CONSORTIUM for BUILDING ENERGY INNOVATION

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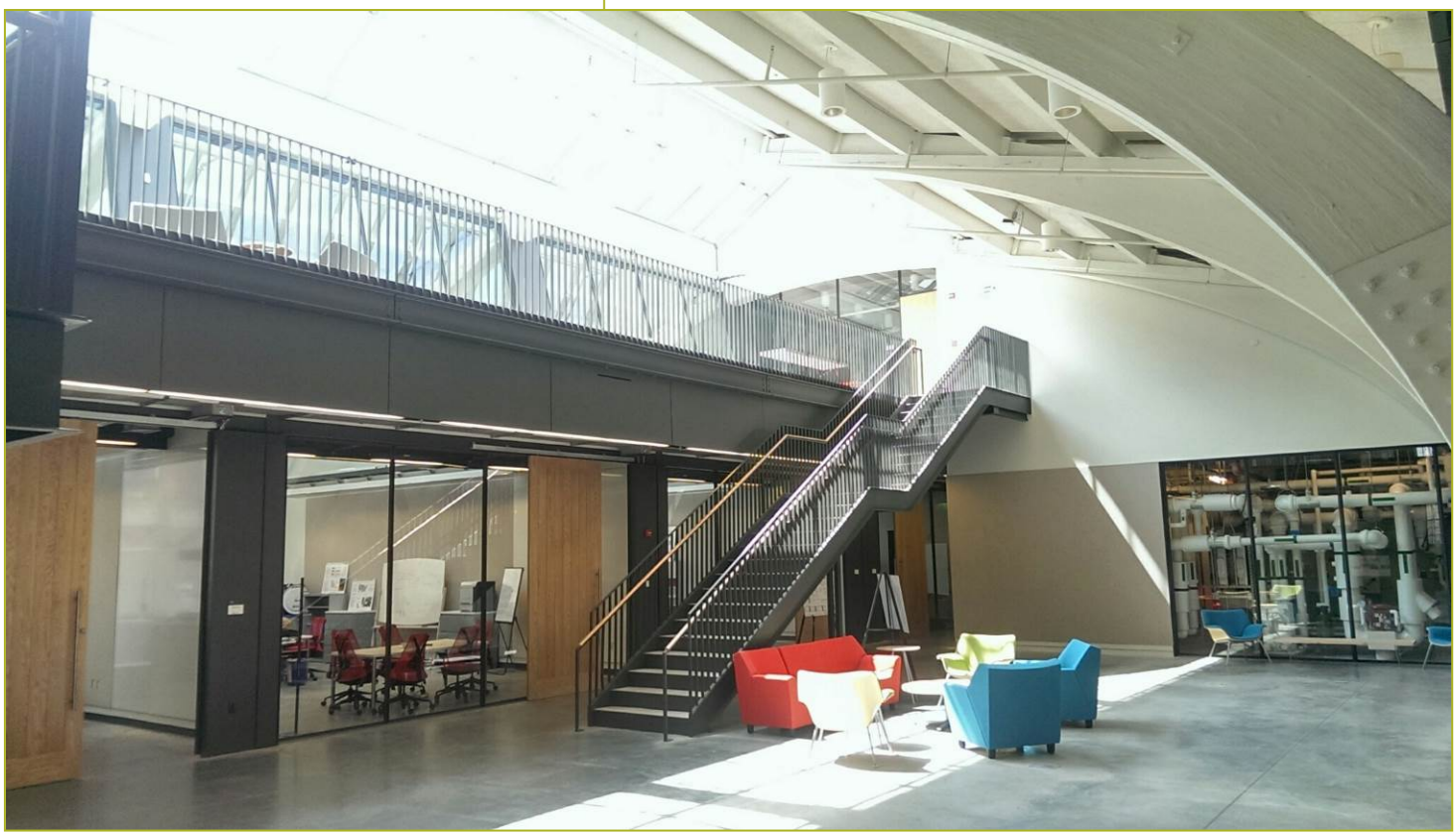

CBEI was referred to as the Energy Efficiency Buildings HUB at the time this report was developed.

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Report Abstract

This report summarized an analysis of ten multifamily buildings for the cost of deep energy retrofits, without including power generation.

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REPORT

RUTGERS
THE STATE UNIVERSITY OF NEW JERSEY

Deep Energy Retrofit Modeling and Cost Effectiveness Study: A Technical Policy Brief

January 2013

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EXECUTIVE SUMMARY

This document comprises a technical evaluation and policy brief by the Rutgers Center for Green Building, with assistance from industry consultants Kipcon Inc./Energy Squared, of the energy savings and cost of 10 commercial advanced energy retrofits (AERs). The ten buildings are benchmarked against the requirements of the New Jersey Clean Energy Program Pay for Performance (P4P) program, performance requirements of the NJ Green Building Manual, and EEB Hub goals. Specifically, this report summarizes the findings from taking 10 multi-family buildings that participated in the P4P program and models additional energy saving measures to determine how costly it would be to take a building to the maximum achievable energy efficiency, without incorporating power generation. Investigation into these improvements leads to the conclusion that effectiveness of energy improvements is determined by more than just economic impact, entailing matters of organizational structure – especially the split incentive between the developer and subsequent building owner, and changes in occupancy patterns and behavior. First costs and lack of knowledge about state incentive programs continue to be barriers to increased energy efficiency gains, as does a low inclination towards sub-metering. A summary of the findings is given below for quick reference. Detailed explanations of the energy savings measures can be found in the later sections.

Measure Name		Energy Conservation Measures	Savings	Annual Electric Use (kWh)	Peak Demand (kW)	Annual Natural Gas Use (MMBtu)	Measure Cost
Building 1	P4P - Measured	Replace Boilers, Replace DHW Heaters, Upgrade Lighting, VFD's on Pumps and Fans, Upgrade AHUs	15.0%	1,436,745	373.4	24,994	$623,900
	NJGBM - Modeled	LED Lighting Upgrade, Install Exterior Lighting Controls, Install Premium Motors w/ VFDs, Install Programmable Thermostats, Replace Chiller, Replace Windows	34.0%	1,285,756	342.1	16,528	$1,834,163
Building 2	P4P - Measured	Replace Boilers, Replace DHW Heaters, Upgrade Lighting, VFD on Pump	18.3%	886,532	326	6,418	$208,750
	NJGBM - Modeled	LED Lighting Upgrade, Install Premium Motors w/ VFDs, Replace PTAC Units, Install Programmable Thermostats, Replace Windows	31.3%	746,422	250.5	5,420	$723,927
Building 3	P4P - Measured	Replace Boilers, Replace DHW Heaters, Upgrade Lighting, VFD on Pump	19.2%	448,614	371.6	4,040	$152,000
	NJGBM - Modeled	LED Lighting Upgrade, Replace Window Units with PTAC Units, Replace Windows, Programmable Thermostats	35.3%	272,378	226.9	3,935	$450,895
Building 4	P4P - Measured	Replace RTUs, Install Occupancy Sensors, Replace Refrigerators, Install Low-Flow Fixtures, Install Programmable Thermostats, Install Boiler Controls	25.0%	931,631	231.8	3,381	$493,574
	NJGBM - Modeled	LED Lighting Upgrade, Upgrade HVAC Units, Replace Windows	35.0%	735,322	183.4	3,568	$1,024,230
Building 5	P4P - Measured	Replace Boilers, Install DHW Heaters, Upgrade Lighting, Install VFD on Pump, Eliminate Garage Heating	23.4%	698,201	277.1	8,113	$418,200
	NJGBM - Modeled	LED Lighting Upgrade, Install Premium Motors, Chiller Upgrade, Replace Windows	31.3%	628,818	242.8	6,943	$397,244
Building 6	P4P - Measured	Replace Boilers, Install VFD on Pump, Upgrade Lighting	16.7%	1,070,162	517.1	14,272	$283,000
	NJGBM - Modeled	Install DHW Heater, LED Lighting Upgrade, Replace Windows, Replace Window Units with PTACs	23.9%	940,169	424.6	13,308	$960,532
Building 7	P4P - Measured	Replace Boilers, Install Premium Pumps with VFD's	22.0%	3,148,108	1279.2	44,392	$1,092,365
	NJGBM - Modeled	Seal Louvers, LED Lighting Upgrade, Install DHW Heaters, Upgrade PTACs	30.0%	2,733,417	911.9	41,034	$2,663,965
Building 8	P4P - Measured	Replace Chiller, Replace AHU, Replace Boilers, Replace DHW Heaters, Premium Pump Motors, Install VFD on Pumps and Fans, Upgrade Lighting	28.0%	1,335,530	530	5,888	$631,800
	NJGBM - Modeled	LED Lighting Upgrade, Window Upgrades Residential Space, Window Upgrades Commercial Space	44.9%	883,653	332.4	4,308	$846,994
Building 9	P4P - Measured	Upgrade Lighting, Replace Windows, Install Programmable Thermostats	20.6%	1,681,060	1168.1	2,174	$1,545,160
	NJGBM - Modeled	Upgrade DHW Heaters, LED Lighting Upgrade, Upgrade PTACs, Install Hot Water Boilers	51.9%	665,620	247.5	5,573	$2,007,150
Building 10	P4P - Measured	Replace Boilers, Replace DHW Heaters, Replace Chiller, Premium Motors, Install VFD's on Pumps and Fans, Upgrade Lighting	19.5%	1,426,925	434.1	13,018	$698,001
	NJGBM - Modeled	LED Ligthing Upgrade, Install Programmable Thermostats	30.3%	1,038,447	292.8	12,888	$357,780

Table 1: Summary of Measures

INTRODUCTION

In this document the Rutgers Center for Green Building, with support from engineering consultants Kipcon, Inc. and an affiliate company, Energy Squared, compare, analyze, and present findings regarding the energy requirements for New Jersey's Clean Energy Pay for Performance Program and the New Jersey Green Building Manual Compliance Path Recommendations for Existing Commercial (and Multifamily) Buildings.

