

Retrofit Audits and Cost Estimates: A Look at Quality and Consistency

L. Eisenberg, C. Shapiro, and W. Fleischer
Consortium for Advanced Residential Buildings

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Golden, CO 80401

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Prepared by:

Steven Winter Associates, Inc.

&

Pratt Center for Community Development

of the

Consortium for Advanced Residential Buildings (CARB)

61 Washington Street

Norwalk, CT 06854

Technical Monitor: Cheryn Metzger

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Unless otherwise noted, all figures were created by CARB.

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Definitions

AC	Air conditioning
AFUE	Annual fuel utilization efficiency
BEopt	Building Energy Optimization (tool)
Btu	British thermal unit
CARB	Consortium for Advanced Residential Buildings
DHW	Domestic hot water
EF	Energy factor
EGUSA	EnergyGauge USA
gal	Gallon
h	Hour
in.	Inch
kBtu	Thousand Btu
MMBtu	Million Btu
MURS	Minimum upgrade reference scenario
NREL	National Renewable Energy Laboratory
NYC	New York City
NYSERDA	New York State Energy Research and Development Authority
o.c.	On center
SEER	Seasonal energy efficiency ratio
TREAT	Targeted Retrofit Energy Analysis Tool
W	Watt

Executive Summary

Retrofit NYC Block by Block is an outreach program targeting owners of one- to four-family homes. With more than 600,000 citywide, these homes are most common building type in New York City (NYC). The program is administered by the Pratt Center for Community Development and implemented by four nonprofit, community-based organizations. Block by Block connects residents, businesses, and religious and civic organizations in predominantly low- and moderate-income neighborhoods with one or more of a half-dozen public and private financial incentive programs that facilitate energy efficiency retrofits.

In this research project, investigators initially sought to evaluate the approach, effectiveness, and energy use reductions accomplished by the Retrofit NYC Block by Block Program. An early objective of this research was to determine if the measures, their costs, and the achieved savings were predictable enough to significantly reduce the use and cost of individualized energy audits and expedite the recommendations process. Unfortunately, the program began operating later than anticipated and the activity has ramped up more slowly than expected. These factors, along with the limited period of performance for this research project, did not allow adequate information to be collected on a significant number of retrofit projects. As a result, the initial research objective could not be accomplished.

Instead, with the Block by Block program in the early stage of operation, research efforts focused on examining the audit reports for quality, comprehensiveness, and consistency. Based on a closer look at six buildings for which utility data were available, two primary areas of concern emerged: the energy savings estimates and the costs of the recommended measures. Audit results were found to be highly variable even across very similar buildings.

A review of audit reports found that model predictions and energy savings estimates were high and not consistent with actual energy usage data. At a recent Building America team meeting, several researchers raised concerns about the accuracy of building simulation programs when modeling older, poorly insulated buildings. Most of the modeling tools were developed for new construction that performs better. Research into this potential modeling problem is warranted.

Using utility data to calibrate the existing building model is an often cited approach to improving accuracy, but obtaining utility data is difficult and time consuming. In addition, these data are often incomplete. It is not apparent that the utility data were entered into the Targeted Retrofit Energy Analysis Tool (TREAT) software (a building modeling tool) in the projects reviewed for this project. Research toward a process that will make household energy use data readily available will enhance future program efforts.

Across the audit reports reviewed, cost information by energy efficiency measure was highly variable. Plausible explanations for the lack of detailed information follow:

- Auditors are often not qualified to provide contractor pricing for the broad spectrum of measures being recommended (i.e., this project revealed that insulation contractors might provide a qualified and competitive price for the insulation measures but might only furnish ballpark estimates for heating system measures).

- Significant remediation costs associated with health and safety are included in the energy efficiency measure costs.
- Total replacement costs are provided instead of the incremental cost of a more energy efficient replacement system.

A reliable third-party resource for efficiency measure cost information such as that under development by the National Renewable Energy Laboratory could help alleviate the inconsistent and unreliable cost information problems.

1 Project Objectives

Important aspects to achieving Building America goals are understanding retrofit delivery practices and the technical challenges involved in implementing packages of efficiency measures at the community scale. In this research project, Consortium for Advanced Residential Buildings (CARB) investigators initially sought to evaluate the approach, the effectiveness, and the energy use reductions accomplished by the Retrofit NYC Block by Block Program.

Retrofit NYC Block by Block is an outreach program administered by the Pratt Center for Community Development. It targets owners of one- to four-family homes. With more than 600,000 structures citywide, these homes are the most common building type in New York City (NYC). Four community-based organizations are participating in Block by Block and each employs one full-time outreach coordinator. The outreach coordinator connects residents, businesses, and religious and civic organizations to incentive programs that facilitate energy efficiency retrofits. They work in predominantly low- and moderate-income neighborhoods. About a half-dozen public and private financial incentive programs are potentially available. The organizations that conducted the outreach in this program, funded by the NYC Council, were (1) Bedford Stuyvesant Restoration Corporation, Bedford Stuyvesant, Brooklyn; (2) Chaaya, CDC, Jamaica and Jackson Heights, Queens; (3) Neighborhood Housing Services of Staten Island, Northern Staten Island; and (4) Sustainable South Bronx, Soundview Section, the Bronx.

Project personnel hypothesized that one- to four-family homes being targeted within each of the four neighborhoods would likely need similar retrofit measures (e.g., roof and cellar insulation, pipe insulation, air sealing, weather stripping, lighting and appliances, and low-flow fixtures, among others). Even though, over time, variation in the row houses has increased because of individual homeowner maintenance and investment, the homes are built at the same time, of the same materials, often with the same floor plan. Therefore, an initial objective of this research was to determine if the measures, their costs, and the achieved savings were being replicated consistently. If so, it might be appropriate to significantly reduce the use and cost of individualized energy audits and expedite the recommendations process.

The initial objectives of this research project were designed to answer the following questions:

- Can row houses of similar types (e.g., steam-heated brownstones) readily achieve similar and significant energy use reductions with common retrofit measures?
- Is there a package, or packages, of measures that could be offered on a large scale and under what conditions?
- What are the energy savings of these measures/packages?
- Can the energy savings be reliably predicted?
- Can the measures be reliably implemented with assured energy savings?
- What barriers are there to mass adoption of this strategy in other neighborhoods?
- How much would lowering contractor prices and transaction costs reduce the cost to implement similar measures at a neighborhood scale?

- Are buildings similar enough (i.e., construction type, heating fuel and equipment, and distribution system) and energy performance predictable enough to consider circumventing the significant hurdle of utility data collection?

The NYC Block by Block program began full operation in spring 2011, later than planned, and operations have ramped up slowly. No comprehensive retrofits were completed within the period of performance of this research project, so none were analyzed in this research. With this change in schedule, the scope of the research needed to be adjusted significantly. The final objectives for this research were designed to answer the following questions:

- Are the program audits high in quality, comprehensive, and consistent across different providers?
- Were auditor energy use and savings projections consistent with modeling projections?

Appendix A contains a report describing the Block by Block Program's outreach approach and accomplishments to date.

2 Technical Approach and Findings

2.1 Data Collection and Tracking System Development

To assist the Block by Block community partners in managing participants and monitoring data, the Pratt Center for Community Development customized a Web-based tracking system on the Salesforce platform. CARB personnel helped create the tracking system by offering recommendations for data items to be collected. Because data were being extracted from a variety of different sources, across several programs, it was important to define what information was necessary to record for analysis purposes. Building on knowledge from previous research and a review of the various audit reports and energy models, CARB advised on critical building characteristics, utility-related inputs, and energy conservation measures for which data fields were developed.

Pratt's database system became available online to its partners in July 2011 after an extensive development period. The system is a unique database of building characteristics, energy use data, audit information, and retrofit implementation activity for NYC's small homes. The database captures energy assessment and retrofit information across all incentive programs (New York State Energy Research and Development Authority [NYSERDA], utility, city, and state and federal programs). Pratt representatives are currently investigating how to make this database tool available to other neighborhood retrofit campaigns.

Pratt staffers are interested in continuing to analyze project data for lessons learned on outreach, program design, and retrofit measures for urban properties. This project meant to test the hypothesis that similar building types require similar types of retrofits. It was also intended to generate ideas about program design that would maximize impact for public dollars invested in housing retrofits. Data collection and entry into the tracking system is a step toward this end, as monitoring and evaluation of building features and energy conservation measures continue to take place at a neighborhood scale.

2.2 Utility Bill Collection and Analysis

Originally, when this research project was devised, CARB intended to evaluate the utility bills collected for each project in the Salesforce tracking system. Looking at energy usage data, namely fuel and electric bills, can yield a quantifiable understanding of each building in terms of utility consumption and offer a way to compare a building against industry benchmarks. Although it would be difficult to tease out savings from individual retrofit measures, a utility bill analysis can identify how each building is performing, assess pre- and post-retrofit usage, and normalize for weather patterns.

The Block by Block program requests homeowner permission to view electricity (Con Edison) and gas (National Grid or Con Edison) utility accounts as part of the intake process. Con Edison's website allows customers to access bills for the past two years by logging in with an account number, which is displayed on a hard copy bill. National Grid data are more difficult to obtain because the website requires a username and password, which have to be set up by the primary account holder. Even though most homeowners gave their permission to view their accounts, a number of hurdles made the information difficult to gather and analyze.

The utility companies did not respond favorably to requests to obtain energy use data for the accounts of homeowners who had given their permission. Therefore, to access the data, Pratt staff and interns had to go online to individually download information month by month for each account. For electric accounts, this was further complicated by the estimated use numbers versus actual and variable billing periods. For the National Grid accounts, that company's requirement for an online password to access the account presented an additional hurdle. Because the majority of homeowners either did not set up a National Grid online account or because they were not comfortable sharing their password, retrieving National Grid data resulted in information from few accounts. Analyzing and comparing utility use information would have been useful, but insufficient data were available to do so.

Con Edison and National Grid are the two main utility companies that serve the five boroughs where the Block by Block program is active. Con Ed provides both electricity and natural gas service to Manhattan and Bronx residents, but delivers only electricity to Brooklyn, Queens, and Staten Island; natural gas in these areas is supplied by National Grid (see Table 1).

Table 1. Utility Service in New York City by Borough

Borough	Electricity	Natural Gas
Manhattan	Con Edison	Con Edison
Bronx	Con Edison	Con Edison
Brooklyn	Con Edison	National Grid
Queens	Con Edison	National Grid
Staten Island	Con Edison	National Grid

The Block by Block program did not attempt to capture use for oil customers. Because there are several oil providers in NYC, tracking down individual oil records for each building would have been labor intensive and tedious. In addition, there is often variability with oil deliveries and dates, making records challenging to piece together.

CARB found that these issues prohibited performing a utility bill analysis, but those with complete utility records (which were located in Con Ed territory in Manhattan and the Bronx), were prioritized for energy modeling analysis.

2.3 Audit Report Findings

To better understand the audit findings beyond what was documented in the database, CARB looked at a sample of six audit reports to evaluate the effectiveness of the audit recommendations for the Block by Block program. Four projects are very similar multifamily buildings, which were constructed in the late 1980s and located within one superblock. Two of the projects are single-family homes constructed in 1920 that are located near the other four buildings.

The audit reports were prepared by one contractor working under the Green Jobs-Green New York Program administered by NYSERDA. The contractor is accredited by the Building Performance Institute as required by the program and there is no reason to believe that the firm is not representative of standard industry practices.

Unfortunately, CARB was unable to physically inspect the buildings to verify the specifications reported in the energy audits.

The audit reports typically recommend several measures and list the costs associated with installing these measures. The measures are then commonly grouped into two or three packages with one package including all suggested measures. Table 2 shows an example of audit recommendation packages from one of the four multifamily building audits, and Table 3 gives the associated cost-effectiveness measures. This audit report is fairly typical of the retrofit recommendations in the six audits. The auditor used the Targeted Retrofit Energy Analysis Tool (TREAT), a building modeling tool, to calculate retrofit savings. Appendix B contains a sample report for a multifamily building.

Table 2. Example Audit Recommendations

Measure	Nonenergy Benefits	Package 1 (\$)	Package 2 (\$)	Package 3 (\$)
Install 7.25 in. of Fiberglass Floor Insulation (R-24)	Improve comfort, increase value of building	1,950		1,950
Reduce Infiltration from 4,845 CFM50 to 3,500 CFM50	Reduce drafts	3,000	3,000	3,000
Install 2-Ton 18 SEER Cooling System	Increase value of building	3,500		
Install Programmable Thermostats	Improve comfort, improve convenience	240	240	240
Install 55 kBtu/h, 95% AFUE Heating System	Increased equity	4,000		4,000
Install 55 kBtu/h, 95% AFUE Heating System	Increased equity	4,000	4,000	
Install New Double Pane Sliding Door	Improve comfort (reduce drafts), increase value of building	2,000		
Install 47 New 15-W Fluorescent Light Fixtures	Reduce maintenance costs	470	470	470
Install 1 Low-Flow Lengthen DHW Discharge Pipe	Reduce water use	100	100	100
	Improve air quality and comfort	200	200	200

Notes: CFM50 is the air flow in cubic feet per minute induced by a 50 Pascal pressure from blower door operation. SEER, seasonal energy efficiency ratio; AFUE, annual fuel utilization efficiency; DHW, domestic hot water

Table 3. Cost-Effectiveness Measures for Example Audit Report

Measure	Package 1	Package 2	Package 3
Total Installed Cost (\$)	19,460	8,010	9,960
Annual Energy Cost Savings (\$)	915	707	760
Annual Kilowatt-Hour Savings (\$)	3,454	2,799	2,699
Total Energy Savings (MMBtu)	37.0	27.6	32.1
Simple Payback (Years)	21.3	11.3	13.1
Savings to Investment Ratio	0.7	1.1	1.1

By looking at the audit reports for these Block by Block projects, CARB discovered several issues with the audit reports, including lack of transparency in cost effectiveness per measure, inclusion of non-energy-related measures in cost-effectiveness savings, and a number of overly expensive measures. Although these issues can vary in degree and manifestation, they are common throughout all of the audits.

