Energy Management in New York City Public Housing

Columbia University for the
New York City Housing Authority

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A Report by Students of the Columbia University
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EXECUTIVE SUMMARY

Already a leader in energy management,

the New York City Housing Authority is embarking on a new era of conservation. Managers and residents alike realize that using less energy is not only an important environmental objective, but also is vital to ensuring the longevity and fiscal health of the City's public housing system.

New York City's plan to preserve and modernize its public housing stock will depend on superior energy performance. Over the past five years, growth in energy prices has exerted significant pressure on the already strained operating budgets of the New York City Housing Authority (NYCHA). In 2008 alone, NYCHA earmarked $530 million for utility expenses, which was nearly twice the amount spent in 2002. To grapple with the rising costs of operating and maintaining its aging housing stock, amid cuts in federal and state funding, NYCHA has embraced energy management to improve its bottom line.

The New York City Housing Authority will also play a pivotal role in the City's quest to reduce greenhouse gas emissions by 30 percent over the next decade. NYCHA's 2,636 buildings represent over 8 percent of New York City's housing stock and they are home to 400,000 residents, which is roughly the population of Miami, Florida. With so many buildings and occupants, NYCHA sizably contributes to New York City's municipal greenhouse gas emissions. By pioneering energy retrofit technologies and implementing them at a large scale, the New York City Housing Authority will pave the way for greenhouse gas mitigation measures in existing buildings throughout the city.

To assist the New York City Housing Authority in meeting these goals, students from Columbia University's Environmental Science and Policy Program have examined research and best practices from a variety of sources, including other public housing authorities, private building managers, military bases, and academic campuses. This research focused not only on the energy saving potential and costs of different strategies, but also on the feasibility of implementation in New York City's public housing.

The report examines four important aspects of an energy conservation program: technology, finance, management, and tenant participation. After discussing these topics in individual chapters, the report concludes with a series of integrated recommendations. Throughout the report, descriptions of exemplary energy management initiatives from around the world are provided in blue text on the side margins.

In the **Technology Chapter**, the report outlines a three step framework for improving energy management in existing buildings:

Step 1: Minimize energy losses through the building envelope.

Step 2: Maximize the energy efficiency of building systems.

Step 3: Employ renewable energy and regenerative technologies.

This framework is designed to help facility managers capitalize on low cost, near-term savings opportunities while maximizing returns on longer-term investments.

The **Finance Chapter** describes innovative strategies for overcoming the high upfront costs of certain energy technologies. Included is a feasibility study that explores the replacement of air conditioning units at NYCHA. By replicating innovative financing and procurement strategies undertaken in the past, NYCHA can upgrade air conditioners throughout its portfolio while using available technology to ensure that overall energy consumption is substantially reduced.

The **Management Chapter** explores two important conservation objectives: 1) integrating energy performance into existing maintenance and operations procedures, and 2) enhancing project management capacity. The importance of engaging residents is then addressed in the **Participation Chapter**, with a focus on opportunities to promote awareness, offer incentives, and empower residents.

The New York City Housing Authority is well on its way to becoming a national leader in conducting energy management of large-scale existing building sites. This report seeks to guide NYCHA along that pathway.

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INTRODUCTION

"Like the climate, NYCHA is facing a crisis. By reducing spending on energy, NYCHA can help save both the environment, through reduced emission of greenhouse gasses, and public housing, by improving NYCHA's financial strength."

Felix Lam, Chief Financial Officer
New York City Housing Authority

The New York City Housing Authority has recognized the importance of energy management for well over a decade. NYCHA's commitment is evident in its careful approach to design, implementation, operations and monitoring of energy saving technologies. Examples of past innovations include NYCHA's refrigerator replacement program and the creation of its Computerized Heating Automation System. In both cases, NYCHA pioneered its own customized solutions because the marketplace did not provide a product that met performance requirements. NYCHA has also fostered a well-trained staff that follows detailed standard operating procedures for energy management.

The rising costs of energy and maintenance expenses in recent years and diminished levels of government subsidization have led NYCHA to incorporate energy efficiency goals into operations and capital planning. In 2008, NYCHA began to implement a multi-phase energy performance contracting program with the support of the U.S. Department of Housing and Urban Development (see the background section for details). This report's recommendations focus on strategies that can be implemented in future phases of the energy performance contracting process.

At the same time, the threat of climate change and the need to mitigate greenhouse gas emissions has sparked interest in reducing NYCHA's carbon footprint. According to former NYCHA Chairman Tino Hernandez, "Many of our early concerns for energy efficiency have now become part of the national discourse. We must continue to change the culture at NYCHA to combat the growing problem of global warming" (Hernandez 2004).

This report surveys energy saving initiatives that are employed at large scale building sites in the United States and around the world. Its goal is to offer the New York City Housing Authority recommendations that can be implemented throughout its housing portfolio and management process.

The report begins by providing background on the evolution of the New York City Housing Authority and its energy management programs. It then focuses on four important aspects of an energy conservation program: technology; financing; management; and participation.

The Technology Chapter outlines a three step framework for improving energy management in existing buildings:

Step 1: Minimize energy losses through the building envelope.

Step 2: Maximize the energy efficiency of building systems.

Step 3: Employ renewable energy and regenerative technologies.

This framework can help housing facility managers capitalize on low cost, near-term savings opportunities while maximizing returns on longer-term investments.

The Finance chapter focuses on creative approaches to minimize or eliminate the upfront costs for energy technologies. Techniques include the use of energy performance contracting, which utilizes predicted savings from energy saving technologies to pay for upfront costs; partnerships with energy services companies; and the use of power purchasing agreements for renewable energy. A feasibility study explores the possible replacement of air conditioning units throughout NYCHA's portfolio; it recommends the use of performance specifications and available technology to ensure that overall energy demand is substantially reduced.

The management chapter explores how NYCHA can enhance maintenance and operations of its housing stock, while streamlining and broadening the adoption of new technologies. A final chapter discusses tenant participation and recommends strategies for enhancing energy awareness, promoting incentives, and empowering residents to participate in energy conservation campaigns.

BACKGROUND

The nation's first public housing authority,

NYCHA was established on January 20, 1934 by Mayor Fiorello H. La Guardia in response to the work of journalists like Jacob Riis who exposed the ghastly tenement living conditions of impoverished New Yorkers. The first public housing complex, First Houses, consisted of 123 apartments and was opened on December 3, 1935 (Hernandez 2004). The monumental occasion was marked by a ribbon-cutting ceremony where First Lady Eleanor Roosevelt had the honor of officially opening the new developments (Amateau 2006). Over 11,000 citizens applied for housing in those first 123 apartments.

Passage of the United States Housing Act in 1937 established a federally aided housing program, which fueled the first wave of public housing development in New York City. The U.S. Housing Act of 1949 expanded efforts by empowering public housing authorities to clear slums and develop public housing through the use of eminent domain. The majority of public housing that exists today was built in the two decades following the 1949 legislation.

Federal support for public housing shifted course in the early 1970's, culminating in the U.S. Housing and Community Development Act of 1974. Section 8 of this act created a voucher program that was intended to provide low-income Americans with a housing subsidy that would cover the difference between market rate rents and their ability to pay for housing. This change in how funding was allocated placed increasing emphasis on private sector construction of housing, and essentially ended government construction of housing sites, which was the dominant method of affordable housing production for the previous three decades. Public housing authorities were still responsible for operating and maintaining their existing housing sites, but they were forced to do so with a diminished level of federal subsidy as a percentage of total funding. Over the next two decades, this diminished funding for public housing sites led to under-investment in capital projects, rehabilitation, and other crucial upkeep. As a result, the nation's public housing stock fell into severe disrepair.

In 1992, the U.S. Congress authorized the HOPE VI program, which implemented the recommendations by the National Commission on Severely Distressed Public Housing (HUD 2009). HOPE VI called for the demolition of distressed public housing and the de-concentration of urban poverty at housing sites. In exchange, it provided federal funding to private partnerships to oversee the redevelopment of demolished sites with less dense, mixed income housing and commercial development. Many public housing authorities in the United States have acceded to the federal government's offer of redevelopment funding, and have begun demolishing their public housing sites. New York City, on the other hand, has not pursued redevelopment because its housing stock was relatively well maintained and in great demand. In fact, the waiting list for public housing contains nearly 132,000 families (NYC.gov 2008).

Funding crisis at NYCHA

Since 1996, the State of New York has not contributed to the operating subsidies of the New York City Housing Authority, even though NYCHA manages sixteen housing complexes that were constructed by the State. To make matters worse, diminished congressional appropriations have cost the New York City Housing Authority $611 million in federal operating subsidies since 2001. This chronic underfunding created a financial crisis for the New York City Housing Authority at the start of this decade, which threatened its long-term mission of providing affordable housing (NYCHA 2009).

In March of 2005, New York City Mayor Michael Bloomberg announced a $2 billion plan to modernize and preserve the City's public housing stock. The following spring, the New York City Housing Authority released its Plan to Preserve Public Housing (NYCHA 2006), which outlined a series of operational changes and capital investments to improve the Authority's financial standing and modernize its housing stock. Promoting energy conservation and efficiency was a key objective.

NYCHA's Housing Stock

Like most public housing authorities in the United States, the New York City Housing Authority has had little opportunity to construct new housing since the early 1970's. In fact, the LEED certifiable building that is currently under construction at the Randolph Houses in Harlem is NYCHA's first newly constructed housing building in over three decades (Redhead 2009). Today, over 63 percent of NYCHA's housing stock is more than 40 years old while nearly all of it is more than 30 years old (NYC.gov 2008) (Katz 2009).

New York City Housing Authority's 2,636 buildings and 343 developments are architecturally varied according to their construction date, urban context, and site density. Generally the housing can be grouped into three types:

- Linear barracks – parallel rows of buildings with relatively flat facades, typically under six stories.
- Centroidal clusters – cross plan variations of up to ten stories with building wings radiating from a central core of circulation, typically in T, L, or X letter shapes or some other permutation.
- High rises – rectangular footprints extruded to between seven and fifteen stories.

Photo 2: The First Houses (1935) in Manhattan -- an example of linear barrack housing.

Photo 1: Williamsburg Houses (1938) in Brooklyn -- an example of the centroidal cluster housing type arranged diagonally on a superblock.

Since the construction of the Williamsburg Houses by the Public Works Administration in 1938, the majority of public housing in New York City was built on superblocks, or larger plots of land formed by the aggregation of several city blocks and the removal of cross streets (Plunz 1990). Another common feature that originated in the Williamsburg Houses is the diagonal alignment of buildings to the street geometry; in some cases this is done to optimize solar gain (Plunz 1990).

After World War II, public housing authorities sought constructional efficiencies to lower their costs and expand housing production. In New York City, this led to the proliferation of high rise housing towers, which took up a smaller percentage of the building site, thus reducing site development costs while maintaining the cost per square foot of construction (Plunz 1990).

In the 1950's almost all of the public housing built in New York City were high-rises with under 20 percent land coverage (Plunz 1990). This constructional method became known as the "tower in the park," and was bolstered by modernist and reformist concerns for bringing 'nature' back into the city. Although this form of urbanism has proven controversial, it nonetheless makes up a large majority of New York City's housing stock.

Nearly all of New York City's public housing was built using concrete columns and slab construction. Facades are made up of brick and cinderblock cavity walls with periodic window penetrations that tend to be undersized compared to other construction of the period. Building facades, floors and ceilings are typically un-insulated, with the underside of the concrete slabs left as unfinished ceilings (Plunz 1990).

Most of NYCHA's housing sites use steam heat provided by boilers and do not have mechanical ventilation systems. Wall mounted air conditioning units are purchased and maintained by individual tenants. Natural ventilation varies by site, though generally the buildings with irregular site plans experience more cross ventilation compared to those with rectangular plans (Plunz 1990). New York City's public housing sites tend to be simple in architectural detail with building finishes and fixtures that are chosen for long-term durability (Plunz 1990).

Photo 3: James A. Bland Houses (1952) in Flushing, Queens – An example of high rise, "tower in the park" housing.

Energy Conservation in New York State

Since the late 1970's, New York State has led in the adoption of energy efficiency standards through its state building code. In 1979, the state unveiled the Energy Conservation Construction Code, which it then expanded in 1989 to include residential buildings. The energy code was rewritten in 1992 and then in 1999, the state adopted its own version of the International Energy Conservation Code. Finally, in 2001, New York Governor George Pataki signed Executive Order 111, which mandated that state buildings reduce energy 35 percent by 2010.

Energy Innovation at NYCHA

In the mid 1990's, the New York City Housing Authority began an energy efficiency retrofit program across all of their apartment complexes, which included heating plant fuel-type conversions, installation of 1.2 million energy efficient windows, and repair of bricks, facades and roofs to ensure air tightness.

In 1996, the New York City Housing Authority partnered with the Natural Resources Defense Council and the New York Power Authority to replace over 180,000 refrigerators with high-efficiency models (Business Wire 2002). A performance specification was created for the new units that called for the elimination of ozone-depleting chlorofluorocarbons, a 20 percent increase in energy efficiency from federal energy standards, and adherence to the Housing Authority's space and durability requirements (U.S. DOE 2004). Prior to this endeavor, none of the energy efficient refrigerators on the market would fit inside small urban apartments. The New York Power Authority worked with 23 other utilities to convince manufacturers of the market potential for the super-efficient apartment-sized refrigerators, which would became the most efficient models on the market. The New York Power Authority also financed the purchase and installation of the new refrigerators, recovering its costs through the savings generated as a result of the replacements. The refrigerator replacement program saved $5.5 million in energy annually and abated 67,000 tons of greenhouse gas emissions.

In 2001, the New York City Housing Authority brought online its first building management system—known as Decision Support for Operations and Maintenance—at the Governor Smith Housing Project. Developed by the U.S. Department of Energy's Pacific Northwest National Laboratory, the system was designed to reduce inefficiencies in the complex's steam-based boiler. An audit in 2005 revealed that annual savings exceeded $275,000 and the system enabled a 19 percent efficiency improvement compared to a baseline year. The system became the model for the Housing Authority's widely implemented Computerized Heating Automation System, which provides remote monitoring and management of NYCHA's 210 large central heating plants. The system tracks boiler and zone-valve operational data, identifies problems, and enables optimization of energy use and emissions reduction.