The Pay for Performance Program, which is open to existing commercial and industrial buildings with an annual peak kW demand electric usage of 100 kW or more, requires buildings to include a package of energy efficiency measures that achieve the minimum performance threshold of 15% reduction in total source energy consumption and a minimum 10% Internal Rate of Return. Furthermore, the ERP must include a comprehensive mix of measures in which lighting cannot make up more than 50% of the total projected savings.

The New Jersey Green Building Manual ("NJGBM" or "Manual") is a comprehensive web-based document that defines a baseline of performance and provides enabling economic and environmental best practices for a green building. The NJGBM Implementation Recommendations include suggested compliance paths that contain specific energy efficiency targets and the additional green building best practices for existing and multi-family buildings.

The Rutgers team evaluated ten (10) multi-family buildings, constructed between 1960 and 1980, geographically located in New Jersey that have already been completed or are currently enrolled in the Pay for Performance (P4P) program. These buildings proceeded with the P4P program to implement energy saving measures and upgrade much of their dated equipment that was serving the building. These energy saving measures included replacing equipment serving heating, cooling, hot water generation, lighting systems and building envelope.

According to the 2003 Commercial Buildings Energy Consumption Survey (CBECS)[1], the ten buildings in this report were constructed in a time frame (1960-1980) that is representative of 35% of all lodging buildings constructed. Boilers and packaged heating units account for roughly 50% of heating equipment used in lodging buildings. Cooling is primarily supplied via unitary and packaged terminal air conditioning equipment for over 75% of lodging properties, while chillers contribute to less than 8% of overall cooling equipment type. In 80% of the lodging buildings surveyed, a centralized water heating system is in place. Lighting still relies heavily on incandescent and fluorescent, with virtually all buildings incorporating these light sources. Refrigeration is limited to individual units (personal refrigerators). Buildings constructed in the time frame encompassing these ten buildings have an Electricity Energy Intensity of 15.3 kWh/ft^2, which is similar to that of all buildings constructed in the time frame at 15.5 kWh/ft^2. Natural Gas Energy Intensity for these buildings, 61 therms/ft^2, is slightly greater than that what is seen for all buildings 44.1 therms/ft^2. An emphasis was put on upgrading these major energy consumers.

[1] "2003 CBECS Detailed Tables: Summary." 2003 CBECS Detailed Tables: Summary. N.p., Sept. 2008. Web. Dec. 2012. <http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html>.

The following report outlines the savings and costs associated with the P4P program as well as additional energy reducing measures that were not included in the program.[2] All measures were modeled in eQuest version 3-64 and meet or exceed ASHRAE 90.1-2009 standards.

[2] Pricing was generated by vender quotes, RS Means, and professional experience. Associated costs may not reflect exact pricing.

BUILDING 1

This building was built in 1966 and is located in Cherry Hill, NJ. It is a 12-story apartment building that houses 250 apartments, a number of offices, and common areas. Each apartment has a fan-coil unit that uses chilled water to provide cooling and hot water for space heating. There are two Heating, Ventilation, and Air Conditioning (HVAC) units on the ground floor that provide cooling and heating to common areas. Heating is generated by four (4) 1,800 MBH boilers located in the basement. Cooling is provided by a 446 ton absorption chiller in the basement coupled with a cooling tower on the roof. Domestic hot water is generated by two (2) 986 MBH water heaters. Associated pumps, fans and motors are used in conjunction with the equipment. Lighting for the building was provided by a number of fluorescent T-12 fixtures and incandescent bulbs.

The following table includes the P4P upgrades and summarizes the individual measures, savings, and costs of work performed for the building. The existing gas fired boilers were replaced with seven condensing boilers, which increased the overall system efficiency from 84% to 89%. Domestic hot water heaters were replaced with two new condensing water heaters, increasing system efficiency from 81% to 94%. The existing incandescent and T-12 fluorescent fixtures were replaced with a combination of CFL, LED exit signs, and T-8 fluorescent fixtures. Existing hot water, domestic hot water, condensing water circulation single speed pumps and cooling tower fans all had Variable Frequency Drives (VFDs) installed on their motors to allow for optimal speed regulation. Makeup Air Units were replaced as the existing units were beyond the ASHRAE Median Service Life of 20 years.

	Measure Name	Installed Cost (incl. design)	Annual Energy Savings		Demand Savings	Annual Cost Savings	Measure Life	Simple Payback	Life Cycle Savings	IRR
		$	kWh	Gas MMBtu	kW	$	years	years	$	%
1	New Boilers for Space Heating	$280,000	-6,929	2,149	0.0	$18,548	20	15.10	-$4,057	2.8%
2	New Boilers for DHW	$70,000	0	1,507	0.0	$13,638	20	5.13	$132,904	18.9%
3	Lighting Upgrade	$87,500	182,598	139	36.0	$24,996	15	3.50	$210,897	27.8%
4	VFDs on Pumps Motors	$80,000	75,357	27	11.0	$10,041	15	7.97	$39,866	9.2%
5	VFD on Cooling Tower Fan Motors	$20,000	25,427	0	16.0	$3,306	15	6.05	$19,461	14.3%
6	New Makeup Air Units	$50,000	115,317	66	14.0	$15,589	15	3.21	$136,095	30.6%
	CM Fees	$20,000	*Overall project management, all fees associated with specific measures should be noted above.*							
	Partner Fees	$16,400	*Per Partner Contract*							
	TOTALS	$623,900.00	391,770	3,888	77.0	$86,117		7.24	$498,765	11.5%

Table 2: Measured Pay for Performance – Building 1

In order to go above and beyond the scope of work from Pay for Performance (P4P), LED fixtures would replace the upgraded CFL and T-8 fluorescent fixtures along with exterior perimeter lighting. An exterior lighting controls system would be installed to minimize the run time of exterior lighting the existing standard efficiency pump and fan motors which had VFD's installed in P4P would be upgraded to premium motors. Remote programmable thermostats would be installed throughout this building in order to create a 3°F temperature setback. The existing 1-stage absorption chiller would then be upgraded to a 2-stage absorption chiller. Lastly, the existing single-pane windows would be replaced with double-pane low-e windows.

Outlined in Table 2 is a summary of the additional measures that were not included in the original P4P scope of work

Measure Name	Energy Conservation Measures	Savings	Annual Electric Use (kWh)	Peak Demand (kW)	Annual Natural Gas Use (MMBtu)	Measure Cost
Baseline	**N/A**	**Baseline**	1,828,515	449.7	28,882	**N/A**
P4P	Replace Boilers, Replace DHW Heaters, Upgrade Lighting, VFD's on Pumps and Fans, Upgrade AHUs	15.0%	1,436,745	373.4	24,994	$623,900
Run 1	LED Lighting Upgrade, Install Exterior Lighting Controls, Install Premium Motors w/ VFDs	17.0%	1,342,939	360.4	24,950	$138,801
Run 2	Install Programmable Thermostats	23.0%	1,302,272	353.5	22,516	$179,400
Run 3	Replace Chiller	29.0%	1,318,644	356.1	18,850	$631,163
Run 4	Replace Windows	34.0%	1,285,756	342.1	16,528	$884,800

Table 3: Modeled NJGBM – Building 1

These additional improvements focused on lighting upgrades, motor upgrades, HVAC and building envelope upgrades. A chart showing savings and associated costs of these additional improvements is shown in Figure 1. The greatest savings come from the chiller and window upgrades, which are the most expensive upgrades for this project. Initially, the most cost effective improvements had been incorporated into P4P (meeting the 10% Internal Rate of Return minimum requirement of P4P). The Simple Payback Period (SPP) of the P4P project was 7.24 years, while the SPP for the NJGBM improvements becomes 13.68 years. Going beyond P4P is achievable but requires a much greater capital investment.

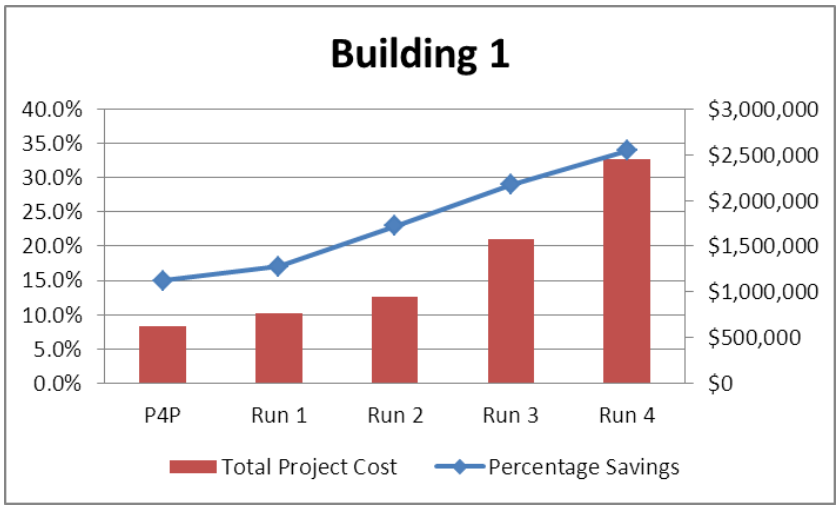

Figure 1: Cost vs. Savings Building 1

BUILDING 2

This building was built in 1962 and is located in Cherry Hill, NJ. The building is six-story building and houses a mixture of studios, one bedroom and two bedroom apartments. Heating for the building is provided via baseboard heaters fed by a 2,247 MBH boiler. Domestic hot water is provided by a 960 MBH boiler. Each apartment unit has a through the wall AC units for cooling. Lighting for the building was provided by a number of fluorescent T-12 fixtures and incandescent bulbs.