The primary issue with these audit reports is that the cost effectiveness of each measure is not clearly reported, which makes it difficult for homeowners to select which measures are the best options out of the entire suggested package. The three packages listed in the six reports reviewed appeared to be an arbitrary collection of upgrades. Packages are not presented systematically from most to least cost effective.

The cost-effectiveness calculations for each measure are also clouded by non-energy-related measures, which reduce the cost effectiveness of the entire package. In many cases, these measures can be justified for health, safety, or cosmetic reasons, but will not reduce energy use. For all audit reports reviewed, some safety-related measures that may not be high-impact energy efficiency measures included:

- DHW pipe replacement (\$200)
- Repair of hole in boiler room ceiling (\$200)
- Door replacement (\$1,000–\$1,500)
- Sliding door replacement (\$2,000)
- Aluminum flashing to fix roof leak (\$2,000)
- Safety valve (\$100)
- Safety pipe (\$100)
- Missing radiator (\$250)
- Carbon monoxide detectors (\$360 each)
- Installation of windows with similar specs to existing windows (\$500–\$4,800).

Some of these measures have limited energy savings potential and questionable cost effectiveness. For example, installing a new double pane sliding door or replacing windows with new windows of similar performance are not cost effective based on energy savings alone. These

measures may have been suggested for cosmetic or repair reasons, but should be excluded from cost-effectiveness calculations.

Finally, several audits included expensive upgrades that are not justified by energy savings. These costs seem expensive in comparison to typical costs and the reasons for these high costs are unknown. Examples of expensive upgrades include the following:

- Exterior wall insulation improvement from R-7 to R-15 (\$8,360)
- Floor insulation from R-10 to R-33 (\$8,960)
- Door replacement (\$1,000–\$1,500).

2.4 Energy Modeling

To further analyze the appropriateness of the predicted energy savings and the cost effectiveness of the suggested retrofit packages, CARB performed energy modeling of the six selected Retrofit NYC projects discussed previously (four two-unit [multifamily] and two single-family homes in the Bronx). CARB used information from the audit reports, city assessor's records, and Google Earth to develop energy models. Audit reports were used to establish the pre- and post-retrofit specifications. Google Earth and the assessor's records were used to establish building geometries. The two single-family buildings were modeled using the Building Energy Optimization (BEopt) tool.¹ The four multifamily buildings were modeled in EnergyGauge USA (EGUSA) because BEopt cannot model multifamily dwellings.²

2.5 Analysis Methodology

All cost analyses were performed using the method outlined by Polly et al. (2011) and all non-energy-related measures were excluded. In their analysis a minimum upgrade reference scenario (MURS) is used as the baseline.

The MURS begins with the existing building at the start of the analysis period and assumes all equipment that wears out over the analysis period is replaced with the same level of efficiency or the current minimum standard, whichever is more efficient. Minimum upgrades are assumed for the reference building so as not to take credit for energy efficiency improvements that would have otherwise occurred through natural wear-out and replacement. In this sense, the MURS is the minimum that a homeowner could do to their house over the analysis period assuming that standards in the future will require at least the current level of efficiency. (Polly et al. 2011, p.10)

Because the equipment in these buildings was older than the predicted lifetime of typical systems, all analyses were performed assuming that the existing equipment was at the end of its lifetime. Cost analyses were performed with an assumed real discount rate of 3%, an inflation rate of 3%, and an assumption that all measures are installed using a 5-year loan with a 7% interest rate, as shown in Table 4.

¹ See <http://beopt.nrel.gov/> for more information.

² See <http://www.energygauge.com/> for more information on EGUSA.

Table 4. Cost Analysis Assumptions

Analysis Period (years)	30
Inflation Rate (%)	3
Loan Rate (%)	7
Loan Period (years)	5

All energy savings analyses are performed using source energy. Energy usage is usually measured in site energy, which is the energy used at the home, typically measured at a utility meter in units of kilowatt-hours (electricity), therms (natural gas), or gallons (fuel oil or propane). Source energy, though, which is the sum of energy used at the home and the energy lost to extraction, conversion, or transmission, is a better metric for measuring energy usage. Site energy can be easily converted to source energy using a site-to-source ratio (Deru and Torcellini 2007) for the given fuel. Table 5 shows assumed fuel costs and site-to-source ratios.

Table 5. Fuel Costs and Site-to-Source Ratios

Fuel	Cost	Site-to-Source Ratio
Electricity	\$0.161/kWh	3.365
Natural Gas	\$1.42/therm	1.092
Fuel Oil	\$3.44/gal	1.158

2.6 Multifamily Buildings (Projects 1–4)

The four multifamily buildings are each composed of two apartments in three-story buildings with a total square footage of 2,325 per building. These buildings are located within one superblock that occupies approximately 12.7 acres and contains approximately 200 buildings.

Most of these buildings, which were built in the late 1980s, have the same appearance, configuration, and size. These buildings represent an excellent opportunity to investigate the possibility of implementing identical measures on a large number of buildings with nearly identical specifications.

Because these buildings have similar specifications and the audit reports suggested similar measures for each building, the effectiveness of each measure was compared using a model that represents the “typical” building. Table 6 gives the specifications for this typical building. The suggested audit reports typically include floor insulation, 32% infiltration reduction, high-efficacy lighting, and high-efficiency space-conditioning equipment.

Table 6. Typical Specifications of Multifamily Buildings

Specifications	Existing	Proposed
Exterior Walls	R-13, 2 × 4, 16-in. on center (o.c.)	—
Exterior Finish	Vinyl siding	—
Roofing Material	Built-up roofing	—
Ceiling/Attic	R-24	—
Foundation	Crawlspace, 2 × 8 with no insulation	R-24 floor insulation
Window Area	20%	—
Window Type	Double clear aluminum	-
Infiltration (CFM50)	4,945	3,375
Ventilation	None	—
Appliances	All standard	—
Lighting	37% fluorescent	100% fluorescent
Cooling	Room AC, SEER 10	Central AC, SEER 18
Heating	80% AFUE	95% AFUE
Ducts	Distribution efficiency = 100%	—
Water Heater	Natural gas, EF = 0.57	—

To analyze the cost effectiveness of the auditor-recommended measures, each measure was isolated in the model to determine the annual utility bill savings. The costs of the measures based on the audit reports were compared to the cost of the MURS based on the costs and lifetimes published in the National Residential Energy Efficiency Measures Database (NREL 2011). All existing equipment was assumed to be at the end of its life. Table 7 shows the utility bill savings, annualized savings, and cost and lifetime assumptions. **The analysis revealed that lighting, infiltration reduction, and floor insulation are cost-effective measures.** Space-conditioning upgrades alone are not cost effective, costing an annualized \$301 per year. The total annualized savings for the package of measures, however, is \$600 per year.

Table 7. Incremental Cost Analysis of Recommended Measures

	Cost of Measure (Proposed, \$)	Measure Lifetime (Proposed, years)	Cost of Measure (MURS, \$)	Lifetime of Measure (MURS, years)	Utility Bill Savings (\$)	Annualized Savings (\$)
Lighting	380	9	168	1	201	516
Infiltration	1,850	999	0	999	134	194
Floor Insulation	1,950	999	0	999	133	191
Heating	8,000	20	3,413	20	65	(272)
Cooling	3,050	14	806	10.5	555	(29)

Figure 1 shows cumulative source energy consumption by measure. Each bar represents the sequential addition of a measure. The cooling system bar farthest to the right includes all measures. Total source energy savings for the entire package is 31%.

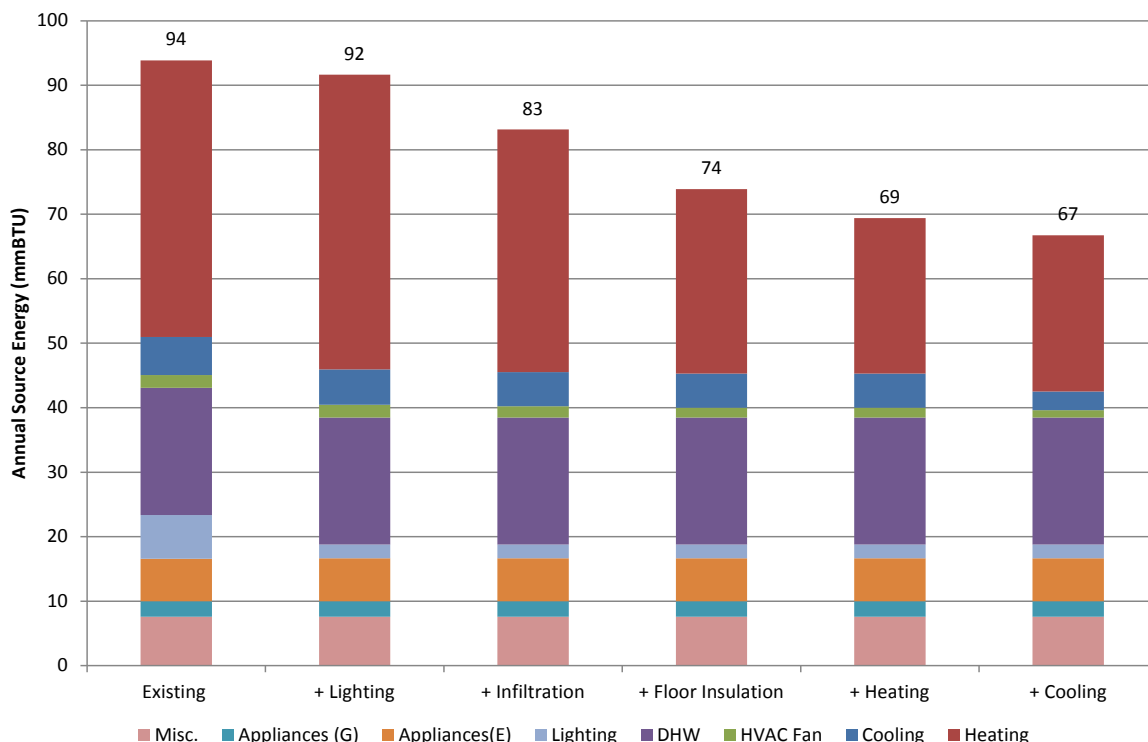


Figure 1. Cumulative annual source energy consumption savings by measure

This analysis is representative of the typical multifamily building and applies to projects 1 through 4.

Table 8 gives the cost analysis for the total packages in all four projects. The total cost is the sum reported by the auditor, including nonenergy-related measures. The modeled cost is the sum of the reported costs for the specific energy measures modeled. The differences among the project results are largely attributable to differences in the costs of the recommended measures and some slight variation in the recommended measures. It is unclear why there was such a large difference in the measure costs given that the same contractor performed all of the audits.

Table 8. Cost Analysis of Multifamily Projects

	Project 1	Project 2	Project 3	Project 4
Auditor-Reported Total Cost (\$)	12,040	19,460	17,760	15,440
Modeled Cost (Energy Measures Only, \$)	8,145	11,615	12,855	7,295
Annual Modeled Utility Bill Savings (\$)	781	728	867	569
Source Energy Savings (% Over Existing)	26	31	32	24
Annualized Savings (\$)	662	468	534	178
Annualized Rate of Return (Real, %)	11	6	7	5
Simple Payback (Years)	10.43	15.95	14.83	12.82

A comparison of the modeled and actual site energy consumption raises concerns about the predicted cooling savings generated by EGUSA. Figure 2 shows a comparison between the modeled energy consumption of the typical building against the actual utility bills for the

projects. No effort was made to adjust the utility bills for weather. The discrepancy between the modeled and actual energy savings during the winter months is understandable because of expected differences in the usage patterns of lighting, appliances, and miscellaneous loads.

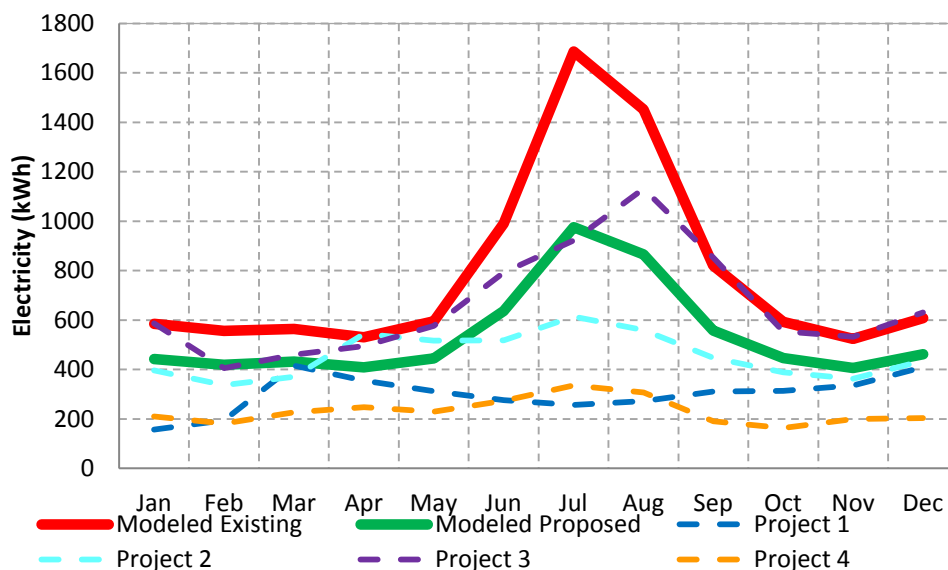


Figure 2. Annual modeled and actual site electrical consumption. The modeled consumption is shown for existing and proposed cases of the typical building. Actual consumption is compiled from the utility bills of the existing buildings.

The very large difference between the modeled and actual electricity consumption during the summer months, however, is most likely caused by the typical usage patterns for window AC units. Kempton et al. (1987) showed that most owners of room AC run their units in an on/off pattern, turning on the unit only when the residents are home and cooling is needed. Residents who run their units thermostatically (using the thermostat), used nearly three times the electricity of the other residents. As a result, installing thermostatically controlled central AC in these units could actually increase the electricity usage of the building. Although the cooling system upgrade may increase comfort, it appears to increase rather than decrease energy use.

