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CASE STUDY

Energy Upgrades in Affordable Multifamily Homes: HOW PROPERTY OWNERS CAN MAXIMIZE THEIR VALUE AND WASTE LESS ENERGY

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EXECUTIVE SUMMARY

This case study highlights the significant savings potential that exists for affordable multifamily housing (AMF) building owners through energy efficiency upgrades. The Natural Resources Defense Council's Center for Market Innovation (CMI) worked with three separate building owners with properties located in New York City ("the City") to assess the process of identifying savings opportunities and to evaluate the availability of financing options that would allow them to realize those savings. The three buildings—one rental property and two cooperative properties—are all large, high-rise buildings subject to the City's Local Laws 84 (LL84) and 87 (LL87), which require owners of private properties of more than 50,000 square feet to benchmark these properties annually and conduct an energy audit and retro-commissioning study every 10 years, respectively. All three buildings' energy consumption was above average, compared with similar multifamily buildings, making them good candidates for an energy upgrade.

Overview of Measures

Energy performance measures (EPMs) are technologies and system improvements that aim to reduce energy through efficiency and conservation. Working with the building owners and Steven Winter Associates, Inc. (SWA), our energy consultant, we identified whole-building packages of EPMs that were cost effective and reduced energy consumption. Due to the similarity in building typology, many of the measures are the same for the three buildings. Some of the recommended measures, like lighting upgrades and installation of low-flow plumbing fixtures, are considered low-hanging fruit; others are more capital intensive, like combined heat and power (CHP), photovoltaics (PV), and orifice plates and thermostatic radiator valves (TRVs). A detailed description of the recommended measures can be found in Appendix A.

Summary of Energy-Reduction and Cost Savings Potential

Using the costs and energy-modeling results from ASHRAE Level II audits, CMI performed a quantitative financial analysis using a value analysis tool that it developed. This open-source tool, calculates the total financial returns for each package of measures. Net implementation costs include the cost of equipment and average labor installation costs. Soft costs such as design fees, or general contractor mark-up are not included as these fees can vary widely depending on the final scope of work.

FIRST-COST HURDLES

To achieve these energy and cost savings, the properties must overcome first-cost hurdles. Like many AMF buildings, these three properties lack the reserves necessary to self-fund. Therefore, they must seek outside sources of financing. This can be challenging for cash-strapped AMF buildings like Tower Gardens, which is currently experiencing negative cash flow.

Still, there are a number of potential financing options available:

- **Conventional recapitalization:** There are instances where a conventional first mortgage refinancing/recapitalization may result in sufficient loan proceeds to permit EPMs to be folded into a project's general scope of work.
- **Green first mortgage refinancing:** A limited number of mortgage lenders are willing to underwrite to a portion of projected energy cost savings. By recognizing a portion of the cost savings in the mortgage sizing, the lender is able to issue a larger loan amount to cover the additional first cost of the EPMs.
- **Energy Service Agreements:** Creditworthy AMF properties with larger capital scopes can take advantage of off-balance-sheet financing mechanisms like energy services agreements (ESAs). These are effectively operating contracts that can offer a no-money-down solution and can be treated as an operating expense, depending on the accounting treatment of the financing arrangement. Under an ESA, a developer funds, installs, and maintains the improvements at the property, and in exchange the owner pays a portion of the savings realized to the developer over an agreed-upon term.
- **Unsecured direct loan:** AMF properties with adequate debt service coverage can also take advantage of unsecured, direct loans underwritten to savings. The New York City Energy Efficiency Corporation (NYCEEC) issues such loans. Unlike mortgage loans, unsecured loans are not collateralized by the property and are full recourse to the borrower.
- **Power purchase agreement (PPA):** In lieu of purchasing a PV or cogeneration system, an owner can enter into a PPA, which is similar to an equipment lease. A developer owns, installs, and maintains the equipment at the host's property; in exchange, the host enters into a contract to purchase the energy output (kWh for PV and for cogeneration) at an agreed-upon price over a specified term (15–20 years). This can result in cost savings for the host, depending on the agreed-upon price of the electric or thermal output compared with the price from the grid. This arrangement also eliminates price volatility over the term of the agreement.