The following table includes the P4P upgrades and summarizes the individual measures, savings, and costs of work performed for the building. The existing gas fired boiler was replaced with five condensing boilers, increasing system efficiency from 80% to 89%. The domestic hot water heater was replaced with two condensing water heaters which increased the system efficiency from 80% to 94%. Existing High Pressure Sodium, incandescent, and T-12 fluorescent fixtures were replaced with more efficient induction, CFL, and T-8 fluorescent fixtures. Lastly, the hot water circulation pump motor was retrofitted with a VFD.

	Measure Name	Installed Cost (incl. design)	Annual Energy Savings		Demand Savings	Annual Cost Savings	Measure Life	Simple Payback	Life Cycle Savings	IRR
		$	kWh	Gas MMBtu	kW	$	years	years	$	%
1	New Boilers for Space Heating	$95,000	-7,457	1,633	0.0	$15,776	20	6.02	$139,706	15.7%
2	New Boilers for DHW	$26,250	0	407	0.0	$4,192	10	6.26	$9,509	9.6%
3	Lighting Upgrades	$46,250	157,606	-198	35.0	$20,025	15	2.31	$192,812	43.1%
4	VFD on HW Pump	$6,250	9,857	-38	0.0	$989	15	6.32	$5,552	13.4%
	CM Fees	$20,000	*Overall project management, all fees associated with specific measures should be noted above.*							
	Partner Fees	$15,000	*Per Partner Contract*							
	TOTALS	$208,750.00	160,006.0	1,804.0	35.0	$40,982		5.09	$312,579	18.2%

Table 4: Measured Pay for Performance – Building 2

As with Building 1, the first measure that would be pursued for the NJGBM would be to upgrade the already upgraded lighting from induction, CFL, and T-8 fluorescent fixtures with all LED fixtures. It should be noted that, LED lighting would be a common upgrade beyond the scope of work of P4P simply because at the time that these buildings participated in P4P, LED fixtures were not allowed by the P4P program because they were not EnergyStar or Design Lights Consortium qualifying products. In addition to upgrading lighting throughout this building, premium motors would replace the standard efficiency motors, the existing 8 SEER Packaged Terminal Air Conditioners (PTACs) would be replaced with 12 EER PTACs. Remote mounted, programmable thermostats would be installed to increase the temperature set-points by 3°F and the existing single-pane windows would be replaced with double-pane low-e windows.

Outlined in Table 4 is a summary of the additional measures that were not included in the original P4P scope of work.

Measure Name	Energy Conservation Measures	Savings	Annual Electric Use (kWh)	Peak Demand (kW)	Annual Natural Gas Use (MMBtu)	Measure Cost
Baseline	N/A	Baseline	1,046,538	360.7	8,222	N/A
P4P	Replace Boilers, Replace DHW Heaters, Upgrade Lighting, VFD on Pump	18.3%	886,532	326	6,418	$208,750
Run 1	LED Lighting Upgrade, Install Premium Motors w/ VFDs	22.3%	806,541	308.5	6,518	$52,727
Run 2	Replace PTAC Units, Install Programmable Thermostats	25.7%	748,148	263.7	6,498	$450,000
Run 3	Replace Windows	31.3%	746,422	250.5	5,420	$221,200

Table 5: Modeled NJGBM – Building 2

The additional improvements impact lighting, motors, HVAC and building envelope. A chart showing savings and associated costs of these measures is shown in Figure 2. Replacement windows would generate the largest savings as the existing windows allowed for undesirable infiltration rates. Simple Payback Period (SPP) for the P4P project was 5.09 years while the SPP for the NJGBM improvements would equate to a 13.16 year payback.

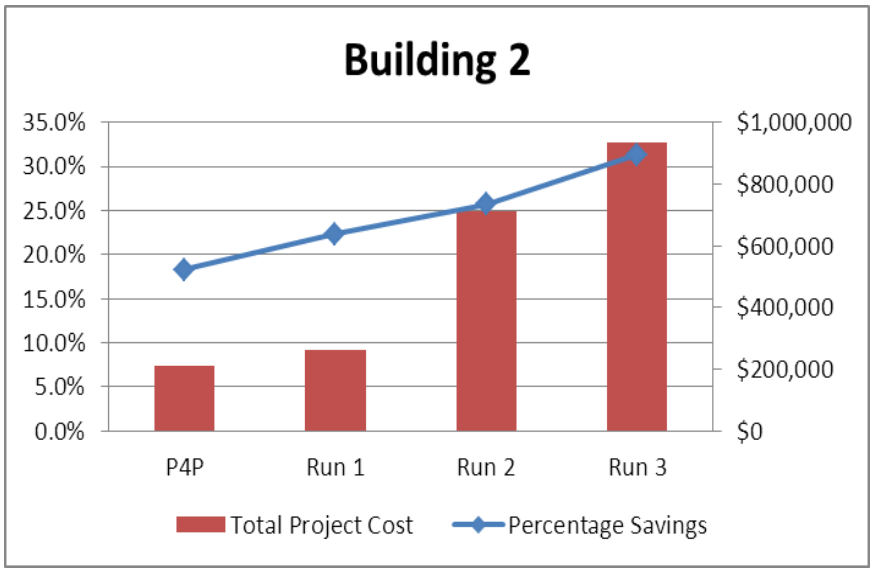

Figure 2: Cost vs. Savings Building 2

BUILDING 3

This building is a six-story apartment building located in Cherry Hill, NJ. Built in 1965, the building houses studios, one bedroom and two bedroom apartments. Heating for the building provided via baseboard heaters fed by two (2) 991 MBH boilers and domestic hot water is provided by a 670 MBH water heater all located in the boiler room. Each apartment unit has a through the wall AC unit for cooling. Lighting for the building was provided by a number of fluorescent T-12 fixtures and incandescent bulbs.

Table 5 includes the P4P upgrades and summarizes the individual measures, savings, and costs of work performed for the building. The two existing gas-fired space heating boilers, operating at 80% system efficiency were replaced with three 89% efficient condensing boilers. The gas-fired water heater was then replaced by two condensing water heaters, increasing efficiency from 80% to 94%. The existing High Pressure Sodium, Metal Halide, incandescent, and T-12 fluorescent fixtures were replaced with Induction, CFLs and T-8 fluorescent fixtures. Lastly, a VFD was installed on the hot water circulation pump motor.

	Measure Name	Installed Cost (incl. design)	Annual Energy Savings		Demand Savings	Annual Cost Savings	Measure Life	Simple Payback	Life Cycle Savings	IRR
		$	kWh	Gas MMBtu	kW	$	years	years	$	%
1	New Boilers for Space Heating	$65,000	-3,139.0	801.0	0.0	$7,324	20	8.87	$43,962	9.4%
2	New Boilers for DHW	$23,000	0.0	431.0	0.0	$4,181	10	5.50	$12,662	12.7%
3	Lighting Upgrades	$24,000	124,019.0	-212.0	17.0	$15,554	15	1.54	$161,686	64.8%
4	VFD on HW Pump	$3,500	3,129.0	-11.0	0.0	$338	15	10.37	$530	5.0%
	CM Fees	$20,000	*Overall project management, all fees associated with specific measures should be noted above.*							
	Partner Fees	$16,500	*Per Partner Contract*							
	TOTALS	$152,000.00	124,009.0	1,009.0	17.0	$27,397		5.55	$182,341	16.0%

Table 6: Measured Pay for Performance – Building 3

Again, LED lighting was the first measure considered when attempting to improve the building performance. Apartments in this building used window air conditioning units rated at 8 SEER. These window units would be replaced with PTACs rated at 12 EER. Single-pane windows would then be replaced with double-pane low-e windows and remote mounted programmable thermostats would be installed. The existing thermostat set-points were a little higher than Buildings 1 and 2, so the setbacks were modeled at 2°F, as opposed to 3°F.

Outlined in Table 6 is a summary of the additional measures that were not included in the original P4P scope of work.

Measure Name	Energy Conservation Measures	Savings	Annual Electric Use (kWh)	Peak Demand (kW)	Annual Natural Gas Use (MMBtu)	Measure Cost
Baseline	-	Baseline	582,026	385.2	4,993	N/A
P4P	Replace Boilers, Replace DHW Heaters, Upgrade Lighting, VFD on Pump	19.2%	448,614	371.6	4,040	$152,000
Run 1	LED Lighting Upgrade	26.9%	345,258	359.8	4,201	$40,575
Run 2	Replace Window Units with PTAC Units	30.7%	301,236	245.7	4,201	$210,000
Run 3	Replace Windows, Programmable Thermostats	35.3%	272,378	226.9	3,935	$200,320

Table 7: Modeled NJGBM – Building 3

Lighting upgrades, HVAC and building envelope upgrades have been incorporated into the model to provide ~15% decrease in energy consumption beyond the P4P scope of work. Each of these upgrades contributed to 5% of the total reduction. A chart showing savings and associated costs of these additional improvements is shown in Figure 3. Simple Payback Period from P4P was 5.55 years but the additional measures for the NJGBM would increase the payback to 11.12 years.