2.7 Project 5

Project 5 is a 1,552-ft², two-story, single-family home constructed in 1920. The building, which is heated with a natural gas furnace, was modeled in BEopt. Table 9 gives the existing specifications, proposed specifications, and costs.

Table 9. Existing and Proposed Specifications and Incremental Costs for Project 5

Specifications	Existing	Proposed	Cost (\$)
Exterior Walls	R-13, 2 × 4, 16-in.o.c. (derated to R-7)	R-17, 5.5-in.fiberglass (derated to R-15)	8,360
Exterior Finish	Stone	—	—
Roofing Material	Light asphalt	—	—
Ceiling/Attic	R-10, 2 × 4, 16-in.o.c.	R-33, 2 × 4, 10-in. cellulose	8,960
Foundation	Uninsulated basement	—	—
Window Area	15%	—	—
Window Type	Double clear	—	—
Infiltration (CFM50)	5700	4700	2,000
Ventilation	Spot vent	—	—
Appliances	All standard	—	—
Lighting	0% fluorescent	100% fluorescent	560
Cooling	9 SEER (modeled as SEER 10)	—	—
Heating	Natural gas, AFUE = 84%	—	—
Ducts	100% distribution efficiency	—	—
Water Heater	Natural gas, 59%	Low-flow shower head	100

Despite the large costs of some of the measures, as discussed in Section 2.3, the recommended measures produced an annualized savings of \$899 and an annualized rate of return of 7%.

Table 10. Cost Analysis for Project 5

Auditor Reported Total Cost (\$)	22,580
Modeled Cost (Energy Measures Only, \$)	19,980
Annual Modeled Utility Bill Savings (\$)	463
Source Energy Savings (% Over Existing)	16
Annualized Savings (\$)	899
Annualized Rate of Return (Real, %)	7
Simple Payback (Years)	43.2

2.8 Project 6

Project 6 is a 1,312-ft², two-story, single-family home constructed in 1920. The building, which is heated with a fuel oil boiler, was modeled in BEopt. Table 11 shows the existing specifications, proposed specifications, and costs.

Table 11. Existing and Proposed Specifications and Costs for Project 6

Specifications	Existing	Post-Retrofit	Cost (\$)
Exterior Walls	Uninsulated, 2 × 6, 24-in. o.c.	R-19, 2 × 6, 5.5-in. cellulose	6,876
Exterior Finish	Siding	—	—
Roofing Material	Dark asphalt	—	—
Ceiling/Attic	Uninsulated, 2 × 6, 24-in. o.c.	R-30, 2 × 6, 24-in. o.c.	2,000
Foundation	Uninsulated basement	—	—
Window Area	15%	—	—
Window Type	Double clear	—	—
Infiltration (CFM50)	4,400	3,000	2,800
Ventilation	Spot vent	—	—
Appliances	All standard	—	—
Lighting	40% fluorescent	100% fluorescent	270
Cooling	SEER 10	—	—
Heating	Fuel oil boiler 73%	—	—
Ducts	None	—	—
Water Heater	Fuel oil, indirect off boiler 62%	—	—

The audit recommendations produced an annualized savings of \$2,593 and a rate of return of 30%, as shown in Table 12. These robust savings are likely the result of the high cost of fuel oil and the low insulation levels of the existing house.

Table 12. Cost Analysis for Project 6

Auditor Reported Total Cost (\$)	21,926
Modeled Cost (Energy Measures Only, \$)	12,946
Annual Modeled Utility Bill Savings (\$)	1,643
Source Energy Savings (% Over Existing)	36
Annualized Savings (\$)	2,593
Annualized Rate of Return (Real, %)	30
Simple Payback (Years)	7.88

2.9 Audit Analysis Conclusions

The modeled results show energy savings of 16%—32% over the existing buildings, along with real annualized rates of return greater than 5%. For most projects, however, the simple payback periods are extremely long. In most cases, the annualized savings from lighting are dominating the analysis because of savings from replacement costs over the life of the fixtures. The space-conditioning system upgrades are not cost effective on their own.

Although these projects are cost effective according to modeled energy savings, audit reports should be improved to address several issues. CARB's observations and recommendations to auditors are as follows:

- Most audits included measures that will not save energy. These measures need to be separated to make clear that they are for cosmetic or health and safety reasons only.
- Window upgrades in general could not be justified because there was no improvement in the specifications of the windows. Quoted prices in some cases were far too high for the listed upgrade, and it is unclear how much of the cost is apportioned to maintenance, health, or safety.
- Auditors included the total price of the measure in their cost analyses. Generally, because these buildings have very old systems, the pricing should be compared to the replacement cost.

3 Technical Challenges and Recommendations

With the Block by Block program in the early stage of operation, research efforts focused on examining the limited number of audit reports available for quality, comprehensiveness, and consistency. Based on a closer look at six buildings for which utility data were available, two primary areas of concern emerged: the energy savings estimates and the costs of the recommended measures. Audit results were found to be highly variable even across very similar buildings.

A review of audit reports found that model predictions and energy savings estimates were high and not consistent with actual energy usage data. At a recent Building America team meeting, several researchers raised concerns about the accuracy of building simulation programs when modeling older, poorly insulated buildings. Most of the modeling tools were developed for new construction that performs better. Research into this potential modeling problem is warranted.

Using utility data to calibrate the existing building model is an often cited approach to improving accuracy, but it is not apparent that the utility data was entered into the TREAT software in the projects reviewed. Obtaining utility data is difficult, time consuming, and often incomplete even when obtained. Research towards a process that will make household energy use data readily available will enhance future program efforts.

Measure cost information is highly variable and there are many plausible explanations including:

- Auditors are often not qualified to provide contractor pricing for the broad spectrum of measures being recommended (i.e., this project revealed that insulation contractors might provide a qualified and competitive price for the insulation measures but might only furnish ballpark estimates for heating system measures).
- Significant remediation costs associated with health and safety are included in the energy efficiency measure costs.
- Total replacement costs are provided instead of the incremental cost of a more energy efficient replacement system.

A reliable third-party resource for efficiency measure cost information such as that under development by the National Renewable Energy Laboratory could help alleviate the inconsistent and unreliable cost information problems.

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Appendix A: Pratt Retrofit NYC Block by Block Report



RETROFIT

NYC | BLOCK BY BLOCK

A Laboratory for Retrofitting
New York City Neighborhoods

Pratt Center for Community Development

4/24/2012



The Pratt Center for Community Development works for a more just, equitable, and sustainable city for all New Yorkers by empowering communities to plan for and realize their futures.

As part of Pratt Institute, we leverage professional skills - especially planning, architecture and public policy - to support community-based organizations in their efforts to improve neighborhood quality of life, attack the causes of poverty and inequality, and advance sustainable development.

The Center was founded at the birth of the community development movement, as the first university-based advocacy planning and design center in the U.S. For almost 50 years, we have helped community groups revitalize their neighborhoods, create and preserve affordable housing, build childcare and community centers, and improve their environment. We have trained hundreds of community leaders and organizations to implement effective community development strategies, and supported a wide array of successful public policy and community planning efforts.

Growing awareness of the threat of climate change and its urgency is evident at not only the policy level but at the street level. We have seen again and again that the residents of New York City want to be part of the solution and make their contribution to addressing the challenges of climate change. Pratt is responding to both the policy and the demands of our constituents by weaving sustainable development objectives throughout our work, from community based planning to industrial development.

Retrofit NYC Block by Block uses and the community outreach and organizing strategies of the community development field to address global warming and to promote energy savings and environmental conservation in New York City's neighborhoods. The initiative is coordinated with Pratt's Energy \$mart Communities contract with the New York State Energy and Research Development Authority (NYSERDA), and the Brooklyn Greens initiative launched in collaboration with the Brooklyn Community Foundation. In addition, Pratt Center also provides technical assistance to community based organizations that conduct outreach under NYSERDA's Green Jobs Green New York initiative. These programs employ research and demonstration, education and information dissemination, policy advocacy, and technical assistance to help maintain affordable housing, improve public health and stimulate economic development in low-income neighborhoods.

Pratt Center appreciates the amazing commitment and skills of the people and community-based organizations that make this work possible. Retrofit NYC Block by Block is implemented by:

- **Bedford Stuyvesant Restoration Corporation**
- **Chhaya CDC**
- **Sustainable South Bronx**
- **Neighborhood Housing Services of Staten Island¹**

¹ This report covers the work done by organizations funded by New York City Council Speaker Christine Quinn. Other retrofit campaigns undertaken by Cypress Hills LDC and El Puente CDC and funded separately are not covered in this report.

Pratt's sustainability services work is supported by:

- New York City Council
- The Brooklyn Community Foundation
- Con Edison
- Deutsche Bank of Americas Foundation
- The Gimbel Foundation
- Local Initiatives Support Corporation
- New York State Energy and Research Development Authority
- The Scherman Foundation
- State Farm
- Steven Winter Associates
- Con Edison
- National Grid

Retrofit NYC Block by Block: A Laboratory for Retrofitting Urban Neighborhoods

I. Executive Summary

Through Retrofit NYC Block by Block, Pratt Center for Community Development partnered with four community development corporations to increase home energy upgrades in New York City through community-based outreach and engagement. The project enabled our partners, **Bedford Stuyvesant Restoration Corporation** (Restoration), **Chhaya CDC**, **NHS of Staten Island** and **Sustainable South Bronx**, to hire a staff person to educate and recruit residents to retrofit their properties and to partner with contractors to facilitate the hiring of local residents in jobs created by increased demand for retrofits.² Pratt Center developed a web-based tracking system to capture program data, convened the groups in person to best practices and problem-solve challenges, and provided extensive technical support for their efforts.

Eleven months into full implementation, the project, particularly the strategy of cultivating early adopters as ambassadors, increased uptake of incentive programs in the targeted neighborhoods. Nearly 600 homeowners signed up to participate, 207 homeowners received completed energy assessments of their homes and 105 have implemented energy upgrades. Ten job trainees have been hired by the two contractors working as partners in the campaigns and more recently, Bedford Stuyvesant Restoration hired their first eight employees in their new retrofit and home improvement company, HouseLift by Restoration.

While these numbers represent an uptick in participation in retrofit programs, these outcomes do not reflect the project's much higher goals. Although momentum continues to build, our results to date suggest that in New York City, where home retrofits have historically lagged behind the rest of the state, community outreach strategies alone are not sufficient to catalyze a level of activity commensurate with the need.

High on the list of obstacles was the barrier of up-front costs for the improvements by low- and moderate-income homeowners. Beginning in spring 2012, our partners will promote the new, innovative financing tool, on-bill recovery, which will enable homeowners to pay for energy improvements on their utility bills. This dual intervention will be rolled out during the last months of Retrofit Block by Block and as part of an expanded community outreach effort funded by the New York State Energy Research and Development Authority's Green Jobs Green New York Program. It will be critically important to realize the potential of on-bill recovery to overcome the hurdle of up-front costs by making it widely and easily available. We are hopeful that this combination of outreach and low-cost/low-risk financing will create a significant uptick in home retrofits. In addition, we are pleased to

² A fifth organization, Cypress Hills Local Development Corporation also implemented the Block by Block strategy under the Brooklyn Community Foundation funded Brooklyn Greens Initiative. Their data was not yet available at the time of this report.

have been constructive in building capacity among New York City's nonprofits to engage their communities in retrofitting their housing.

At the same time, other obstacles related to the nature of New York City's housing stock and contracting industry suggest that exploration of alternative strategies for dramatically increasing the level of retrofits and related jobs is also warranted. More than half the small homes have two to four units, complicating program intake and implementation. Further, the home improvement contracting industry in New York City is more fragmented and organized by trade more than it may be in other parts of the state, making the comprehensive audit approach more difficult to implement here.

Pratt Center plans to research alternative approaches to increasing retrofits. This report describes our initiative including the obstacles and opportunities we encountered and offers some lessons and recommendations for increasing retrofits among New York City's small homes. Promising ideas for further development include:

- Standardize retrofit packages and aggregate installment for similar housing types;
- Improve methods to easily track and report on energy savings
- Increase regulation at key points, e.g., sale, home improvement, replacement of major systems;
- Integrate energy efficiency upgrades into the home improvement industry
- Intervene at the time of heating and hot water system replacements
- Make the Weatherization Assistance Program (WAP) more widely available and determine eligibility by census tract in low-income, urban neighborhoods
- Integrate weatherization funds with other financing for affordable, healthy homes to address needed capital repairs and health issues

II. Introduction

Over 600,000 of New York City's million buildings are one- to four-family homes. These buildings knit together block after block of New York City's residential neighborhoods, house approximately 38% of the city's residents and generate about 17%³ of the city's carbon emissions. Virtually all of these homes would benefit from upgrades to reduce the use of heating fuel, electricity and water. Wide-scale retrofits would also reduce owner and tenant costs for heating, electricity and water, improve housing durability, safety and comfort, and reduce other emissions and excess sewage while adding much-needed jobs for neighborhood residents.

The Pratt Center for Community Development created Retrofit NYC Block by Block as a research and demonstration program to learn about the obstacles and opportunities to generating retrofits at neighborhood scale and to test strategies to increasing retrofits to further both our community development and sustainability mission. Through this initiative, funded by the New York City Council, Pratt subcontracts with four neighborhood-based organizations to run campaigns to educate and

³ PlaNYC 2011 Carbon Emissions Inventory (based on 2009 data).

engage homeowners about how even small improvements can benefit health, housing affordability and the environment and to enlist homeowners and tenants in the available retrofit incentive programs.

Retrofit NYC is supported by funding from the New York City Council and administered through a contract with the New York City Department of Housing Preservation and Development. The project works in tandem with the Brooklyn Greens initiative, supported by the Brooklyn Community Foundation, which also employs a block by block strategy to retrofit neighborhood homes. The initiative was seeded by and benefits from the New York State Energy and Research Development Authority (NYSERDA) Energy Smart Communities program, which Pratt coordinates in Brooklyn and Queens. Retrofit NYC Block by Block relies on existing retrofit incentive programs to underwrite the cost of implementing retrofit measures. These include the NYSERDA Green Jobs Green New York Program, the National Grid Enhanced Home Air Sealing and Insulation Program (discontinued in September 2011), the federal Weatherization Assistance Program (WAP) and other programs such as NYSERDA EmPower NY and the Con Edison Direct Install programs (see incentive program descriptions in the appendix). Steven Winter Associates provided some assistance analyzing our data through a US Department of Energy Building America contract that ended October 31, 2011.



