extra incentives.

Detailed research and analysis of the potential for green retrofitting in existing residential high-rise buildings suggests that green retrofitting is both feasible and practical, and Battery Park City Authority has resources at its disposal to foster the growth of green retrofitting in the neighborhood. Ultimately, green retrofitting in Battery Park City is imperative to achieve urban sustainability and strengthen the BPCA's role in environmental leadership in New York and the world.

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Appendices

A. Green Retrofitting Building Model – The Gateway Complex

B. Retrofit Analysis: Energy Efficiency

C. Sample Operations and Maintenance Plan

D. Case Study: Public Education in El Paso, Texas

E. Recommendations for Future Research

F. The Green Matrix

G. GREEN Team Members

APPENDIX A: Green Retrofitting Building Model
The Gateway Complex

The Gateway Complex in Battery Park City was selected to serve as an example of a typical residential building within BPC with the capacity to undergo green retrofitting. The following profile of the Gateway Complex was compiled from Gateway management input, utility data, and an on-site tour. The Gateway profile was then used to identify the most relevant areas of concern for green retrofitting opportunities and to develop cost-benefit recommendations outlined previously in this report.

The Plaza 400 Building, Battery Park City, NY

The Gateway Complex is a series of six buildings consisting of three low-rise buildings; two at seven stories and one at 6 stories, as well as three high-rise buildings at 34 stories each. They were the first residential buildings to be completed on the BPCA site. The construction was completed in 1982 and the buildings were fully occupied by 1983.

The building structure is composed of honeycomb concrete. Drywall separates rooms within apartments, and exterior walls consist of concrete and gray aluminum sheeting.

Types of Apartments within Gateway

Type of Unit	# of Units at Gateway	Sq. Ft.	Comments
Studios	334	425-475	Primarily ~425 Sq. Ft.,
1 Bedroom	992	764-825	Primarily 764-775 Sq. Ft., (3 or 3.5 total rooms)
2 Bedroom	292	1,180	(5 or 5.5 total rooms)
3 Bedroom	44	1,200	(5+ rooms)
TOTAL	1,662		

Figure 1

Energy

Energy consumption in Gateway is directly linked to the appliance models used within each apartment as well as lighting and insulation. Appliances are usually replaced when a tenant moves out, but only if needed. Common appliances used in Gateway apartments include:

In-Unit Heating/Cooling Systems

Unit heating and cooling is done by in-room systems of 9,000 BTU in bedrooms and 12,000 in living rooms. All are made by GE and were placed after 2001. The filters are washable, and do not have to be replaced. They are models AZ25E12D(2/3/5)BM1 and AZ22E09D(2/3/5)BM2. There was roughly one H/C unit per window in observed apartments.

Heating/Cooling System

Lighting

Common light bulbs are fluorescent Sylvania cool white, 20 Watts, 24-inch tubes. Incandescent lights are commercial-grade, extended-life 50 Watt; 5,000 hours of life. Tenants are responsible for changing their own light bulbs.

Refrigerators

The current refrigerators are the 18 cu. ft. model MG79412 made by GE. All of these were replaced after 2001.

Microwave & Dishwasher

Dishwashers

GE model GSD4200JCC.

Microwaves

GE Spacemaker.

Stoves

Gas GE Profile model number JGB20BEHCT

Washers

Each of the 3 high rise buildings has 16 washers and 16 dryers. Each of the 3 low-rise building has 3-4 washers and 4 dryers. Information on the specific models in use was not available.

Windows
Windows are single-paned and held in an aluminum frame. There is at least one window in each unit that may be slid open vertically.

Indoor Environmental Quality

All apartments are ventilated through rooftop exhaust vents; the 30-inch belt-driven model 4HX88A. However, all heating and cooling is done through the in-unit mechanisms mentioned earlier. Each apartment has two; roughly 12x12 inch filter traps that can be cleaned by pulling them out of the unit and physically removing any pollutants.

Small forced-air HVAC systems, Acorn products, are used to heat and cool building corridors. Observed ducts do not appear to have external or internal insulation (see photo below).

HVAC SYSTEM

All apartments are subject to repainting with conventional paints once a tenant moves out. A tenant may also request that their apartment be repainted every third year of occupancy.

Current Building Materials

Common Areas

During an on-site tour, a floor-by-floor installation of new carpet and wallpaper within the hallways and common spaces was taking place. There was no specification as to whether these materials environmentally safe or how the old materials were being disposed of; within the normal waste stream or recycled.