Strategic Planning for Energy

In 2008, the New York City Housing Authority earmarked $531 million of its $2.8 billion operating budget (19 percent) to utility costs (NYCHA 2008). This level of spending was nearly twice as much as the Housing Authority spent in 2002 ($268 million), despite the fact that the same amount of energy was used in both years (21 million MMBTUs). The cause of this cost increase was the steep rise in oil prices that occurred over this six year period—from $20 per barrel to $145 per barrel. As mentioned previously, the Housing Authority lost over $600 million in federal funding due to inadequate congressional appropriations during the same time period. Taken together, the Housing Authority's rising energy costs and falling federal subsidies pose a serious strain on its operating budget.

The Housing Authority also faces rising costs in maintaining its aging housing stock and infrastructure, and diminishing capital subsidies to undertake necessary replacements. Meanwhile, the Housing Authority has committed to reduce its greenhouse gas emissions to help New York City reach its goal of a 30 percent reduction by 2017 (PlaNYC 2009).

According to the Housing Authority, these "urgent physical conditions and fiscal circumstances require NYCHA to raise its energy management agenda to a broad, strategic level."

The recent economic recession has resulted in a drastic deflation in the price of oil, rendering future utility costs uncertain. While this period of dampened global demand and lower utility costs will create temporary relief for NYCHA's operating budget, it is only a matter of time before the cost of oil approaches pre-recession levels. Uncertainty about future energy costs adds complexity to investment decisions, but it also brings an element of urgency. Undertaking strategic investments now will allow the New York City Housing Authority to realize much needed savings in future years, when operating budgets are likely to once again be strained by high fuel costs and increasing maintenance needs.

Green Building Innovation in New York City

New York City has also led in green building innovation and energy efficiency. The 1999 establishment of the Office of Sustainable Design and the publication of the High Performance Building Guidelines kicked off a decade of innovation in which more than 60 public projects were built that incorporated sustainable design practices. In 2005, the City Council passed Local Law 86, which requires half of the City's municipal buildings to achieve 20 percent energy and water savings as well as certification under the U.S. Green Building Council's LEED rating system.

In 2007, Mayor Michael Bloomberg initiated a citywide sustainability plan, known as PlaNYC, which outlined 127 initiatives for improving energy efficiency, environmental health and quality of life while accommodating one million new residents over the next 25 years. Collectively the initiatives were designed to address the City's "greatest challenge," climate change (Bloomberg 2007). Two PlaNYC initiatives are of primary relevance to the New York City Housing Authority: 1) Preserving New York City's existing affordable housing stock; and 2) Reducing municipal energy consumption by 30 percent in the next ten years.

NYCHA's Multi-Phase Energy Performance Contracting Program

In April of 2008, the New York City Housing Authority submitted its preliminary plan for a multi-phase energy performance contracting program to the U.S. Department of Housing and Urban Development.

Under the innovative financing mechanism of a performance contracting program, the New York City Housing Authority will be able to achieve significant energy savings with no up front capital costs. This will be made possible through contracting with an energy services company that is willing to bear the initial costs of installing the equipment in exchange for reimbursement using future savings from reduced energy consumption (U.S. HUD).

Phase one of the performance contracting program will generate an estimated $62.5 million in annual savings that can be invested to undertake subsequent phases of the contract. During phase one, the New York Power Authority's Energy Services Division will serve as a construction manager.

The Clinton Climate Initiative is providing technical assistance in the preparation of the energy performance contract proposal. The organization will also provide NYCHA with access to its network of technical experts, its purchasing consortium, its partner financial institutions, energy services companies and technology vendors. This collaboration will enable the New York City Housing Authority to lower its total program costs, minimize risk, and expedite project implementation. NYCHA has already begun implementing phase one of the contracting program and is conducting additional planning for latter phases. The recommendations in this report focus on opportunities that can be implemented in future phases of the energy performance contracting process.

See the next page for details about the first phase of NYCHA's multi-phase energy performance contracting program.

Phase 1 of NYCHA's Energy Performance Contracting Program

Instantaneous Hot Water Heaters

NYCHA is in the process of replacing existing hot water systems with energy efficient instantaneous water heaters that heat water on demand rather than storing it. This modification reduces pressure saves significant amounts of fuel.

Apartment and Common Area Lighting Upgrades

NYCHA is replacing existing lighting systems in both apartments and common areas. By replacing an average of six light bulbs per apartment with compact fluorescent bulbs and upgrading common area lighting with high efficiency lamps and ballasts NYCHA stands to reduce energy consumption by 15 percent overall. Since 2007, over 150,000 compact florescent light bulbs were installed in approximately 26,000 NYCHA apartments.

Boiler Replacements

Thirty-nine central heating plants in thirty two developments are scheduled for rehabilitation. High efficiency boilers will be installed and will be networked to apartment temperature sensors and to the Computerized Heating Automation System, which provides remote monitoring and management of 210 large central heating plants. The Computerized Heating Automation System reports boiler and zone-valve operational data, identifies problems, and enables ongoing optimization to minimize energy costs and carbon emissions.

Additional measures:

- Elevator replacements
- Housing Authority Remote Monitoring Service for Elevators
- Planting of over 10,700 trees
- Energy Efficiency Master Plans for select housing sites

TECHNOLOGY

In an environment of competing opportunities

a public housing authority requires a systematic approach to implementing energy efficiency projects. This chapter describes a process whereby housing authorities can capitalize on low cost, near term savings opportunities while achieving the most attractive pay-back periods for longer-term investments.

The chapter describes a three step framework for optimizing energy performance in public housing:

- Reduce energy losses through the building fabric
- Ensure efficient use of fossil fuels
- Employ renewable energy technologies

The London-based Association for the Conservation of Energy developed this framework and social housing authorities throughout the European Union have used it to retrofit multi-family subsidized housing (Guertler and Smith 2006). In cold climate countries like Poland—which have similar climates and annual heating demand as New York City—it is estimated that this approach can generate energy savings of up to 70 percent for individual buildings (Guertler and Smith 2006). Widely implementing these strategies in the multifamily housing sectors of cold climate countries can lead to a 34 percent energy reduction (Guertler and Smith 2006).

According to this framework, facility managers seeking to improve energy performance should begin with an energy audit and weatherization activities to seal the building envelope. Reducing unwanted air exchange with the outside will lead to savings on heating energy during the winter and cooling energy during the summer. After weatherizing the building envelope to prevent energy loss, facility managers should increase the energy efficiency of building systems such as elevators, lighting, and air conditioning. Once building systems are operating optimally, facility managers are in a position to maximize returns on investments in renewable energy generation.

Step 1: Minimize Energy Losses

Minimizing energy losses through the building envelope should be the front guard of any conservation campaign.

According to the New York City Energy Conservation Steering Committee, savings in space heating and cooling represent over 40 percent of total potential savings from the City's greenhouse gas reduction program (NYC Energy Conservation Steering Committee 2008).

While some of these savings can be achieved through retrofitting or replacing heating and cooling systems, an even larger portion of the savings can be achieved through efforts to minimize energy loss through building envelopes. This process is known as weatherization.

Energy Audits

Conducting an energy audit is an inexpensive, yet essential prerequisite for weatherization. A blower door test is a common auditing technique that evaluates the air-tightness of an apartment. A powerful fan and a pressure gauge are mounted to a doorframe in a sealed room. When the fan is turned on, the air is evacuated from the room, creating a pressure differential that draws in outside air through cracks in the façade. By adjusting the fan speed to achieve a constant pressure differential, the technician performing the audit is able to calculate the rate of air leakage (Shelter Technology 2009). Identifying the source of leaks is typically done by sense of touch or by using a spray bottle to release a fine particle mist.

Blower door tests are frequently used in combination with an inexpensive visualization technique known as thermographic scanning. By pointing a thermographic scanner towards a suspected leakage area, technicians are able to record an image in the infrared (heat) radiation spectrum that identifies the problem location. Each surface that is documented in the image is rendered a color of a temperature spectrum. This makes it easy to identify thermal deficiencies in the apartment's walls, floors and ceilings, which can then be remedied through weatherization techniques.

Weatherization at Peter Cooper Village and Stuyvesant Town – New York, N.Y.

Building managers at Peter Cooper Village and Stuyvesant Town in Manhattan have conducted energy audits during apartment turnover periods for many years. When new owners purchased the complexes and audited the buildings, they were pleasantly surprised by how airtight they were, despite the fact that exterior walls were un-insulated (Steven Winters Associates 2008). The air-tightness and excellent thermal performance of the buildings were direct results of the routine auditing and maintenance that occurred each time a new resident moved in (Brabon 2009).

Photo 4: Blower door test installation in an apartment

Weatherization

The goal of weatherization is to protect a building—and its heated and cooled interior spaces—from temperature differentials from outside air. Weatherization can be classified into three main categories of activities: 1. Draft-reduction measures such as air-sealing or weather-stripping; 2. Measures to reduce stack effect and pressure differentials causing energy losses; and 3. Insulating measures such as installing new doors and windows, and adding interior and exterior insulation. Weatherization techniques are often inexpensive and many of them can be incorporated into routine refurbishment or maintenance cycles. They are considered to be the most cost effective energy conservation retrofit measures.

Weatherization of high-rise buildings is an especially cost-effective technique, since these buildings have relatively low ratios of surface area to volume and a low level of formal and architectural detail. Efforts to seal cracks, minimize thermal bridging, and add insulation are finite in scope yet lead to substantial energy savings and efficiency gains. As the 'low hanging fruit' of energy management, weatherization techniques should be incorporated into facility managers' standard operating procedures whenever possible.

Apartment Turnover Weatherization

An ideal time to perform energy audits and weatherization remedies is when an apartment is being turned over to a new resident. Blower door tests and interior thermographic scans can be performed in one hour or less, which enables facility managers to schedule them between apartment painting and other refinishing work, with minimal disruption to residents. Weatherization remedies such as air-sealing can be contracted out to qualified firms or can be conducted by in house staff or contractors who are handling other aspects of the apartment turnover process. Incorporating these energy audits into the standard operating procedures for apartment turnover will help to reduce energy losses throughout the building, maintain the air-tightness of the building fabric, and conserve heating and cooling energy. This practice will also improve the thermal comfort and well-being of residents.

Exterior Thermographic Scanning

Thermographic scanning is also extremely useful for documenting the energy performance of the entire building façade. The goal of exterior thermographic scanning is to identify the presence of thermal bridges, or large expanses of heat conducting material that allow for energy exchange between apartment interiors and the outside elements. The presence of thermal bridges allows for rapid heat loss to the outside during the winter and heat gain to the inside during the summer. These problem spots are frequently located at the interface of different building elements or between materials types, such as window frames, balconies, and the meeting of floor slabs and facades. Thermal bridges increase energy costs, promote growth of mold and mildew, and during extreme temperature fluctuations, they can also jeopardize the health and safety of residents.

Social housing authorities throughout the European Union use exterior thermography to assess energy performance and rehabilitation needs. Housing managers are increasingly embracing the quest for minimum energy buildings—i.e. structures that are so thermally efficient and air tight that they require only the smallest amounts of energy for heating and cooling.

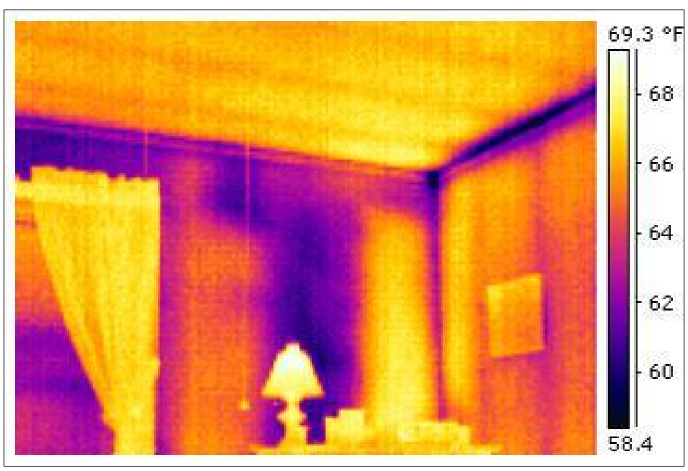

Photo 5: Thermographic scan of an apartment interior

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One cause of heat loss that was discovered during the energy audit is known as 'stack effect' (Steven Winters Associates 2008). Perforations in the building foundation and floor slabs—such as elevator shafts and piping risers—were causing warm air to be sucked up from the bottom of the building and released at the top, like a giant chimney. This stack effect caused significant energy losses and reduced thermal comfort inside apartments (Brabon 2009).

Several methods of mitigating stack effect were devised. First, excessively large penetrations in foundations and floor slabs were reduced in size and insulated where appropriate. Second, hallways and other public spaces inside the buildings were pressurized so that air could not be easily sucked through the building. Pressurization also helped reduce migration of odors between apartments and helped keep conditioned air inside apartments where it was desired.

Other technologies included

- Air-to-air heat exchangers to recover energy from exhausted air.
- Heat sensors in each apartment that moderate boiler operation.
- Development of an energy management system.
- Installation of on-site renewable energy.

Minimum Energy Building: The Dunaújváros Housing (Solanova), Hungary

Thermographic scanning and energy audits of Dunaújváros Housing in Hungary revealed that substantial heat loss was occurring through panelized concrete façades of the buildings.

To remedy this situation, housing facility managers choose to install a 16 cm, prefabricated 'exterior insulation and finish system' directly to the exterior surface of the building (Csoknyai 2007). Additional energy improvements included the installation of new windows, roof and cellar insulation, and 72 square meters of solar thermal collectors to heat domestic hot water. Following the renovations, the building's thermal energy performance improved by 81.3 percent, meeting the mid-range of estimates from model simulations (Csoknyai 2007).

The before and after heating consumption levels demonstrate the savings from installing the exterior insulation and finishing system and the other measures. Monthly heating before the renovations (2004-5) is shown in red, while heating consumption afterwards (2005-6 & 2006-7) is shown in green and blue.

Minimum Energy Buildings

German architects and engineers began in the 1980's to develop houses that required little or no energy for heating and cooling—they called these structures Passive Houses. To achieve such little energy use required air-tight interior spaces that were highly insulated from exterior temperature fluctuations.

Since the passage of the European Commission's Energy Efficiency in Buildings Directive, a number of social housing authorities have adapted the Passive House model to the rehabilitation of poorly built housing complexes from the 1950's and 1960's. The resulting "Minimum Energy Buildings" have achieved up to 70 or 80 percent energy savings relative to their consumption levels prior to the renovation (Guertler and Smith 2006). These buildings demonstrate the potential for multi-family buildings to use minimal levels of heating and cooling energy while maintaining comfort levels.