Figure 1A Bronx resident telling her neighbor about her energy assessment and Home Tune-up Retrofit.

II. Retrofit NYC Block by Block

Rationale

The financial, environmental, health and even personal comfort benefits of retrofitting have been known for years, if not decades. However, Pratt Center saw relatively low uptake of the retrofit incentives from our efforts to enlist building owners through presentations at public meetings and website resources. Pratt staff observed the following barriers:

- 1) General lack of awareness about the benefits of energy retrofits: Although the federally funded Weatherization Assistance program has been retrofitting buildings for thirty years, it is not common practice to undertake energy assessments or improvements to reduce energy use among New York City's homeowners.
- 2) Multiple financing options are difficult to navigate: A variety of city, state, federal and utility programs and tax incentives are available but there is no one place where homeowners can receive information or get guidance on all the options to figure out which is best for them. Most homeowners do not know their options.
- 3) High up-front costs: The energy assessments generated through Retrofit NYC typically recommend improvements ranging from \$1,000 to as much as \$52,000. For most residents, even if the energy savings are projected to pay off those costs in a reasonable amount of time, the required upfront investment is prohibitive. In the current economy, many homeowners are

reluctant to take loans, even low interest loans, particularly in neighborhoods that have seen large numbers of foreclosures.⁴

In 2009, Pratt collaborated with the Bedford Restoration Corporation to create a pilot project to offer all the residents on two contiguous city blocks free, comprehensive energy assessments to provide homeowners with an individualized set of recommendations to make their homes more energy efficient, healthy, safe and comfortable. Our premise was that neighborhood-based education and outreach could stimulate uptake, while lowering costs and generating jobs. We followed-up each energy audit with individualized assistance to access financial incentives. Seventeen homes on those blocks were audited and 13 implemented some of the measures via comprehensive retrofits, free installation by Restorations Justice Corps workforce program or homeowner implemented work. The contractor in the pilot lowered their standard audit fees to participate. In addition 48 free street trees were planted on the blocks through NYC's MillionTrees program and the community garden and church on the block were upgraded by Restoration Corporation's Justice Corps program.

On July 1, 2010, the New York City Council awarded Pratt funds to expand our initial pilot project to include retrofit outreach campaigns in four neighborhoods, Bedford Stuyvesant, Brooklyn; Jamaica, Queens; NHS Staten Island; Soundview, Bronx. The Retrofit NYC Block by Block project:

- Relies on community development corporations to tap their neighborhood's networks -- block associations, religious institutions, civic associations, and community boards to increase awareness and educate residents. The community organizations identify and cultivate early adopters to be local champions for home upgrades for energy savings to increase awareness through trusted neighborhood agents.
- Provides individualized assistance to residents to find the best package of incentives to meet their needs, follows through with residents to explain their energy assessment and encourage them to implement high impact retrofits, facilitating their use of an optimum package of incentives.
- Partners with contractors who demonstrate a high level of competency and customer service as a means to lower upfront costs and negotiate job opportunities for neighborhood residents.
- Refers neighborhood residents to jobs with participating contractors.



⁴ On-bill recovery, a mechanism that enables homeowners to pay for their retrofits on their utility bills was not available during the period covered by this report.

- Collects and analyzes outreach building, audit and retrofit data through a shared, web-based tracking system to learn about best practices in outreach, audits and retrofits for the one- to four-family housing stock.

Implementation

In November 2010, Pratt Center and our four community partners announced the Retrofit NYC Block by Block initiative with City Council Speaker Christine Quinn. Because of delays in the contracting process, the community partners were not able to hire their outreach workers until early 2011, with the exception of Restoration, which had already hired an outreach worker in fall 2010 using funding from the Brooklyn Community Foundation. To prepare the new hires, Pratt Center provided **a three-day training session** which included an overview of building science and retrofit measures, existing retrofit incentives and programs, the process of conducting an energy audit and coordinating with contractors to implement audit recommendations, best practices for conducting homeowner outreach and lessons learned from our pilot, and our Block by Block tracking system. We additionally developed a **step-by-step guide** that suggests strategies to generate local retrofit demand on topics such as the recruitment of block leaders, conducting post-retrofit meetings, follow-up calls, and other crucial steps to ramping-up demand. The groups continue to meet monthly to share information and best practices.

Pratt Center **mapped each neighborhood** for eligibility criteria for the various incentive programs including income, heating fuel use and number of units. Based on this data and their social networks, we worked with each partner to designate a target area for their outreach effort. Each partner chose between two and fifteen blocks.

Retrofit NYC Block by Block was launched in each neighborhood with a **kick-off event** announcing the initiative, inviting the local councilmember and requesting target block residents to sign up. Outreach workers also organized and attended other block, homeowner and civic association meetings to recruit early adopters and local champions. The events were held at accessible, local venues including schools, churches, and restaurants. Attendance at community events varied from 20 to 60 individuals. Most events generated twelve to twenty completed intake forms. The events attracted local press and generated local interest in the program. The community partners then followed-up with individuals asking for additional referrals to their neighbors.

Each community organization employed **multiple strategies to engage residents** including door knocking, mailings, community events, and home visits as part of their strategy with some groups emphasizing one outreach tactic over another. Attending and presenting at existing events organized in the community as an invited speaker and then providing individualized, in-person follow-up was most



Figure 2 SSBX's Home Tune-Up Team with Contractor Mario Viscovich, Apex Engineering. Apex has hired nine SSBX graduates.

effective in generating audits and retrofits. Mass mailing and flyers were least effective. Door knocking was effective only when conducted together with recognized neighbors/block leaders. Referrals from customers already engaged in the retrofit process also proved to be a successful means of finding more interested residents.

Pratt subcontracted with Sustainable South Bronx to offer 50 homeowners high-impact, low cost energy efficiency measures including caulking, weather-stripping, compact fluorescent light bulbs, (CFLS), low flow shower heads and aerators for free while providing work experience for graduates of the Sustainable South Bronx BEST for Buildings Program. The **Home Tune-up Program** was intended to be used as an incentive to homeowners to undertake an audit while providing paid, part-time work experience for trainees. Home Tune-up also aimed to encourage homeowners to undertake more costly measures by reducing overall retrofit costs and to ensure that homeowners move forward with recommendations in their energy assessment. Home Tune-up increased the number of homes receiving low-cost retrofit measures and 14 job trainees received some paid work experience, in some cases leading to jobs. The project only led to homeowners moving forward to a comprehensive retrofit in a few cases. Recipients, though eager to make the improvements, were reluctant to borrow the money to make them.

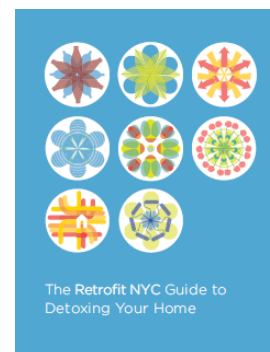
In order to maximize the local economic impact of Block by Block retrofits and ensure green job creation, Pratt **vetted and engaged accredited retrofit contractors**. We worked with Laborers' Local 10, one of the unions representing retrofit workers, to identify criteria for vetting contractors according to job quality and employment practices. We then developed a contractor vetting questionnaire, and disseminated it to all of the city's eligible retrofit contractors in December 2010 and again in November 2011 (See Initial Results below for more information). Where possible, we checked contractor references and made on-site quality assurance visits. We shared the results with our community partners who, in turn, formed strategic alliances with contractors who committed to hiring local job trainees and maximizing their work's impact on Block by Block neighborhoods.

Retrofit NY was integrated with our **Sustainable Houses of Worship initiative** to retrofit religious buildings and engage congregations in energy efficiency. Through this program, Pratt Center assisted houses of worship in our target communities to conduct energy audits of their properties and to take advantage of resources and incentives provided by Con Edison and NYSERDA to implement energy efficient improvements. We have found that religious buildings can generally save thousands of dollars every year for even modest up-front investment. Pratt also organized a workshop for the managers of religious institutions to learn how to reduce energy costs through management techniques. In Bedford Stuyvesant in particular, the churches have proven to be critical allies, often providing meeting space, participating in energy assessments and improvements themselves and helping to enlist congregants to the cause.



Figure 3 Mt Pisgah Church received an audit and implemented measures projected to save \$13,000 per year. Reverend Johnny Ray Youngblood is accepting a Beacon of Sustainability plaque; 13 residents signed up for audits that Sunday.

Pratt Center continues to provide technical support, convenes the community partners, shares best practices and develops and distributes planning and implementation tools. For example, Pratt provided decals for the doors of homeowners who undertook a retrofit to help raise visibility of the initiatives and created a Guide to Detox homes that offers provocative information about actions consumers can take to improve the health of their home by reducing pesticides, harmful cleaning products and the like.



Most importantly, Pratt developed a unique, **web-based tracking system** to:

- 1) assist our partners in managing and reaching out to contacts via email and mail merges,
- 2) track contacts, audits, retrofits and energy saving outcomes for individual homeowners, neighborhoods and across the project
- 3) generate reports highlighting trends and key outcomes across New York City

The tracking system came on line and was made available to our partners in July 2011 after an extensive period of development. It is a unique database of building characteristics, energy usage data, audits, and retrofits of NYC's small homes and is able to capture energy assessment and retrofit information across all incentive programs (NYSERDA, utilities, city, state and federal programs). Pratt is interested in making it available to other neighborhood retrofit campaigns.

In the last quarter of Retrofit NYC ending June 30, 2012, Pratt will assist our partners to promote on-bill recovery, the breakthrough financing mechanism by which homeowners can pay for retrofits on their utility bills. The financing mechanism is being rolled out in spring 2012 after being passed into New York State law in June 2011.

Pratt Center is providing technical assistance to the 11 community-based organizations/partnerships working as outreach contractors for the New York State Energy and Research Development Authority (NYSERDA) under the Green Jobs Green New York project to couple this innovative financing product with grassroots outreach (the three Retrofit NYC groups that applied to NYSERDA – Chhaya, NHS of Staten Island and Sustainable South Bronx - are part of partnerships that were awarded outreach contracts). Even as we aggressively support our CBO partners and NYSERDA, Pratt is mining its data and the lessons learned from Block by Block to develop alternative ways to reach scale in retrofitting New York City homes. Meanwhile, we count it as a part of Retrofit NYC Block by Block's successes that participation in the program has built the capacity of our community based partners to integrate environmental initiatives into their organizations and helped them qualify for the Green Jobs outreach contracts.

III. Results

The following program data represents approximately eleven months of full implementation, from March 1, 2011 when all the participating community based organizations had their outreach workers in place to January 31, 2012; Restoration began their outreach July 1, 2010 and this also includes their data from that time.

At the outset of the project, Pratt and our four community partners set a goal to make 2,000 contacts with homeowners in each neighborhood in one year. Based on the pilot project, we initially estimated that approximately 20 percent of all homeowners contacted would apply for an audit and that half of those would complete an audit (200 homes per neighborhood). We additionally assumed that 80% of all homeowners who completed the audit would implement at least one retrofit measure (160 per neighborhood). We also pledged to, collectively, train 30 individuals for retrofit jobs, and to work with contractors to secure local green employment for trainees.

In eleven months of outreach, each neighborhood met or exceeded annual goals to aggressively reach out to residents. Over 16,000 homeowners were contacted through four neighborhood retrofit campaigns through neighborhood meetings, mailings, door-knocking, phone calls and individual meetings. However, the rates of sign-up were below what we expected based on our pilot project.

B January 31, 2012, 590 homeowners signed up for the program by submitting all necessary information to be determine eligibility for incentive programs. The highest sign-up rates were in the neighborhoods that provided the most individualized support to homeowners. About 9% of those contacted in Bedford Stuyvesant completed intakes, 5% in the Bronx and only 2% in Staten Island and Queens neighborhoods. Restoration has been conducting outreach the longest and the high number of block associations in that neighborhoods provide a beneficial social infrastructure that does not exist in the other neighborhoods, partially explaining their higher rates of enrollment in retrofit programs. NHS of Staten Island conducted several large mailings which are included in their contacts; if only personal contacts are considered, the rate of sign-up would likely be higher. Sustainable South Bronx began relying almost entirely on personal referrals after the initial kick-off event and Restoration continued to work its network of block associations while NHS of Staten Island working in North Brighton, where there are fewer block associations, relied on large mailings and flyer distribution.

Of the homeowners that signed up, 207, have completed comprehensive energy assessments. The energy assessments were primarily completed through the NYSERDA Green Jobs Green NY Program (GJGNY) Program (50%) and the National Grid Enhanced Air Sealing and Insulation Program (EHSIP) which was offered in Brooklyn, Queens and Staten Island to National Grid heating gas customers until it was discontinued in September 2011 (39%). Our data shows that 22 homeowners received audits through the federal Weatherization Assistance Program (WAP) for people earning below 60% of Area

Results by Incentive program and outreach teams as of January 31, 2012

Incentive Program		BSRC	SSBx	NHS SI	Chhaya	Total all Neighborhoods
Contacts Made*		2686	1955	9120	3150	16,911
All Intakes	Homeowners signed up for block by block	240	109	173	68	590
Nat Grid	Audits completed	52	0	29	0	81
	Retrofits completed	40	0	10	0	50
GJGNY	Audits completed	19	54	25	6	104
	Retrofits completed	1	2	2	0	5
WAP	Audits completed	15	2	1	4	22
	Retrofits completed	15	1	1	4	21
EmPower	Energy Survey and Retrofits	14	1	12	2	29
All Audits		86	56	55	10	207
All Retrofits		70	4	25	6	105

*contacts represent 7 months of data; we stopped collecting contact data after 9/30.