Financial Analysis Summary	Regina Pacis	Tower Gardens	River View Tower
Source Energy Reduction	28%	21%	29%
Annual Utility Savings	22%	22%	29%
Total Annual Savings	$80,600	$203,100	$514,500
Weighted Average Expected Useful Life (EUL)	16	17	17
Discount Rate	5.0%	5.0%	5.0%
Total Gross Savings over EUL	$1,289,000	$3,452,700	$8,746,500
Present Value of Cost Savings over EUL	$873,524	$2,289,763	$5,800,507
Net Implementation Costs	$558,300	$1,037,700	$1,634,400
Net Present Value of Investment	$315,224	$1,252,063	$4,166,107
Return on Investment over EUL	56%	121%	255%
Internal Rate of Return	12%	18%	31%
Simple Payback in Years	7	5	3

Future Opportunities

Throughout this engagement with the three AMF buildings, the CMI team experienced firsthand the very real barriers facing owners as they pursue energy efficiency for their properties. Time, knowledge, and internal capacity constraints, together with financing obstacles, make the process of an energy upgrade challenging. Yet, there is a renewed focus on the AMF sector, with new resources coming soon to help. New York City recently launched its Retrofit Accelerator to address the needs of larger buildings, which are already subject to LL84 and LL87. The New York State Energy Research and Development Authority (NYSERDA) expects to reopen its Multifamily Program with technical and financial assistance to help AMF buildings achieve source energy savings of 25 percent or more and provide incentives for individual measures as well. NYCEEC has developed an exciting new tool called the eeficienSEE calculator, which can estimate energy and cost savings for buildings covered under LL84 and LL87 just by entering the address, allowing owners to get a sense of potential savings before conducting an audit. NYSERDA has also established a program offering long-term, low cost financing for solar installations. In addition, multifamily building owners and residents can also subscribe to Shared Solar projects in their community, receiving credits on their utility bill. And New York State utility energy efficiency programs, previously restricted to buildings with 75 units or fewer, are now able to provide incentives to all multifamily buildings. These along with other initiatives that the City and state are working on are intended to support building owners in unlocking potential energy efficiency savings in the AMF sector.

INTRODUCTION

Ensuring the availability of affordable multifamily housing (AMF) is an important part of a vibrant, productive, and equitable city. For many AMF buildings, energy consumption and utility costs are the largest operating and maintenance expense. This case study highlights the compelling business case for energy upgrades to reduce energy costs in the AMF sector.

PROJECT BACKGROUND

The three AMF properties examined in this study are located in Brooklyn, the Bronx, and Manhattan. Constructed between 1960 and 1975, they are all high-rise masonry structures with two-pipe steam heating systems and are master-metered for electricity. The two cooperative buildings use No. 2 heating oil; the rental property has a dual-fuel boiler that uses natural gas and oil.

Building	Year Built	Type	Gross SF	Units	Stories	Fuel Type	Location
Regina Pacis	1972	Low-Income Rental (Seniors)	132,209	167	18	Gas/Oil	Brooklyn, NY
Tower Gardens	1961	Moderate-Income Cooperative (Families)	242,700	209	14	#2 Oil	Bronx, NY
River View Tower	1965	Moderate Income Cooperative (Families)	400,800	386	24	#2 Oil	Manhattan, NY

REGINA PACIS

Building in need of an update. More than 40 years old, the building's systems and apartment units are in need of a significant face-lift. CB Emmanuel Realty LLC, the developer of the property, is planning to refinance with New York State Homes and Community Renewal (HCR) using bond and the federal low-income housing tax credit (LIHTC) program and to perform moderate rehabilitation as part of its acquisition strategy. While in overall good condition, the building's mechanical systems, common area spaces, and apartment interiors are well past their prime. With utility expenses representing more than 40 percent of the building's total operating budget, CB Emmanuel wanted to explore the potential for folding energy efficiency and renewable energy strategies into its rehabilitation scope.