Maintenance Activities

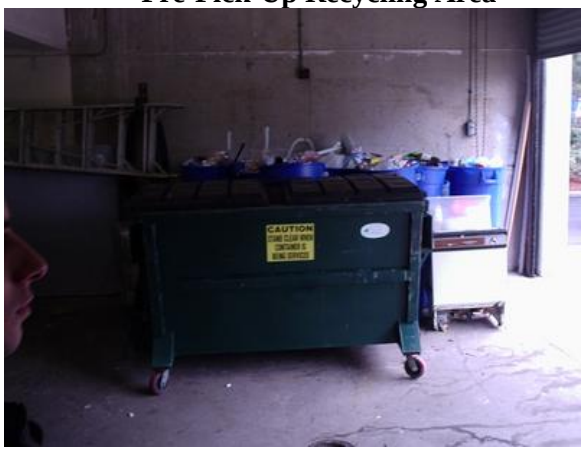
Neither asbestos nor lead-based materials are used in the Gateway Complex.

Recycling

The complex complies with NYC laws for recycling, however, upon inspection, it appears that the facility has less than adequate facilities for disposal of recycling materials on each floor (only one bin is available). All tenant-generated trash is deposited in a chute where it is compacted and then removed from loading docks on the ground floor.

Floor Recycling Area

Pre-Pick-Up Recycling Area



Apartment Decor

Kitchens generally have plastic (Formica) counters, pressed-wood cabinetry and linoleum-like floors. The bathrooms have tile flooring and the remaining floor space is covered by a wood parquet floor over concrete. Wood floors have an oil-based finish, as compared to a water-based finish. Painted wood trim runs along walls. Venetian blinds installed on observed windows. Although these are standard furnishings, some apartments have been retrofitted with different materials. Recently, a three-bedroom unit was refurbished with new materials, including granite counter tops, tile flooring in the kitchen and bathroom, wood cabinetry, as well as more advanced appliances.

Wood Flooring

Operations and Maintenance

Gateway employs a full porter staff (including full-time and part-time employees) that cleans hallways, lobby, and other common areas. A short list of products that are currently in use for the cleaning and other maintenance activities is as follows:

Cleaning Products	
Purpose	**Product currently in use**
Drain/loading dock area cleaner	National Waste-Away (with live bacteria)
Rug Shampoo	Legends Champion
Silicone	True Value brand
Floor Stripper	Pro-link brand; bottom line non-ammoniated
Hallway Cleaner	Pine Scrub Soap
Paint	Paint with VOCs
Wallpaper	Wallpaper used only in hallways. After 9/11 the wallpaper was cleaned but not replaced
Hardwood Floor Finish	Oil-based

Figure 2

After units are vacated, they undergo scheduled maintenance to repaint walls, repair appliances, wiring and sockets, and sand worn flooring. Exterior maintenance of the buildings occurs monthly. Also, landscaping is performed by an outside contractor with water provided by a built-in sprinkler irrigation system. Similarly, there is an indoor pool attached to the 400 Plaza Building maintained by an outside contractor.

There are extensive bike rooms in the 200, 400, and 600 Buildings (the high-rises), but they are unorganized which may make it difficult for tenants to utilize them.

Each apartment is metered for its electricity and gas use, which is then paid directly to the Gateway management in lieu of separate utility bills paid to the utility company.

Water

Water used within the building is directly drawn from New York City's water supply. The shower heads and toilets in Gateway are both conventional products without water-saving mechanisms. The domestic hot water is supplied by two boilers on the top floor; Bryan Flexible Tube boilers, Model number CL-150WT. They were installed in 1981 and use 1.5 million BTU normally, with a minimum BTU requirement of 750,000. There is also a fire protection sprinkler system in the commercial areas such as the loading dock and garage, but none in the residences.

Sink

Toilet

Building Plumbing Fixtures

	Studio	1 bedroom	2 bedroom	3 bedroom	High Rise	Low Rise	TOTAL
Faucets	3	3	4	4	-	-	5332
Shower heads	1	1	2	2	-	-	1998
Toilets	1	1	2	2	-	-	1998
Dishwasher	1	1	1	1	-	-	1662
Washers/Dryers	0	0	0	0	16	4	20

Figure 3

Source: Mr. Jim Heller, The Gateway Complex (2005)

General Impressions

The Gateway Complex's appearance from the outside is somewhat misleading. The exterior is not particularly striking in comparison to the number of well-designed residential buildings in the northern section of Battery Park City such as Solaire. However, Gateway buildings house spacious apartments that are continually updated newer appliances, better quality materials, and flooring. This updating process however, does not focus on green practices or employ green technologies or products. Since many of the improvements occur as tenants vacate apartments, a greening process would probably be most feasible on an apartment-by-apartment basis. The demand for Gateway rentals appears to be consistent and significant, which does not encourage the owner to adopt green retrofitting measures. However, as indicated in the cost-benefit analysis of green retrofitting, investing in green practices and technologies is feasible for existing buildings like the Gateway and results in numerous environmental and human health benefits.