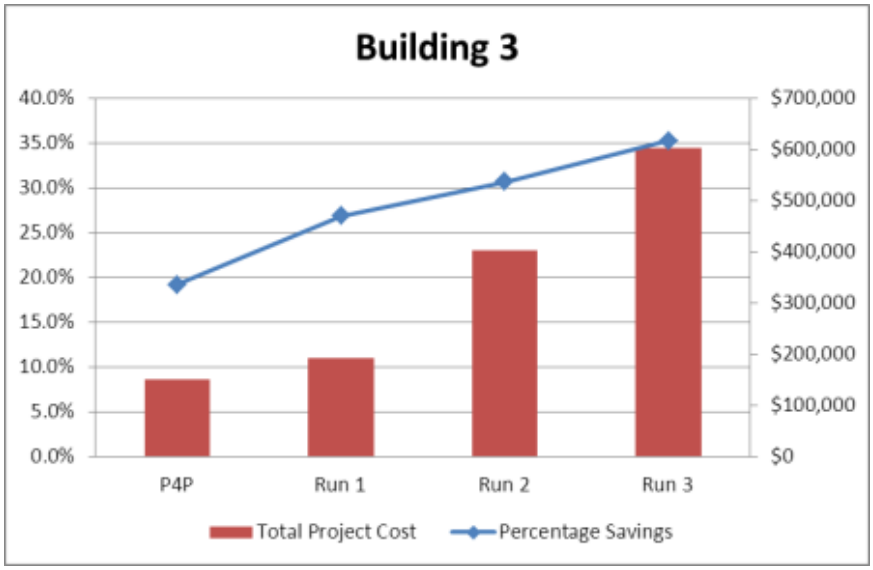

Figure 3: Cost vs. Savings Building 3

BUILDING 4

This building is a four-story, 168,861 ft^2 residential building located in Woodbury, NJ. Built in 1980, the building houses 200 apartment units, common areas and a number of offices. Heating is provided by five gas fired boilers in the boiler room then circulated to the heating coils throughout the building. Domestic hot water for entire building is generated by three gas fired boilers. Two hundred through the wall packaged air conditioners provide cooling for each individual apartment. Two makeup air units on the roof and a number of split DX systems are used to condition air for common areas and offices. Lighting for the facility is provided by a mixture of fluorescent T-8 fixtures and compact fluorescent bulbs.

The following table includes the P4P upgrades and summarizes the individual measures, savings, and costs of work performed for the building. Rooftop Units (RTUs) were upgraded from 8 EER units to 13.3 EER units along with installation of a heat recovery system that captures heat from the exhaust fans and pre-treated supply air to the common areas. Occupancy sensors were installed throughout the building, where applicable with code. Replacement of fixtures was not considered as the lighting in this building was already upgraded to CFL and T-8 fixtures. EnergyStar refrigerators replaced existing units and low flow plumbing fixtures were installed in the apartments. These two measures were not considered in the other buildings discussed mainly because the owners did not want to invest in these upgrades. Programmable thermostats were a viable option for P4P so they were included for this building. Lastly, a new boiler control system was installed to reduce full load operation.[3]

	Measure Name	Installed Cost (incl. design)	Annual Energy Savings		Demand Savings	Annual Cost Savings	Measure Life	Simple Payback	Life Cycle Savings	IRR
		$	kWh	Gas MMBtu	kW	$	years	years	$	%
1	Common space RTUs w/Energy Recovery	$280,000	-13,181	3,872	77.0	$55,787	15	5.02	$385,982	18.3%
2	Common Space Lighting	$15,000	14,819	-9	3.0	$2,445	15	6.13	$14,188	14.0%
3	Energy Star Refrigerators	$56,700	38,053	-37	8.0	$6,062	17	9.35	$23,113	7.6%
4	Low Flow Fixtures	$40,000	0	146	0.0	$2,184	15	18.32	-$13,928	-2.4%
5	Programmable T-stats	$67,500	757	70	0.0	$1,191	15	56.68	-$53,282	-13.3%
6	Outdoor Reset - Space Heating	$5,000	-6	32	0.0	$467	15	10.71	$575	4.5%
	CM Fees	$12,174	*Overall project management, all fees associated with specific measures should be noted above.*							
	Partner Fees	$17,200	*Per Partner Contract*							
	TOTALS	$493,574.00	40,442	4,074	88.0	$68,136		7.24	$327,274	10.9%

Table 8: Measured Pay for Performance – Building 4

[3] Savings from the Low Flow Fixtures and Programmable Thermostats for this building were minimal. Both fixture flow rate and heating temperatures were already low, so changes to these components resulted in marginal savings. Regardless, the owner wanted these improvements made to the facility, and they qualified in the program due to high savings from other measures. This being said, Low Flow Fixtures and Programmable Thermostats usually warrant generous savings and should be considered on a case-by-case basis.

For the NJGBM, the first thing upgraded would be the existing CFL and T-8 fluorescent fixtures, which would be replaced with LED fixtures. Next, the remaining HVAC units, ranging from a 1 ton 9.4 EER unit to 5 ton 8.5 EER units, would be replaced with 14 SEER units. Lastly, new storm window technology would increase the benefit of the existing double-pane low-e windows.

Outlined in Table 8 is a summary of the additional measures that were not included in the original P4P scope of work.

Measure Name	Energy Conservation Measures	Savings	Annual Electric Use (kWh)	Peak Demand (kW)	Annual Natural Gas Use (MMBtu)	Measure Cost
Baseline	-	**Baseline**	972,073	319.8	7,455	**N/A**
P4P	Replace RTUs, Install Occupancy Sensors, Replace Refrigerators, Install Low-Flow Fixtures, Install Programmable Thermostats, Install Boiler Controls	25.0%	931,631	231.8	3,381	$493,574
Run 1	LED Lighting Upgrade	32.0%	784,695	209.2	3,638	$447,800
Run 2	Upgrade HVAC Units, Replace Windows	35.0%	735,322	183.4	3,568	$576,430

Table 9: Modeled NJGBM – Building 4

The new list of measures accounted for a 10% increase in energy savings over the P4P project. The new measures included lighting upgrades, HVAC and building envelope upgrades. A chart showing savings and associated costs of these additional improvements is shown in Figure 4. The largest savings reduction came from the upgrade to LED lighting. It would be very difficult to generate additional savings beyond Run 2 without investing in renewable energy. Simple Payback Period (SPP) for the P4P portion was 7.24 years, with the NJGBM improvements raising the SPP to 15.26 years.

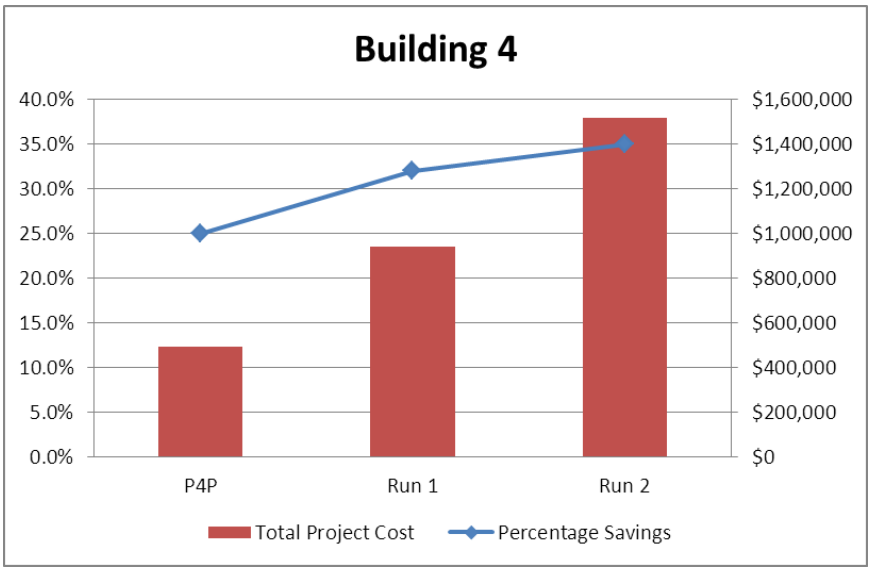

Figure 4: Cost vs. Savings Building 4

BUILDING 5

This building is a residential high-rise building located in Elizabeth, NJ. The building was built in 1960 and contains nine residential floors and common area spaces. The building also has a two-story parking deck with the first floor of the deck being enclosed and heated. Lighting for the building is provided by a several different types of fixtures including T-12 fluorescents, high-pressure sodium, incandescent bulbs and compact fluorescent bulbs. The building utilizes a 2-pipe fan coil unit in each apartment. Heating to the fan coil units, garage space heaters and the generation of domestic hot water is served by an 8,400 MBH steam boiler in conjunction with a heat exchanger. Cooling is provided by a 150 ton chiller located in the garage with the cooling tower located on the roof of the building.