One practice that is increasingly utilized to retrofit social housing in Europe is the application of Exterior Insulation and Finishing Systems to building facades. These prefabricated panels sandwich together various layers of insulative materials, protective elements, and exterior finishes, and they are applied directly to the façade of existing buildings. The panels come pre-assembled and they can be cost-effectively adapted to a variety of architectural conditions. Finally, they can be designed to add architectural detail, color, and texture to the facades of high-rise multi-family buildings.

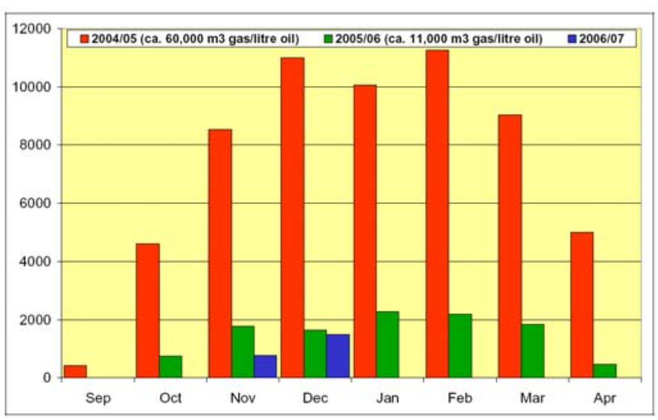

Illustration 1: Heating fuel use before (red) and after (green & blue) a retrofit according to minimum energy building criteria at Dunaújváros Housing in Hungary.

Step 2: Maximize Fossil Fuel Efficiency

Once the exterior envelope is weatherized to minimize energy losses, building managers should turn their attention to maximizing the efficiency of electricity and fossil fuel use.

Lighting Controls

When installed and used properly, lighting controls have the potential to reduce up to 15 percent of a building's lighting energy load (Lawrence Berkeley National Laboratory 2009).

Lighting controls come in many different forms and are adaptable to almost any control need. Their most common and beneficial function is to turn off or lower the luminosity of lighting systems when they are not in use. According to Eldridge Bell, a licensed electrical engineer at Aurum Consulting Engineers, the most common types of lighting controls are occupancy sensors, photocells and astronomical time-clocks, all of which are discussed below.

Instituting a program to implement lighting controls can be done from both a standard operating procedure approach as well as from an experimental pilot program approach. In the standard operating approach, lighting controls can be installed whenever lighting fixtures are changed, or when other renovation activities occur, or even during apartment turnovers. In a pilot program approach, lighting controls can be installed and monitored on a trial basis to determine their performance level, energy saving potential, and ease of use.

Occupancy Sensors

Occupancy sensors are a cost-effective and simple technology that turn off the lights when a room is empty. The sensors come in ceiling and wall-mounted forms, but can also be integrated into individual fixtures. Some occupancy sensors can be manually operated in the same fashion as a wall light switch. Thus, a common upgrade for existing rooms is to install occupancy sensors that function as manual and automatic lighting switches. Therefore, an occupant can either turn off the lights when they are not in use or they will be turned off automatically after 15 minutes. In some spaces, such as stairwells, occupancy sensors can be used to reduce the lighting output by half by turning off every other lamp on a fixture when no one is present. This saves energy while meeting building fire and safety code requirements for appropriate light levels at all times.

Bi-level lighting at Starrett City – Brooklyn, N.Y.

In 1997, the managers of Starrett City in Brooklyn—the largest federally subsidized housing development in the United States—worked with lighting consultants to improve the dependability and energy efficiency of hallway and stairway lighting.

Assessments revealed that most of the public hallways and stairwells in Starrett City were unoccupied at night and throughout much of the day. Hallways and stairways had inadequate lighting that was not meeting NYC code requirements and was operating inefficiently because lighting replacement schedules were not being met.

Consultants proposed replacing conventional ballasts and fixtures with a bi-level lighting system that used two 13 Watt compact fluorescent bulbs. The system was designed to maintain illumination of one of the light bulbs at all times—which was required to meet code requirements—while illuminating the other bulb only when an occupancy sensor detected motion. As a result, energy use for hallway lighting was reduced by 40% (Warren 2000).

Starrett City's bi-level lighting retrofits are applicable to a wide range of multi-family building types and could be undertaken for a payback period of four years or less (Cherry 2007).

Photocells

Photocells are devices that switch lighting systems on or off based on the ambient levels of sunlight. In essence, photocells make sure that lights are off during the day and on at night. Photocells are available in both indoor and outdoor versions. For public housing authorities, photocells are most applicable in outdoor applications, since there is a significant payback from keeping high power outdoor lights off during daylight hours (Mortgage 2009). In addition, Eldridge Bell notes that photocells have the potential to work well with older control systems such as time-clocks, discussed in further detail below. By using new photocells in conjunction with existing time-clock controls, the number of photocells can be reduced from one per lamp to one per lighting circuit. In this configuration, the photocell serves as a backup off-switch that works with the least amount of modification of the existing lighting system.

It is important to note that photocells must be mounted or shielded appropriately so that light from other buildings and vandalism do not interfere with their operation. In some cases, lighting control systems are networked for remote user controllability, which might be a desirable option for public housing authorities, but can also add to the cost and complexity of the systems.

Astronomical Time-Clocks

Astronomical time-clocks are generally located at the electrical panel serving the lighting circuit load. By using a programmed time setting, astronomical time-clocks serve as time switches to determine when to turn outdoor lights on or off. Timed lighting controls require routine testing, and if maintenance workers forget to reset the clocks or do so incorrectly, the lighting may stay on continuously until the mistake is noticed. This can lead to significant amounts of wasted energy, not to mention it can give off the impression that the public housing authority does not value energy conservation. This problem can in part be corrected by replacing older time-clock systems with new astronomical time-clock systems that adjust to sunrise and sunset times automatically. However, if the clock override is left on for testing purposes, then the lights will still remain on. Thus, regardless of the technology being employed for outdoor lighting, where there are time-clocks in use, standard operating procedures must be followed strictly so as to prevent the override from being left on.

Challenges to implementation

Building fire and safety code requirements pose challenges to implementation of both occupancy sensors and photocells. NYCHA is required to maintain a certain level of lighting in areas frequented by residents such as stairwells and hallways. In order to ensure that the appropriate amount of light is provided at all times, the installation of occupancy sensors must be limited to every other fixture or to a bi-level switched fixture. Retrofitting lighting fixtures is a complicated task that has not yet proven cost effective to NYCHA since its housing portfolio contains over 18,000 stairwells. However, NYCHA is in the process of installing motion sensors in employee-only areas, where residential building codes do not apply. Nevertheless, there are still issues of employee safety in these areas.

The use of outdoor photocells presents its own challenges. Photocells require constant cleaning to ensure that they operate properly, and older models may not have a long lifespan. NYCHA has experimented with photocells in stairwells with windows so that they can be activated based on natural lighting, but the technology is not widely employed.

Air Conditioner Replacement

Air conditioning is a major use of energy in the New York City Housing Authority's buildings. It is estimated that about 75 percent of the Housing Authority's 177,976 apartment units use air conditioners, with an average size of approximately 6,000 BTUs (Kass 2009). The number of air conditioners in New York City has also been on the rise in recent years and this trend is projected to continue since regional climate models warn of increased intensity, duration and occurrence of heat waves. For this reason, the New York City housing authority should investigate the potential energy savings and payback periods of providing tenants with new, highly efficient air conditioners. Since highly energy efficient air conditioners are widely available and inexpensive, implementation of an air conditioner upgrade is more of a financial and management issue than a technological one. A feasibility study on the replacements of air conditioners throughout NYCHA's housing portfolio is included in the Finance chapter.

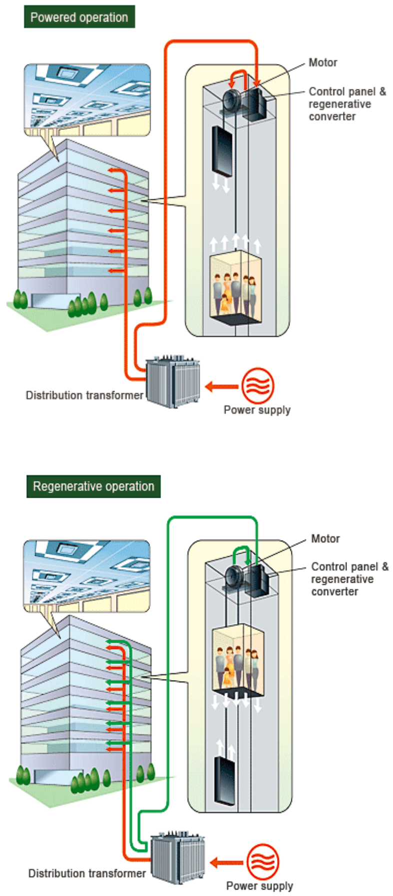

Illustration 2: Elevator hoist-way with regenerative drive capability. In the top illustration, upward lifting of the elevator car requires the input of electrical power. In the bottom illustration, regenerative drives create power as the elevator car is lowered back down to the bottom floor.

Elevator Upgrades

Recent innovations in elevator motors, drives, and control software enable energy savings of up to 75 percent, as well as the elimination of toxic materials, and a smoother and quieter ride (Cosby 2009).

With its $423 million capital fund allocation through the recent economic stimulus package, the New York City Housing Authority plans to undertake elevator replacements and upgrades throughout its housing portfolio (New York State Assembly 2009). This capital campaign provides an opportunity to improve elevator performance and energy efficiency at the same time.

Innovation in Motors and Drives

Throughout the United States, electricity is conveyed over long distances in the form of alternating current power, which entails the bidirectional movement of electrons. This is done so that electricity can be moved from the point of generation to the point of use with relatively fewer efficiency losses. However, many types of equipment require the conversion of alternating current to direct current power, which entails electron movement in a single direction. This conversion process leads to efficiency losses.

The New York City Housing Authority currently employs the use of both direct current and alternating current powered elevator motors. In direct current systems, the building's electricity is converted to direct current using a motor and generator, which then sends power to the elevator's direct current traction motor (Sachs 2005). In contrast, alternating current elevator motors are driven directly by the electrical power available in the building. This allows for a higher efficiency since electricity conversion is not required.

Two main trends have sparked innovation in elevator technology: 1) the advancement of alternating current drive technology; and 2) the need to conserve space (Sachs 2005). The newest alternating current motors are able to operate using variable voltages and variable frequencies, which allows them to adapt to different loading conditions and minimize energy use. New alternating current motors also do not require standby power, unlike direct current motors which may require a constant 500 to 1000 Watts of power.

Responding to space constraints, today's most efficient alternating current motors utilize flat-belt technology, which employs a smaller diameter sheave as compared to conventional systems. This enables the motor to rotate faster and deliver more torque, while eliminating the need for a gear system, which makes the entire setup more compact than conventional geared motors (Sachs 2005). Instead of requiring a machine room to house the motor and drive, these gearless systems can be situated atop of the hoist-way, freeing up valuable space within a building (Sachs 2005). Depending on base case scenarios, recent technological advances in motor and drive systems can generate energy savings of up to 75 percent relative to the initial system (Cosby 2009). Additionally, alternating current powered systems are compatible with energy regeneration technology (Sachs 2005).

Regenerative Drives

Traditional elevator motors produce waste energy that must be dissipated as heat within the building, adding to waste heat loads and reducing the elevator's efficiency (Sachs 2005). Using regenerative drives, waste energy can be reused onsite or fed back into the electrical grid for other utility customers (Otis 2008). In a 25-story residential high rise simulation, the use of regenerative drives was shown to reduce energy consumption by 30 percent compared to a geared traction motor system (Sachs 2005). Regenerative drives can generate approximately 10 kW of electricity per elevator hoist-way (Sachs 2005). Regenerative drive controllers can be easily implemented during elevator renovations, especially ones that entail moving from old traction systems to new ones. The cost effectiveness of the upgrade depends on factors such as building size, elevator equipment being replaced, traffic flow, and electricity rates, to name a few (Cosby 2009).

Elevator Controls

The efficiency of an elevator system can be improved through updating its control system. Recent innovations enable energy saving features such as turning off elevator cars when usage is minimal, or positioning cars at appropriate floors depending on the movement of people (Sachs 2005). More advanced systems respond to peak demand by reducing power usage.

Water Conservation Measures

Water conservation measures such as low-flow showerheads and faucets have proven track-records for functionality and fast pay-back. A federal study of the life cycle costs of low-flow showerheads and faucets found that savings from reduced hot-water use alone exceeds the cost of installation.

Energy Savings from the Addition of Aerators

Photo 6: Detail photograph of a low-flow showerhead

The addition of aerators to kitchen and bathroom faucets would reduce the flow-rate from three gallons per minute (gpm) to 2.2 gallons per minute. Implementing this simple retrofit in New York City's public housing can save over three million gallons per day and nearly 1.175 billion gallons per year.[1] A conservative estimate that only two minutes, or 20 percent, of this faucet water use is heated to 80°F results in an energy savings of 13,394,093 kWh from foregone heating.[2] Additionally, avoided sewer system pumping would lead to 722,494 kWh per year in energy savings.[3]

Energy Savings from Showerhead Replacements

Replacing older, three gallon per minute (gpm) showerheads with low-flow, two and a half gallon per minute fixtures can save over 500,000 gallons of water daily and over 183 million gallons per year in New York City public housing.[4] This reduction in water usage would result in a tremendous energy savings from the avoided heating of this water to shower temperature (106°F)—approximately 23,865,571 kWh annually.[5] Energy savings based on avoided sewer system pumping equates to an additional 112,890 kWh per year.

Aggregate Savings

These two off the shelf technologies represent a combined savings of over 1.35 billion gallons per year. The avoided pumping and heating translates to an annual energy savings of over 38 million kWh or 3.2 percent of NYCHA's annual energy use.

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[1] Assuming on average of ten minutes of sink water use per day, residents could save an average of eight gallons daily. Applying this average savings to NYCHA's 402,370 residents represents a daily savings of 3,218,960 gallons, or an annual savings of 1,174,920,400 gallons.

[2] This assumption is conservative because in all likelihood more then 20 percent of faucet water use would be heated. The Natural Resources Defense Council's study, "Energy Down the Drain, estimates that 80°F is the average temperature of heated faucet water. Heating to 80°F requires 0.057 kWh.

[3] The energy savings from avoided pumping is based on the figure of 0.46 kWh for every 100 cubic feet of water, which was included in NYCHA's Preliminary Plan for Multiphase Energy Performance Contracting Program.

[4] Replacing 3.0 gpm fixtures with 2.5 gpm fixtures would save an average of 2.5 gallons per person each day (assuming five minutes of use). Estimating conservatively that only half of NYCHA's 402,370 residents shower at this rate every day would lead to a savings of 502,963 gallons or an annual savings of 183,581,300 gallons.