Potential Savings: SWA recommended eight energy-saving measures. A description of these measures can be found in Appendix A.

Typical Annual Utility Cost: $360,700					
Measure	Annual Savings	Savings as % of Typical Utility Costs	Cost	Rebates*	Simple Payback (Years)
Orifice Plates & Thermostatic Radiator Valves	$12,900	3.6%	$219,100	$0	17.0
2. Low-Flow Plumbing Fixtures	$14,400	4.0%	$8,800	$0	1.0
3. Linkageless Burner	$8,600	2.4%	$71,400	$0	8.3
4. Common Area Lighting Upgrades	$9,000	2.5%	$43,900	$0	4.9
5. Apartment Lighting Upgrades	$7,900	2.2%	$80,800	$0	10.2
6. Community Room Thermostat	$200	0.1%	$1,500	$0	7.5
7. Advanced Submetering	$19,300	5.4%	$98,800	$0	5.1
8. Photovoltaics (Solar Panels)	$9,000	2.3%	$200,000	$166,300	4.1
TOTAL	**$80,600**	**22.3%**	**$724,300**	**$166,300**	**6.9**

* Con Edison and NYSERDA have recently expanded their rebate offerings, which may further improve the economics of these investments.

Financial Analysis

The package of measures recommended for Regina Pacis produces projected cost savings of $80,600 annually, or nearly $1.25 million in savings over the weighted average expected useful life of the combined measures. Regina Pacis would reduce its yearly source energy consumption by 28 percent and realize yearly utility cost savings of 22 percent. Total implementation costs would be $558,000 after incentives and investment tax credits of $166,300. As shown in Table 1, this translates into an investment net present value (NPV) of $315,224 (assuming a 5 percent discount rate), a return on investment of 56 percent, and an internal rate of return of about 12 percent. CB Emmanuel can expect the investment to pay for itself in seven years.

TOWER GARDENS

Building in need of an energy upgrade. Despite a refinancing in 2006, Tower Gardens still faces rising utility expenses, which represent almost 54 percent of its total annual operating budget. With local wages and fixed operating expenses out of its control, Prestige and the coop board saw reining in utility costs through a whole-building energy upgrade as a tremendous opportunity. Rather than waiting until the filing deadline of June 2017 to comply with New York City's LL87 energy audit and retro-commissioning regulation, Prestige and the board chose to act now to explore solutions to Tower Gardens' that could reduce this significant expense.

Savings Potential: SWA recommended eight cost-effective energy-saving measures:

Typical Annual Utility Cost: $927,400					
Measure	Annual Savings	Savings as % of Typical Utility Costs	Cost	Rebates*	Simple Payback (Years)
1. Orifice Plates & Thermostatic Radiator Valves	$50,900	5.5%	$315,300	$0	6.2
2. Closing of Elevator Smoke Vents	$900	0.2%	$3,000	$0	3.3
3. Advanced Submetering	$46,500	5.0%	$123,300	$0	2.6
4. Cogeneration (CHP)	$70,900	7.5%	$350,000	$0	5.0
5. Common Area Lighting Upgrades	$16,500	1.8%	$81,700	$0	5.0
6. Apartment Lighting Upgrades	$8,900	1.0%	$15,700	$0	1.8
7. Ground-Floor Window Upgrades	$900	0.1%	$10,800	$0	12.0
8. Apartment Refrigerator Standards (Energy Star®)	$7,600	0.8%	$137,900	$0	18.1
TOTAL	**$203,100**	**22.0%**	**$1,037,700**	**$0**	**5.0**

* Con Edison and NYSERDA have recently expanded their rebate offerings, which may further improve the economics of these investments.