The following table includes the P4P upgrades and summarizes the individual measures, savings, and costs of work performed for the building. The existing gas fired boiler was replaced with four condensing boilers, raising system efficiency form 75% to 89%. Three new domestic hot water heaters were to supply domestic hot water separately from the space heating boilers for a new system efficiency of 94%. Incandescent, High Pressure Sodium, and T-12 fluorescent fixtures were replaced with CFL, Induction, and T-8 fluorescent fixtures. VFD's were installed on the domestic hot water pump motor, chilled water pump motor, and condensing water circulation pump motor. Lastly, after upgrading the wet sprinkler system with a dry system, the need for heating in the parking garage was eliminated.

	Measure Name	Installed Cost (incl. design)	Annual Energy Savings		Demand Savings	Annual Cost Savings	Measure Life	Simple Payback	Life Cycle Savings	IRR
		$	kWh	Gas MMBtu	kW	$	years	years	$	%
1	New Space Heating Boilers	$140,000	-6,195.0	2,166.0	0.0	$22,043	20	6.35	$187,941	14.7%
2	New DHW Heaters	$40,000	0.0	363.0	0.0	$3,841	20	10.42	$17,138	7.2%
3	Lighting Upgrades	$60,000	173,062.0	-364.0	30.0	$20,551	15	2.92	$185,332	33.8%
4	VFD on Pump Motors	$35,000	49,668.0	-141.0	10.0	$5,511	15	6.35	$30,795	13.3%
5	Eliminate Garage Heating	$100,000	1,944.0	1,339.0	-3.0	$14,441	15	6.92	$72,392	11.7%
	CM Fees	$25,000	*Overall project management, all fees associated with specific measures should be noted above.*							
	Partner Fees	$18,200	*Per Partner Contract*							
	TOTALS	$418,200.00	218,479.0	3,363.0	37.0	$66,386		6.30	$450,398	14.1%

Table 10: Measured Pay for Performance – Building 5

Further savings could be realized by upgrading the lighting to all LED lighting, installing premium motors in place of the existing standard efficiency motors, upgrading the existing electric chiller 150 ton (Electric Input Ratio decreased from 0.202 to 0.1887), and installing new storm window technology provide an additional benefit to the existing double-pane low-e windows, similar to what would be done in Building 4.

Outlined in Table 10 is a summary of the additional measures that were not included in the original P4P scope of work.

Measure Name	Energy Conservation Measures	Savings	Annual Electric Use (kWh)	Peak Demand (kW)	Annual Natural Gas Use (MMBtu)	Measure Cost
Baseline	-	**Baseline**	916,680	313.7	11,476	**N/A**
P4P	Replace Boilers, Install DHW Heaters, Upgrade Lighting, Install VFD on Pump, Eliminate Garage Heating	23.4%	698,201	277.1	8,113	$418,200
Run 1	LED Lighting Upgrade, Install Premium Motors, Chiller Upgrade	25.1%	656,335	258.1	8,157	$219,968
Run 2	Replace Windows	31.3%	628,818	242.8	6,943	$177,276

Table 11: Modeled NJGBM – Building 5

By combining lighting upgrades, motor upgrades, chiller upgrades and building envelope upgrades into the model, an additional 8% savings were achieved. Programmable thermostats were not considered in this building due to the fact that the existing conditions did not leave room for additional setback savings. A chart showing savings and associated costs of these additional improvements is shown in Figure 5. Similar to Building 2, replacement windows generated the largest savings as the existing windows allowed for undesirable infiltration rates. Simple Payback Period (SPP) for this building was 6.3 years when it was taken through P4P. By pursuing the additional improvements, SPP would be increased to 9.21 years.

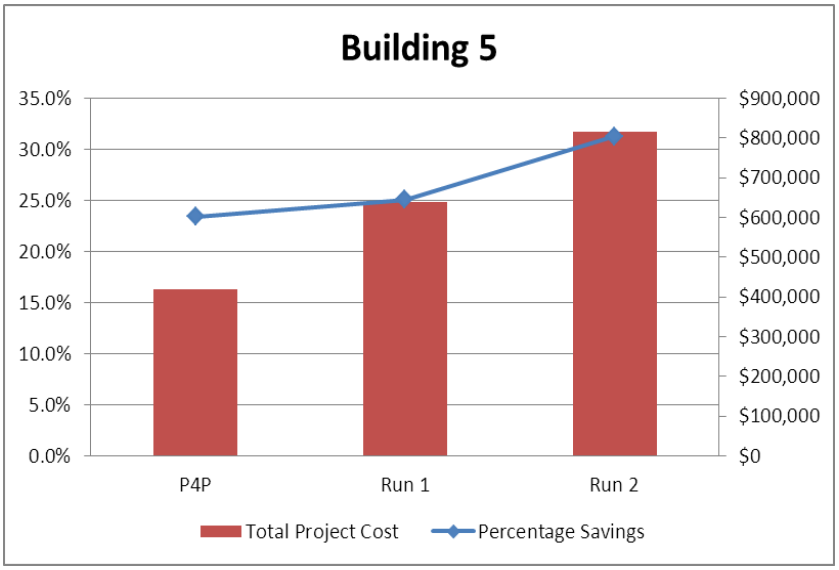

Figure 5: Cost vs. Savings Building 5

BUILDING 6

This building is located in New Brunswick, NJ and was constructed in 1964. The building consists of 169 apartment units with its first floor being rented to commercial clients. The building contains two entrances on either side of the long building and is comprised primarily of brick. The hallway to the apartments is opened and exposed to outside conditions and separated only by a perforated brick structure. Windows are all operable and are single-pane. The lobbies utilize ceiling high windows and glass double doors. Lighting is provided by a mixture of T-12 fluorescents and incandescent bulbs. Heating is provided by hot water baseboards in the apartments served by two (2) 8,978 MBH boilers. Domestic hot water is generated by a 1,796 MBH boiler. Cooling to the units is provided by window units in the apartments.

Table 11 includes the P4P upgrades and summarizes the individual measures, savings, and costs of work performed for the building. The two existing gas-fired boilers were replaced with five condensing boilers, increasing system efficiency from 77% to 89%. Circulation pump motors were fitted with VFDs. Existing Metal Halide, High Pressure Sodium, incandescent and T-12 fluorescent fixtures were replaced with Induction, CFL, and T-8 fluorescent fixtures.

	Measure Name	Installed Cost (incl. design)	Annual Energy Savings		Demand Savings	Annual Cost Savings	Measure Life	Simple Payback	Life Cycle Savings	IRR
		$	kWh	Gas MMBtu	kW	$	years	years	$	%
1	New Space Heating Boilers	$160,000	-14,490.0	2,796.0	0.0	$26,243	20	6.10	$230,430	15.5%
2	VFD on Supply Pumps	$40,000	162,444.0	-439.0	19.0	$17,022	15	2.35	$163,206	42.3%
3	Lighting Upgrade	$46,600	162,432.0	-232.0	33.0	$19,105	15	2.44	$181,472	40.8%
	CM Fees	$20,000	*Overall project management, all fees associated with specific measures should be noted above.*							
	Partner Fees	$16,400	*Per Partner Contract*							
	TOTALS	$283,000.00	310,386.0	2,125.0	52.0	$62,370		4.54	$538,708	21.1%

Table 12: Measured Pay for Performance – Building 6

The owner was not interested in installing domestic hot water heaters in P4P, so naturally they became the first upgrade for the NJGBM, which would increase domestic hot water system efficiency from 80% to 94%. LED Lighting would replace the P4P upgrade, and 9.4 EER window units would be replaced with 12 EER PTACs.

Outlined in Table 12 is a summary of the additional measures that were not included in the original P4P scope of work.

Measure Name	Energy Conservation Measures	Savings	Annual Electric Use (kWh)	Peak Demand (kW)	Annual Natural Gas Use (MMBtu)	Measure Cost
Baseline	-	**Baseline**	1,380,548	568.5	16,397	**N/A**
P4P	Replace Boilers, Install VFD on Pump, Upgrade Lighting	16.7%	1,070,162	517.1	14,272	$283,000
Run 1	Install DHW Heater, LED Lighting Upgrade	19.3%	1,013,351	505.5	14,034	$275,470
Run 2	Replace Windows, Replace Window Units with PTACs	23.9%	940,169	424.6	13,308	$685,062

Table 13: Modeled NJGBM – Building 6

DHW Heaters became the first measure to be modeled for the additional runs. The remaining measures cover lighting upgrades, HVAC and building envelope upgrades. These additional upgrades totaled an 8% reduction in energy consumption but at a great financial cost. A chart showing savings and associated costs of these additional improvements is shown in Figure 6. The existing thermostats were programmable and upgrading them would ultimately require a behavioral change to see added benefit. It would not be viable to quantify these changes so this upgrade was not part of Building 6. Simple Payback Period (SPP) for P4P was 4.54 years and would be increased drastically to 13.94 years in order to incorporate the additional improvements.