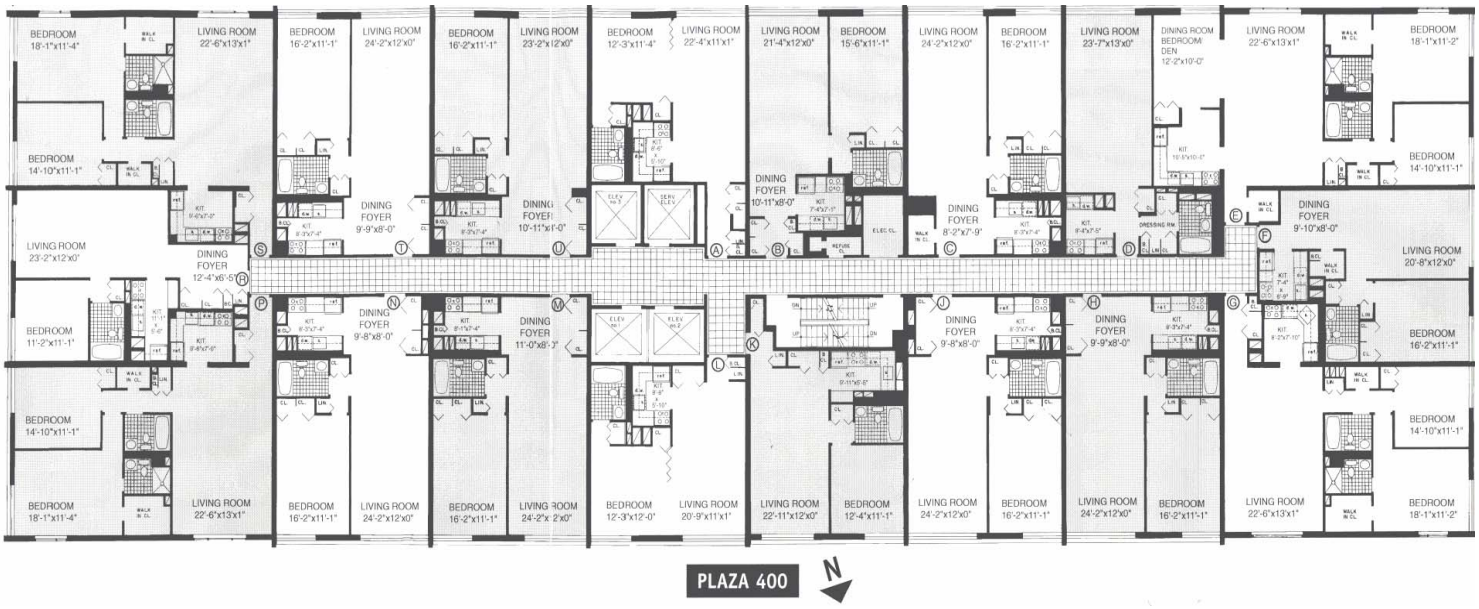


Figure 4
Source: Gateway Complex Brochure (2005)

The typical floor plan for the 34-story, Plaza 400 high-rise building at the Gateway Complex.

Typical Room Schematics
Gateway Complex – 400 Building – 34 story high-rise

Studio Apartment

Figure 5
Source: Gateway Complex Brochure (2005)

One-Bedroom

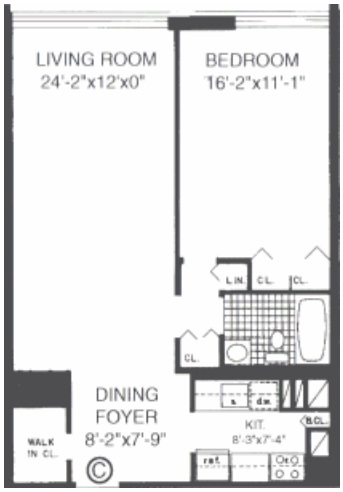


Figure 6
Source: Gateway Complex Brochure (2005)