[5] Although at NYCHA hot water is heated to 120°F, this calculation assumes that the average desired temperature coming out of the faucet is 106°F, based on data from the National Resources Defense Council's study, "Energy Down the Drain." This lower temperature provides a more conservative estimate of energy savings. Further, calculations based off use temperature are more applicable to the instantaneous hot water systems that have been installed. Heating water to 106°F requires 0.13 kWh.

Step 3: Employ Renewable Energy Technology

Once building managers have minimized energy losses and maximized energy efficiency they should investigate renewable energy technologies. At this point building managers will be able to maximize their pay-backs on these investments.

Solar Thermal Systems

Solar thermal systems are mature and widely available technologies that have experienced substantial market growth and improved technological performance in recent years (Wang, Li et al. 2000).

Solar thermal systems typically have two components, a solar collector and a storage tank. The solar collector gathers energy from the sun and uses various methods to heat the water, which is then stored in the tank. The tank stores the heated water until it is ready for use, with a traditional water heating system providing additional heating as necessary. There are two types of solar thermal collectors: 1) flat-plate collectors, and 2) evacuated-tubes.

Flat-plate systems are the most commonly used solar thermal systems. In a flat-plate system, an insulated and weatherproofed panel containing a heat absorbent black metal material is placed in the path of sunlight. Water is heated in pipes behind the flat plate, causing it to circulate through the system by natural convection.

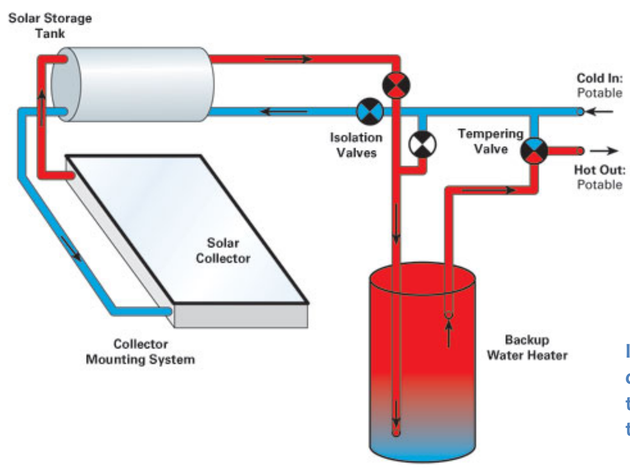

Illustration 3: Schematic diagram of a flat plate solar thermal system that uses thermsyphoning

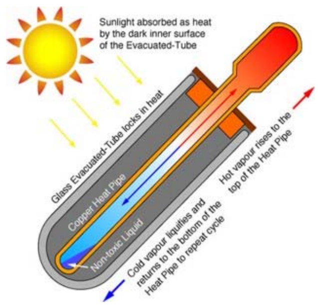

Illustration 4: A schematic diagram of an individual tube in an evacuated tube system.

Photo 7: An evacuated tube system installed on a roof.

In an evacuated tube system, sunlight passes through an outer glass tube and heats an absorber tube inside. A vacuum in the glass prevents temperature loss, and a heat pipe carries the collected energy to the water storage tank. Because the glass tube has a high thermal conductivity, it is able to transfer large amounts of heat with a marginal rise in temperature. The absorber concentrates heat and does not emit it back into the tube; this combined with the presence of a vacuum allows better radiation capture and reduces the risk of the water freezing in cold temperatures. Although more expensive than a flat-plate system, evacuated tubes are more practical in colder climates (Wang, Li et al. 2000).

Photovoltaic-Thermal Systems

Photovoltaic-thermal systems integrate solar thermal collectors with photovoltaic cells in one system that enables the dual production of electricity and hot water (or in some cases, ventilated air).

By using an integrated systems approach, photovoltaic-thermal systems can achieve a 65 percent efficiency level through capturing and converting sun energy into both hot water and electricity (Huang 1991). By comparison, a stand alone photovoltaic system achieves a much lower efficiency level of 15 percent because large amounts of sunlight energy are wasted in the form of dissipated heat (Sumathy, Huang et al. 2002). The advantage of an integrated system is that the water flowing through the solar thermal collector acts as a cooling agent for the photovoltaic panel while at the same time making use of the acquired heat energy. This improves the efficiency of electricity generation while heating water that can be used for domestic consumption.

Solar thermal systems can be easily integrated with instantaneous hot water systems, and doing so helps to reduce energy consumption by pre-heating the incoming water into the system. This can be achieved most effectively by dividing the heating and cooling processes into high and low pressure stages, which enables significantly lower water temperature to drive the system—approximately 75°C, which is easily obtainable from diffused solar radiation.

Photo 8: Rendering of a combined solar thermal and photovoltaic system.

Lower operating temperatures results in higher thermal efficiency and more consistent output through low-level periods of sunlight. This system design also allows for the use of simpler solar collectors, thus reducing the initial cost of the system. Temperature in the collectors averages 40-45°C above ambient temperatures, which makes year-round operation of the system feasible, thus lowering the marginal costs (Sumathy, Huang et al. 2002). Integrating this temperature differential into an instantaneous hot water system lowers the overall steam usage in the water heating process.

Parapet Mounted Wind Turbines

In an urban environment, the pressure differentials created by wind flowing over and around a building provide an ample supply of airflow (Grant et al. 2007). In essence, this airflow is an untapped resource waiting to be harvested. To extract the power from the wind there are specially designed wind turbine technologies that fit on a building roof parapet. Public housing authorities can take advantage of natural wind flows over their buildings to generate electricity by installing these parapet mounted turbines where space is available (Dopp 2009).

Co-generation

Distributed generation systems produce energy close to the point of use, which typically doubles the efficiency in terms of fuel input-to-energy output ratio compared to conventional power generation in central plants. This means that the same amount of energy can be produced with half the amount of fuel, making distributed generation an effective approach to reducing greenhouse gas emissions (NorthEastDG 2008). According to the New York City Energy Conservation Steering Committee, the creation of distributed generation systems will account for at least 5 percent of the City's greenhouse gas reduction by 2017 (NYC Energy Conservation Steering Committee 2008).

Co-generation is a type of distributed generation that a number of housing authorities have successfully implemented. A co-generation system is designed to capture the waste heat produced in the power generation process and reuse it onsite to meet demands for hot water, steam, or cooling.

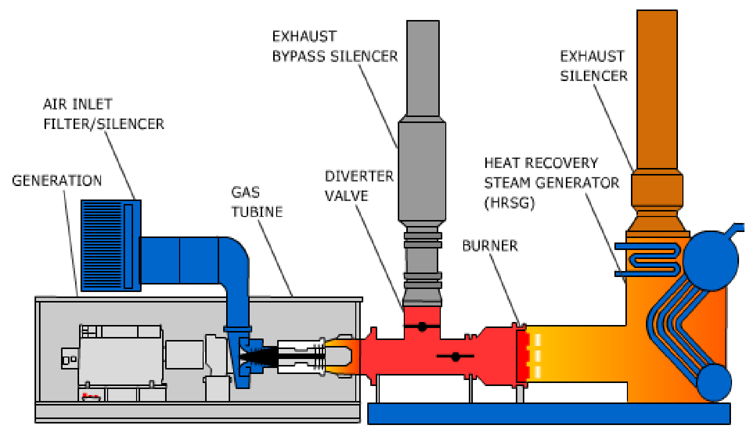

Illustration 5: Schematic diagram of a co-generation system. Natural gas combustion occurs in the burner—pictured in red—which produces steam that is driven through the turbine to generate electricity, which is shown on the left side of the diagram. On the right side of the diagram pictured in orange, is a heat recovery system that captures excess heat from the combustion process for reuse in heating air and hot water.

Co-generation is ideal for large-scale housing complexes because of the systems' potential to reduce utility costs. For example, Chelsea's Penn South co-op in Manhattan realized $1.5 million in savings through its co-generation plant (Mannino 2008). Across the river in Queens, North Shore Towers has been powering its three buildings with co-generation for over three decades, reporting savings of $750,000 annually (Mannino 2008).

Regulatory Barriers

The transmission efficiency, availability of financial incentives and the potential savings resulting from co-generation and other forms of distributed generation make them potentially desirable investments. However, a number of barriers to implementation exist that stem from the complications of connecting distributed generation systems to the utility grid without negatively impacting safety, reliability and quality of supply (ConEd).

The electricity grid is currently designed in a top down manner with defined power flows (Christopoulos and Wright 1999). In the event of a grid shut down, because distributed generators can still run, there is the potential for them to release power onto the grid in the opposite direction of defined flows. Reverse power flows can be extremely hazardous, and as a result ConEdison is in the process of implementing protection mechanisms throughout its service area to enable safe distributed generation (Dondi, Bayoumi et al. 2002), (Commssion 2004), (ConEdison 2009).

Siting & Sizing Complications

Although co-generation helps lower carbon and pollutant emissions on a city-wide level, it may increase emissions in close proximity to where the system is sited, because co-generation systems typically burn fossil fuels (Lamoureux 2002). State air quality permitting processes can slow down the installation of co-generation facilities (Elliott, Shipley et al. 2003).

The sizing of a co-generation system is an important and complex cost consideration. If space constraints only allow for the installation of a small co-generation system, a housing authority will need to continue buying grid-based power, which will make the system less cost-effective. On the other hand, if the system is very large, it will compete with other potential rent-earning land uses and can become visually undesirable. 'Standby' electricity tariffs also factor into the sizing decision, as systems generating more than 15 percent of a building's power needs shift the building to a more costly rate class. If co-generation is financially feasible for the site, public housing authorities must balance these factors to determine the most cost effective system size (Hammer 2004). Ideally, a housing authority would be able to work directly with its utility provider to streamline the permitting process and develop a cost-effective rate structure to promote on site co-generation.

Co-generation at Sommerville, MA Housing Authority

Sommerville Housing Authority installed two 60kW co-generation units in 2003 in large private housing complexes that were similar to NYCHA's housing stock.

The co-generation systems were installed when the boilers were up for replacement and the housing authority decided to undertake a heating fuel conversion to natural gas. New piping for the co-generation system was installed while the apartments were occupied by coordinating water shut downs with residents.

The cost of each co-generation system came to $135,000. Savings from hot water and heating efficiency were estimated to be $25,490. Therefore the system is expected to provide a payback period of 5.32 years, well within the confines of the housing authority's twelve year loan.

The Sommerville Housing Authority contracted AMERESCO to design and install the system, secure a municipal loan and pass the permitting process.

Although Sommerville is not utilizing an instantaneous hot water system, their cogeneration plants are compatible. Sommerville Housing Authority is planning two more co-generation projects for next year; one in an 84 unit complex and one in an 80 unit complex (Smith 2009).

Recommendations

To capitalize on low cost near term savings while achieving the most attractive pay-back periods for longer-term investments, the New York City Housing Authority should consider undertaking energy performance activities according to the three-step framework outlined in this section: Minimize energy losses, then maximize efficiency, and finally employ renewable technologies.

The Housing Authority should conduct routine energy auditing and weatherization of its housing stock to minimize the amount of energy that is lost in the heating and cooling process. Several inexpensive auditing strategies—such as blower door tests and thermographic scanning to spot air leaks—can be incorporated into NYCHA's typical apartment turnover protocol. Thermographic scanning can also be used on the outside of buildings to visualize heat loss through the façades, which would help to focus and economize repair work. The integration of weatherization techniques into NYCHA's standard operating procedures will ensure that the reduction of energy losses is maintained over time.

Once it has minimized energy losses, the Housing Authority should focus on efficient use of fossil fuel energy. Among the many technological solutions that can be implemented are improved lighting controls, alternating current gearless elevator motors with regenerative breaking, high efficiency air conditioners, and technologies to reduce the amount of hot water used in buildings.

After energy efficiency has been maximized through updating existing building systems, the Housing Authority ought to then pursue the implementation of renewable and regenerative technologies such as solar hot water heating, combined solar thermal and photovoltaic systems, co-generation, and roof mounted wind turbines.

The New York City Housing Authority has already taken many steps to implement energy efficient technology in its existing building stock. To ensure continued improvement in the energy efficiency of their buildings, the Housing Authority should fully integrate energy saving processes into their standard operating procedures. At the same time they should strive for an adaptive and preventative maintenance regime that will reduce energy losses and maintain optimal functionality of new technologies.

Wherever possible, the Housing Authority should use best available technology to maximize the energy efficiency and thermal performance of refurbishments even if they are not the most cost-effective presently. This strategy accounts for the likelihood that energy efficiency standards and energy costs are going to increase, especially as the US begins the process of mitigating its impact on climate change.

FINANCE

The advantage of energy efficiency retrofits,

compared to other capital expenditures, is that they generate savings over time and can be financed as an investment with positive returns. The high upfront costs of energy technologies, however, have posed a steep barrier to implementation for many public housing authorities.

The recent advent of innovative financing strategies has fundamentally altered the investment equation for energy technologies. Three financing approaches are discussed in this chapter: 1) energy performance contracting; 2) partnering with energy services companies; and 3) power purchasing agreements.

What unites these approaches is that they each use projected savings from energy efficiency retrofits to pay for the initial costs of the projects. Future energy savings are treated as a payback that justifies and makes possible the initial investment. A feasibility study at the conclusion of this chapter demonstrates how NYCHA can use innovative financing strategies to replace window air conditioners throughout its housing stock while realizing rapid returns on its investment.

Innovative Finance at NYCHA

As discussed in the Background section, the New York City Housing Authority recently submitted a proposal for a multi-phase performance contracting program to the U.S. Department of Housing and Urban Development. Phase one of the performance contracting program will generate an estimated $62.5 million in annual savings that can be invested to undertake subsequent phases of the program.

NYCHA is currently working with the energy services company, AMERESCO, on certain aspects of phase one of the energy performance contracting program. AMERESCO's scope of work includes boiler replacements, lighting retrofits, heating controls, and underground pipe work. The contract is totaled at $18 million.

Innovative Financing Strategies

Most organizations require financing mechanisms to make capital purchases. Innovative financing strategies help organizations manage risk and overcome the high upfront costs of implementing energy technologies.

Energy Performance Contracts

Under an energy performance contract, the savings generated from energy efficiency upgrades are used to help finance the project. The energy performance contract can be used to implement a range of activities including: utility efficiency measures (electricity, natural gas, fuel oil, propane and water), co-generation or other forms of distributed generation, installation of renewable power sources, and improvements to operations and maintenance—all of which must be cost-effective throughout their lifecycle.