Median Income. It is likely that we are undercounting participation of homeowners in the WAP program because the teams had difficulty getting the WAP audit reports from the WAP providers and only audit reports received were counted as completed audits. In addition, many homeowners referred to the WAP did not receive audits in the time frame of our data collection; they were often put on waiting lists of a year or longer

When the National Grid program was available, Restoration and NHS of Staten Island encouraged homeowners to use the National Grid program because, even though the homeowner had to pay a small fee for the energy assessment (\$50)⁵ the assessment came with up to two hours of air sealing work, ensuring that at least some energy upgrades would take place. The Green Jobs Green NY assessments are free to most of our target population based on their income and were used exclusively in the Bronx, where homeowners were not eligible for the National Grid program. Use of Green Jobs Green NY audits increased in Brooklyn and Staten Island after the EHSIP program was discontinued. NYSEERDA's EmPower program, which offers energy walk-through surveys in individual apartments, rather than comprehensive, full house audits, was used in 29 apartments; therefore, we did not count the EmPower surveys as audits in our data.

The top five retrofit measures recommended by the energy assessments were:

⁵ Restoration came to an agreement with a contractor that the audit fee would be reimbursed to the homeowner making the EHSIP audit and air sealing free to those homeowners.

- 1) Compact Fluorescent Light bulbs (CFLs)
- 2) Attic /roof insulation
- 3) Infiltration reduction/air sealing
- 4) Door replacement
- 5) Low flow showerheads

The audits were completed primarily by three contractors.

Virtually all the assessments recommended CFL bulbs, attic roof insulation and air sealing. Assessments conducted under the National Grid EHSIP program, which did not provide incentives for heating system improvements, recommended heating system upgrades in only two cases whereas heating system improvements were a common recommendation in the GJGNY assessments. As a result, the total package of GJGNY recommendations tends to be much more expensive, averaging \$19,211 per home vs. National Grid averaging \$1,071 per home for Retrofit NYC participants. The highest audit package came in at over \$50,000.

To date, 105 homes were upgraded for energy efficiency; 76 (37%) of the 207 homeowners receiving comprehensive energy assessments implemented energy upgrades on their homes. The energy upgrades were completed through: the National Grid EHSIP program (50); WAP (21); EmPower, (29); and Green Jobs Green NY (5). As above, WAP retrofits are likely undercounted because the WAP groups often do not provide the outreach groups with audit or retrofit information. The retrofits conducted under the National Grid EHSIP program consist mostly of air sealing work that accompanied the audits. Most of the measures that were implemented tended to be the relatively low cost, top recommended measures (see above). We are hoping, with the availability of on-bill recovery, to increase retrofit uptake in the last quarter.

Workforce Results

Our community partners trained 108 individuals with barriers to employment for green jobs, and had secured employment for 32 trainees. Nine residents were hired by one contractor; another contractor hired one. Fourteen Sustainable South Bronx Best for Buildings graduates were given paid, temporary, part-time placements through the Home Tune-Up program. Bedford Stuyvesant Restoration Corporation's new company, HouseLift by Restoration, recently hired their first eight employees.

Discussion of Results

Retrofit NYC Block by Block has increased the uptake of energy assessments and retrofits in the targeted neighborhoods. However, even in the difficult economic times in which Retrofit NYC Block by Block is operating and in the relatively low-income communities targeted, we had expected higher rates of audit completions and energy upgrades.

We anticipate that the availability of on-bill recovery will significantly improve our outcomes; our shared tracking database will enable our outreach groups to easily circle back to homeowners that have dropped out at some phase of the process.

However, we are also aware that New York City has historically had a low rate of retrofits in the NYSERDA Home Performance Program; we believe NYC represents fewer than 5% of the retrofits completed statewide. We have seen that, even with increased awareness, many more people signed up for the programs than undertook retrofits; the rate of follow-through is very low. We suspect that some of the lackluster performance is related to the relative difficulty of implementing the program in homes with multiple apartments and tenants, which represents more than half of New York City's one- to four-family housing stock. Nearly all the homes that have gone through Home Performance are single-family homes. Standard audit practices that require participation of all tenants and audit reports geared to one-family homes is likely to continue to be a hurdle in New York City. We have found that both landlords and tenants have some aversion to sharing the income and utility information needed to qualify for incentives. Pratt Center is interested in working with NYSERDA and other key stakeholders to continue to develop solutions to achieve dramatic increases in energy retrofits among New York City homeowners.

IV. Interim Observations and Lessons Learned

Retrofit NYC Block by Block was considered by the GJGNY working groups as a model when the GJGNY outreach was being designed and many of the lessons we have learned, obstacles we have encountered and opportunities we are meeting will apply to these new, expanded efforts. These lessons and observations follow below.

Community-based outreach

Retrofit NYC Block by Block provides evidence that neighborhood based outreach campaigns can increase demand for energy assessments and retrofits. Of the 590 homeowners who joined the program, we are confident that few, if any, would have signed up for energy assessments but for the Retrofit NYC program. By way of illustration, the two zip codes with the most Green Jobs Green NY audits are the Bronx and Staten Island neighborhood and half or more of the referrals were from Retrofit NYC partners NHS of Staten Island and Sustainable South Bronx. In some neighborhoods, all of the audits came from Block By Block outreach efforts. Community groups found that enrollments were highest in summer when community outreach is most active and effective, contrary to normal seasonal variations in the



Figure 4 Yury Polonsky, Contractor, Jedidah Baptiste, Restoration Outreach Worker and Irene Evans, former Block Association President working on beautification efforts at the Hancock Street Block Association where 17 homes are being retrofitted.

Borough	Zip Code	GJGNY Total Referrals	Retrofit NYC Referrals	Percent
Staten Island	10310	21	12	57%
Bronx	10473	30	23	77%

Brooklyn	11216	7	5	71%
Brooklyn	11233	17	17	100%
Brooklyn	11221	6	6	100%

Figure 5 Retrofit NYC audits completed by the GJGNY program as compared to all GJGNY audits.

industry which see upticks during the colder months. In seven years of the

availability of Home Performance, 412 New York City homeowners enrolled.

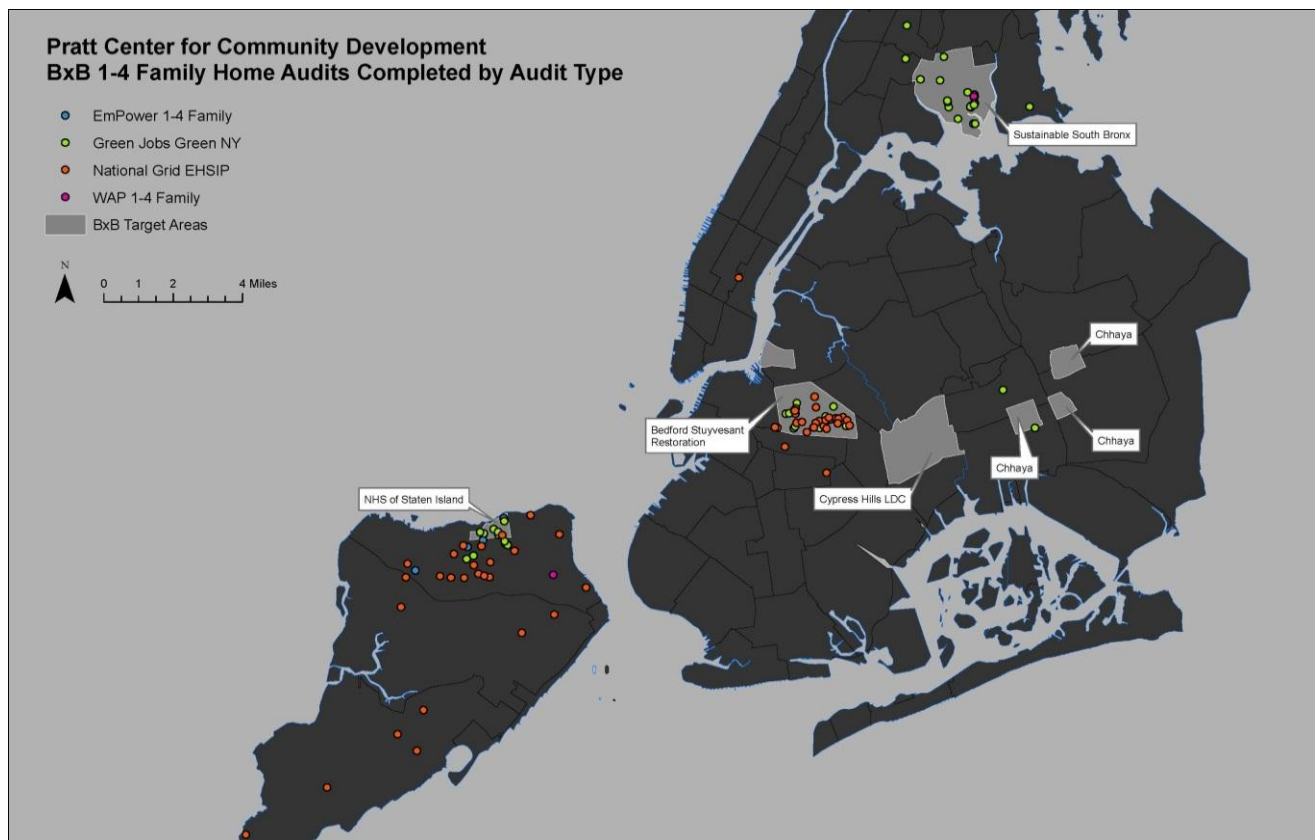
Virtually none of the homeowners we reached out to have heard of an energy retrofit or knew of anyone who had ever had an energy assessment the first time they were introduced to the initiative. The initial kick-off meetings provided not just encouragement, but education about the need to save energy, what energy assessments and retrofits are, how that would help them and the environment, and explanations of the steps to get an energy assessment for their home. We found that the most effective outreach workers were persistent and driven about following up with individual homeowners. By targeting low income people, we have also taken on the toughest neighborhoods. Statewide, Home Performance has served homeowners with higher incomes who are more likely to qualify for financing or to be able to pay for home improvements themselves.

Momentum builds over time; local champions can help move toward the “tipping point.” Given the complexity of this program with its multiple players – Pratt, community partners, contractors, incentive programs, funders, council members --program ramp-up took time. Furthermore, the campaigns only begin to build steam when the early adopters become champions, that is, when resident leaders take responsibility to enlist their neighbors in energy assessments and retrofits. In Bedford Stuyvesant, where outreach has been in place the longest, the first six months of the campaign saw ten audits completed and no retrofits (July 1 –December 31, 2010) Restoration is now logging about 15 audits per month and learning from contractor partners about homeowners who sign up for energy assessments directly with the contractor, indicating that the initiative is gaining traction. In one case, one homeowner who became a true believer has recruited 16 homeowners into the program. Similarly, in the Bronx, once she developed a critical mass of customers who trusted her, the outreach worker began to rely solely on referrals to enlist homeowners to undertake retrofits. It should be expected in the GJGNY program, that outreach will gain momentum after about a half-year of program implementation.

According to studies on the widespread adoption of new technologies, there is a “tipping point” when “early adopters” or “innovators” who adopt the change reach approximately 15% of the target market, such that it begins to become self-propelling or becomes the norm.⁶ By way of illustration, Bedford Stuyvesant has 17,000 buildings; at the point at which we reach 2550 successful retrofits, the market should take over and an outreach program such as ours will no longer be needed. Retrofit NYC delivered 70 retrofits in less than a year; we would want to see a much accelerated pace to achieve the tipping point.

⁶ Driving Demand for Home Energy Improvements, <http://drivingdemand.lbl.gov/> Fuller, M., C. Kunkel, M. Zimring, I. Hoffman, K.L. Soroye, and C. Goldman. LBNL-3960E. September 2010

Neighborhoods with well-developed social networks are easier to penetrate. Bedford Stuyvesant, where the Retrofit NYC Block by Block project was piloted, has a long history of community organization. The neighborhood has some 200 churches and numerous block associations and civic groups. These networks, even dormant ones that became reinvigorated through the Retrofit NYC campaign, make outreach easier and more effective. In North Brighton, Staten Island, where there is less social infrastructure, or in Jamaica, where networks are organized by language and ethnic group, our outreach workers have had a slower time finding local champions and building momentum. In these neighborhoods, individual referrals may be most effective. CBO partners are also working to better integrate the retrofit outreach with homeownership and financial counseling.



Contractors are critical partners. Nonprofit partners addressed a barrier to homeowner participation by referring trusted contractors. By engaging with selected contractors, Sustainable South Bronx and Restoration have found it is easier to coordinate and schedule audit and retrofit appointments with homeowners as well as to get copies of reports and updates on progress. They find that the homeowners, with little knowledge about how to screen retrofit contracts, often ask for a referral and feel most comfortable if the referral comes from a trusted source. Furthermore, contractor relationships enabled the outreach workers to attend audits, sit in on audit report meetings with the homeowner and, therefore learn about how the assessments and retrofit programs work in practice. Contractor partnerships will be essential for implementing aggregation models and getting to scale.

At the same time, our community partners are not, themselves contractors and, without bidding out the recommended improvements, they cannot accurately judge whether the prices are competitive. They are putting their trust with homeowners on the line for a business partner whose main interest is, explicitly, gaining profitable work. When a partner contractor includes recommendations that seem too expensive, submit inadequate or late audit reports, or puts costs in the scope that do not appear in the audit report, it can jeopardize the credibility of the outreach worker and the program. Partnerships with multiple contractors are most beneficial to foster competition. Sustainable Works in Washington State offers an alternative approach that separates the audit from the retrofit work and where work is bid out to qualified contractors by trade, e.g., request bids for insulation of 15 roofs or 10 gas hot water heaters in one neighborhood.⁷

Closing the deal requires ongoing assistance. Given that retrofits are relatively unknown, programs are complicated, and the retrofits require outlay of significant resources, frequent assistance and contacts with the owner are required. They must follow-up with every individual to complete applications, ensure they get their assessments and reports and then move forward on at least some upgrades. Tracking and reporting results are also time consuming. When financial systems to pay for energy retrofits are better established and the practice is more streamlined, this labor intensive process may no longer be needed. However, given the current funding and policy environment (e.g., there are no requirements for homeowners to get energy assessments or improve energy efficiency of their homes) and the lack of widespread consumer awareness, this individualized approach is warranted.