Two-Bedroom

Figure 7
Source: Gateway Complex Brochure (2005)

Three-Bedroom

Figure 8
Source: Gateway Complex Brochure (2005)

APPENDIX B: Retrofit Analysis: Energy Efficiency

Performance of Retrofits for Central Steam Heating Systems

Measure	Average Energy Savings	Average Percent Savings[1]	Range of Savings	Average Cost	Average Payback (Range)	Sample Size
Improved boiler control and main line and radiator air venting, single-pipe steam	1,800 therms	10%	-14%-25%	$1,100	1.3 years median (0.4 to infinite)	13
Tune-up of atmospheric coal-to-gas conversion boiler	not available	4% heating gas use	3%-5%	$160	0.4 years (0.3-0.5)	4
Tune-up of atmospheric coal-to-gas conversion boiler	710 therms	6% heating gas use	0%-14%	$160	0.51 years median (0.2 to infinite)	6
Vent dampers on atmospheric brickset coal-to-gas conversion boiler and tank-type water heater(s)	770 therms	6%	1%-12%	$2,400	20 years (3.2-36.9)	2
Vent dampers on atmospheric brickset coal-to-gas conversion boiler only	1,400 therms	9%	6%-12%	$1,300	2 years (1.2-3.5)	4
Two-pipe steam-to-hot water conversion	3,900 therms	27%	16%-39%	$28,0001	12 years (5.5-27.3)	11
Single pipe steam to hot water conversion	4,400 therms	19%	13%-27%	$58,000	34 years (19.1-51.3)	4

Figure 1

Performance of Retrofits for Central Hydronic Heating Systems

Measure	Average Energy Savings	Average Percent Savings[1]	Range of Savings	Average Cost	Average Payback (Range)	Sample Size
Boiler water reset and cutout control versus constant temp and manual shutoff, ATM CI boiler	1,100 therms	18% heating gas use	10%-25%	$450	1.2 years (0.3-2.8)	4
Boiler water reset versus manual reset, ATM CI boiler	1,100 therms	10%	4%-16%	$250	0.5 years (0.2-1.0)	5
Boiler water reset and cutout control versus various preconditions, ATM CI boiler	1,200therms	9%	5%-18%	$630	5.1 years (0.2-24.3)	8
Distribution water reset versus constant temp, power SFT boiler	2,100 therms	9.5% heating gas use	5%-13%	$4,000	4.8years (2.3-8.1)	3
Electronic ignition and vent dampers on gas-designed CI ATM boiler(s) and tank-type water heater(s)	780 therms	6.5%	-1.5%-9%	$2,300	4.4 years median (4.0 to infinite)	4
Electronic ignition and vent dampers on gas-designed CI ATM boiler(s) only	210 therms	2%	1.6%-2.1%	$1,400	14.4 years (8.2-20.7)	2
Tune-up of coal to gas conversion boilers	220 therms	2%	1%-3%	$160 2.0 years	(1.1-4.1)	4 (1 PWR, 3 ATM)
Tune-up of gas-designed CI ATM boiler	78 therms	1% heating gas use	0.4%-3.0%	$120	(.09-infinate)	3
Energy cost allocation	1,500 therms	16%	9%-22%	$1,300	1.4 years (0.6-2.7)	9
Front end modular boiler	4,800 therms	8%	-3.7%-19%	$35,000	21 years median (6.7-infinite)	8

[1]Savings are given as percentage of whole-building gas use, except where noted.

Figure 2

Performance of Retrofits for Domestic Hot Water

Measure	Average Energy Savings	Average Percent Savings[1]	Range of Savings	Average Cost	Average Payback (Range)	Sample Size
Water heater with integral flue damper versus standard tank-type water heater	110 therms	5%	(4.1%-6.1%)	$560 (incremental)	10.6 years (9.0-12.2)	2
Condensing water heater versus standard tank-type water heater	240 therms	28%	(28.1%-28.3%)	$2400 (incremental)	19.9 years (19.5-20.3)	2
Demand-based control of tank and recirculation loop temperature versus constant aquastat control	1,500 therms	16%	(15.2%-17.1%)	$1400	1.9years (1.6-2.2)	3
Time-based control of tank and recirculation loop temperature versus constant aquastat control	980 therms	10%	(8.1%-12.9%)	$940	2.2 years (1.3-3.0)	3

[1]Savings are given as percentage of whole-building gas use, except where noted.