In addition to the above listed measures, Tower Gardens is exploring a conversion from oil to natural gas heating fuel, which will increase utility cost savings and likely shorten the payback period for the package of measures. Further studies are required to evaluate the costs and feasibility of implementing a fuel conversion. Note that the above measures were analyzed presuming that No. 2 heating oil remains in place. Should Tower Gardens pursue an oil to natural gas heating conversion, the cost savings and paybacks related to each measure would change due to the interdependency of the measures.

Not surprisingly, the measures that have the largest up-front costs and more complex implementation processes are often the measures that can deliver the greatest savings. As discussed later in this report, there are resources available to help building owners navigate through the complexity of installing and financing these measures.

Financial Analysis

The package of measures is projected to produce $203,100 in yearly cost savings—equivalent to more than $3 million in total gross cost savings over the weighted average expected useful life of the combined measures. This represents a reduction in yearly source energy consumption of 21 percent and yearly utility cost savings of 22 percent. Total implementation costs are $1,037,700. No incentives were assumed for this analysis. This translates into an investment net present value of $1.25 million (assuming a 5 percent discount rate), a return on investment of 121 percent, and an internal rate of return of 18 percent. The board can expect the investment to pay for itself in five years.

RIVER VIEW TOWER

Building in need of an energy upgrade. Like Tower Gardens, River View Tower's utility expenses represent a significant share of its yearly operating expenses—approximately $1.8 million out of a total operating budget of $4 million, or 43 percent. Over the past five years, the building has been using reserves to gradually make repairs and upgrades, including the installation of a new boiler and backup generator. But the building's runaway utility expenses have not been addressed through these improvements.

Savings Potential: SWA recommended 10 cost-effective energy-saving measures:

Typical Annual Utility Cost: $1,800,000					
Measure	Annual Savings	Savings as % of Typical Utility Costs	Cost	Rebates*	Simple Payback (Years)
1. Orifice Plates & Thermostatic Radiator Valves	$95,300	5.29%	$416,400	$0	4.4
2. Low-Flow Plumbing Fixtures	$67,400	3.74%	$24,000	$0	0.4
3. Advanced Submetering	$86,200	4.79%	$217,100	$0	2.5
4. Cogeneration (CHP)	$182,700	10.15%	$450,000	$0	3.0
5. Common Area Lighting Upgrades	$45,500	2.53%	$59,500	$0	1.3
6. Apartment Lighting Upgrades	$9,900	0.55%	$61,800	$0	6.2
7. Garage Fan Demand-Controlled Ventilation	$1,600	0.09%	$12,000	$0	7.5
8. Apartment Refrigerator Standards (Energy Star®)	$17,000	0.94%	$218,600	$0	12.9
9. Photovoltaics (Solar Panels)	$8,900	0.50%	$175,000	$0	20.0
TOTAL	**$514,500**	**29%**	**$1,634,400**	**$0**	**3.2**
10. Conversion to Natural Gas Heating & Hot Water	$409,600	22.76%	TBD	$0	N/A

* Con Edison and NYSERDA have recently expanded their rebate offerings, which may further improve the economics of these investments.

Financial Analysis

Based on the projections, River View Tower would realize total annual savings of $514,500, or more than $8 million in total gross savings over a weighted average expected useful life of the combined measures (17 years). River View Tower would reduce its yearly source energy consumption by 30 percent and realize yearly utility cost savings of 29 percent. Total implementation costs are $1.63 million with no incentives assumed. Utilizing a 5 percent discount rate, the net present value of the investment is estimated at $4.17 million. This reflects a return on investment of 255 percent and an internal rate of return of 31 percent. The investment would reach payback in about three years. This analysis does not include conversion from oil to natural gas fuel; further scoping studies are required to determine cost effectiveness. Still, the difference in commodity pricing is projected to result in yearly savings of more than $409,000. Like Tower Gardens, should River View Tower decide to pursue an oil to natural gas heating conversion, the costs savings and paybacks of the above measures would change due to the interdependency of the measures.