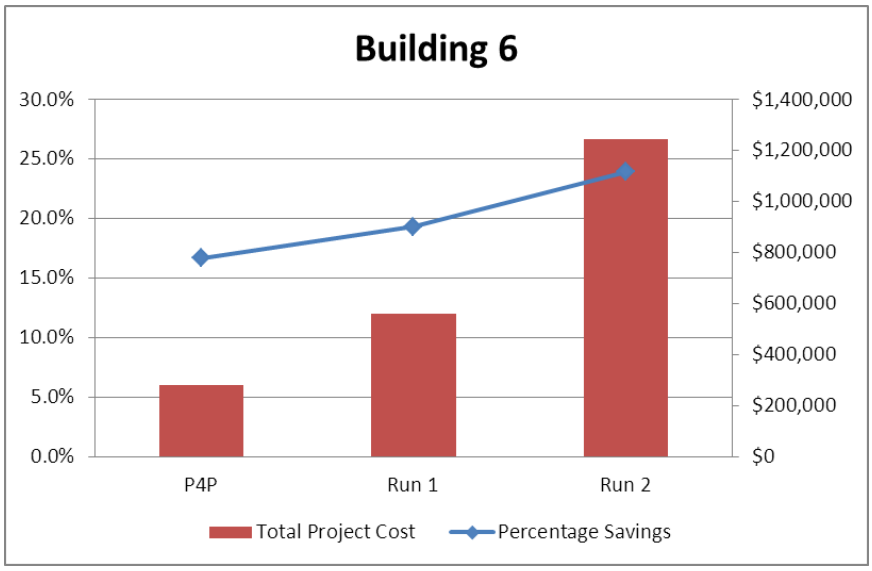

Figure 6: Cost vs. Savings Building 6

BUILDING 7

This building consists of two towers that mirror each other on a fenced in plot of land in Newark, NJ. The buildings were built in 1960 and house a multitude of personnel including many students that attend neighboring universities and colleges. Each building contains 340 rental units and contains a convenience store located at the base of the building. The two towers share a common space heating system with the boilers located in the South Tower mechanical room. The towers utilize a steam boiler where only the lobby utilizes steam heat. The remainder of the building utilizes hot water via heat exchanger in each tower. There is a redundant boiler as back-up also located in the South Tower. Each building houses its own DHW boilers. Cooling to each apartment is accomplished by PTAC units. Lighting is provided by different types of fluorescent and incandescent fixtures.

The following table includes the P4P upgrades and summarizes the individual measures, savings, and costs of work performed for the building. The existing steam boiler was replaced with three condensing boilers, increasing system efficiency from 70% to 89%. The three hot water standard efficiency pump motors were replaced with premium efficiency fitted with VFDs. Lastly, incandescent and T-12 fluorescent fixtures were replaced with CFL and T-8 fluorescent fixtures.

	Measure Name	Installed Cost (incl. design)	Annual Energy Savings		Demand Savings	Annual Cost Savings	Measure Life	Simple Payback	Life Cycle Savings	IRR
		$	kWh	Gas MMBtu	kW	$	years	years	$	%
1	Higher Eff HW Boiler	$811,365	-57,934	17,873	0.0	$228,268	20	3.55	$2,584,681	27.9%
2	VFD Pump	$62,000	71,854	-252	0.0	$8,361	15	7.42	$37,808	10.4%
3	Lower Lighting Density	$150,000	343,153	-652	57.0	$47,262	15	3.17	$414,215	31.0%
	CM Fees	$10,000	*Overall project management, all fees associated with specific measures should be noted above.*							
	Partner Fees	$59,000	*Per Partner Contract*							
	TOTALS	$1,092,365.00	357,073	16,969	57.0	$283,891		3.85	$2,967,704	25.6%

Table 14: Measured Pay for Performance – Building 7

Each apartment in this building had a louver system that allowed for fresh air to enter into the rooms. This system was old and prone to infiltration. Therefore, the first measure would be to properly seal these louvers to minimize infiltration when outside air was not desired. LED lighting would be installed to see added savings in lighting power consumption. Domestic hot water heaters would replace the existing heat exchangers, which were not included in P4P because the owner did not desire the improvement, so it was included in the additional measure for NJGBM. Finally, the existing 8 EER PTACs would be replaced with 12 EER PTACs.

Outlined in Table 14 is a summary of the additional measures that were not included in the original P4P scope of work.

Measure Name	Energy Conservation Measures	Savings	Annual Electric Use (kWh)	Peak Demand (kW)	Annual Natural Gas Use (MMBtu)	Measure Cost
Baseline	-	**Baseline**	3,505,181	1335.9	61,361	**N/A**
P4P	Replace Boilers, Install Premium Pumps with VFD's	22.0%	3,148,108	1279.2	44,392	$1,092,365
Run 1	Seal Louvers	26.0%	3,055,245	1182.9	41,036	$64,800
Run 2	LED Lighting Upgrade, Install DHW Heaters, Upgrade PTACs	30.0%	2,733,417	911.9	41,034	$2,599,165

Table 15: Modeled NJGBM – Building 7

This building has louvers that bring in fresh air to each apartment, these louvers are old and in need of improvement however the building owner was not interested in the improvement because the tenants pay their utility bills. Additionally, this complex has old PTAC units that could be upgraded to more efficient PTACs. These additional improvements each equated to a 4% reduction in energy savings. Similar to Building 6, programmable thermostats were not a viable option because of the existing thermostat functionality. A chart showing savings and associated costs of these additional improvements is shown in Figure 7. Simple Payback Period in P4P was 3.85 years but the NJGBM measures would increase the payback to 9.48 years.

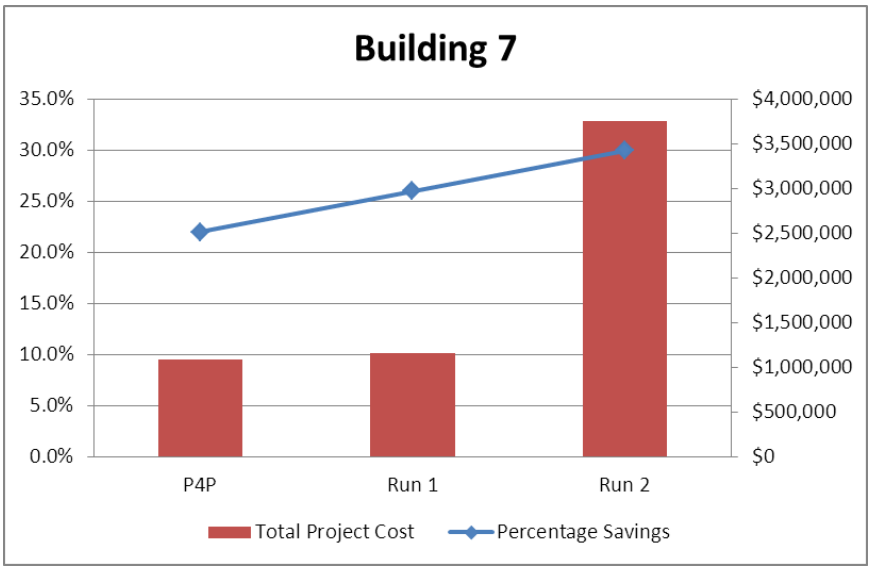

Figure 7: Cost vs. Savings Building 7

BUILDING 8

The 14-story apartment building was constructed in 1966 and is located in Fort Lee, NJ. This building has 130 apartment units with the first residential floor being rented to commercial clients. Next to the apartment building is a three-story building that houses a number of businesses. Two 8,375 MBH steam boilers (100% redundant) located in the mechanical room serve fan coil units, the absorption chiller and domestic hot water needs. Because steam is needed all year round, maintenance rotates boilers every week. These two boilers never operate at the same time. Chilled water is supplied by a 188 ton absorption chiller-cooling tower system. Via 2-pipe loop, hot and chilled water are pumped to fan coils in the apartments. Heating for all three stories of the commercial building is provided by the same boiler, but have three different cooling systems. The first floor has a water cooled system with a dry cooler on the roof. The second and third floors are cooled by split DX systems with both the AHUs and condensing units located on the roof. Lighting is provided by an assortment of fluorescent and incandescent fixtures.

Table 15 includes the P4P upgrades and summarizes the individual measures, savings, and costs of work performed for the building. The existing chiller, which was 45 years old and beyond its useful life, was replaced with a new water-cooled chiller, 0.48 kW/ton IPLV efficiency. Existing 7 EER DX Split Units were upgraded to 11-12 EER units. The existing boilers provided space heating and domestic hot water and were replaced with three condensing boilers and a condensing domestic hot water heater. Old Air Handling Units (AHUs) were replaced with new, higher efficiency units. Standard efficiency pump motors were upgraded to premium efficiency pump motors with VFDs. A VFD was also installed on the cooling tower fan motor. Incandescent and T-12 fluorescent fixtures were replaced with CFL and T-8 fluorescent fixtures.