To initiate an energy performance contract, a public housing authority must submit a proposal to the U.S. Department of Housing and Urban Development describing the scope of work and its projected savings. Once approval is granted, the housing authority can then develop detailed programs, contracts, schedules and financing for the energy retrofits.

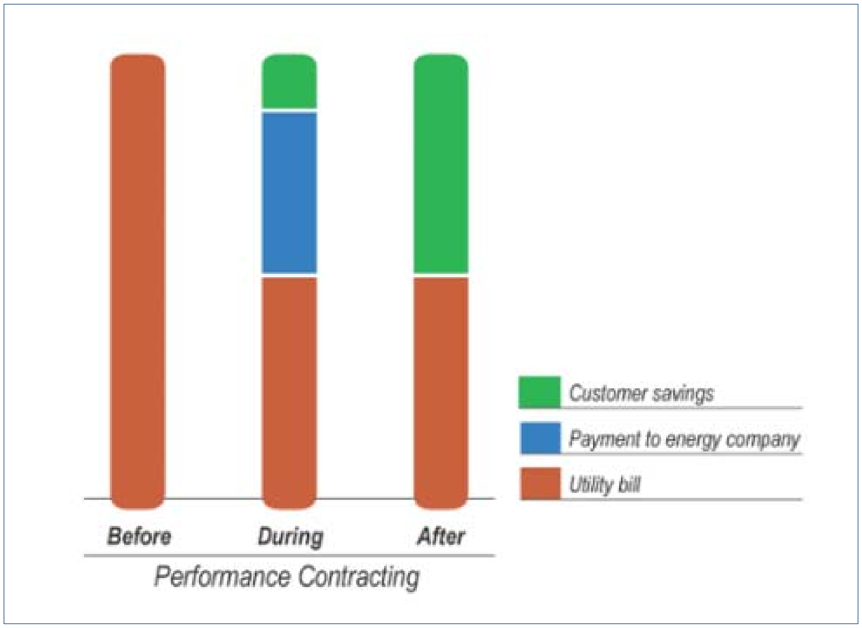

Illustration 6: The financing structure of a typical performance contract.

Energy Services Companies

It is often difficult for a single organization to handle all of the steps required to undertake energy retrofits. Organizations may lack the expertise to identify appropriate technologies, may be unable to find qualified technicians, or may have trouble financing the project.

Energy services companies help remedy this situation by coordinating all aspects of an energy performance contract. The company will see the project through from the initial energy audit to the installation and maintenance of the technologies, if desired. It will pay for all costs related to design and installation of the new equipment, with no up-front costs to the housing authority (AMERESCO, 2009). In return, as the housing authority realizes savings in the form of lower utility bills, it pays the energy services company a portion of those savings to reimburse them for the upfront costs.

Among the many advantages of partnering with an energy services company is its attention to the technology's entire lifecycle, since its investment return is contingent on the realization of long-term energy savings. An energy services company frequently provides maintenance and monitoring activities as a part of its contracts, which helps ensure that energy savings will continue to accrue over the lifecycle of the equipment. Once the project is completely paid for, future energy savings will accrue directly to the customer.

According to Karl Goetze of the Vermont Energy Investment Corporation, organizations that have the potential for substantial energy savings and who have an existing operating budget, are ideal candidates for partnering with an energy services company (Goetze, 2009). A number of public housing agencies have worked successfully with energy services companies—see the examples throughout this chapter.

Somerville Housing Authority partnership with AMERESCO

The Somerville Housing Authority engaged the energy services company, AMERESCO, to conduct an audit and undertake energy retrofits. AMERESCO clearly outlined savings expectations before the project began and the actual savings exceeded the initial projections. In total, the Somerville Housing Authority invested $2.35 million and realized an annual savings of over $315,000. Energy savings included 1.92 million kWh of electricity, 27,600 therms of natural gas, and over 20,000 CCF of water. The following measures, among others, were implemented:

- Conversion of electric heat to gas
- Apartment temperature controls
- High efficiency hot water system
- Basement & crawl space insulation
- Installation of water saving devices
- Lighting retrofits
- Consolidation of electric meters
- Window replacement & air-sealing.
- Installation of co-generation
- Replacement of space heat boilers

AMERESCO encountered a problem installing weatherization measures on the exterior doors of the apartment building. Though the company was determined to overcome the issue, the Somerville Housing Authority decided to forgo those measures since the installation cost would exceed the potential savings. This adaptive management exemplifies the flexibility and responsiveness of performance contracting with an energy services company.

Power Purchasing Agreements

A power purchasing agreement enables a public housing authority or business to install a solar power system with no upfront costs. Prior to the advent of power purchasing agreements, solar power systems were beyond the reach of most institutions because of high upfront costs (Behar 2009).

Under a power purchasing agreement, a building manager agrees to purchase power generated from a photovoltaic system that an independent solar company designs and installs onsite. The solar company owns the system and receives all relevant tax rebates and government grants. This enables the company to finance the system so the customer pays little or no upfront cost.

Under the agreement, power is purchased at a fixed rate that is lower than the cost of current utilities for a pre-defined period of between 10 and 20 years (Garland Energy, 2009). In return, the solar company maintains and monitors the system, ensuring consistent operation and delivery of power.

The fixed utility rate provided by a power purchasing agreement is especially attractive in areas with high or increasing utility rates, such as California and New York State. By locking in a cost for electricity over the lifetime of the contract, power purchasing agreements greatly reduce the risk and complications of implementing renewable energy systems.

Eliminating uncertainty about energy price fluctuations facilitates decision making about long-term energy technology investments (Renewableenergyworld.com 2008). Power purchasing agreements are well suited for public housing authorities and other government entities that own and occupy their buildings for the long-term.

Power Purchasing Agreements

The **Long Island Power Authority** recently announced a partnership with BP Solar and EnXco, to fund a 50 megawatt solar project that will generate enough electricity to power more than 6,500 homes. As of the end of February, 2009, the Long Island Power Authority was finalizing the details of a power purchasing agreement with the two developers that will guarantee delivery of power for a 20 year period at a competitive fixed price. The majority of the project will be installed on land managed by Brookhaven National Laboratory, a Department of Energy facility. The solar project will become the largest in New York state history.

Kohl's Department Store recently signed a power purchasing agreement with SunEdison. The agreement will lead to the installation of photovoltaic systems at all of Kohls' stores, which will generate an average of 10 to 20% of annual energy needs. Kohls has agreed to purchase electricity from SunEdison at a fixed price for at least 10 years, which will help to insulate the firm from electricity price volatility while lowering its carbon footprint. Kohls' creation of a distributed network of photovoltaic systems under one power purchasing agreement is a model for other organizations that seek to install renewable power systems across multiple building sites (Behar 2009).

Oakland Public Housing Authority Performance Contracting

The Oakland Housing Authority partnered with an energy services company to oversee the state of California's first energy performance contract, which involved work at hundreds of apartments in housing sites that were diverse in design and scattered throughout the city. Judy Monnier of the Oakland Housing Authority was pleased with the patience shown by the energy services company while working under difficult conditions.

In total, the Oakland Public Housing Authority invested $2.3 million for energy upgrades that had a payback term of 12 years. In fiscal year 2007, the gross energy savings attributed to the efficiency upgrades exceeded $391,000, of which $221,000 went to debt service for the upfront costs. This left a net savings of over $169,000, much to the delight of Oakland Housing Authority management (Monnier 2009).

Retrofits included:

- Fluorescent & LED lighting
- Water saving devices
- EnergyStar appliances
- High-efficiency condensing boilers and furnaces
- Variable Air Volume HVAC system with variable frequency drive fans
- Installed EPA's "Sleep is Good" utility management program

Incentives & Grants

The New York City Housing Authority can apply for a number of local, state and federal grants and incentives to offset some of the upfront costs of undertaking energy efficiency and technology upgrades.

U.S. DEPTARTMENT OF HOUSING & URBAN DEVELOPMENT

Three Year Rolling Base Program

A public housing authority that undertakes an energy efficiency project retains half of the utility savings accumulated after the first and second years, one-third of the savings in the third year, and one-sixth of the savings in the fourth year. The result is that within the four years of the program, the housing authority realizes 150 percent of its first year's savings.

Frozen Base Incentive

Under this incentive the three-year rolling base utility consumption is frozen at the level of consumption before installation of the energy improvement measure. If a public housing authority uses an energy performance contract or third party financing to complete energy efficient projects, it can borrow non-HUD funding and also keep 100 percent of the cost savings from energy-efficiency improvements. At least 75 percent of these yearly profits can be used to pay off the loan until it is fully amortized.

Capital Fund Financing Program

Under the Capital Fund Financing Program a public housing authority can borrow private capital to make improvements by pledging a portion of its future annual capital funds to debt service payments. Energy technologies and retrofits are eligible for financing under this program.

NEW YORK STATE

Solar Electric Incentive Program

This program provides cash incentives for the installation of new solar electric or photovoltaic systems. New York State's Renewable Portfolio Standard has allocated $13.8 million in incentives through 2009, and more funding may become available if the program is successful. Applications will be accepted through September 30, 2009, or until funds are fully committed.

Combined Heat & Power / Renewable Generation Technical Assistance

Under this program, the New York State Energy Research and Development Authority will cost share up to $50,000 of the total cost of selected 'Technical Assistance Studies' performed by an independent service provider. For electrical customers of Consolidated Edison Company of New York, Inc., the New York State Energy Research and Development Authority will cost-share up to $100,000 on selected studies.

Renewable Portfolio Standard Customer-Sited Tier Fuel Cell Program

$11.2 million is available for financial incentives to support the installation and operation of fuel cell systems in New York State, with up to $1 million available per fuel cell system. Funding is on a first-come, first-served basis until May 29, 2009 or until all funding has been fully committed.

New York Energy $mart Programs

The New York State Energy Research and Development Authority's ENERGY STAR Multifamily Building Initiative can aid NYCHA's rehabilitation projects by providing technical assistance on the installation of renewable technologies, advanced metering, real-time pricing strategies, and co-generation.

Division of Housing & Community Renewal Weatherization Assistance Program

Public housing buildings in New York State may receive up to 50 percent of the cost of energy efficiency and weather protection measures identified through an audit. The New York State Energy Research and Development Authority supplements the Weatherization Assistance Program with incentives for the installation of electric-efficiency measures. Some cost sharing is required.

Continued from previous page

To date, energy savings have reached a total of 5.6 million kWh of electricity, 271,000 therms of natural gas, and more than $1.7 million dollars.

The Oakland Housing Authority was able to implement a comprehensive retrofit package within a feasible financing horizon by bundling fast pay-back retrofits (lighting and water conservation measures) with slower payback improvements such as boiler and furnace replacements.

In 2007, the California Public Utilities Commission recognized the Oakland Public Housing Authority by awarding it the Flex Your Power Award.

Air Conditioner Replacement Feasibility Study

This case study demonstrates the feasibility and energy saving potential of a campaign to replace existing air conditioning units owned by residents with new energy efficient models supplied by NYCHA.

NYCHA's cost of installation can be recouped well within the air conditioner's lifetime, followed by the generation of net savings. Technological features of the new air conditioners can help to reduce overall demand levels and can overcome potential rebound effects of implementing the program

Background

Air conditioning use accounts for an estimated 11% of NYCHA's total electricity consumption, or approximately 132 million kWh per year (Kass 2009). It is assumed that approximately 75 percent of NYCHA's apartments (133,482 units) have one air conditioner each, with an average capacity of 6000 BTUs.

The use of air conditioners is on the rise in the New York City region. Con Edison estimates that one million new room air conditioning units were installed between 2003 and 2008, and they project an additional 850,000 units by 2013 (EnergyNY 2009). Furthermore, climate models warn of an increase of intensity, duration and occurrence of heat waves in New York City. Based on these predictions, more of NYCHA's residents are likely to use air conditioners in the future, which provides a strong incentive for addressing air conditioner inefficiency.

The Energy Efficiency Ratio

Each air conditioning unit sold in the United States comes with an Energy Efficiency Ratio (EER) that quantifies the capacity of the unit (in BTUs) divided by the amount of energy (in Watts/1000) required to run the unit when the outside temperature is 95° Fahrenheit. The minimum energy efficiency ratio of a new 6000-Btu EnergyStar air conditioner is 10.7 (energy input of 0.5607 watts at 95° Fahrenheit outside temperature). The proposed replacement air conditioners in this case study are assumed to have this EER.

Efficiency of Existing Air Conditioners at NYCHA

Since air conditioners at NYCHA are privately installed and operated by tenants there is uncertainty regarding the efficiency ratings and hourly usage of the units.[i]

Three scenarios were developed to estimate the average energy efficiency ratio of existing air conditioners at NYCHA. For each scenario, an estimate was made of daily hours of operation per air conditioner (assuming a 100 day summer) so that total energy use equaled NYCHA's consumption estimate of 132,000,000 kWh.

Scenario A (Lower savings potential)

- Existing units are 15% less efficient than new unit
- EER of 9.3
- Energy input of 0.645 Watts
- Average daily use of 15.3 hours per unit

Scenario B (Moderate savings potential)

- Existing units are 20% less efficient than new unit
- EER of 8.9
- Energy input of 0.674 Watts
- Average daily use of 14.7 hours per unit

Scenario C (Higher savings potential)

- Existing units are 25% less efficient than new unit
- EER of 8.6
- Energy input of 0.698 Watts
- Average daily use of 14.2 hours per unit

Estimate of Savings

Annual energy and financial savings were used to conduct a cash flow analysis of each scenario. The net savings (in net present value) of replacing all existing units with new Energy Star units was then calculated for up-front costs of both $75 and $125 per unit.[ii] Payback periods were also calculated for each scenario.

As the table on the next page demonstrates NYCHA can realize substantial energy and cost savings by replacing existing air conditioners with high efficiency units. Each scenario yields a net savings, ranging from $238,471 to over $15 million. In all cases payback occurs in less than ten years, and can be as little as 3.3 years.

Existing Unit Efficiency Scenarios	Annual Savings	$ 75 Cost per unit		$ 125 Cost per unit	
		Net savings (Net present value)	Payback period	Net savings (Net present value)	Payback period
Scenario A 15% less efficient	17.3 million kWh $2.245 million	$6,912,571	5.3 years	$238,471	9.8 years
Scenario B 20% less efficient	22.2 kWh $2.887 million	$11,747,867	4.0 years	$5,073,767	7.1 years
Scenario C 25% less efficient	25.9 million kWh $3.368 million	$15,374,454	3.3 years	$8,700,354	5.9 years

Barriers to Implementation

One of the major concerns surrounding an air conditioner replacement program is that tenants who previously did not have air conditioners would buy-in to the program, causing a net increase in electricity usage.