FINANCING SOLUTIONS

There are a variety of financing options available to fund first costs, ranging from conventional first mortgage loan refinancings to off-balance-sheet operating contracts like ESAs and PPAs. Of course, a property's ability to access any particular type of financing will depend on its current financial position and ability to obtain the necessary consents from other lenders, investors, and regulators who already have a stake in the property. A brief assessment of the potential financing vehicles for each property follows.

REGINA PACIS

CB Emmanuel intends to acquire and recapitalize Regina Pacis with HCR using bonds and the federal LIHTC program. The company expects the refinanced first mortgage in combination with the LIHTC equity raise will be sufficient to fund the first six EPMs. Should there be a funding gap, it could consider an unsecured direct loan underwritten to projected cost savings from, say, NYCEEC to supplement its capital stack. While an unsecured direct loan is theoretically possible,

it would require mortgage lender and equity investor consents. This can be challenging for an LIHTC transaction, since conventional lenders and investors are generally less comfortable with full recourse loan instruments that underwrite to projected energy cost savings.

CB Emmanuel is also considering acquiring a photovoltaic system via a PPA, instead of purchasing a PV system outright and folding it into the general rehabilitation scope. Typically the PPA price of electricity is less than or equal to the grid price; CMI ran a theoretical PPA analysis that showed that the cost to Regina Pacis would be approximately the same. The PPA would eliminate price volatility over the term of the agreement because the price per kWh and annual escalation rate are locked in. In contrast, if CB Emmanuel purchased a PV system outright and was able to take advantage of incentives and investment tax credits, the implicit price of electricity generated by the system would be less than what the building currently pays, resulting in a cost savings of $9,000 to $10,000 annually.

TOWER GARDENS

Tower Gardens currently has a debt coverage ratio of less than 1. As such, an unsecured direct loan or an ESA may not be available financing options. Tower Gardens could consider a traditional first mortgage refinancing in conjunction with a modest increase in shareholder assessments. Theoretically, this could provide sufficient loan proceeds to fund the recommended package of EPMs. While an increase in assessments is not an optimal solution, it is a practical one. A modest increase in assessments today could serve to reduce the need for assessment increases for years to come.

Alternatively, a green mortgage refinancing could make the energy upgrade feasible without an increase in assessments. On a theoretical basis, if a green mortgage lender is willing to recognize 50 percent of Tower Gardens' cost savings ($101,550) in its loan underwriting, it could issue a large enough loan amount to repay the property's existing first mortgage and fund all eight EPMs. Tower Gardens' negative cash flow would be transformed into positive cash flow of approximately $78,000 in the first year after implementation. This scenario assumes a 5 percent refinancing rate and a 20-year term.

RIVER VIEW TOWER

River View Tower has positive cash flow. It is in a strong financial position to participate in an ESA or unsecured direct loan from NYCEEC. Of course, utilizing either of these financing vehicles would require existing mortgage lender consent, which can sometimes be challenging to obtain. Nonetheless, these two options are available to facilitate an energy upgrade at the property.

River View Tower could pursue a conventional mortgage refinancing without taking into consideration energy cost savings and still have sufficient surplus loan proceeds to fund the first nine recommended EPMs. This theoretical scenario presumes a 5 percent refinancing rate, 30-year amortization and term, no reduction in utility expenses for underwriting purposes, and no increase in shareholder assessments. It represents the most straightforward means of funding the recommended EPMs. Alternatively, if River View Tower had access to a green mortgage financing program that recognized up to 50 percent of energy cost savings in its loan underwriting, it would theoretically be able to support a first mortgage loan amount of more than $12 million. This substantially higher loan amount would enable the property to refinance its existing debt, fund the first nine EPMs, and have more than $3.7 million in unused proceeds to fund other improvements. Only a handful of national and New York lenders offer green mortgage products; these include the Community Preservation Corporation (CPC), Fannie Mae, the State of New York Mortgage Agency (SONYMA), and the New York City Housing Development Corporation (HDC), which makes loans only to properties regulated by the New York City Department of Housing Preservation and Development (HPD).