	Measure Name	Installed Cost (incl. design)	Annual Energy Savings		Demand Savings	Annual Cost Savings	Measure Life	Simple Payback	Life Cycle Savings	IRR
		$	kWh	Gas MMBtu	kW	$	years	years	$	%
1	New Electric Chiller	$175,000	-57,862.0	5,495.0	-106.0	$39,781	25	4.40	$517,709	22.6%
2	1st Floor DX Split	$45,000	57,000.0	0.0	33.0	$8,664	15	5.19	$58,430	17.6%
3	New Boilers	$200,000	-6,414.0	2,963.0	0.0	$25,218	20	7.93	$175,180	11.1%
4	New DHWH	$50,000	0.0	870.0	0.0	$7,691	10	6.50	$15,604	8.7%
5	2nd Fl DX Split	$55,000	52,227.0	0.0	36.0	$7,939	15	6.93	$39,769	11.7%
6	3rd floor AHU	$24,000	47,722.0	0.0	11.0	$7,254	15	3.31	$62,595	29.6%
7	New Premium Pumps	$18,800	487.0	11.0	0.0	$171	15	109.77	-$16,755	-18.4%
8	VFD on 2-pipe Loop	$10,000	43,245.0	-151.0	5.0	$5,238	15	1.91	$52,536	52.3%
9	VFD on Cooling Tower	$5,000	2,514.0	0.0	3.0	$382	15	13.08	-$438	1.8%
10	Lighting Upgrades	$7,000	10,367.0	-18.0	4.0	$1,417	15	4.94	$9,912	18.7%
	CM Fees	$20,000	*Overall project management, all fees associated with specific measures should be noted above.*							
	Partner Fees	$22,000	*Per Partner Contract*							
	TOTALS	$631,800.00	149,286.0	9,170.0	-14.0	$103,754		6.09	$872,541	15.1%

Table 16: Measured Pay for Performance – Building 8

Lighting would be upgraded from the CFL and T-8 fluorescent fixtures to LED throughout. Single-pane windows would be upgraded with new storm window technology to mimic the benefits of double-pane low-e windows.

Outlined in Table 16 is a summary of the additional measures that were not included in the original P4P scope of work.

Measure Name	Energy Conservation Measures	Savings	Annual Electric Use (kWh)	Peak Demand (kW)	Annual Natural Gas Use (MMBtu)	Measure Cost
Baseline	-	**Baseline**	1,484,816	516	15,058	**N/A**
P4P	Replace Chiller, Replace AHU, Replace Boilers, Replace DHW Heaters, Premium Pump Motors, Install VFD on Pumps and Fans, Upgrade Lighting	28.0%	1,335,530	530	5,888	$631,800
Run 1	LED Lighting Upgrade	36.5%	990,969	407.3	6,378	$412,020
Run 2	Window Upgrades Residential Space	43.5%	933,886	376.6	4,290	$331,326
Run 3	Window Upgrades Commercial Space	44.9%	883,653	332.4	4,308	$103,648

Table 17: Modeled NJGBM – Building 8

Multiple improvements were included in P4P, leaving only a few, less financially feasible measures to be modeled. These measures consisted of lighting upgrades and building envelope upgrades. A chart showing savings and associated costs of these additional improvements is shown in Figure 8. Simple Payback Period (SPP) from P4P was 6.09 years and the additional measures would raise this SPP to 7.93 years. These additional improvements were not available at the time of P4P participation so were not included in that project.

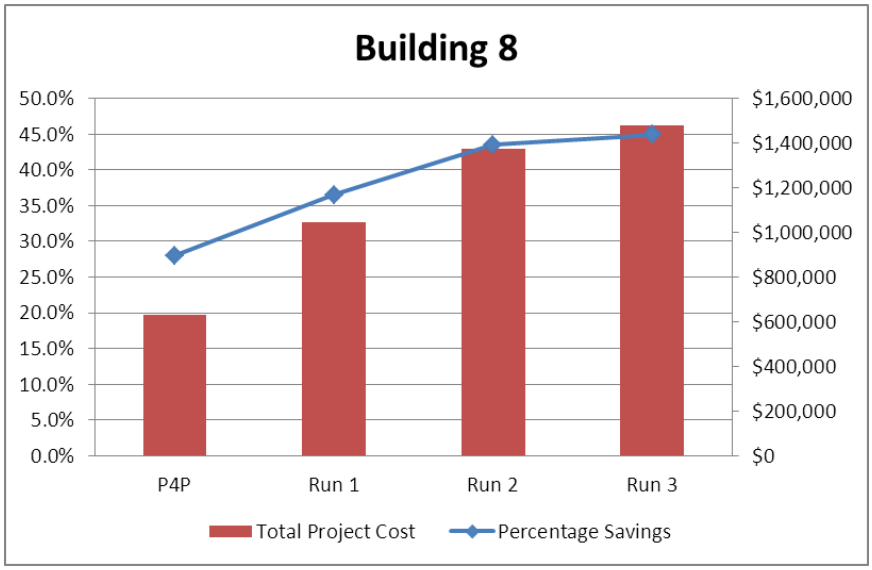

Figure 8: Cost vs. Savings Building 8

BUILDING 9

This building is a 10-story, 165,680 ft^2 residential building located in Keyport, NJ. The building was constructed in 1975 and houses 208 apartment units. Each apartment unit utilizes a through the wall PTAC unit for cooling with electric baseboard for heating purposes. There are several 100% outside air HVAC units on the roof that serve the common areas. Lighting is provided by a mixture of fluorescent T-12 fixtures and incandescent bulbs.

The following table includes the P4P upgrades and summarizes the individual measures, savings, and costs of work performed for the building. This building could not qualify in P4P because it did not achieve the minimum 10% IRR requirement. A large portion of the savings came at too great a cost. The measures that had been considered were replacing the incandescent and T-12 fluorescent fixtures with CFL and T-8 fluorescent fixtures. The existing single-pane windows would be replaced with double-pane low-e windows. Programmable thermostats would be installed to reduce space conditioning requirements during unoccupied hours.

	Measure	Installed Cost (incl. design)	Annual Energy Savings		Demand Savings	Annual Cost Savings	Measure Life	Simple Payback	Life Cycle Savings	IRR
		$	kWh	Gas MMBtu	kW	$	years	years	$	%
1	CFL - Indoor Fixture	$5,000	96,309	0	0.0	$20,211	2	0.25	$33,673	387.2%
2	Fluorescent Fixtures	$14,110	73,014	0	0.0	$15,457	6	0.91	$69,624	108.2%
3	Window Replacement	$1,500,000	252,161	0	0.0	$59,878	50	25.05	$40,647	2.5%
4	Programmable Thermostats	$10,150	41,598	0	0.0	$3,491	8	2.91	$14,356	30.2%
	CM Fees	$0	*Overall project management, all fees associated with specific measures should be noted above.*							
	Partner Fees	$10,800	*Per Partner Contract*							
	TOTALS	$1,540,060	463,082	0	0.0	$99,037		15.55	$147,499	3.0%

Table 18: Measured Pay for Performance – Building 9

Additional savings would be achieved by upgrading the existing domestic hot water heaters with the 94% efficient condensing hot water heaters used in in the other buildings. Lighting would be upgraded to LED lighting. The existing 9 EER PTACs, which provide electric cooling and heating would be replaced by 12 EER cooling only PTACs and new condensing boilers would be installed to provide heating to the building.

Outlined in Table 18 is a summary of the additional measures that were not included in the original P4P scope of work.

Measure Name	Energy Conservation Measures	Savings	Annual Electric Use (kWh)	Peak Demand (kW)	Annual Natural Gas Use (MMBtu)	Measure Cost
Baseline	-	**Baseline**	2,144,143	1504.9	2,174	**N/A**
P4P	Upgrade Lighting, Replace Windows, Install Programmable Thermostats	20.6%	1,681,060	1168.1	2,174	$1,545,160
Run 1	Upgrade DHW Heaters, LED Lighting Upgrade	25.4%	1,620,876	1169.2	1,653	$857,000
Run 2	Upgrade PTACs	26.4%	1,599,556	1169.2	1,653	$379,500
Run 3	Install Hot Water Boilers	51.9%	665,620	247.5	5,573	$770,650

Table 19: Modeled NJGBM – Building 9

All improvements for this building were very costly, however large savings could be achieved by upgrading DHW heaters, lighting, PTACs and installing a central boiler plant. A chart showing savings and associated costs of these additional improvements is shown in Figure 9. This building did not qualify for P4P as the Simple Payback Period (SPP) was 15.6 years. These additional measures would go raise this SPP to 17.86 years.

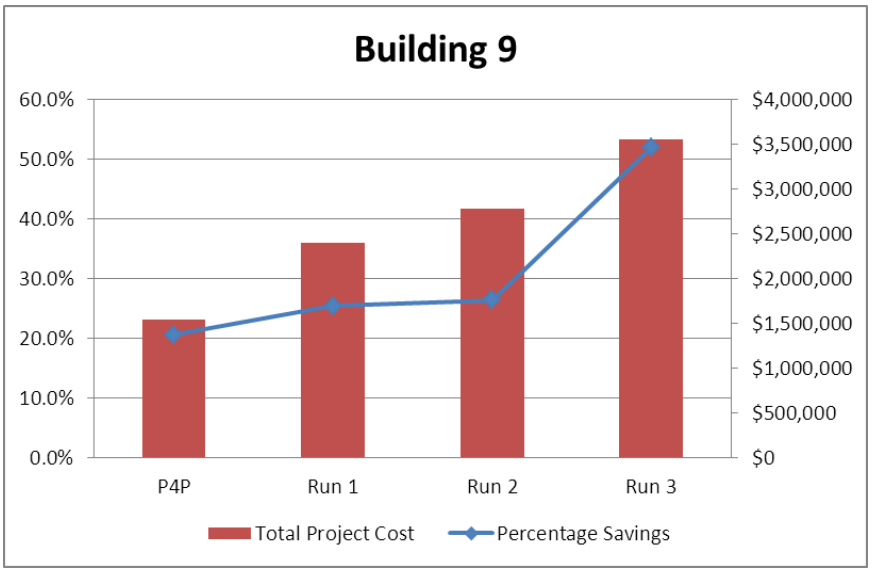

Figure 9: Cost vs. Savings Building 9

BUILDING 10

This building consists of twenty-one floors with a basement level and is located in Passaic, NJ. The building was constructed in 1963 and houses 228 condominium units. Next to the building is a two level underground and aboveground parking lot. Two 9,000 MBH steam boilers (100% redundant) serve fan coil units with the use of a heat exchanger. The same boilers also generate domestic hot water needs. The boilers never operate simultaneously. Chilled water is supplied by 230 ton electric chiller-cooling tower system. Via 2-pipe loop, hot and chilled water pumped to fan coils in the apartments. Lighting is provided by several types of fluorescent and incandescent fixtures.