Figure 3

On-site Power Generation: Microturbines, Gas Turbines, & Fuel Cells

Application	Installed Costs $/kWh	Maintenance Costs $/kWh	Life Expectancy	Efficiency
Mircoturbine				
30 kw	1576	$.01-.01	10	23
70 kw	1713	$.01-.01	10	25
80 kw	1708	$.01-.01	10	24
1000 kw	2263	$.01-.01	10	26
Small Gas Turbine				
1 MW	1403	0.0096	20	22
5 MW	779	0.0059	20	27
10 MW	716	0.0055	20	29
25 MW	659	0.0049	20	34
Fuel Cell (type)				
200 kw (PAFC)	5,200	0.029	10	36
10 kw (PEMFC)	5,500	0.033	10	30
200 kw (PEMFC)	3,800	0.023	10	35
250 kw (MCFC)	5,000	0.043	10	43
20000 kw (MCFC)	3,250	0.033	10	46
1000 kw (SOFC)	3,620	0.024	10	45

Figure 4

Distributed Generation Emissions

Application	Nitrogen Oxide Emissions (lbs/MWh)	Carbon Monoxide Emissions (lbs/MWh)	Total Hydrocarbons (lbs/MWh)	Carbon Dioxide Emissions (lbs/MWh)
Microturbine				
30 kw	0.72	0.45	<.15	1535
70 kw	1.25	1.51	<.16	1650
80 kw	0.45	0.27	<.16	1585
1000 kw	0.5	1.38	<.18	1765
Small Gas Turbine				
1 MW	2.4	0.7	--	1825
5 MW	1.1	0.6	--	1475
10 MW	1.1	0.5	--	1375
25 MW	0.9	0.4	--	1080
Fuel Cell (type)			**VOCs (lbs/MWH)**	
200 kw (PAFC)	0.04	0.05	0.01	36
10 kw (PEMFC)	0.1	0.07	0.01	30
200 kw (MCFC)	0.1	0.07	0.01	35
250 kw (MCFC)	0.06	0.04	0.1	43
2000 kw (MCFC)	0.05	0.04	0.01	46
1000 kw (SOFC)	0.05	0.04	0.01	45

Figure 5

APPENDIX C: Sample Operations and Maintenance Plan

Setting Goals & Implementing an Operations and Maintenance Plan

The following is a simple methodology for regular operations and maintenance of residential buildings which may be used to improve both building efficiency and the quality of life of building occupants.

Short Term Goals: Daily

Routine maintenance operations performed by tenants:

- Clean unit air conditioning filters
- Turn off heating/cooling system when leaving unit (during the day)

Routine maintenance operations performed by management:

- Buy products in bulk and make them available at a nominal fee:
    - Energy efficient light bulbs
    - Low-flow showerheads
    - Low VOC paint
    - Faucet aerators
- Provide information about household appliances/ products, cleaning supplies, and renovation materials
- Renovate and maintain the building with green appliances and materials
- Develop robust building recycling program
- Replace cleaning supplies with green products for use in common areas

Mid Term Goals: 3-6 months

- Replace showerheads with low-flow equivalent
- Replace toilet tanks with low-flow system
- Replace carpeting as needed with low VOC carpets
- Repaint units with low VOC paint
- Refinish wood flooring with water-based finish
- Develop Owner–Manager–Tenant communication strategy
- Identify the best replacement model for HVAC and water boiler in anticipation of future replacement

Long Term Goals: 1-5 years

- Designate and facilitate a bike storage facility
- Replace HVAC unit with more efficient and most appropriately scaled model
- Establish annual building commissioning for benchmarking purposes
- Replace windows and window treatments with well-insulated and efficient models

APPENDIX D: Case Study – Public Education in El Paso, Texas

El Paso is the fifth largest city in Texas, with a unique and persistent need for stringent water conservation. The city has more than 700,000 residents and lies on the border of two nations and three states.[11] The city has a desert climate, receiving an average of 8.8 inches of rain annually, and has few sources of readily available potable water. By contrast, New York City receives an average of 47.25 inches of rain annually.[12] El Paso's primary source of water, freshwater aquifer Hueco Bolson, had lost 80% of its water supply by the early 1990s. In 1990, it was predicted that the remaining water would be consumed entirely by 2025.[13]

In an effort to stabilize the water level in the Hueco Bolson, the city employed a three-part strategy calling for increasing use of alternative water sources, including surface water and reclaimed water, as well as encouraging conservation through rates and rebates. An integral part of this strategy, still in effect today, is ongoing public education.