SUMMARY

All three properties have the potential to realize significant energy and cost savings through the implementation of energy efficiency measures. All three are subject to the City's LL87, with filing deadlines coming up within the next year and a half. Now is the optimal time to assess savings potential and explore how cost-effective measures can be implemented at these buildings. Since most AMF buildings do not have the resources to self-fund these improvements, the key next step is to evaluate financing options to overcome first-cost hurdles. There are a variety of resources in the City and New York State that can assist with financing. HCR now has special financing for Mitchell Lamas and requires benchmarking and improved energy standards for all preservation projects. NYCEEC, CPC, HDC, HPD, and Fannie Mae provide energy efficiency financing products underwritten to projected cost savings. And NYSERDA has a financing program for solar PV, and for those unable to deploy solar on their building, access to the benefits of solar via a "community solar" program.

CMI in collaboration with SWA has published an Affordable Multifamily Housing Integrated Energy Retrofit Process Guide specifically written to help AMF property owners and other decision makers through the energy upgrade process from concept through implementation. For City buildings covered under LL84 and LL87, there is also the New York City

Retrofit Accelerator, a technical and financing platform akin to a one-stop shop, where knowledgeable service providers are available to help guide owners through the technical aspects of an energy upgrade as well as connect them with suitable financing options.

The triple-bottom-line benefits of energy upgrades are undeniable. Now more than ever, there is a focus on bringing energy efficiency to the AMF sector, with increasing resources and assistance available to AMF owners.

APPENDIX A: MEASURES

Orifice Plates and Thermostatic Radiator Valves (TRVs). Orifice plates and TRVs are a more efficient alternative to replacing broken steam traps in two-pipe steam heating systems like the ones in the three Mitchel-Lama properties in this study. Two-pipe steam systems typically have issues with unbalanced and uncontrollable heating, with large portions of the buildings being overheated and small portions being underheated. Overall, this results in higher-than-necessary energy consumption. To address the problem, steam traps must be replaced every three years, though this is rarely done.

Orifice plates in combination with TRVs offer a more permanent and efficient solution to balancing and regulating space heating. Their installation allows occupants to easily adjust the amount of heat in each room, as needed. TRVs sense room air temperature and open or close to maintain comfort. This serves to eliminate overheating, increase efficiency, and conserve fuel.

Closing of Elevator Smoke Vents (Glass). In high-rise buildings, some of the largest commonly found openings where energy can escape are vents at the top of elevator shafts and stairwells. These openings are intended to vent smoke in the event of a fire. However, there are two other code-compliant options that allow the partial or full closure of vent openings: installing annealed glass to partially cover the vent opening, or using motorized dampers that fully cover the opening and open mechanically. The latter saves more energy, but at a substantially higher installation cost.

Submetering. All three buildings are master-metered for electricity, with resident and common area electricity use billed to one central account. Tenants are not directly charged for their electricity use. Instead, apartment electricity use is included in residents' maintenance charges, the amount based on apartment size.

With submetering, residents become financially responsible for their electricity usage. Each apartment unit receives an advanced (digital) meter so tenants can view their electricity consumption and control their behavior to reduce utility costs. Residents are often resistant to the idea of submetering because they see it as an additional financial burden, but in reality it can empower them to lower their overall housing costs. Studies conducted by NYSERDA and HCR have shown significant electricity savings of 18 to 26 percent when advanced meters individually monitor each apartment unit's electricity consumption.

Cogeneration. Combined heat and power (CHP), also known as cogeneration, is the simultaneous production of electricity and thermal energy (heat) on-site. Larger buildings with high domestic hot water usage are typically good candidates for CHP. CHP systems are combustion appliances that require sufficient gas service and venting. They also require thermal storage (i.e., water tanks) to act as a heat battery. Despite these space and siting challenges and an involved construction process, CHP's energy and cost benefits frequently outweigh these challenges, especially in buildings the size of Tower Gardens or River View Tower.