The following table includes the P4P upgrades and summarizes the individual measures, savings, and costs of work performed for the building. The existing steam boilers provide space heating and domestic hot water generation and were replaced by new space heating condensing boilers and new condensing domestic hot water heaters. The existing 14.3 EER electric chiller was replaced by a new water-cooled chiller with 0.543 kW/ton efficiency. Premium motors replaced existing standard efficiency pump motors. VFDs were installed on the pump motors and cooling tower fan. The existing incandescent and T-12 fluorescent lighting were replaced with CFL and T-8 fluorescent fixtures.

	Measure Name	Installed Cost (incl. design)	Annual Energy Savings		Demand Savings	Annual Cost Savings	Measure Life	Simple Payback	Life Cycle Savings	IRR
		$	kWh	Gas MMBtu	kW	$	years	years	$	%
1	New Space Heating Boilers	$235,000	-5,875.0	4,628.0	0.0	$46,354	20	5.07	$454,626	19.1%
2	New DHW Heaters	$90,000	0.0	1,372.0	0.0	$13,994	10	6.43	$29,375	9.0%
3	New Electric Chiller	$267,800	115,607.0	0.0	77.0	$16,763	25	15.98	$24,097	3.8%
4	New Pumps	$40,000	1,190.0	14.0	0.0	$315	15	126.84	-$36,235	-19.5%
5	VFD on 2-pipe Loop Pump	$17,000	52,015.0	-180.0	5.0	$5,706	15	2.98	$51,120	33.1%
6	VFD on Cooling Tower Fan	$9,000	8,535.0	0.0	2.0	$1,238	15	7.27	$5,774	10.8%
7	Lighting Upgrades	$10,000	16,431.0	0.0	2.0	$2,382	15	4.20	$18,442	22.7%
	CM Fees	$1	*Overall project management, all fees associated with specific measures should be noted above.*							
	Partner Fees	$29,200	*Per Partner Contract*							
	TOTALS	$698,001.00	187,903.0	5,834.0	86.0	$86,753		8.05	$517,998	10.2%

Table 20: Measured Pay for Performance – Building 10

LED lighting would replace all CFL and T-8 fluorescent fixtures. Programmable thermostats would be installed to allow for 2°F temperature setbacks.

Outlined in Table 20 is a summary of the additional measures that were not included in the original P4P scope of work.

Measure Name	Energy Conservation Measures	Savings	Annual Electric Use (kWh)	Peak Demand (kW)	Annual Natural Gas Use (MMBtu)	Measure Cost
Baseline	-	Baseline	1,614,828	519.7	18,852	N/A
P4P	Replace Boilers, Replace DHW Heaters, Replace Chiller, Premium Motors, Install VFD's on Pumps and Fans, Upgrade Lighting	19.5%	1,426,925	434.1	13,018	$698,001
Run 1	LED Ligthing Upgrade	28.0%	1,052,734	295.8	13,672	$222,780
Run 2	Install Programmable Thermostats	30.3%	1,038,447	292.8	12,888	$135,000

Table 21: Modeled NJGBM – Building 10

For this last building, there were only a couple of improvements that could be considered. Lighting upgrades and HVAC controls were modeled for a 10% savings increase over P4P. Additional savings are possible, but renewable energy sources will need to be considered. Window replacements were not considered for this model as the existing windows are in good condition so there would be minimal savings. A chart showing savings and associated costs of these additional improvements is shown in Figure 10. Simple Payback Period (SPP) from P4P was 8.05 years and would be decreased to 7.31 years with the NJGBM measures. Here the major savings came from the LED lighting upgrades which did not qualify in the P4P program at time of participation.

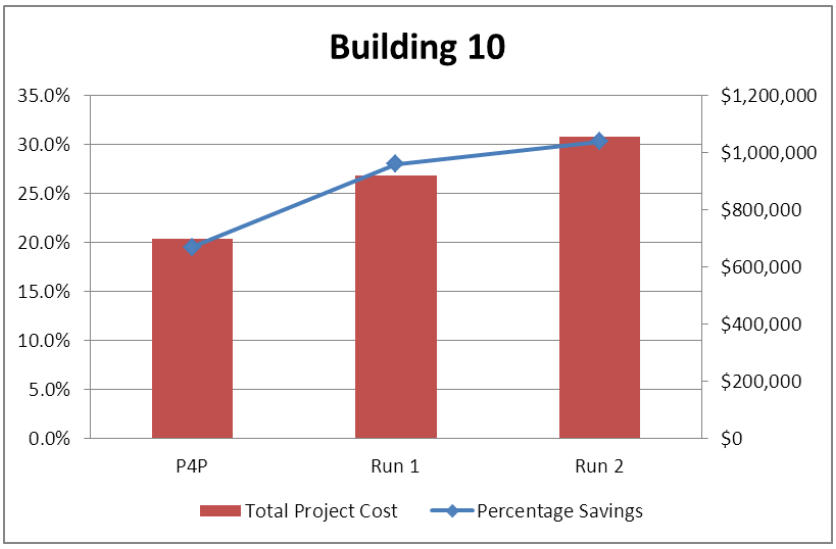

Figure 10: Cost vs. Savings Building 10

CONCLUSION

Multi-family buildings can see the greatest savings by upgrading lighting, HVAC and windows. Most improvements are cost effective, however when trying to attain savings greater than the current NJCEP P4P Program there is a trend towards diminishing returns on investment. LED lighting and replacement windows were among the most common upgrades that would be recommended in the additional runs. These two measures, although costly, accounted for some of the greatest savings in each building. Many upgrades focus on the major energy consumers for these buildings as shown in CBECS, heating, cooling, lighting, and water heating.

In creating an Advanced Energy Retrofits (AER) guide for the Multi-family housing sector one would need to consider the ownership of the building, occupancy schedules, and behavioral characteristics of tenants, in addition to the economic impact of installing energy improvements. Some of the economically feasible measures were not included in the P4P program simply because tenants pay their utility bills directly and the owner didn't want to invest in upgrades that would only save the tenant on utility costs.

Indeed, it has been the experience of our engineering industry partners that most residential new construction is performed with the lowest cost options as standard. This is attributed to the fact that the developer is typically looking to sell the project as soon as possible and therefore maximize his or her immediate profit. This is less often the case for commercial office or retail where the owner will hold onto the building for some period of time, although certainly the split incentive problem is present there as well. As a result, residential construction usually forgoes a relatively small capital cost investment in energy saving options (Energy Management Systems, additional insulation, condensing boilers, etc.) that would yield ongoing energy savings for the life of the building. This disconnect in building construction needs to be addressed. It is our opinion that these items should be incorporated into the energy codes, making it mandatory for developers to install energy efficient equipment

Specific to Building 5, having a parking garage located below a building is usually a good indicator of significant potential energy savings. In a garage, the standard wet sprinkler system has the lowest first cost. This system requires heat to stop any potential freeze condition. The heat in these systems typically comes in the form of electric resistance heating, which is the lowest initial cost. Without controls, the heat operates throughout the year at highly elevated temperatures, where a 35°F constant temperature would be acceptable. The installation of a simple control system (accurate temperature sensing and variable output control) will save a substantial amount of energy. Better yet, would be the installation of a dry sprinkler system where no heating would be required.

Even though we are simulating the buildings' energy usage, this only estimates the occupant behavior relative to energy. We have seen many buildings where the occupancy declines significantly in the winter yet the owners still leave the heating in vacant areas at a constant 72°F. This is especially typical of a building that has a single electrical meter and the residence is billed based upon their pro-rata square footage occupancy of the building. It is typical for a building with sub-metered electrical, to realize a savings of up to 20% compared to a single meter. One method to more accurately model the

occupancy behavior would be to data log specific energy usage in the existing building. Data logging is very valuable, but requires a lot of work up front.

Another common, large energy saving project is when an energy auditor finds a building with windows fully open during the winter. This is indicative of a poorly controlled heating system where the building has limited or no local heating control and therefore forces the occupants to waste energy by overriding the system in order to obtain reasonable conditions. Zone control should be mandated under new construction as it is difficult and expensive to retrofit into a building. This leads to a crucial point, regardless of how well a building has been designed, it is imperative that the energy consuming systems, at very least, be commissioned during construction and re-commissioned on a regular basis for the life of the system.

Incentive programs help push people in the direction of energy improvements, but often, few people know of these programs. An effort must be made to educate people about such incentive programs as well as good energy practices. A large emphasis is placed on lowest capital costs, which often kill energy projects, when in fact the long term benefits from these improvements would offset any savings the owners/tenants thought they were gaining by opting for the lower upfront cost. Therefore, incentive programs, such as P4P, offer a way to overcome the capital cost barrier.