El Paso's educational programs are managed by the City's Water Conservation Education Department, an entity specifically developed to be an "informal science provider" and educator for all ages within the community and throughout area schools. The department educates the community of El Paso about water issues through school outreach programs, community events, festivals and presentations, essay and poster contests for Drinking Water Week, conservation kits, games, educational brochures and literature, videos and education kits, as well as comprehensive website with links to other resources. Within the community, the Water Conservation Education Department partners with other civic organizations, government agencies, environmental organizations as well as universities and museums. These aforementioned organizations and institutions aid with outreach and provide additional resources that contribute to the department's research and educational goals. Homeowners are also a target audience for education on the City's Water Conservation Ordinance which restricts landscape watering days and times, manages permitting for extended watering and limits car washing. The City also tries to incentivize homeowners by offering cash rebates for purchases of qualifying water-efficient products, including refrigerated air conditioning, water and energy efficient clothes washer, ultra low-flow toilet as well as turf rebate to discourage the water-intensive upkeep of grassy lawns.[14]

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[11] City of El Paso. "Discover El Paso Demographics." 2005. City of El Paso Texas. 30 March 2005. http://www.elpasotexas.gov/econdev/demographics.asp.
[12] NewYorkCityWeather.Com. "New York Weather." 2 April 2005. http://www.nycitytourist.com/new-york-weather.html.
[13] Tamez-Ogden, David. "Water: A growing Concern in The Border's Desert Communities." May 1996. Frontera NorteSur. 3 April 2005. http://www.nmsu.edu/~frontera/old_1996/may96/9may1096.html.
[14] El Paso Water Conservation Education Department. "Educational Programs." 2004. El Paso Water Utilities. 28 March 2005. http://www.epwu.org/conservation/education.html

The results of their efforts have been positive. In the past 15 years, despite a steady increase in population, Hueco Bolson pumping has declined gradually. The city's dependence on the aquifer declined from 60 percent of the total water consumption in 1989 to only 33 percent in 2002. As a result, new projections on Hueco Bolson's fate, accounting for reasonable assumptions of customer growth, water consumption and possible droughts, show that freshwater from the aquifer is expected to be available for 100 years or more.[15] El Paso also has a new image since the water education campaign began. The uniquely southwestern feel of the city is a result of numerous landscaping improvements to existing and new homes, which use less water by including native plant species, rocks and synthetic turf.

While public education has not been the only factor in the magnitude of water conservation, it has been a vital component. Education has helped the community understand the importance of water conservation, the City Ordinance, the City's Rebate Program, and how to take both collective and individual action to reduce water consumption.

*Photo and logo courtesy of El Paso Water Utilities

[15] Fitch Ratings. "Fitch Rates El Paso, Texas Water Sewer Rfdg Bonds 'AA.'" March 17, 2005. Press Release. 2 April 2005. http://biz.yahoo.com/bw/050317/175651_1.html.

APPENDIX E: Additional Recommendations for Future Research

Building management commitment to the continual improvement of building performance is a key component of successful green buildings. This may be achieved through regular research in new and upcoming technologies or practices that may be implemented on site. Below is a list of recommendations for future research. Many of the recommendations can be accomplished by partnering with related institutions in order to carry out the research; higher education (like local universities with green building and urban planning programs), state institutions (NYSERDA performs and sponsors related research), and green building institutions (like the USGBC) are several examples.

Energy

- Consider implementing a peak load management program the reduces amount of kWh used by signing a mandatory peak load reduction agreement with Con Edison. In so doing, residents and/or building managers can receive financial compensation for agreeing to reduce demand at peak load time.

- Consider a long-term contract with Con Edison Solutions for lower rates on "green" power for BPCA buildings (residential, municipal, and commercial).

- Investigate other city-wide ENERGY STAR® and demand-side management programs to determine how BPCA can promote or implement such energy conservation initiatives.

Track improvements in renewable power generation technology. As costs decrease, particularly in solar applications, it will be more feasible to adopt them. Tidal power is one example of a renewable energy technology that shows promise in New York.

Indoor Environmental Quality

- Perform comprehensive studies on cost savings from health benefits associated with IEQ improvements. One possible means of accomplishing this is to liaison with universities that have public health programs and engage in public health research.

- Create a comprehensive list of green cleaning companies in New York and negotiate to supply Battery Park city with those products for a lower price.