To address this valid concern, it is worthwhile to examine the worst case scenario that all NYCHA households request installation of the new units. Assuming an EER of 10.7, this would lead to a total annual load of 141,450,791 kWh, or an increase of 9.45 million kWh per year, and a cost increase of roughly $1.3 million per year. This increase in energy usage and costs would be a real problem if it came to fruition.

To avoid this possibility, a pricing mechanism—such as a buy-in fee or excess demand charge—can be used to limit the total amount of air conditioners installed or the hours of use.[iii] Such a target can be based on desired energy savings, cost savings, or other criteria. However, use of a pricing mechanism raises affordability concerns, and it may be unpopular and politically unfeasible.

Technological Solutions to Overcome Barriers

The air conditioner models on the market already have energy saving features that automatically power down when indoor or outdoor temperature drops to a certain low level. These features would decrease the amount of time that units are being operated—relative to the 14 + hours of current estimated daily use—which would lead to energy and financial savings.

NYCHA can use its 1996 refrigerator replacement program as a model to develop a state of the art air conditioning unit that includes demand management features that would help ensure overall energy savings.

For example, a demand management feature can be set to power off air conditioners during daytime hours. If tenants are home they would be able to override this feature manually, but a substantial savings would be realized from turning off units while occupants are not home. If these features were able to reduce average daily usage by one hour (to 13.2 hours per day), NYCHA would break even on energy use even if every single apartment used air conditioning. If average use were lowered by two hours per day, then NYCHA can save 8 percent of its energy.

By focusing on technological solutions to excessive air conditioner use, NYCHA can both save energy and create an innovative model for future projects.

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i. An effective useful life of ten years was assumed for the units. Some units may be quite inefficient if they were installed over ten years ago (before 1999, the minimum required EER was 8.5), while newer units would be more efficient (since 2000, the minimum EER has been 9.5). Based NYCHA's estimate, it was assumed that the average capacity of units is 6000 BTUs. Three scenarios are analyzed to address uncertainty about average energy efficiency ratios and the hours of use.

ii. This is the same discount rate that was used by the New York City Energy Conservation Steering Committee in their Long-term plan for municipal greenhouse gas reduction. Energy costs were assumed to be non-inflationary (fixed at 0.13 per kWh) which has a conservative effect on the net savings estimates. This is especially conservative given the likely rise in energy costs once the United States regulates carbon emissions.

iii. This would be in addition to the $10 yearly fee NYCHA tenants must already pay for using an air conditioner.

Recommendations

Public housing authorities are often risk averse when considering implementation of energy saving technologies. They usually require savings from reduced energy use to exceed the cost of debt service and demand very fast pay-back periods. Technologies with higher upfront costs and unproven payback periods are declined in favor of the predictability of well known solutions. In part, this fiscal conservatism is due to the unpredictable nature of energy savings. Project management limitations, uncertain estimates, and the dynamic influences of building systems are other reasons to fear that energy efficiency upgrades may yield less savings than anticipated.

Creative financing schemes have the potential to help housing authorities overcome the barriers of unpredictability, high upfront costs, and operational challenges. For example, NYCHA's 1996 partnership with the New York Power Authority to replace refrigerators exemplifies how partnerships and creative financing can facilitate technological innovation and significant energy savings. In keeping with this practice, partnerships might be forged with non-profit organizations, government agencies, utilities, or academic institutions to implement energy efficiency improvements.

An air conditioner replacement program would enable NYCHA to replicate these past successes. Creative financing and technological solutions like demand management systems embedded in the air conditioners would enable NYCHA to overcome risks and realize long-term energy and cost savings.

Negotiating power purchasing agreements and collaborating with energy services companies are other examples of partnerships that serve to diminish risk by reducing upfront costs, stabilizing operational expenses, and allocating tasks appropriately.

Existing financial strategies should be enhanced as well. Since NYCHA is an authority by name, it has the power to issue bonds. If possible, the Housing Authority should consider issuing bonds for energy efficiency related projects. Finally, NYCHA should consider incorporating energy efficiency improvements into its capital budget, rather than treating them as separate endeavors. Since energy efficiency projects realize a return on investment, bundling them with other capital projects will increase the attractiveness and performance of capital spending.

MANAGEMENT

According to New York City's Long-Term Plan

to Reduce Energy Consumption and Greenhouse Gas Emissions, city agencies are in need of:

> A structured approach to implementing projects that balances the acceleration of simple, cost-effective projects with the need to begin more advanced initiatives, which require longer lead times.

The technology chapter presented a three step methodology for improving energy management that began with low cost efforts to stem energy losses, followed by projects to improve energy efficiency, and finally initiatives to generate on-site renewable energy. The finance chapter then discussed innovative approaches to pay for each of these types of endeavors.

This chapter explores the myriad management challenges and opportunities for improving energy performance in public housing. Its focus is twofold: (1) improved operations and maintenance of existing building systems to save energy; and (2) the implementation of new technologies.

Management Challenges

For decades, budgetary constraints have limited the New York City Housing Authority's ability to undertake capital improvements and maintain its buildings at an optimal level. NYCHA's operating budget has experienced stress from all sides. As residents' income levels began to drop in the late 1960s and 1970s, the Housing Authority began generating less revenue from rent, while at the same time, receiving fewer federal and state subsidies. Meanwhile, maintenance and operations costs have risen substantially as New York City's public housing stock ages and as utility costs increase. For years, NYCHA has been forced to do more with less.

In the past, this constant financial strain may have undermined the energy performance of NYCHA's housing stock. However, with the rising cost of energy over the past few years—as well as New York City's efforts to address its greenhouse gas footprint—NYCHA now has compelling justification to undertake energy efficiency retrofits and capital improvements that generate long-term reductions in operating expenses.

Engineers and facility managers at the New York City Housing Authority are mindful of the complexity and constraints of operating under such limited resources. Furthermore, the scale of NYCHA's building portfolio, the unrelenting demand for housing occupancy, and the agency's determination to conserve its aging housing stock has created a cautious approach to technological innovation and change. To implement a new technology at NYCHA it must be tested under the toughest of conditions, demonstrate the capacity for long-term durability and maintenance, and be relatively simple to use so that future staff and building operators can continue its operation. Furthermore, although private companies have developed energy efficiency products and services, they are often incapable of scaling up to meet NYCHA's procurement needs. For these reasons, introducing technological change at NYCHA has been a gradual process.

For New York City to realize its ambitious goal of reducing greenhouse gas emissions by 30 percent in the next decade, city agencies, including NYCHA, must significantly increase their energy management project activity (NYC Energy Conservation Steering Committee 2008). For NYCHA, this means more fully integrating energy management objectives and procedures into its operations and maintenance, while increasing its capacity to test, implement, and monitor new technologies that can save energy and improve building management.

Optimizing Operations & Maintenance

Facilities managers have traditionally measured operations and maintenance success in terms of reliability. However, the emerging importance of energy efficiency renders this an insufficient metric. Without any significant capital investment, building managers can achieve a 5 to 20 percent energy savings through proper operations and maintenance alone (Federal Energy Management Program, 1999). Operations and maintenance strategies can also result in a healthier building and improved tenant comfort. They can help to achieve the fullest returns on capital investments and facilitate future decision making about energy management initiatives. Described herein are a range of strategies for optimizing operations and maintenance for energy performance.

Energy Standard Operating Procedures

Many institutions have recognized the importance of comprehensive standard operating procedures for energy efficiency. Standard operating procedures are valuable because they promote consistency and gradual learning in building management, while also providing a context for adaptive management.

Energy Audits and Simulations

Conducting an energy audit is a crucial step in the planning of any retrofit project or energy management program. In addition to evaluating the physical fabric of a building, as described in the technology section, energy audits can be used to evaluate nearly every building system, including heating ventilation & cooling systems, hot water heating, electricity and potable water use. Energy audits are useful for evaluating if a potential project is cost-effective based on existing performance criteria. They can also be used to provide benchmarks for future performance, which may be important to investors, budgeting departments, and stakeholders.

Energy audits are also useful as routine building monitoring tools. Even though the building envelope, systems and control set points may not change from year to year in a static building, the energy usage may change drastically. Audits can help determine the cause of unexpected energy use fluctuations, whether they are due to climatic conditions, changes in tenant behavior, or unsuspected damage to equipment or building systems.

John Avina, president of Abraxas Energy Consultants, warns that basic energy audit methods may neglect key elements. Therefore, he recommends conducting audits in conjunction with energy simulations, which involve the comparison of actual energy use to expected energy use given the climatic conditions. This comparison of actual energy use to expected energy use can help determine if the building fabric and systems are performing well and if the buildings' energy goals are being met. Analysis software can also convert the actual, target and deviance energy amounts into dollars saved and spent.

Energy simulation is also very useful in comparing energy performance among a group of similar buildings, which is a central methodology in Brazil's Six Cities Project for energy efficiency (Carlo and Lamberts 2008). Experts recommend undertaking several re-evaluations to properly fit the simulation models to the actual building profile. If this is done properly, these results can then be extended to other typologically similar buildings.

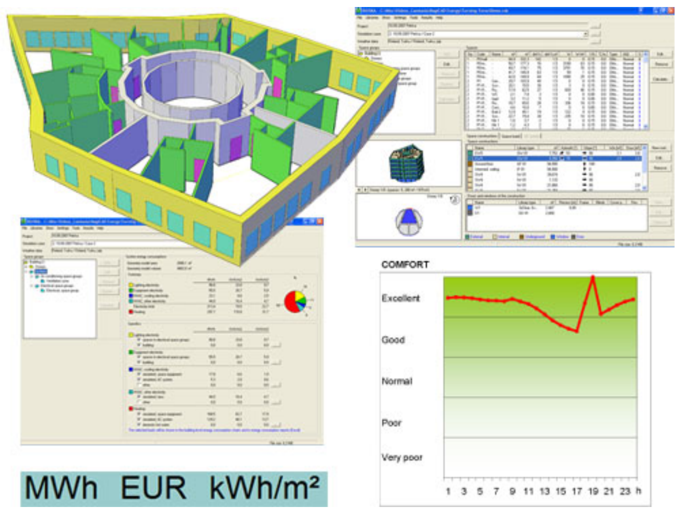

Illustration 7: An example of an energy simulation software system.

Turnover Procedures

Each year, the New York City Housing Authority turns over approximately 3 percent of its housing stock to new occupants. Every apartment turnover is an opportunity to implement energy-related standard operating procedures that could not otherwise be undertaken in occupied apartments. The turnover period is an ideal time to undertake indoor energy auditing such as blower door tests and thermographic scanning to assess air-tightness and heat loss potential. These tests are inexpensive and can be conducted by in-house staff in less than an hour. If problem spots are located, they can quickly be repaired prior to the reoccupation of the apartment. Over time, these routine turnover weatherization procedures will improve the overall air-tightness of NYCHA's buildings, improve thermal comfort for residents, and reduce energy use substantially.

Turnover Procedures at Peter Cooper Village & Stuyvesant Town - New York, NY

After acquiring the high-rise housing complexes Peter Cooper Village and Stuyvesant Town in 2006, the Tishman Speyer Company hired sustainable design consultants Steven Winters Associates to conduct a comprehensive energy audit and propose strategies to reduce energy consumption by 20 percent (SWA, 2008). Although the buildings in these complexes were un-insulated, the energy audits revealed that they were remarkably efficient in terms of heating energy usage. Consultants determined that this efficiency was the result of a fastidious long-term maintenance regime undertaken by the former building owners.

Each time an apartment was turned over, the former building managers had conducted blower door tests to assess air tightness and heat loss potential (Brabon 2009). Air sealing was performed on an as needed basis to eliminate leaks and remedy thermal bridges. By making weatherization a standard operating procedure for apartment turnover, the former managers were able to maintain the building fabric cost effectively and conveniently. In fact, the building was so air tight that adding insulation was not considered to be a cost-effective or necessary retrofit measure, and was not undertaken by the new owners.

Building Management Systems

According to the management principle of "What gets measured gets done," it is essential to know how the equipment and infrastructure in a building is working in order to fix or maintain it (Cohen et al, 2008). This requires data collection on a consistent basis, allowing for measurement across time and in comparison to different buildings.

Building management systems allow managers to gather data on building systems and take necessary action to optimize performance. These powerful tools are especially useful for identifying and analyzing energy savings opportunities. Two types of building management systems are particularly applicable for energy management:

- **Energy Information Systems:**
  According to the New York City Energy Conservation Steering Committee, these systems "gather and analyze energy use data from building-level and/or end-use level meters to provide facility managers with time-series information on energy use and electric demand at intervals as short as five minutes" (2008). These systems can be used to monitor lighting, HVAC, elevators, and other mechanical systems.

- **Energy Management and Control Systems:**
  These systems are similar to energy information systems but they have the added capability of communicating with and remote controlling the equipment being monitored (New York City Energy Conservation Steering Committee 2008). The New York City Housing Authority's Computerized Heating Automated System is an example of an energy management and control system.

In recent years, building management systems have evolved towards employing a standardized data platform that can collect and analyze information about a range of building systems. One such system, known as the BACnet protocol, was developed by the American Society of Heating, Refrigerating and Air Conditioning Engineers and is becoming an international standard that is being used by a number of energy services companies.

Computerized Heating & Automated System (CHAS)

In 2007, NYCHA implemented its Computerized Heating Automated System (CHAS), which enables staff to monitor and remotely control all 210 central heating plants. CHAS also provides information on the amount of heat each building receives as well as alerting NYCHA's Emergency Services Department to potential emergency conditions (e.g., flooding). The system is expected to save NYCHA $20 million a year in fuel costs. One of the goals of the CHAS system was to "create a management tool that will support efforts to utilize a streamlined and specialized workforce oriented to contemporary, micro-processor based heating controls and equipment."

NYCHA seeks to expand the CHAS interface to include other building system monitoring, including water usage, indoor air temperature, and lighting usage. Another monitoring system that could be integrated with CHAS is the Housing Authority Remote Monitoring System (HARMS) for elevators. The HARMS program will allow NYCHA engineers to monitor the performance of every elevator in its portfolio from a central location. HARMS is expected to provide NYCHA with an annual savings of $600,000.

Retrocommissioning

Once a building management system has been implemented, the facilities manager can systematically monitor the building's energy use and identify the most wasteful and inefficient systems. This process is known as retrocommissioning (New York City Energy Conservation Steering Committee 2008). A building manager can then determine ways to correct these inefficiencies, either through maintenance and improved operations, or through capital upgrades. The retrocommissioning methodology can also be used to undertake periodic functional testing of building equipment and systems in order to maintain optimal performance and energy efficiency (New York City Energy Conservation Steering Committee 2008).