Messaging for comfort, health and specific homeowner needs is more effective than energy savings. Homeowners are frequently most satisfied with the improvements to their homes' comfort and the benefits to their health. Use of the phrase "energy upgrade" is preferable to "retrofit;" likewise "energy assessment" is better received than "energy audit." Until evidence that specific retrofit measures actually reduce energy consumption becomes more widespread, increased comfort will remain the strongest, most credible selling point.

Pairing retrofits with behavior change education for homeowners is likely to improve program impacts. Evidence is increasing that behavioral modifications can make as much difference as physical improvements in reducing energy use. Education on behavior change should be incorporated into outreach programs.

Tracking energy use is proving difficult. The Retrofit NYC intake process includes a request for residents' permission to view and track their utility information and audit reports for research purposes. In most cases the residents will sign this without hesitation. We wish to track energy use, the most important benchmark of program success and to provide feedback to homeowners so they can be more knowledgeable about their use and how they compare to their neighbors. However, securing that information has proven extremely difficult. We are only able to download Con Edison electrical information one account at a time and by billing period. Because billing periods vary substantially, e.g., they may include one month or several months, it is difficult to compare homeowners' use over time.

⁷ Sustainable Works:: <http://sustainableworks.com>

National Grid requires a password to view on-line information gas account information. Most often, homeowners do not have or do not know their password adding a barrier that has made it nearly impossible to track gas usage.

Retrofit Incentive Program Considerations

New York State has one of the most ambitious energy reduction goals in the nation, to reduce electricity use by 15 percent from forecasted levels by 2015. To reach that goal, the Public Services Commission oversees the Energy Efficiency Portfolio Standard (EEPS) and funds a plethora of incentive programs supported by surcharges to utility customers.

Engaging homeowners in these programs, administered by NYSERDA and the utility companies, has been the focus of Retrofit NYC Block by Block.

In the absence of regulation, the incentive programs help stimulate interest; work should be done at the time of audit We find that free or very low cost measures are needed to motivate homeowners. At the same time, the programs are complicated to explain and there are multiple programs available, depending on income, heating fuel and building size. The number of choices and many doors, through which a building owner might enter, can be confusing to the consumer. In Retrofit NYC, National Grid's EHSIP Program, which offered air sealing at the time of the audit and a meaningful incentive for roof insulation, was the most frequently used program when it was available. While many factors may have influenced that result, we would conjecture that simple, streamlined programs are easier to understand and use for the outreach worker, the contractor and the homeowner. Implementing energy upgrades at the time of the energy assessment generates more energy upgrades than relying on the owners to follow-up the recommendations in the assessment.

Regulation, in tandem with incentives, has been demonstrated to increase retrofit uptake. Regulations, such as [Boulder Smart Regs](#), a law requiring the owners of all of Boulder, Colorado's rental housing to meet an energy efficiency standard, would likely be more effective in generating scale. In addition, stricter regulations about upgrading heating systems, hot water heaters, appliances and other equipment at the time of replacement, would gradually improve the efficiency of systems in use. Regulations that require energy assessments to be provided to purchasers by homeowners selling their homes could introduce energy use into the home buying decision, educate purchasers and influence the market to value energy efficiency.

Low-cost financing is needed to eliminate the obstacle of up-front costs. The average cost of the recommended measures by Green Job Green NY energy assessments for which we have data (43 reports) is over \$19,000. Even if homeowners elect to implement a small portion of the measures, the retrofits require an outlay of upfront cash that is a well-known obstacle in the retrofit industry. Furthermore, particularly in the low- and moderate-income neighborhoods in which our partners are working, many owners are averse to taking loans. They often know of people who have lost their homes



Figure 6 Pratt Center created decals for the doors of homeowners who participated in energy retrofits as one way to raise the visibility of the retrofit work.

to foreclosure but rarely know of anyone who has benefitted from a retrofit. Finally, of those homeowners who have applied for low-cost Green Jobs Green NY financing, about half have been declined for the loans. We are eager to test out the efficacy of on-bill recovery, which allows homeowners to finance the costs of retrofits on their utility bills, as a market stimulator.

A single point of entry would help increase uptake of retrofits. National Grid, Con Edison and NYSERDA each provide information about the incentive programs offered by their organizations. Retrofit NYC plays a role in assisting individuals take advantage of the opportunity that best suits their needs, interests and budget. Pratt has conceived and conducted initial development of the NYC Energy Funds Finder which would be a web-based eligibility tool that directs any New York City building owner to the incentive programs for which they would be eligible. We are seeking resources and partners to implement the Funds Finder.

Frequently changing incentives are a barrier to scaling up retrofits. During the short course of Retrofit NYC program implementation, the retrofit incentives and programs available have changed. For example, the National Grid Enhanced Air Sealing and Insulation Program was shut down with virtually no notice after being available for less than one year; both homeowners and contractors who were relying on the program were caught short. While Pratt updates its web resources and let partners know of new programmatic guidelines and parameters, frequent program design changes add a degree of difficulty for outreach workers, contractors and homeowners.

Tailor retrofit programs for urban settings. More than half the small homes in NYC are two- to four-units. Yet the incentive programs are easiest to use for single-family homes. For example, one barrier to program entry to GJGNY has been the requirement that owners provide a utility use history for all tenants. The homeowners often do not have access to that information for their tenants and it is not clear if or how that information is used. In the National Grid program, the program was limited to homeowners who had direct access to the roof cavity even though the configuration of many New York City homes is that the owner lives on the ground floor and rents out upper floors. A stumbling block to participation in the Weatherization Assistance Program is the presence of illegal units, most often in the basements. Further, audit report templates appear to be designed for the single-family home. Contractors are not required to list which units/portions of the house have been audited. Finally, the contractor industry is commonly organized by trade here which may be different than upstate communities where the retrofit contractors may be general contractors. Designing the programs to reflect NYC multifamily housing stock and trades-oriented contracting industry would improve uptake.

Comprehensive Energy Assessments

It was a goal of the Retrofit NYC Block by Block initiative to analyze audit data to learn whether and which recommendations achieved the highest energy savings relative to expenditure and whether similar buildings consistently need common measures that could be broadly implemented. Indeed, the audits did result in common recommendations, suggesting that it might be possible and desirable to

create standard audit packages. Inconsistent audit quality caused us to question whether the individual, BPI audit is a necessary prerequisite to the retrofit incentive programs.

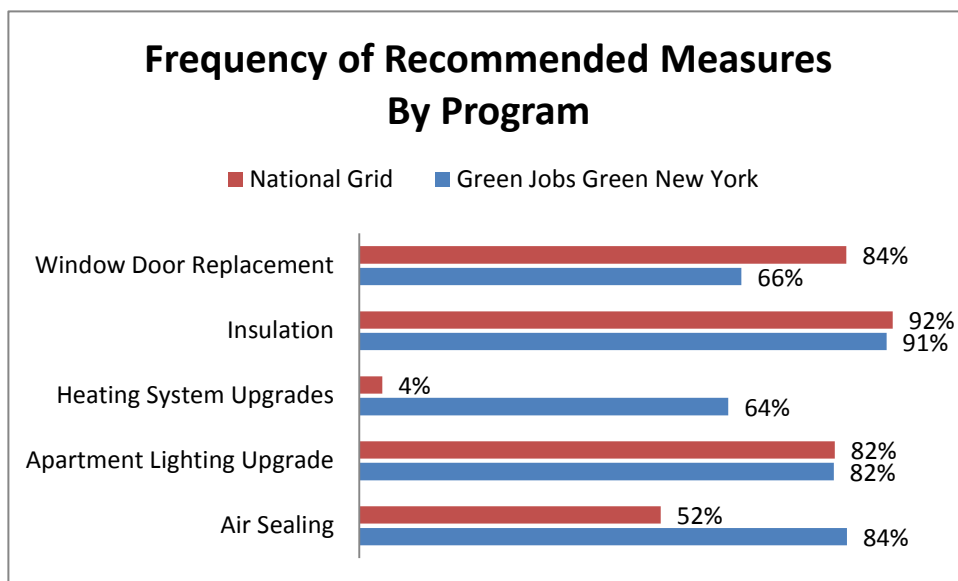
Audit reports were not persuasive to homeowners: The BPI Energy Assessments required by the National Grid and Home Performance Programs are expected to be an educational tool as well as a compelling sales tool. In order for homeowners to easily judge the benefits of the recommended measures, audit reports should provide a clear, simple list of each recommended measures with its itemized cost, projected energy savings and payback period. The reports should always include the homeowner's current energy use and cost. A common standard, across all programs, requiring this simple information in a clear format would enable homeowners to make informed, reasoned decisions to pursue appropriate retrofit measures. The reports received by the homeowners are long and full of jargon; they are neither clear nor compelling and they require explanation by the contractors and interpretation by the outreach workers, adding extra labor and cost to the process.

The "comprehensive" energy assessment appears to get skewed to the incentives and/or the expertise and interests of the contractor: We found a discrepancy in the audits under different programs that we suspect might relate more to the program than to the differences in the housing stock. The National Grid program, which paid for

air sealing and insulation, generated only two heating system upgrade recommendations for 82 completed audit reports while the GJGNY audits included 39 different heating system recommendations in 57 completed audit reports. Similarly, there are no recommended water heater repairs or replacements in the 82 National Grid reports while there are eight water heater

related recommendations in the 57 GJGNY reports. We do not conclude that the National Grid program's emphasis on insulation is unwarranted, but question whether the energy audits are truly comprehensive. Furthermore, contractors may be under-recommending items that are not typically included in their contracts with the homeowner. For example, new appliances would not be in the scope of work of the contractor but would be a separate purchase by the homeowner. Only four GJGNY audits recommend a new refrigerator. These issues could be expected to arise in any program designs where the auditor and the contractor are one and the same.

Some audit reports did not reflect competitive pricing: We have also seen a lot of variance on projected costs (\$15 light bulbs), certain costs omitted (e.g., one audit includes the cost of a new gas boiler but not the cost of decommissioning the old oil tank). These kinds of discrepancies lead to mistrust by the



outreach workers and homeowners. An independent review of six audits by Steven Winter Associates, a national expert in energy efficiency, found a lot of variability in measure pricing. In one case, an insulation contractor is listing a \$0 cost for items beyond his expertise (heating recommendations). This is problematic when the audit report is required for financing applications; it adds another step for the homeowner, a possible deterrent to continuing the retrofit process.

Some audit reports did not appear to be tailored to the individual home: In some cases, auditors seem to be performing boilerplate audits that repeatedly include the same minor measures. A common package from one contractor is: replace ten bulbs, replace front door, and add attic insulation. Given the program emphasis on individualized home assessments, we would expect the assessments to be more reflective of the particularities of each building and occupant. Some audits are incomplete: they do not contain adequate basic details about the building such as heating system distribution type and equipment or a date when the audit took place.

The similar measures across energy audit reports combined with some inconsistencies in audit completeness and quality and the lack of persuasiveness of the reports to motivate homeowners to implement measures raises questions about whether they are a necessary prerequisite for energy efficiency upgrade programs designed to scale up home energy upgrades.

VI. Recommendations for further research and program development

Many, but not all, of the pieces of the retrofit puzzle have been put into place. The community-based outreach and marketing model represented by Block By Block and now embodied in the Green Jobs Green NY program will continue to engage more small homeowners than would otherwise join the existing incentive programs. This outreach is useful to develop early adopters and build momentum. On-bill financing should remove the financing obstacle and provide a relatively easy and safe way to pay for retrofit measures. However the slow rate of retrofit uptake in New York City, even with the benefits of aggressive community outreach, suggest that exploration of alternative strategies for dramatically increasing the level of retrofits and related jobs is needed. Some of the pieces are still missing.

In the final months of Retrofit NYC Block By Block, Pratt Center and our partners will:

Promote On-Bill Recovery: Pratt Center will work with our community and other industry partners to realize the potential of on-bill recovery to solve the hurdle of up-front costs. Even though low-cost loans are available to residents in New York, alternative financial instruments that do not ‘feel’ like a loan would increase retrofit uptake. We need to make sure to differentiate on-bill recovery from more traditional loans and to make it widely available for qualified homeowners.

Research and test the hypotheses that similar homes require similar measures that can become a standard package of measures and that can be aggregated to reduce costs. If a standard package of cost-effective measures can be identified for New York City’s housing types, and these packages could

be bid out to achieve cost efficiencies, then we believe costs would come down, the contracting process would be simplified and it would be possible to ramp up retrofits more quickly and at less cost. Pratt Center is exploring the feasibility of testing standard packages for similar types of homes.

Pratt will also work with industry partners to:

Develop means for homeowners to easily track and report on energy savings. The difficulty accessing, tracking and reporting on energy use data is an obstacle to reducing energy use. Customers are willing to share their energy use information, but records need to be more easily accessible in order to accurately predict the energy saving potential and ongoing savings of a given dwelling. The entire retrofit industry would benefit from greater certainty of which measures do or do not save energy for particular housing types, and the circumstances that influence savings. This analysis will only be possible when energy use data is available for all retrofitted homes over a period of a few years.

In addition, Pratt will convene industry partners to consider additional ways to scale up home retrofits. Promising ideas include:

- *Develop ways to better integrate energy upgrades with existing home improvement practices.* Americans are spending in the range of \$300 billion each year improving their homes.⁸ It is logical to think that, at the time that the owners are making these improvements is also when they might consider incorporating energy efficiency improvements such as insulation, new appliances and light fixtures. Selling retrofits as a stand-alone upgrade appears more difficult than selling home improvements; we propose educating contractors and homeowners so that home remodeling integrates best practices in energy efficiency in order to multiply energy efficiency outcomes. While this is a highly fragmented industry – small, self-employed contractors make up more than two thirds of the industry - we believe that directing incentives to home improvement contractors to include energy efficiency and water saving measures would likely multiply into greater energy savings than we are seeing by trying to create a stand-alone business model for energy efficiency.
- *Increase regulation and incentives at home sales, major home improvements and system replacement.* *Increase regulation and incentives related to heating and hot water system replacements:* Regulation, in conjunction with technical assistance and financial incentives has proven more effective than incentives alone. Sales, major home improvement projects and systems replacement offer opportunities to regulate improvements in efficiency. Boilers and hot water heaters are frequently replaced at the point when they break down. That on-the-spot investment can lead to inefficient fuel use for some thirty years. Energy efficiency requirements of new systems should be upgraded so that it is not possible to

⁸ According to the Joint Center for Housing Studies:
http://www.jchs.harvard.edu/publications/remodeling/remodeling2011/r11-1_1_intro_and_summary.pdf

purchase new, inefficient systems. Furthermore, any time major work is being conducted on a home (e.g., a permit is required), homeowners and contractors should be encouraged via to install insulation, upgrade appliances and systems, etc. for energy efficiency.