- Conduct marketing research on tenants of green buildings (and retrofitted green buildings when possible) and tenants of conventional buildings to determine differences in quality of life and priorities.

Materials and Resources

- Investigate "green" products thoroughly to ensure there are no negative environmental or health impacts.

Water

- Investigate the increased modularity of onsite gray and black water systems.

- Utilize policy incentives that can cover capital costs of improvements to water infrastructure.

Multi-Category Initiatives

- Investigate the possibility of installing meters to measure both water and electricity use in each residential unit (if not already in place).
    - Studies show that when a multi-residential building has one meter, the potential reduction is from 17%-39% but when each residential unit has access to real-time information on their own usage the potential for reductions can be 24%-47%.

- Conduct further research specifically on green technologies used in high-rise residential construction. Current studies and cost-benefit analyses focus almost exclusively on technologies sized for single-family homes.

- Collaborate with or sponsor further studies on synergistic pollution reductions and cost savings for technologies which overlap functional areas. For example, HVAC studies report energy saved from retrofits but do not discuss health benefits associated with improved indoor air quality.

- Request a detailed comparative study between cities with comprehensive green policies and incentives versus cities with minimal policies/incentives and cities with no policies/incentives.

APPENDIX F: The GREEN Matrix

The Green Matrix serves as a synthesis of this report's findings, displaying three recommendations per target area. The recommendations are rated by three categories – savings, investment costs, and environmental benefits. The contents of this table serve as a general guide to green retrofitting as applied to any typical building in Battery Park City.

The first category in the matrix is cost savings, measuring a recommendation's ability to bring a financial return on investment. To represent savings, a piggy bank symbol  *is displayed. One piggy bank represents minimum cost savings. Two represents a modest savings, while three represents a substantial cost savings – most likely to be achieved within the first few years after implementation.*

The second category represents anticipated investment costs. A cost symbol  *is used; one symbol represents a comparatively similar or slightly increased expenditure to in comparison to conventional technologies or practices. Two symbols represents a fair increase in the costs of implementation; additional sources of funds would be needed to implement recommendation. Three symbols represent a substantially more expenditure undertaking.*

Finally, the recommendations are compared over the multiple areas of green retrofitting, with an environmental symbol  *that represents a recommendation having a green attribute in that category. This allows for easy comparison of where a recommendation may fall under multiple target areas.*

GREEN Matrix – Part 1

	Green Recommendation	Savings	Cost Above Conventional	Conserves Energy	Contributes to IEQ	Uses Green Materials	Conserves Water	Behavioral (Operations)
Energy Efficiency	Change light bulbs to compact fluorescent varieties.	🐷🐷🐷	$	🌳				🌳
	LED Exit Signs (building-wide installment opportunity, not dependent on tenant cooperation)	🐷🐷🐷	$$	🌳				🌳
	Green power purchasing (no matter how much electricity is used, it will *all* come from green sources) -Currently only .05¢/kwh fixed 12-month premium-	🐷	$	🌳				
Water Efficiency	Fix leaks and encourage behaviorial reductions	🐷🐷🐷	$	🌳			🌳	🌳
	Reduce flow of sinks and showers	🐷🐷	$	🌳			🌳	🌳
	Reduce flow of toilets	🐷🐷	$	🌳			🌳	🌳
Indoor Environmental Quality (IEQ)	Install an Energy Recovery System/ Heat Recovery System	🐷🐷🐷	$$	🌳	🌳			
	Purchase Air Filters	🐷	$	🌳	🌳			
	Low-E Windows	🐷🐷	$$	🌳	🌳			

GREEN Matrix – Part 2

	Green Recommendation	Savings	Cost Above Conventional	Conserves Energy	Contributes to IEQ	Uses Green Materials	Conserves Water	Behavioral (Operations)
Alternative Materials and Conservation	Use of green adhesives, stains, coatings, and finishes		$					
	Use of low-VOC paint		$$					
	Use of green cleaning products		$					
Operations & Maintenance (O&M)	Perform a Building Commissioning to Produce a Performance Report and Enable Benchmarking		$					
	Create an Operations and Maintenance Building Plan, including a Communications Strategy		$					
	Buy bulk items and resell at a nominal price. For example: energy efficient light bulbs, faucet aerators, low VOC paint, air filters.		$					

APPENDIX G:

Battery Park City Authority
Green Building Consulting Group
Columbia University

Julie McLaughlin

Julie Anne McLaughlin brings Peace Corps experiences in Environmental Education from two years of service in Nicaragua. Julie's background is in environmental science with a BA from Bucknell University in Environmental Studies and English. She has field experience in Tropical Ecology and has also worked as a Congressional Intern on Capital Hill. More recently, she has done research and analysis on Environmental and Energy Markets.