Implementing New Technologies & Retrofits

An important goal for public housing authorities seeking to improve energy management is to increase their project management capacity and their rate of testing, implementing, and monitoring new technologies throughout their portfolios. The following pages outline potential strategies for capacity building and project management.

NYCHA's Technology Implementation Process

Over the years, NYCHA engineers and building managers have developed a multi-phase approach to assessing the applicability of new technologies to the city's public housing portfolio. As described by Francis Redhead, NYCHA's Chief of Performance Contract Division, the process includes:

- Identifying a new technology or product at a trade show or through consultants.
- Examining specifications to determine potential feasibility at NYCHA
- Undertaking a pilot installation at a typical housing site and monitoring for a period of time
- Pending successful initial results, expanding the pilot to additional sites
- Operating the multiple pilots typically for a minimum of one year to generate seasonal data
- Analyzing data and performing cost benefit analyses
- Considering barriers to scaling up or ongoing operation
- If feasible, cost effective and desirable, presenting the technology to NYCHA's board of directors
- Considering incorporating technology or product in routine maintenance schedules, capital improvements, or energy efficiency retrofit projects.

Performance Specifications

A specification is a document that describes how a building product, material, or piece of equipment should be designed and manufactured. Performance specifications differ from traditional specifications in that they describe how a building system should perform in terms of energy efficiency, capacity, or some other functional criteria, rather than how the system should be made. The advantage is that they help ensure that performance criteria will be met in a cost-effective manner, while leaving the details of how to meet the criteria up to the contractor or product manufacturer, who are best equipped to make those decisions. If the building manager's purchasing power is large, as in the case of a public housing authority, the private sector will be motivated to compete for the business and achieve the prescribed performance goals.

Refrigerator Performance Specifications

In 1996, NYCHA developed performance specifications for the replacement of over 180,000 refrigerators with high-efficiency models (Business Wire 2002). The specifications called for new units to be free of ozone-depleting chlorofluorocarbons, 20 percent more energy efficient than federal energy standards, and able to meet NYCHA's space and durability requirements (U.S. DOE 2004). The New York Power Authority partnered with NYCHA and solicited interest from 23 other utilities to convince manufacturers of the market potential. Several manufacturers responded to the request for proposals. In the end, NYCHA developed the most efficient refrigerator on the market. The program saved $5.5 million in energy annually and abated 67,000 tons of greenhouse gas emissions.

As described in the Air Conditioner Replacement Feasibility Study, the New York City Housing Authority could consider producing a performance specification for a highly efficient customized air-conditioner with energy demand management features. Development of a performance specification for the air conditioning unit could allow NYCHA to offer energy efficient replacement models while using technological innovation to ensure that overall energy use declined throughout its residences.

Commissioning

Commissioning is a systematic process whereby trained experts monitor and test a piece of equipment or an energy saving technology to ensure that it is designed, installed and functioning according to the design intent and that it meets the expected performance goals. Although the process primarily takes place after the equipment is installed, a commissioning plan ought to be created during the planning and design phases. Periodic re-commissioning should be planned and budgeted for in advance. The goal of commissioning is to enable troubleshooting, diagnostic monitoring and analysis that will uncover system problems and allow for optimization. A closely related process is ongoing measurement and verification, in which facility managers monitor utility consumption and cost savings using engineering calculations, metering, utility bill analysis, and computer simulation. Close monitoring ensures that energy efficiencies are optimally maintained throughout the life of the project, which is essential for successful project financing.

Standard Operating Procedures for New Technologies

Implementing new technology often requires standard operating procedures to ensure optimal operation. For example, most solar thermal systems are installed with an auxiliary heating source that augments the heating of water when solar gain is limited. Because of the use of this auxiliary heating source, detecting system underperformance for the solar thermal equipment requires the use of control procedures or integrated monitoring devices (Solar Energy Industries Assn. 2009). These types of monitoring and control devices are typical in larger systems. If a monitoring company is involved, it may be able to fix the problem remotely. In other instances, a fix may be as simple as needing to clean the solar collector surface.

Training

The New York City Housing Authority operates training centers for employees and outside organizations. It would be valuable to incorporate energy related training into these sessions. The curriculum could emphasize energy auditing, weatherization, standard operating procedures for energy efficiency, commissioning processes, and working with building management systems. Along with training, NYCHA should provide incentives for building staff to exercise extra attention and care regarding energy management issues.

Photo 9: Workers demolishing an old hot water tank at a NYCHA property before installation of the new instantaneous hot water heaters.

Recommendations

The New York City Housing Authority can expand its existing efforts to incorporate energy performance criteria into standard operating procedures for maintenance and operation. For example, indoor energy audits and weatherization can be conducted during the apartment turnover process for minimal cost and disruption to residents. Since these measures take very little time to implement, they can easily fit into the existing time frame of the apartment turnover process. This would ensure that energy efficiency measures and preventative maintenance occurs before the new tenants take residence in the apartment, which will result in long-term energy savings and improved comfort and well being for the residents.

NYCHA should also seek to expand the use of its existing building management system, the Computerized Heating Automated System, to include other building system monitoring of electricity use, water management, or air conditioning use. Where relevant, control features can be built into the system to allow for remote operation and testing. Once fully operable, the building management system can be employed to conduct retrocommissioning to identify especially wasteful building systems and design improvements.

The New York City Housing Authority faces challenges with the time it takes to research and implement new technologies. The capacity of the existing staff limits the number of technologies that can be researched and tested, thus limiting the rate at which the Housing Authority can implement new energy management measures and realize savings. NYCHA is not alone in this limitation. According to the New York City Energy Conservation Steering Committee, project management limitations are the main obstacles to City agencies in implementing energy management initiatives.

To overcome this obstacle, the New York City Housing Authority should consider increasing the number of staff tasked with researching and implementing new technology. Other recommended strategies include: conducting more frequent deployment of pilot installations of new technologies to monitor their effectiveness; exploring innovative procurement strategies to expedite bidding and contracting processes, and partnering with outside institutions to develop performance specifications or technologies that facilitate energy savings in public housing.

Finally, wherever possible, the New York City Housing Authority should incorporate energy performance objectives into its capital project execution. The New York City Energy Conservation Steering Committee recommends the following criteria for selecting and prioritizing energy-related capital projects:

Every major renovation or rehabilitation project should be studied for its energy implications, and the coupling of energy efficiency practices should be considered and prioritized according to the above criteria.

Criteria for Prioritizing Capital Projects

Listed below are the New York City Energy Conservation Steering Committee's criteria for prioritizing capital projects, as detailed in the City's Long-Term Plan to Reduce Energy Consumption and Greenhouse Gas Emissions of Municipal Buildings (2008).

- Projects are cost-effective
- Projects can be replicated in numerous facilities with relatively little site-specific engineering effort
- Projects address defunct or badly outmoded control systems
- Projects address multiple building systems, such as lighting and heating, ventilation and cooling
- Projects contribute to peak load reductions
- Projects characterized by long development cycles and large potential greenhouse gas reductions

PARTICIPATION

The importance of engaging residents in

energy management campaigns cannot be understated. This chapter addresses three key factors in encouraging successful resident involvement: 1) Promoting awareness, 2) Providing incentives, and 3) Empowering residents.

Promoting Awareness

Residents who are well informed about the importance of energy conservation will likely become more efficient users of electricity. In multi-family housing, however, lack of awareness is a common barrier to reducing energy consumption.

A recent survey of social housing residents in Europe found that they generally had limited understanding about energy efficiency and the role they can play in conservation measures (Karner 2007). In some cases, residents were not able to give examples of energy efficient behavior. The residents later realized, however, that they were already taking action through routine tasks such as closing blinds or curtains at night and on summer days, which save energy by moderating light and indoor temperature. This research led to the creation of a multi-city pilot project to train and engage social housing residents in energy efficiency measures.

Outreach

Raising awareness of energy efficient practices should be an ongoing campaign involving a suite of outreach materials (McMakin, Lundgren et al. 2000). A recent report on behavior-based energy efficiency in military housing recommends using pamphlets with energy efficiency tips, posters, children's artwork, demonstration videos starring residents, and promotional gifts such as t-shirts or refrigerator magnets (McMakin, Lundgren et al. 2000). If used effectively, and updated periodically, these materials can help promote a lasting conservation effort.

EXISTING OUTREACH EFFORTS AT NYCHA

The New York City Housing Authority has made great efforts to engage residents in energy conservation measures. NYCHA's tenant handbook describes a number of concrete steps for reducing energy use, including tips for replacing light-bulbs, using less cooking gas, using air-conditioning efficiently, and improving thermal comfort through passive strategies such as closing blinds to limit solar gain.

In the fall of 2007, NYCHA expanded its outreach efforts by initiating *Speaking Green*, a quarterly lecture series—cosponsored by the Clinton Climate Initiative—that brings together staff and residents, along with local business and community leaders. Dr. Jose López, a research professor in oceanography, opened the series with a presentation on climate change and its impact on the Housing Authority's urban communities. According to NYCHA Environmental Coordinator, Margarita López, the lecture series highlights "the need for each individual to recognize [his or her] responsibility to be part of the solution for global warming" (NYCHA Employee Bulletin, August 2008).

NYCHA's energy efficiency campaign has also established resident training and job opportunities. For example, six residents of the Queensbridge South Houses were recently trained and hired to install and maintain new lighting systems.

Engaging children in energy efficiency campaigns is a particularly effective approach. One activity that was successful in military housing was having children fill out educational worksheets that identify energy usage and conservation benefits in each room of their home (McMakin, Lundgren et al. 2000). Even if parents are already using energy efficient practices, children can reinforce this desired behavior.

Energy Usage Data

When residents know how much electricity they are consuming at any given time, they are more likely to conserve (Schonhardt 2008). Studies suggest that customers who have real-time consumption data use between 3 percent and 15 percent less electricity compared to customers who lack that data (Jha 2009). This feedback serves as a learning tool that can lead to more efficient energy use by residents (Darby 2006). A new metering technology known as a "smart meter" can provide this real-time feedback on electricity use (Jha 2009).

Another method of providing residents with feedback about their energy use is to issue statements that compare residents' consumption with a desired level or with their neighbors' consumption. Studies have found that providing residents with energy-use comparisons was an effective way of encouraging conservation (Kaufman 2009). This practice promotes awareness of social norms about energy use, which leads to behavior change (Schultz, Nolan et al. 2007). Several utilities around the country have attempted to provide customers with comparative data on their energy use (Kaufman 2009).

Researchers caution that the effect of comparing residents' energy use to their neighbors can lead to unintended increases in energy use for residents who use less than the average level. These individuals can become complacent about their energy use or might feel encouraged to consume more energy to move closer to the norm. Researchers emphasize the importance of providing positive or negative feedback with the data comparisons.

Another obstacle to implementing real-time data metering or comparative energy statements is that these endeavors would require some form of sub-metering of individual apartments, which is not currently available at the New York City Housing Authority's apartments. A recent effort to implement sub-metering at the privately managed Peter Cooper Village and Stuyvesant Town complexes in Manhattan proved challenging. The complex's managers, Tishman Speyer, ultimately withdrew their application for sub-metering from the New York State Public Service Commission because of resident opposition. Any effort to implement sub-metering at the New York City Housing Authority—even if used for informational purposes only—would have to be carefully approached and would require the support of residents.

The California Youth Energy Services Program

Located in Berkeley, California, the mission of Rising Sun Energy Center is "to create a society that uses water and energy responsibly and equitably." To achieve its mission, Rising Sun Energy Center provides services such as public education about sustainable behaviors and technologies, free residential energy and water audits, and technologies and workforce development programs for youth and young adults with barriers to employment.

Its flagship program is California Youth Energy Services. This program provides young adults ages 15 to 22 with summer employment conducting energy efficiency retrofits. Program participants receive training in auditing techniques and the installation of water and energy saving technologies. After training, participants provide their skills and expertise to residential households.

Since 2000, California Youth Energy Services has trained over 400 young people and conducted more than 9,000 residential energy audits. The program has achieved residential energy savings of 2,500,000 kWh and 31,220 Therms.

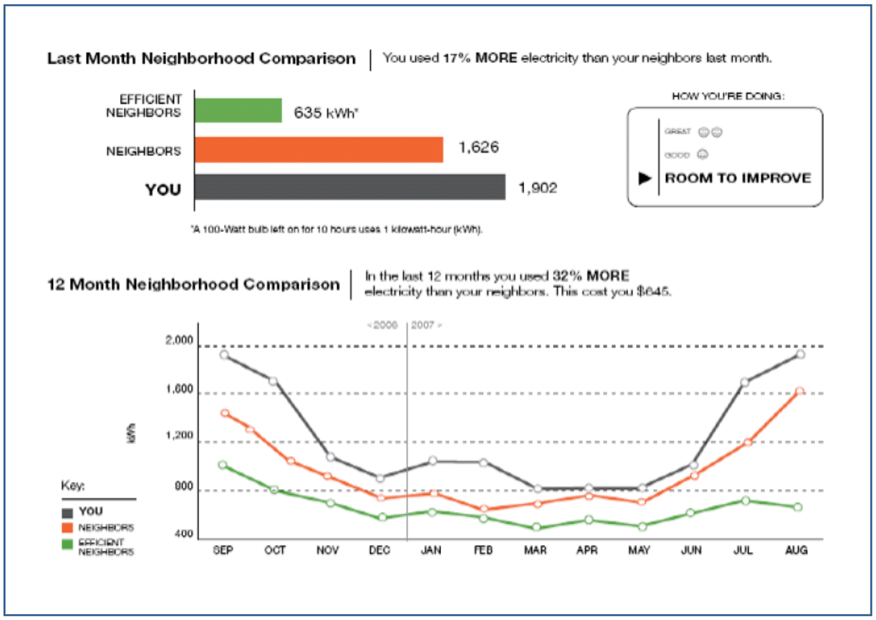

Illustration 8: An example of an energy simulation software system.

Providing Incentives

One of the challenges to implementing resident energy efficiency measures at NYCHA is that the majority of residents (93 percent) pay a flat monthly fee for utilities as part of their rent. This fee does not account for how much energy is actually used, and in most cases residents are not individually metered. From a conservation perspective, this is disadvantageous since residents are more likely to reduce energy use if they have an economic motivation. Yet any effort to charge residents for their actual energy use has political and financial implications because it can jeopardize affordability.