- *Integrate education on behavior change:* Research suggests that there are significant energy savings to be gained through behavioral change. Tracking results through energy saving projections has a tendency to inflate audit results and could ultimately decrease confidence in the energy assessments. Outreach programs such as Retrofit NYC should combine behavioral change with energy upgrades and maintain energy savings as the bottom line outcome.

Other policy recommendations include:

- *Make the Weatherization Assistance Program (WAP) more widely available and develop eligibility by census tract in low-income neighborhoods.* Given long waiting lists, Retrofit NYC outreach has had limited success accessing the WAP program for eligible homeowners. In addition, the eligibility process is extremely time consuming for providers and recipients alike. We would recommend creating an alternative eligibility for neighborhoods that have a high percentage of income eligible residents so that the program could be implemented at scale, improving homes faster and spending fewer resources on bureaucracy.
- *Integrate weatherization funds with other financing for affordable housing to address needed capital repairs.* Many homes occupied by low-income residents suffer from deferred maintenance. In particular, we found that roof replacement and mold were frequent problems that could disqualify homeowners from participation in the Weatherization Assistance Program. Given these issues, our partner in Cypress Hills found the WAP process so laborious and ineffective for homeowners in their neighborhood that they are using alternate housing capital funds to implement a capital repair program that integrates roof and boiler repair and replacement with weatherization measures.

VII. Conclusions

The Retrofit NYC Block by Block initiative has generated an increase in home retrofits and jobs in the industry in New York City but not at the scale or pace needed to address the urgency of climate change or in line with the benefits that would accrue to the homeowners themselves. It has also increased capacity at the community level and provided experience to suggest new ways of scaling up home retrofits in New York City. The next year will be crucial as community-based organizations combine outreach efforts with on-bill recovery to make financing for the up-front costs of energy upgrades widely and easily available.

Pratt is planning a study to document the potential, feasibility and reduced costs of adopting standardized measures for similar housing types to promote the possibility of cost-saving retrofit aggregation. We are eager to work with stakeholders to dramatically increase the scale of NYC home retrofits. Promising ideas include:

- Standardize retrofit packages and aggregating installment for similar homes
- Develop means for homeowners to easily track and report on energy savings
- Integrate energy efficiency upgrades into the home improvement industry
- Regulate to achieve energy upgrades at sales, home improvements and heating and hot water system replacements
- Make the Weatherization Assistance Program (WAP) more widely available and develop eligibility by census tract in low-income, urban neighborhoods
- Integrate weatherization funds with other financing for affordable, healthy homes to address needed capital repairs and health issues

In the current context and at month eleven of full implementation, Retrofit NYC Block BY Block is stimulating demand for energy assessments and retrofits. With on-bill recovery, we see continued promise in this neighborhood-based approach to cultivate the early adopters as the market develops and programs and policies are refined.

It is hard to imagine a more important priority than stopping and reversing global warming. It will require the mobilization of every segment of our population and every sector of our economy. Retrofit NYC Block By Block offers insights into the challenges and opportunities to achieve the highest level of participation

Appendix:

http://prattcenter.net/sites/default/files/users/pdf/homeowners_cutsheet.pdf

PROGRAM	SUMMARY
Weatherization Assistance Program (WAP)	<ul style="list-style-type: none"> • No- or low-cost for participants • Energy audit • Improvements include insulation, air sealing, heating system repairs, energy efficient lighting, window repair/replacement and other weatherization services • If landlord is not eligible, but 50% of tenants are, a landlord contribution is required.
NYSERDA EmPower New YorkSM	<ul style="list-style-type: none"> • Free for income-qualified households • Improvements include cost-effective electric reduction measures such as lighting and refrigerator replacement, insulation, and health and safety measures • Available to renters and homeowners
HEAP Heating Equipment Repair or Replacement	<ul style="list-style-type: none"> • No cost furnace repair or replacement for low-income households • Benefit amount varies from case to case • Maximum benefit is \$6000 per household
NYSERDA Assisted Home Performance with ENERGY STAR®	<ul style="list-style-type: none"> • Subsidy for home energy upgrade work • 50% back on the installation costs up to \$5000 for a single-family home and up to \$10,000 for a 2-4 family home • Upgrades could include air sealing, insulation, heating and cooling system improvements, energy efficient lighting, and other improvements
NYSERDA Home Performance with ENERGY STAR®	<ul style="list-style-type: none"> • Subsidy for home energy upgrade work • 10% back on the installation costs up to \$3000 • Upgrades could include air sealing, insulation, heating and cooling system improvements, energy efficient lighting, and other improvements
Green Jobs-Green New York	<ul style="list-style-type: none"> • No-cost audit for households making less than \$124,600 per year • Low-cost audits based on a sliding scale for households making above \$124,600 per year • Low interest loan fund • Loan interest rates are 3.49% or 3.99% for a limited time • Can be combined with Assisted Home Performance with ENERGY STAR® or Home Performance with ENERGY STAR®
National Grid Enhanced Home Air Sealing and Insulation Program (EHSIP)	<ul style="list-style-type: none"> • \$50 Participation fee offers a Comprehensive Home Assessment and up to 2 hours of air sealing • 50% incentives up to \$3000 for attic insulation • Must be a National Grid gas heating homeowner
National Grid Residential Energy Efficiency Heating Program	<ul style="list-style-type: none"> • Product rebates • \$200 for a 90% high efficiency furnace • \$1000 for a 90% high efficiency condensing hot water boiler • \$300 for indirect water heaters • \$25 for an ENERGY STAR® thermostat
ConEdison Residential Programs	<ul style="list-style-type: none"> • \$50 energy survey with free measures • Rebates for eligible HVAC Electric and Gas systems and air duct sealing • Rebates for second refrigerator recycling • Rebates for ENERGY STAR Room ACs (seasonal program) • Free Programmable Thermostat
NYSERDA Solar PV Incentives	<ul style="list-style-type: none"> • Grants for purchasing and installation of new Solar Electric or Photovoltaic (PV) systems • \$1.75 per watt up to a maximum of 7 kW per site/meter, up to 50% of the total installed system costs • Can be combined with federal, state, and city tax rebates • Visit www.powernaturally.org/Programs/Solar/Installerspv.asp?i=1 for eligible installers

Appendix B: Example Block by Block Audit Report



YOUR HOME ASSESSMENT

New Yorkers are spending more money than ever to heat and cool their homes. Many homeowners are not getting the comfort they are paying for. Many homes suffer from cold spots, rooms that are too hot or too cold, ice dams, drafts, building rot, and mold and mildew problems. They may all be common signs that the house is not properly insulated or that the heating system is improperly balanced, or that moist air in the house is not being effectively controlled. Many homes are simply heating the outdoors.

Now there's something you can do about it. The Home Performance with ENERGY STAR initiative is sponsored by the New York State Energy Research and Development Authority (NYSEDA) as part of the New York Energy Smart (SM) Program. Contractors participating in this initiative have successfully completed a comprehensive skills evaluation in home performance diagnostics. Each participating contractor has earned certification through the Building Performance Institute (BPI), a nationally recognized organization for building science technology that sets the standards for assessing and improving the energy performance of homes.

About Your Home's Assessment

Your Home Assessment is customized to identify the particular needs of your home based on our analysis. The information that your Contractor gathered has been entered into a computer software package that helps your Contractor determine the most cost-effective measures you can take to make your house more efficient and comfortable. This report outlines that analysis, prioritizes recommended home repairs and helps you determine the best improvements for your home.



BUILDING INFORMATION

Address:

Total Floor Area: 3,120 Sq.Ft.

Heated Floor Area: 2,340 Sq.Ft.

Year built: 1987

PREPARED FOR

Name: [Redacted]

Phone: [Redacted]

Email:

Date:

PREPARED BY

Name:

Address:

Phone:

Fax:

E-mail:

YOUR ASSESSMENT

Blower Door Tests & Air Leakage

Everyone assumes that a home is built with enough insulation to help keep warm air inside during the winter, and outside in the summer. But the truth is that not all insulation performs the same, and insulation is only half the solution to making sure that your home performs at its best and to your satisfaction.

The second part of the solution to creating a better living environment is reducing uncontrolled air leakage. Typically, as much as 25% of your heating and cooling dollars escape through unseen cracks and gaps in your home, which are usually found in attics, basements, duct systems, and around floors, doors, and windows. If you combine all the holes and gaps in a typical house, it can be like leaving a window or door wide open year-round. In addition, sealing air leaks also helps prevent moisture from entering the attic and walls, which protects your home from structural or insulation damage.

Your certified Home Performance Contractor has assessed the air loss in your home using a “blower door test,” an effective and accurate method to expertly measure and identify areas where air is escaping. You probably saw it being used during the site visit. The test provides some key information about your home. “Shell Leakage” indicates the measurement of air leaking into your home. The “Building Air Tightness Limit” indicates how much air should be entering your home to help ensure that you have sufficient fresh air even when the windows are closed. If you have too much air infiltration, your Contractor will provide recommended measures to the seal air leaks. If the test indicates that your house is tight, your Contractor may recommend mechanical ventilation to assist in the removal of potential indoor air pollutants.

Stopping Air leaks

Once air leaks are detected, a variety of materials are used to eliminate air passages in attics, basements, and living spaces. The materials used in air sealing include sealant foams, rigid baffles, caulking, weather-stripping, and foam board insulation. When leaks are properly sealed, less air escapes into your attic, or passes through walls, floors, and vent stacks, or is drawn into your basement. This procedure also helps prevent moisture problems, including peeling paint and structural damage in walls and building cavities. For this reason, air sealing must accompany most attic insulation work.



YOUR HOME'S RESULTS

Air Leakage

Blower door test has indicated that your building shell leakage is 4845 CFM50. The current industry standard is 1493.86 CFM50.

YOUR ASSESSMENT

Insulation

Insulation decreases your energy usage by slowing heat loss and is most effective when installed in conjunction with air sealing. Insulation also acts as a sound buffer, so you can enjoy a quieter home.

Several insulation types are available.

- Cellulose insulation is an excellent insulator made out of recycled newsprint treated with a fire retardant. It provides excellent coverage, filling in gaps often left between insulation batts and ceiling or wall joists.
- Foam insulation can be one of several products, generally spray polyurethane or spray polyisocyanurate. These are environmentally safe synthetic foams that fill gaps and holes, have excellent insulation values and block air movement.
- Fiberglass batts are the most common form of insulation. The batts must be installed very carefully to avoid leaving gaps that become leakage paths for air.



YOUR HOME'S RESULTS

Insulation

FLAT ROOF

Wood 2x8 frame, fiberglass insulation, R-24 with area of 780 square feet, adjacent to outdoors.

FLOOR ABOVE GRADE

Wood 2x8 frame, none insulation, R-5 with area of 780 square feet, adjacent to vented crawlspace.

RIM JOIST

Brick 8" frame, none insulation, R-1 with area of 118 square feet, adjacent to outdoors.

SLAB BELOW GRADE

Concrete 4" frame, none insulation, R-0 with area of 780 square feet, adjacent to ground.

WALL

Concrete 8" frame, none insulation, R-1 with area of 354 square feet, adjacent to ground.

Concrete 8" frame, none insulation, R-1 with area of 118 square feet, adjacent to outdoors.

Wood 2x4 frame, fiberglass insulation, R-13 with area of 2,832 square feet, adjacent to outdoors.

YOUR ASSESSMENT

Heating and Cooling Systems

About half of your home's energy costs are for heating and cooling. That's why maximizing its efficiency is important. One way to maximize performance on an existing system is through periodic maintenance, including cleaning and tuning. Oil systems should have maintenance performed annually, while gas-fired systems should be checked and serviced every two years. If your system is more than 10 years old, it may be time to replace the system with a high-efficiency and correctly sized system. New gas-fired systems should have an Annual Fuel Utilization Efficiency (AFUE) rating of at least 90%, while the minimum efficiency for oil furnaces and all types of hot water boilers is 84% AFUE. If you are considering a new system, ask for one with the ENERGY STAR label for optimum efficiency. If your Contractor recommends that your system be replaced, the assessment summary at the end of this report will include the system's estimated cost, annual savings and payback (the projected number of years it takes for the fuel savings to pay for the system).

Forced Air Duct Distribution System

If you have a warm air or central air conditioning systems, the forced air supply and return ducts should be as tight as possible to ensure that the conditioned air is delivered to rooms evenly. Supply duct leaks can contribute to high energy bills and an uncomfortable living space. Return leaks can pull mold, dust and other unwanted particles into your home. To prevent this air leakage through the seams and joints of the duct work, they should be sealed with mastic including the connections to the registers in the ceilings and floors. There are several types of duct insulation available. The most common is vinyl-faced fiberglass. This insulation is important for keeping the conditioned air inside the ducts at the desired temperature when being delivered to the rooms in your home. Duct insulation should be cut to fit with all seams properly secured with mechanical fasteners (staples, straps) to achieve the optimum R-value. Duct tape alone is not recommended. These measures are especially important when any duct work is located in attics or crawl spaces. In areas where duct work is not accessible for fiberglass and mastic to be applied may still have leaks that require sealing. In these cases, ducts can be sealed by injecting sealant in to the ducts. This method is available from some contractors.



YOUR HOME'S RESULTS

Heating and Cooling Systems

Main Heating System

Your main heating system is a furnace with forced air distribution. It was manufactured in 1987. The efficiency of this furnace is 78 %. The fuel is natural gas. Your distribution system efficiency is 100%.

Backup Heating System

Your backup heating system is a furnace with forced air distribution. It was manufactured in 1983. The efficiency of this furnace is 82 %. The fuel is natural gas. Your distribution system efficiency is 100%.