Because CHP consumes more energy on-site, it generally causes an increase in site energy usage. But the carbon footprint reduction and source energy savings are still significant, since CHP brings generation to the site, meaning less reliance on the grid. This results in significant savings at the power plant level. It also provides important sustainability, resiliency, and cost savings benefits. To more accurately determine the financial benefits of CHP, Tower Gardens would need to undertake a feasibility study to determine the best location for the units and the costs associated with installation. That study is beyond the scope of this demonstration project.

Linkageless Burner Retrofit. Compared with a standard modulating burner, a linkageless burner system delivers a more precise mixture of air and fuel during the combustion process. This results in higher efficiency. Standard burners with mechanical linkages have components that can fall out of calibration. Linkageless systems use sensors and microprocessors to deliver the most efficient fuel-to-air ratio. System components like the fuel valve and combustion damper are powered by separate actuators, which can be calibrated for optimal positioning at a range of firing rates. Additionally, these systems have the capability to communicate with building automation systems, resulting in reduced fuel costs.

Photovolataics (PV or Solar Panels). Solar panels can offer great savings by allowing users to harvest energy from sunlight rather than purchasing it from the grid. In order for this measure to be cost-effective, a building must have sufficient roof area and a high electricity cost. The cost-effectiveness of this measure also depends, of course, on the initial installation cost of the system. Recognizing that PV systems can be expensive, the federal government, along with state and city entities, offers a variety of incentives to defray the initial outlay. If an owner can take advantage of these incentives, including NYSERDA or utility incentives, federal investment tax credits (ITC), and accelerated depreciation losses, a PV system can produce attractive returns and meaningful savings. Up-front costs can be eliminated through lease or PPA financing programs, but that means the tax credits and other benefits are monetized by the financier.

Common Area Lighting Upgrade. In older properties, hallways, stairwells, community rooms, and rear building spaces are often illuminated by conventional and inefficient lighting fixtures. Upgrading these fixtures to high-efficiency LED equivalents will improve lighting efficiency (lumens/watt), reducing energy consumption. Additionally, LEDs typically have a more appropriate color-rendering index for clarity and visual recognition under low-light conditions. These qualitative benefits offer improved vehicular and resident safety.

LEDs last longer than regular incandescent or fluorescent lamps and do not require any more maintenance than existing fixtures. To further optimize energy use and cost savings, occupancy sensors can be installed on stairwell LED fixtures to reduce light levels when the space is unoccupied. This again reduces electricity consumption and results in greater cost savings.

Apartment Lighting Upgrade. The in-unit inspections of all three properties revealed that residents use traditional incandescent light bulbs and that some hard-wired fixtures would need to be replaced to accommodate LED bulbs. When residents do not pay directly for their electric usage, they do not have a financial incentive to upgrade fixtures and purchase the pricier, but more efficient bulbs. To address this, building management could purchase LED lighting in bulk to sell to the residents at cost. This type of program could be used to offset first costs and increase resident awareness.

Window Upgrade. Replacing all single-pane windows with double-glazed, argon-filled, low-E thermally broken windows will minimize energy loss by reducing heat transfer. This produces cost savings in the form of reduced fuel consumption for heat.

Apartment Refrigerator Standards. Many of the buildings' apartments have older, inefficient refrigerators instead of newer Energy Star–rated units. On average, new Energy Star–rated units would use 30 percent less energy than currently installed models. The audit recommends that the cooperatives' policies be revised to require residents replacing their units to purchase an Energy Star–rated model and that the property buy Energy Star–rated units in bulk. This approach would offset the slightly higher first costs of purchasing a higher-efficiency refrigerator and would result in electric cost savings for the building (or for residents if submetering is implemented).

Low-Flow Plumbing Fixtures. Installing low-flow plumbing fixtures can reduce flow rates, which in turn can help decrease water bills and domestic hot water energy costs. This measure is generally highly cost-effective, with a payback of less than one year.

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