Although most NYCHA residents are not billed directly for their energy use, this does not mean that they have no incentive to conserve. As Chief Financial Officer Felix Lam pointed out at the opening lecture of the *Speaking Green* Series, conservation is vital to the Housing Authority's fiscal health and the longevity of its housing stock:

> Like the climate, NYCHA is facing a crisis. Since 2001, [it] has lost more than 1/2 billion dollars in federal aid, while energy costs have increased by 81 percent since

Sacramento Municipal Utility District Comparative Billing

In 2008, the Sacramento Municipal Utility District, in conjunction with the software company, Positive Energy, sent out statements to 35,000 randomly selected customers. The statements compared each customer's energy usage with that of 100 similar sized homes as well as the top 20 percent of energy efficient households (Ceniceros 2008; Kaufman 2009).

In addition to the data comparison, the statement included positive affirmation if customers were energy efficient. If customers were less efficient, they were encouraged to lower their usage. An initial assessment of the program found that customers who received the comparison statements reduced their energy usage 2 percent compared to those receiving the standard statements (Kaufman 2009). The utility plans on surveying customers to determine which of their energy conservation practices were the most effective (Ceniceros 2008).

In the sample statement to the left, the customer's actual level of energy use is shown in black. Comparisons to efficient households are shown in green and to overall households in orange. The box titled "How you're doing," delivers feedback about customers' energy use. In this statement, the customer has "room to improve."

2002. By reducing spending on energy, NYCHA can help save both the environment, through reduced emission of greenhouse gasses, and public housing, by improving NYCHA's financial strength.

Residents also have an incentive to conserve because money saved on energy costs can be used to improve other aspects of their housing.

A number of approaches using positive incentives are possible in public housing. For example, residents can be offered a financial reward, gift certificate or other prize if their energy usage is below a set standard, either on an apartment or building basis. Offering positive incentives for practicing energy conservation would be simpler to implement and be more popular with residents than charging them for excessive energy use, yet it would still lead to energy conservation and savings for the housing authority.

Another possibility is to hold a competition between buildings within a complex, or between similar-sized buildings throughout NYCHA, to determine which buildings are the most energy efficient. Residents of winning buildings can be rewarded with financial rebates, a cookout or event sponsored by NYCHA, a grant made to the tenant association, improvements to common areas, or other prizes. A competitive approach to energy savings would enhance conservation efforts and help promote energy efficiency as a social norm.

Empowering Residents

To maximize residents' involvement in energy conservation efforts, they must feel empowered to bring about the desired change. By far the most effective way of empowering residents is to involve them in the planning and implementation of the campaign, preferably early in the process (Karner 2007). Involving residents in this way legitimizes the process. Residents are also an important resource for the building management, since they are intimately familiar with the building and its occupants' behavior (Karner 2007). Residents can help identify inefficient practices that occur in the building and suggest improvements. Resident involvement also strengthens the perception of social norms surrounding energy conservation.

University of California at Berkley Energy Saving Competition

The University of California at Berkeley established an energy conservation competition between dormitories that involved over 5,000 students (Berkeley.edu 2007). The dormitory with the largest percent decrease in energy consumption compared with a baseline average was declared the winner. The competition garnered energy savings of more than 11 percent (Berkeley.edu 2007). Although Berkeley's dormitory competition did not offer a reward to students, one could have been offered to serve as an additional motivator.

University of Toronto Energy Saving Campaign - Toronto, Ontario, Canada

A similar effort, entitled "Rewire," was undertaken by the University of Toronto Sustainability Office. Students were encouraged to sign a card pledging that they would be more conscious of their energy-related behavior and would reduce their energy usage. Following outreach efforts, surveys indicated that students were more aware of their electricity use and were more likely to use energy efficiently (Stokes 2006).

Energy Conservation Pledges

Studies have found that the use of energy conservation 'pledges' is an effective approach to engaging resident participation and promoting feelings of empowerment. Residents are given information about different conservation approaches and asked to choose which actions they desire to undertake. Programs implemented at the University of Toronto and Mary Washington University have demonstrated the effectiveness of this approach—see the description accompanying this chapter.

Green Jobs

Creating energy-related training and employment opportunities for residents is another opportunity for promoting awareness and empowerment. As mentioned previously, the New York City Housing Authority has already undertaken a 'green collar jobs' training and employment program on a small scale. The Housing Authority also runs a "Pre-Apprenticeship Training Program" that has trained over 250 residents for placement in building trade apprenticeships (NYCHA 2009). In the future, these programs can be expanded to include energy efficiency training and job placement.

Photo 10: Graduates of the Bronx Environmental Stewardship Training (B.E.S.T.) program install a green roof on the Sarah Lawrence College Taylor Residence Hall.

University of Mary Washington Energy Conservation Campaign Fredericksburg, VA

Mary Washington University and the energy services company NORESCO recently partnered to conduct an energy conservation campaign on campus. Prior to the campaign, students were surveyed about their energy outlooks and consumption behaviors. NORESCO used the survey data to identify the most wasteful practices, which included taking long showers, leaving computers on during periods of non-use, and leaving fans and air conditioners on when no one was home. The company then worked with Resident Assistants to develop an information and direct outreach campaign.

Follow-up surveys indicated that students had become more energy conscious as a result of the campaign (Reuters 2008):

- 33 percent more students turned off air conditioners when not in use.
- 29 percent more students turned off computers
- 18 percent more students used the low-energy hibernate function on their computers
- 11 percent more turned off printers and speakers.
- Shower times decreased by 3 percent
- Frequency of showers increased by 7 percent

Chicago Housing Authority Green Jobs Program

From 1997 to 2001, the Chicago Housing Authority trained a group of residents to undertake basic energy audits. Participating residents received two weeks of training by the environmental consulting firm Kouba-Cavallo Associates, followed by one month of mentorship. Contact between the residents and Kouba-Cavallo continued on an as-needed basis after the conclusion of the mentorship stage. The program ended in 2001 after completing the energy audits needed by the Chicago Housing Authority.

The program was successful in training residents and provided a stepping stone for many to gain employment in other industries. Because residents conducted energy audits, they became aware of how much energy their neighbors were using and came to understand the factors that play into either a higher or lower level of energy consumption.

Recommendations

Promoting energy conservation among public housing residents requires three types of effort: 1) increasing awareness about energy use and the benefits of conservation; 2) creating incentives for residents to conserve; and 3) engaging and empowering residents in the process.

The New York City Housing Authority has already taken positive steps to reach out to residents. For example, NYCHA's tenant handbook outlines practical measures for conserving energy. Also, the Housing Authority's *Speaking Green* lecture series is helping to build awareness among residents about climate change and New York City's commitment to climate change mitigation.

Additional efforts should focus on actively involving residents in the creation and implementation of energy efficiency measures, because knowledge is best acquired through action. A possible outreach program could ask residents to conduct a self-audit of their energy use and make pledges towards reducing energy consumption. Complementary programs could be developed for children, who could then assist their parents in undertaking energy saving measures.

Creating a "green" demonstration apartment in the housing complex would enable hands-on learning about energy efficient practices. This approach would go well with a large-scale energy retrofit campaign and can be used to showcase the results.

Another technique to bring home conservation messages is to install easy-to-read educational inserts or stickers outlining energy saving tips inside of kitchen cabinets. These stickers can be updated as apartments are turned over or as new technologies are implemented.

To maximize resident involvement, NYCHA should develop incentives for residents to conserve. The fact that most of the Housing Authority's building stock is currently master-metered makes comparison of individual resident's energy consumption infeasible.

However, assuming that periodic consumption data is available on a per building basis, NYCHA can do the following:

1) Establish energy use baselines for similar buildings using the past 3 years of consumption data

2) Share financial savings from reduced energy use with the building or complex's tenant association

3) Encourage the building or tenant association to return the savings to residents in the form of a special event or improvements to common spaces

From an administrative perspective, this scheme is simply structured and would be easy to implement. By lowering energy use, it would achieve needed operational savings for the Housing Authority. At the same time, by sharing a portion of the savings, it would benefit residents and empower them in the process.

Partnering with building or tenant associations would be valuable for soliciting feedback about inefficient practices that occur in the building as well as gathering suggestions for improving these practices. Resident involvement through the tenant associations would also strengthen the perception of social norms surrounding energy conservation.

A final opportunity to engage residents would be through green jobs training and employment. The New York City Housing Authority should consider expanding its existing program and partnering with an outside organization to aid in outreach, training, and job placement.

CONCLUSION

Energy efficiency improvements are multifaceted

in scope and require innovation in each of the four domains explored in this report. Creative financing enables the implementation of advanced technology, which is reinforced by effective project management and operations, and supported through robust resident participation.

As the New York City Housing Authority plans the next phase of its energy performance contracting process, it should consider potential investments within the context of the three-step framework described in this report:

- Minimize energy losses through the building envelope.
- Maximize the energy efficiency of building systems.
- Employ renewable energy and regenerative technologies.

The goal of this framework is to capitalize on low cost, near-term energy saving opportunities while maximizing the benefits of longer-term investments. Although this process is described here as three successive steps, in reality, the planning and implementation of each stage will overlap.

First and foremost, the New York City Housing Authority should take advantage of cost-effective auditing techniques to identify areas in need of repair on the envelopes of its buildings. Undertaking weatherization will prevent the escape of heated air during the winter, while maximizing air conditioner efficiency and passive cooling comfort during the summer. Facility managers can easily incorporate energy audits and weatherization into the standard operating procedures for apartment turnover. This will enable ongoing preventative maintenance of building envelopes with minimal disruption to existing residents. Tenants can do their part by reporting drafts or improperly sealed windows to facility managers. Finally, savings yielded from routine weatherization—as well as government grants and loan guarantees—can be used to undertake more capital intensive retrofits, such as applying insulation, sealing slab perforations, and mitigating stack effect.

To maximize the energy efficiency of its building portfolio, NYCHA can replace outdated elevator motors with state of the art models, install low flow faucets and showerheads to reduce water heating, and retrofit lighting systems with efficient fixtures and controls to reduce demand. NYCHA can also investigate replacing residents' existing window air conditioners with high efficiency units. As outlined in the feasibility study, the cost of purchasing new air conditioners can be rapidly recouped through energy savings over the lifecycle of the units. NYCHA can build on the precedent of its 1996 refrigerator replacement program by utilizing performance specifications and industry partnerships to procure high efficiency air conditioning units for its residents. Incorporating demand management features and other available energy saving technologies can ensure that overall energy use decreased, even if the number of residents using air conditioners grows as a result of the program. A program promoting social norms about energy use can augment technological approaches by engaging residents in the energy conservation process.

As the New York City Housing Authority reduces energy losses and increases the efficiency of building systems, it should begin planning for the implementation of renewable and regenerative energy technologies. Solar thermal systems, for example, are a cost-effective add-on to the instantaneous water heaters that NYCHA has already implemented. Coupling solar-thermal systems with photovoltaic cells can help to increase the efficiency of both systems, while decreasing demand for electricity from the congested grid. Financing can be facilitated by a power purchasing agreement or the New York State Solar Electric Incentive Program. Since solar power systems require staff training and ongoing maintenance, they present an opportunity for green jobs development. NYCHA can establish partnerships with local non-profits and energy training centers, possibly through the support of federal workforce development training grants.

Through adopting these practices, the New York City Housing Authority can enhance its proficiency and leadership in energy management. Treating energy conservation as a core mission will enable NYCHA to alleviate financial stress, promote the longevity of its housing stock, and become a national model for large-scale greenhouse gas mitigation.


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GLOSSARY

Alternating current (AC) powered motors: Motors driven directly by the AC electrical power available in the building.

Air-tightness: The ability to prevent air from escaping or entering.

Co-generation: A process where waste energy is used to produce heat or electricity in an industrial facility.

Commissioning: A systematic process whereby trained experts ensure that an energy performance system is designed, installed and functioning according to the design intent as well as meeting performance goals established by the housing authority.

Distributed generation: Systems which are designed to capture and use the waste heat produced in the power generation process on-site in response to a thermal demand, such as steam, hot water, or cooling.

Direct current (DC) powered motor systems: A motor operated on Direct Current, which is converted from alternating current using an AC motor and DC generator.

Energy performance contract: An agreement between a public housing authority and the US Department of Housing and Urban Development that authorizes and structures funding for the "design, acquisition, installation, testing, operation, and where appropriate, maintenance and repair of energy conservation measures" at public housing sites.

Evacuated tube system: Solar thermal system in which sunlight passes through an outer glass tube and heats an absorber tube inside.

Flat-plate systems: The most commonly used solar thermal systems. In a flat-plate system, an insulated and weatherproofed panel containing a heat absorbent black metal material is placed in the path of sunlight. Water pipes behind the plate heat the water inside, causing it to circulate through the system by natural convection.

Insulation: Material which is used to slow the heat transfer through walls and hence aid in keeping a constant temperature.

Mature technology: Technology that has been in use for a long time such that it can be assumed that its inherent problems have been diminished.

Occupancy sensors: Technology that turns off lights automatically when no one is present in a room.

Photocells: Lighting control systems that involve sunlight dimming systems.

Photovoltaic-thermal systems: A system that integrates photovoltaic and solar thermal technologies into one single system with dual production of electricity and heat energy.

Power purchasing agreements: Essentially a contract between the solar provider and customer, typically over a 15- to 25-year term, which includes a fixed annual rate increase.

Superblocks: Plots of land in which several city blocks are aggregated together and cross streets removed to create larger landmasses.

Thermal bridges: Relatively small areas on building facades, roofs, and foundations where high levels of heat loss or gain occur relative to the rest of the building.

Thermal conductivity: The ability of matter to transfer heat.

Thermsyphoning: A process whereby water moves through a system when warm water rises as cool water sinks.

Thermographic photography: Photography which provides a visual assessment of thermal leaks.

Weatherization: a suite of activities that reduce energy consumption and improve efficiency by protecting a building—and its heated and cooled spaces inside—from the outside elements.

ACRONYMS

NYCHA: New York City Housing Authority.

HUD: U.S. Department of Housing and Urban Development.

EUROACE: European Alliance of Companies for Energy Efficiency in Buildings.

LEED: Leadership in Energy and Environmental Design.

ESCO: Energy Services Company.

AARE: American Recovery and Reinvestment Act.

DOE: U.S. Department of Energy

PHA: Public Housing Authority.

DSOM: Decision Support for Operations & Maintenance.

NRDC: Natural Resources Defense Council.

NYPA: New York Power Authority.

WAP: Weatherization Assistance Program.

CFFP: Capital Fund Financing Program.

PPA: Power Purchase Agreement

CHAS: Computerized Heating Automated System.

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