Cooling System

Your house has a cooling system with efficiency of 10 SEER and a forced air distribution. It was manufactured in 2006. Your distribution system efficiency is 100%.

YOUR ASSESSMENT

Windows and Doors

It's important to have well-insulated, high performance windows and doors. You'll see and feel the difference through improved comfort, reduced condensation and lower utility costs. Look for the ENERGY STAR label to identify the most efficient windows, skylights, and sliding glass doors. A window's insulating ability is measured by its U-value. Since heat flows from warm to cold in the winter, heat flows from your home interior through the windows to the colder exterior. The reverse occurs in the summer.



Health and Safety Inspection

Your Building Performance Contractor has been trained to inspect and test combustion appliances such as heating equipment, ovens and water heaters, for proper performance to ensure safe operation. This comprehensive evaluation includes measurement of carbon monoxide produced by the appliance and an evaluation to ensure that potentially dangerous combustion gases are not introduced into the home. Certified Home Performance Contractors test for any combustion safety problems before and after performing any insulation and/or air sealing measures.



YOUR HOME'S RESULTS

Windows and Doors

Your house has the following windows:

Double pane clear window. Quantity: 9

Your house has the following doors:

Panel door with 7/16-in. panels with metal storm door and estimated R-Value of 2.70.
Quantity: 3

HEALTH AND SAFETY INSPECTION

The following measurements were performed in your home:

1. Location: Combustion Appliance Zone CAZ
Measurement Type: Depressurization (Base)
Measured Value: 0.0 Pascal
Problem Description:
2. Location: Combustion Appliance Zone CAZ
Measurement Type: Depressurization (Worst Case)
Measured Value: 0.0 Pascal
Problem Description:
3. Location: Hot Water Heater
Measurement Type: Carbon Monoxide
Measured Value: 3.0 PPM
Problem Description:
4. Location: Hot Water Heater
Measurement Type: Carbon Monoxide
Measured Value: 6.0 PPM
Problem Description:

YOUR ASSESSMENT

Health and Safety Inspection - Continued

5. Location: Hot Water Heater
Measurement Type: Flue Draft
Measured Value: -6.0 Pascal
Problem Description:
6. Location: Hot Water Heater
Measurement Type: Flue Draft
Measured Value: -3.0 Pascal
Problem Description:
7. Location: Oven Unvented
Measurement Type: Carbon Monoxide
Measured Value: 0.0 PPM
Problem Description:
8. Location: Primary Heating System
Measurement Type: Carbon Monoxide
Measured Value: 6.0 PPM
Problem Description:
9. Location: Primary Heating System
Measurement Type: Flue Draft
Measured Value: -3.0 Pascal
Problem Description:
10. Location: Secondary Heating System
Measurement Type: Carbon Monoxide
Measured Value: 6.0 PPM
Problem Description:
11. Location: Secondary Heating System
Measurement Type: Flue Draft
Measured Value: -3.0 Pascal
Problem Description:

YOUR ASSESSMENT

Health and Safety Inspection - Continued

The following observations were made during a visual inspection of your home:

1. Venting Type1: High static pressure flame retention head oil burner
2. Gas Dryer Fuel: No problems observed
3. DHW Heater Spillage (Worst)1: Pass
4. Main Heat Spillage (Worst)1: Pass
5. 2nd floor closet: air leakage
6. acces panel: air leakage
7. 2nd floor bathroom: air leakage threw ceiling
8. co detectors: no co detector
9. DHW discharge: pipe too short

YOUR ASSESSMENT

Water Heaters

Typical improvements of domestic hot water system include insulating an existing tank, replacing the existing tank with a more efficient model using the same fuel, or replacing the existing tank with another fuel source, usually natural gas or a heat pump water heater. If your hot water pipes are not insulated in a cold basement, your Home Performance Contractor will often recommend insulating the first six feet of pipe.



Appliances

When it's time to buy or replace your home appliances, be sure to ask for models with the ENERGY STAR label. These appliances use up to 50% less energy than conventional models, saving you money on utility bills while reducing air pollution. For example, ENERGY STAR labeled clothes washers use up to 60% less energy and 36% less water. In one year, that's more water than the average person drinks in a lifetime. Many dishwashers that carry the ENERGY STAR label are built with innovative technology to clean better while using less energy and water. And, today's ENERGY STAR labeled refrigerators use half the energy of a 10-year old conventional refrigerator.



YOUR HOME'S RESULTS

Domestic Hot Water System

Your water heater was manufactured in 2004. Its fuel is natural gas. It has a rated volume of 80 gallons and a rated input capacity of 75,500 Btu/Hr. The heater is located in a conditioned space and is set at 120 F.

Appliances

You have the following appliances in your home:

Bathroom exhaust fan, 50 cfm 1 with estimated annual electricity usage of 2 kWh. Quantity:1

Bathroom exhaust fan, 50 cfm 2 with estimated annual electricity usage of 2 kWh. Quantity:1

Bathroom exhaust fan, 50 cfm 3 with estimated annual electricity usage of 2 kWh. Quantity:1

Clothes dryer, natural gas 1 with estimated annual electricity usage of 96 kWh, annual natural gas usage of 92 Therm. Quantity:1

Clothes washer, hot-cold water cycle 1 with estimated annual electricity usage of 156 kWh and annual hot water usage of 7,188 gallons.

Quantity:1

Color TV, typical usage with estimated annual electricity usage of 110 kWh. Quantity:1

Color TV, typical usage2 with estimated annual electricity usage of 110 kWh. Quantity:1

Color TV, typical usage3 with estimated annual electricity usage of 110 kWh. Quantity:1

Computer, typical usage with estimated annual electricity usage of 130 kWh. Quantity:1

Computer, typical usage2 with estimated annual electricity usage of 130 kWh. Quantity:1

YOUR ASSESSMENT

Appliances - Continued

Range, gas, with pilot 1 with estimated annual electricity usage of 0 kWh, annual natural gas usage of 180 Therm. Quantity: 1

Range, gas, with pilot 2 with estimated annual electricity usage of 0 kWh, annual natural gas usage of 180 Therm. Quantity: 1

Refrigerator-auto def top freezer, 1990 model with estimated annual electricity usage of 884 kWh. Quantity: 1

Refrigerator-auto def top freezer, 1990 model 2 with estimated annual electricity usage of 884 kWh. Quantity: 1

YOUR ASSESSMENT

Lighting

When replacing light bulbs or installing new light fixtures, you'll save time and money when you choose models that have earned the ENERGY STAR. According to the EPA, today's ENERGY STAR labeled lights equal or surpass the quality of light found in conventional incandescent bulbs, using 75% less energy and lasting 10 times longer. You'll save on energy bills plus the cost and trouble of constantly replacing bulbs.



YOUR HOME'S RESULTS

Lighting

You have the following lighting fixtures in your home:

- 16 15-Watt fixtures.
- 43 60-Watt fixtures.

YOUR SUMMARY

This report addresses the key recommendations for improving the comfort, safety and efficiency of your home. You should use it as a guide for deciding what work you want to have done. Remember, your Home Performance Contractor is ready to complete these projects promptly, and the work is guaranteed.



Selected Packages



Measure Description	Non-energy benefits		Package1	Package2	Package3
1st floor adjacent to crawlspace: Upgrade 780 square feet of existing floor above grade to Carpet w/Pad, 0.75" Wood, 2x10 16" OC, 9.25" Fiberglass, R-32	Improve comfort, increase value of building.	➔	\$ 2,000	\$ 2,000	\$ 2,000
Rim Joist Insulation : Upgrade 118 square feet of existing rim joist to Gyp Bd, 2x10 16" O.C., 6" High Density Foam, R-31	Improve comfort, increase value of building.	➔	\$ 1,080	\$ 1,080	\$ 1,080
Heated Area Infiltration Reduction: Reduce overall air leakage of heated area from 4845 CFM50 to 3500 CFM50.	Reduce drafts.	➔	\$ 2,050	\$ 2,050	\$ 2,050
Cooling System Improvement : Install 18 SEER 24,000 Btu/hr cooling system. Reuse existing distribution system.	Increase value of building.	➔			\$ 3,500
Thermostat Improvement : Install 2 programmable heating/cooling thermostats.	Improve comfort, improve convenience.	➔	\$ 240	\$ 240	\$ 240
third floor furnace: Install new natural gas 55,000 Btu/hr FURNACE with efficiency of 95.0 %.	Increased equity.	➔	\$ 4,000		
sliding door replacement: Install 1 double pane clear window with wood/vinyl frame.	Improve comfort (reduce drafts), increase value of building.	➔	\$ 2,000	\$ 2,000	\$ 2,000
Lighting Replacement : Replace 47 existing lighting fixtures with 47 new 15-Watt 15 W Fluorescent.	Reduce maintenance, reduce replacement cost (fluorescent bulbs last 10,000 hours whereas incandescent bulbs typically last less than 1,000 hours).	➔	\$ 470	\$ 470	\$ 470
Refrigerator: Removed Appliances: 1 Refrigerator-auto def top	Increase value of building, reduce	➔		\$ 1,000	\$ 1,000

YOUR SUMMARY

freezer, 1990 model; Added Appliances: 1 Appliance 1		environmental risk due to old ozone-depleting refrigerants.			
● Low Flow Device Installation : Install 1 low flow devices	● Reduce water use.	➔	\$ 100	\$ 100	\$ 100
● DHW discharge Pipe: Improve the following condition uncovered during dhw discharge : pipe too short	● Improve indoor air quality and comfort.	➔	\$ 200	\$ 200	\$ 200
● CO detectors: Improve the following condition uncovered during co detectors : no co detector	● Improve indoor air quality and comfort.	➔	\$ 120	\$ 120	\$ 120
Total Installed Cost			\$ 12,260	\$ 9,260	\$ 12,760
Annual Energy Cost Savings			\$ 845	\$ 870	\$ 987
Annual KWh Savings, KWh			2,734	3,057	3,781
Total Energy Savings, MMBtu			37.9	37.0	39.5
Simple annual payback, years			14.5	10.6	12.9
Savings to Investment Ratio			1.0	1.4	1.1

The following fuel prices were used to estimate annual energy cost savings, payback and savings to investment ratio:

- Natural gas: 1.4200 \$/Therm
- Electricity: 0.1610 \$/kWh
- Oil #2: 3.4400 \$/Gallon
- Propane: 2.9400 \$/Gallon

YOUR SUMMARY



Home Performance with ENERGY STAR is sponsored by the New York State Energy Research and Development Authority (NYSERDA) and developed under the New York Energy SmartSM Program to help New Yorkers save money, energy and the environment.

Homeowner Financing Incentive
Selected Package _____
Total Amount _____
Eligible Measures at ____ % _____ with Home Performance with ENERGY STAR Financing
Additional Measures at ____ % _____
Monthly Payment of _____ for _____ term.
-or-
Cash Back _____

Common House Problems That Cause High Energy Costs and Sacrifice Comfort

Many homes have these common problems which may go undetected by the homeowner. The problems are color coded in the diagram below.

Problem: Inadequate Insulation Levels

Effects: Warm and cool air escapes, causing heating and cooling equipment to work harder than necessary. Ice damming may occur, leading to roof and ceiling leaks. Freezing pipes.

Problem: Air Leakage

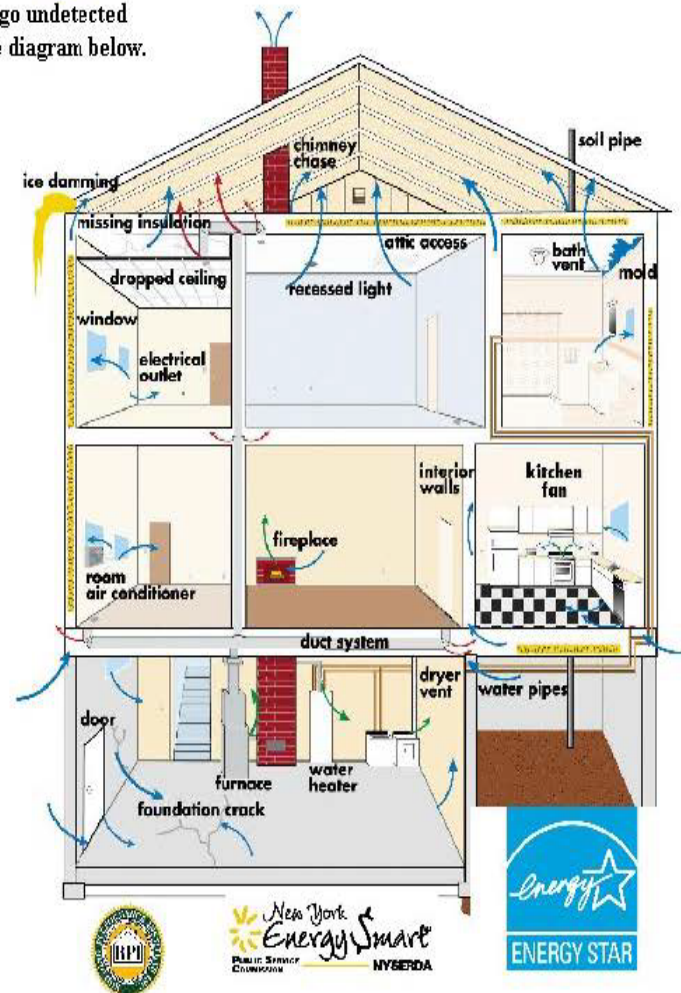
Effects: Drafts and cool spots. Overworking of heating and cooling equipment. Moisture problems leading to peeling paint, mold, mildew or structural damage in walls and attic. Inadequate air exchange causing unhealthy air quality, high humidity or dryness.

Problem: Duct Leakage

Effects: Uneven distribution of warm or cool air. Uncomfortable room temperatures. Poor heating and cooling equipment performance.

Problem: Improperly Vented Appliances

Effects: Dangerous carbon monoxide fumes can enter the living space when gas or oil-fired appliances are not vented properly. This is known as backdrafting and often occurs with poorly vented heating systems, stoves, water heaters and clothes dryers.



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