Daniel Olson

Dan spent nearly two years working for SCA Environmental, Inc., an environmental consulting company that specialized in hazardous materials remediation; primarily in asbestos and lead abatement. As a Certified Site Surveillance Technician (CSST), Dan compiled site surveys, monitored abatement activities, and produced reports for numerous clients throughout southern California. Dan graduated from the University of Wisconsin - Madison, where he majored in International Relations and Environmental Studies.

Erik Alm

Erik has focused his career on research into green technologies and finding ways to incorporate them into the design of sustainable communities. Since his graduation from the University of Vermont with a degree in Environmental Studies in 1997, he managed a marketing department for an ecological engineering firm and then worked as a consultant recommending ecological water management strategies. Erik has also conducted research for Sustainable Chicago, a Midwest advocacy group, and he worked with the USGBC-Chicago Chapter.

Irene Boland

Irene brings experiences in green building from participating in the Department of Energy's 2002 Solar Decathlon. She is a trained mediator and facilitator with experience in conflict resolution in urban communities. Irene brings communications experiences from Portland Oregon's regional planning government, Metro, and education experiences from the Chesapeake Bay Foundation. Irene graduated from the University of Virginia's School of Architecture with a Bachelor's of Urban and Environmental Planning and has worked in both carpentry and xeriscaping.

Vanessa Cobb

Vanessa has two years experience conducting market research primarily in the engineering & construction industry, followed by three years experience analyzing consumer purchase dynamics and developing sales and marketing strategies for a major beverage company in Houston, Texas. She recently conducted primary research identifying and comparing LEED certified building projects nation-wide for a Houston real-estate development company. Vanessa is particularly interested in energy efficiency and renewable energy technologies. She graduated from Rice University in 1999 with B.A. degrees in Policy Studies & Spanish.

Eileen Eaton

Eileen recently graduated from the University of Massachusetts at Amherst with a B.S. in Environmental Science and a minor in Resource Economics. Her honors thesis is entitled, The Political Controversies Surrounding the Use of Benefit-Cost Analysis in Environmental Regulations. Eileen gained experience at the Environmental Protection Agency developing Environmental Management Systems (EMS)in public schools. She strongly supports using incentive-based policies to effectively alter industry behavior and improve environmental quality.

Meghan Newcomber

Meghan Newcomer comes from a science and policy background. She has written reports for New Zealand's Department of Conservation on preserving Brown Teal, a threatened species. Meghan understands the importance of involving critical stakeholders in environmental policy making processes in order to achieve feasibly and effective outcomes. Meghan graduated from Mary Washington College with a Bachelors in Political Science and Biology.

Joanna Pajkowska

Joanna has four years of experience in Finance and a strong interest in expanding to Corporate Social Responsibility. Her career ambitions aim to improve corporate environmental and social actions and reporting in light of their economic growth.

Yonathan Perl

Coming from a profit oriented sector, Yonathan Perl has gained his experience working in the Hospitality industry in both Switzerland and the U.S. In former roles, he combined allocation and development of resources and men power while adhering to strict policies and budget constraints for the Human Resources department of the Israeli Defense Force. As a native of a developing country, he understands the importance of creating a better living environment in order to improve life quality at private levels. Yonathan graduated from Washington State University in 2004 with a Bachelors of Hospitality Business Management.

Lara Wallentine

Lara brings her experience as an Environmental & Diversity Corporate Communications Manager. She has expertise in Media relations, Public Affairs, SRI Investor Relations, Event Planning, Teaching, Print and Broadcast Media Reporting, and Philanthropic Leadership. Lara graduated from University of North Texas, Cum Laude, with a BA in Environmental Journalism.

Adam Zeller

Before coming to Columbia, Adam Zeller designed public outreach and educational programs for Helen Neuhaus and Associates of New York City and Earth Day Coalition of Cleveland, Ohio. In the former role he assembled public hearings and informational meetings on New York City and State environmental and transportation projects, including National Environmental Policy Act-mandated public participation requirements. In the latter he worked with U.S. Environmental Protection Agency to organize a series of conferences on citizen involvement in federal air pollution permitting programs. Adam graduated from Baldwin-Wallace College in 2000 with a Bachelors degree in English and Sociology.